Corrective Measures Implementation Work Plan

Remedial Construction Phase I

Former DuPont East Chicago Facility, Indiana

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ACRONYMS AND ABBREVIATIONS

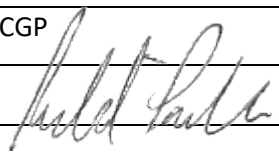
°C	Degree Celsius
ADQM	Analytical Data Quality Management
AOC	Area of Concern
AMSL	Above Mean Sea Level
ASTM	American Society for Testing Materials
ASTSWMO	Association of State and Tribal Solid Waste Management Officials
BERA	Baseline Ecological Risk Assessment
BGS	Below Ground Surface
CA	Corrective Action
CAO	Corrective Action Objectives
CLP	Contract Laboratory Program
CMS	Corrective Measure Study
CMI	Corrective Measures Implementation
C-O-C/COC	Chain Of Custody
CSM	Conceptual Site Model
DCP	Donor Compliance Package
DO	Dissolved Oxygen
DQO	Data Quality Objective
ECGP	East Chicago Gateway Partners, LLC
EI	Environmental Indicator
ELAP	Environmental Laboratory Approval Program
ESAM	Environmental Sampling and Analytical Methods

FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gas
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
IAC	Indiana Administrative Code
IDEM	Indiana Department of Environmental Management
IDW	Investigation-Derived Waste
IRM	Interim Remedial Measures
ISCF	In-Situ Chemical Fixation
ISCR	In-Situ Chemical Reduction
ISS	In-Situ Stabilization
LCS	Laboratory Control Sample
LDPE	Low-Density Polyethylene
LVA	Low Void Aggregate
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MS/MSD	Matrix Spike / Matrix Spike Duplicate
MW	Monitoring Well
NTU	Nephelometric Turbidity Units
ORP	Oxidation-Reduction Potential
PID	Photo Ionization Detection
PCB	Polychlorinated Biphenyls

PM	Project Manager
PRB	Permeable Reactive Barrier
PST	Pneumatic Slug Test
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility investigation
RSL	Remedial Screening Level
SA	Source Area
SOP	Standard Operating Procedure
SWMU	Solid Waste Management Unit
SWPPP	Storm Water Pollution Prevention Plan
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity characteristic Leaching Procedure
TSCA	Toxic Substances Control Act
UCL	Upper Confidence Limit
U.S	United States
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
WMU	Waste Management Units
WP	Work Plan

RESPONDENT CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I have no personal knowledge that the information submitted is other than true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

By:	Mr. Richard Parrish - ECGP
Signature:	
Date:	8-8-19
Time:	3 pm (Eastern)

1 PURPOSE AND OBJECTIVE

This work plan sets forth the requirements for implementation of the design, construction and operation of corrective measures at the Former DuPont East Chicago Facility, herein referred to as the Facility, pursuant to the RCRA § 3008(h) Administrative Order on Consent (Docket No. RCRA-05-2019-003) executed by E.I. du Pont Nemours and Company (DuPont), Chemours Company FC, LLC (Chemours) and East Chicago Gateway Partners, LLC (ECGP) on November 16, 2018 with the United States Environmental Protection Agency, Region 5 (USEPA 2018b). The work proposed under this order will implement the corrective measures selected by the USEPA in the Final Decision and Response to Comments with respect to the Facility Conceptual Model and Remedial Action Objectives finalized on July 18, 2018 (USEPA 2018a).

1.1 OVERVIEW OF WORK PLAN APPROACH

The overall approach of this Corrective Measures Implementation (CMI) Work Plan is to complete the required tasks for the design, construction and operation of the corrective measures concurrently with the process necessary for redevelopment. For proper implementation of corrective measures and redevelopment to occur with long-term sustainable effects, supplemental studies, surveys and investigations will be required. In general, studies will rely upon previously collected data to model or conclude new information, surveys will rely upon non-intrusive field activities and investigations will rely upon intrusive field activities. These information gathering mechanisms will provide means for remedial design optimization and redevelopment constructability planning. This approach will result in a phased and sequenced remedial design and construction. Remedial construction “Phase I” will focus on short-term remedial objectives related to soil remediation and preliminary groundwater treatment. Remedial construction “Phase II” will focus on long-term remedial objectives related to full scale treatment of groundwater and the landfill closure. A diagram of the phased approach to the implementation of the CMI is provided in **Exhibit 1**.

1.2 REMEDIAL CONSTRUCTION PHASE I

The remedial design, construction and development implementation components that will be addressed under the scope of Remedial Construction Phase I include the following:

- Remedial Design and Construction:

- Survey Work
- Groundwater Baseline Event
- Preliminary Groundwater Treatment
- Source Area Soil Excavation, Treatment and Disposal
- In-Situ Stabilization of Saturated Source Area Soil
- Permeable Barrier Cover Importation, Specification and Construction
- Remedial Groundwater Performance Monitoring

- Development Related Activities:

  - Clearing and Grubbing
  - Concrete Survey and Slab/Foundation Removal
  - Geotechnical Investigation
  - Gary Road Access and Construction
  - Landfill Investigation and Beneficial Reuse Determination Study
  - Ground Improvement and Preparation
  - Low Void Aggregate (LVA) Processing and Manufacturing

A project sequencing flow diagram with primary elements of the supplemental field investigation work plan and corrective measures design and construction of the CMI Work Plan is provided in **Exhibit 2**.

In the event that unknown release(s) or threat of a release(s) of hazardous waste or hazardous constituents to the environment are encountered during the CMI Work Plan and/or redevelopment/construction activities, the EPA will be notified, and an Interim Remedial Measures Work Plan will be prepared and submitted to the USEPA as required in the Administrative Order on Consent.

1.3 REMEDIAL CONSTRUCTION PHASE II

The remedial design, construction and development implementation components that will be addressed under the scope of Remedial Construction Phase II include the following:

- Remedial Design and Construction:

- Full- Scale Groundwater Treatment and Monitoring
- Biowall Construction
- Facility Landfill Closure
- Hydrogeologic Study/ Fate and Transport Assessment
- Remedial Groundwater Performance Monitoring

- Development Related Activities:
  - Clearing and Grubbing
  - Ground Improvement and Preparation
  - Low Void Aggregate (LVA) Processing and Manufacturing
  - Building Design and Construction
  - Stormwater Systems and Hydraulic Controls
  - Facility Access Controls
  - Building Engineering Controls/ Vapor Barrier

1.4 LONG-TERM MONITORING AND MAINTENANCE PLAN

A long-term monitoring and maintenance plan will be implemented upon completion of Remedial Construction Phase I and II. This will include monitoring for long-term goals and remedial objectives.
The components that will be addressed under the Long-Term Monitoring Plan include the following:

- Post-Redevelopment Groundwater Treatment Contingencies and Modification
- Long-term Performance Monitoring
- Long-term Operation & Maintenance
- Property Access Controls
- Institutional Controls

1.5 PROJECT ORGANIZATION AND MANAGEMENT

Impact Environmental Indiana LLC, herein referred to as the "Contractor" is working under contract to East Chicago Gateway Partners, LLC, herein referred to as the "Owner" in accordance with the Order on Consent to execute the implementation of this work plan. The Project Manager and key personnel responsible for managing this project are provided in **Exhibit 3**.

1.6 DOCUMENT ORGANIZATION

This work plan provides a comprehensive background of the Facility's characteristics, history and presents the proposed work activities to achieve design and/or construction criteria with respect to implementation of the corrective action measures in accordance with the USEPA Final Decision. Furthermore, planned development activities that will be conducted concurrently with remedial construction activities are outlined in this plan.

1.7 TIMELINE AND SCHEDULE OF ONSITE ACTIVITIES

A project schedule of proposed activities is provided in **Exhibit 4**. This is presented as a Gantt chart and includes all phased remedial activities, coordination milestones, task durations and expected completion dates. All scheduled activities are contingent on the USEPA approval of this work plan. Furthermore, due to the nature of these activities, timeframes and durations may be modified based on actual field conditions and approvals of the USEPA. The project schedule will be updated each quarter and presented in the Quarterly Progress Report to the USEPA.

2 BACKGROUND AND ENVIRONMENTAL SETTING

The Facility, which is identified as 5215 Kennedy Avenue, East Chicago, Indiana, is 440 acres in areal extent. It is bound on the north by the Riley Park residential neighborhood and various commercial properties, the south by the East Branch of the Grand Calumet River, the east by commercial properties (including the City of East Chicago Solid Waste Transfer Station), and the west by Kennedy Avenue and the former USS Lead Refinery (Superfund Site currently undergoing cleanup under EPA CERCLA authority). The location of the Facility is referenced in **Figure 1**: Facility Location Map.

The Facility historically operated as a chemical manufacturing facility for Grasselli Corporation from 1892 to 1929 and subsequently by DuPont from 1929 until the Facility was closed in the mid-1980s. Dupont maintained the property until the Facility was transferred to Chemours in 2015 and was sold to ECGP in 2018. The Facility entered the RCRA Corrective Action Program in 1997. Below is a brief description of the RCRA Corrective Action Program milestones achieved under ownership of Dupont and Chemours:

RCRA Process Milestone	Owner/Party	Purpose	Year
RCRA 3008 (h) Administrative Order on Consent	USEPA/ DuPont	Enforcement Order based on discovery of a release	1997
Current Conditions Report	DuPont/ CH2M2 Hill	Identify and define Facility contamination	1997
Phase I RCRA Facility Investigation (RFI)	DuPont/ DuPont Corporate Remediation Group (DCRG)	Identify and define Facility contamination	2002
Installation of PRB Wall - Interim Remedial Measure (IRM)	DuPont/ DCRG	IRM to mitigate migration of contaminated groundwater off-site	2002
Current Human Exposure Under Control - Environmental Indicator (EI)	DuPont/ DCRG/ USEPA	Human exposure designated as “under control” by USEPA	2004

Phase II RFI	DuPont/ DCRG	Identify and define Facility contamination	2005
Migration of Contaminated Groundwater Under Control - EI	DuPont/ DCRG/ USEPA	Migration of contaminated groundwater designated as under control	2005
Human Health Risk Assessment (HHRA)	DuPont/ Pioneer Technologies Corporation	Identify human health risks associated with exposure to Facility contamination	2011
Baseline Ecological Risk Assessment (BERA)	DuPont/ Parsons	Identify ecological risks associated with exposure to Facility contamination	2012
Buffer Zone IRM Excavations	DuPont/ Parsons/ Summit	Excavate, treat and dispose on-site contaminated soils within the Buffer Zone Area	2013 - 2016
Corrective Measures Study	DuPont / Parsons	Evaluate and propose final remedial actions	2015
Final Decision Response to Comments	USEPA/ Chemours/ ECGP	USEPA selected final remedies	2018
RCRA 3008 (h) Administrative Order on Consent for Corrective Measures	USEPA/ ECGP/ Chemours/ Dupont	USEPA Enforcement Order to complete selected remedies	2018

DuPont, Chemours and ECGP executed an Administrative Order on Consent in November 2018 with the USEPA to perform the CMI Work Plan at the Facility. The RCRA program administrators, for convention, sectioned off areas of common land use at the Facility into five distinct areas as presented below.

- The Redevelopment Area: This area consists of approximately 155 acres and encompasses the former manufacturing area located within the central and western portion of the property. Future industrial and/or commercial use is anticipated for this area. The topography of the area is nearly flat and ranges in elevation from +589 to +591 above mean sea level.

- The Open Area: This area consists of approximately 50 acres and includes an approximately 25-acre solid waste landfill. The former landfill operated during historical manufacturing operations; however, discontinued use in 2002. A majority of the landfill consists of filter cake derived from waste water treatment systems onsite (CH2M Hill 1997). North of the landfill location is approximately 25 acres of wooded areas and wetlands. Future industrial and/or commercial use is anticipated for this area. The Open Area topography ranges in elevation from +589 to +591 amsl along relatively flat areas to the north and +599 to +601 amsl within the Solid Waste Landfill Area.

- The Buffer Zone: This area is located directly east of the open and Redevelopment Area and separates these portions from the adjacent Natural Area. The Buffer Zone Area is approximately 200 feet wide and extends across the width of the property oriented north to south occupying approximately 20 acres. The Buffer Zone Area is intended to provide additional protection to the Natural Area and its resources. Vegetation and habitat management will continue to support the health of the Natural Area. The Buffer Zone Area has undergone various IRM to mitigate the migration of contamination into the Natural Area (Parsons 2016c). Two large brush piles, each approximately 16,000 Cubic Yards (CY) remain in the Buffer Zone Area resultant of IRM activities. The Buffer Zone Area is not considered part of this CMI Work Plan and is being managed by The Nature Conservancy. The topography of the area is nearly flat and ranges in elevation from +579 to +590 above mean sea level.

- The Natural Area: This area is approximately 172 acres and has remained undeveloped retaining its unique dune and swale habitat. The Natural Area is managed by The Nature Conservancy for habitat and wildlife preservation and is protected from future development. The Natural Area is not considered part of this CMI Work Plan and is being managed by The Nature Conservancy. The topography of the area is nearly flat and ranges in elevation from +579 to +590 above mean sea level.

- The Active Manufacturing Area (Leased Area): This area consists of approximately 30 acres leased and managed by WR Grace Industries. This area is the only remaining portion of the Facility that maintains

manufacturing operations. The topography of the area is nearly flat and ranges in elevation from +583 to +587 above mean sea level.

- The Annex Area: This area is approximately 10 acres in size and consists primarily of wetlands. This parcel has not been previously investigated due to ownership discrepancies; however, based on a determination by USEPA must be evaluated (USEPA 2018b). Currently, a investigative work plan is being developed by Chemours and will be submitted to the USEPA. The topography of the area is nearly flat and ranges in elevation from +586 to +593 above mean sea level.

The boundaries, existing structures, natural features and designated areas described above are presented in **Figure 2:** Facility Map.

2.1 TOPOGRAPHY

The elevation of the Facility, as presented on the United States Geological Survey (USGS), Highland, Indiana Quadrangle Map, ranges approximately from +585 to +595 feet above mean sea level. In general, higher topographic elevations are in the Open Area and gently slopes south-southwest toward the Grand Calumet River (CH2M Hill 1997).

2.2 REGIONAL GEOLOGY

The Facility is situated within the Calumet Lacustrine Plain physiographic province that extends from Lake Michigan southward to the Valparaiso glacial moraine and occupies the former bed of glacial Lake Chicago (currently Lake Michigan). As the southern lobe of the lake receded approximately 12,000 years ago, a layer of clay and silt were overladen by meltwater silt, sand and gravel deposits. Three (3) distinct relict lake shorelines were formed, named Glenwood, Calumet and Toleston beaches, with each successive receding period. The Toleston Beach formation is comprised of a surficial Dune and Swale complex defined as linier elevated sandy dunes between valleys of marsh swales. This geological unit is known as Calumet Sand and is observed from grade to a maximum depth of 65 feet below ground surface (bgs). Calumet Sand was deposited on glacial till known as Lacustrine clay known to be 100 to 150 feet thick, consisting of stiff grey silty clays mixed with discontinuous lenses of sand and gravel. This clay till encounters a bedrock stratum at 150 to 200 feet bgs consisting of Devonian Shale and Limestone, Silurian Dolomite, Ordovician and Cambrian limestone, sandstone and shale, and Precambrian Granite (CH2M Hill 1997).

2.3 GEOLOGY

The Facility is underlaid by naturally occurring uniform unconsolidated beach sand (Calumet sand) overlying clay till, at approximately 40 bgs. Surface overburden in the developed areas of the Property were altered by filling and regrading. Soil, steel mill slag, sinters, bricks, and other fill materials were used to create a secure foundation within the former manufacturing area. The fill and debris overlie portions of the native beach and dune sand deposits. However, due to the undulating nature of the dunes and swale habitat system, fill depths vary across the Property ranging from 0 to 12 feet bgs. Sand, peat and silt have been reported below these fill depths. The base of the Calumet sand (sand clay till interface) is encountered at approximately 40 bgs and is overlying a Silurian dolomite bedrock formation at approximately 150 feet bgs (CH2M Hill 1997). **Figure 3** provides a cross sectional view of the geological conditions of the Property.

2.4 REGIONAL HYDROGEOLOGY

The regional geology of northern Lake County, Indiana contains two (2) principal aquifer systems, which lie within the Calumet Lacustrine Plain physiographic province. As discussed above, the evident surficial geologic features are a product of continental glaciation. The unconsolidated Calumet Aquifer directly underlies the subject property and consists of saturated Calumet Sand, recharged by precipitation infiltration. Regionally, this aquifer extends from Lake Michigan encompassing the northern quarter of Lake County. The Calumet Aquifer is unconfined and ranges from 5 to 65 feet in thickness. Beneath this aquifer is a clay till confining layer with a thickness of 100 to 150 feet, atop a bedrock stratum. Within the regional bedrock contains a second aquifer identified as the Silurian and Devonian Carbonates Aquifer System. This system consists of saturated fractured and weathered carbonate rock layers formed during the Silurian and Devonian periods. The depth and thickness of this aquifer varies greatly, however water wells that penetrate this system are drilled to an average depth of 230 feet bgs and produce viable water for public supply and irrigation (CH2M Hill 1997).

2.5 HYDROGEOLOGY

Groundwater is encountered from 0 to 10 bgs within fill and Calumet sand underlying the Facility. Based on potentiometric surface maps developed during various groundwater studies by Parsons, groundwater at the Facility is separated into two flow pools. A hydraulic divide separates these pools and runs from east to west along the northern portions of the Redevelopment and Open Area. **Figure 4** provides a Groundwater Elevation Contour Map. This creates a north flowing groundwater pool (Pool A) towards the Riley Park neighborhood

influenced by home basement sump pumps and local sewer pumps. South of the hydraulic divide is a flowing groundwater pool (Pool B) discharging to the Grand Calumet River. Horizontal hydraulic gradients are steepest towards the river, ranging from 0.004 to 0.01 feet. Horizontal hydraulic gradients to the north flowing towards Riley park are lower and range from 0.002 to 0.008 feet. Estimates of horizontal hydraulic conductivity range from 10 to 88 feet per day. Groundwater velocity ranges from approximately 20 feet per year north of the groundwater divide to roughly 70 feet per year south of the hydraulic divide (Parsons 2015a).

2.6 DUPONT FACILITY HISTORY AND USES

In 1892, Grasselli Corporation purchased the property and developed the land for the manufacturing of industrial inorganic chemical products. Development first occurred primarily along Kennedy Avenue on the western portion of the Facility and as operations increased throughout the early 1900s and land uses expanded eastward. By the 1920s, the current leased industrial area and former industrial area were fully populated with manufacturing plants and other associated structures and features. Primary products manufactured at the Facility were acid products, reagents, silica products, agricultural chemicals, various zinc, ammonia and chloride-based products. From 1910 to 1940, plant operations grew from 14 to 21 production lines at the Facility. During this growth period, DuPont assumed management of the facility until 1936 when it was officially deeded to DuPont. In 1948, operations peaked at 23 production lines and began manufacturing organic chemicals. This primarily consisted of Freon products (trichlorofluoromethane), recently developed by DuPont with General Motors. Freon products were manufactured by request of the federal government and dominated organic chemical production at the Facility. Other organic chemicals produced were several organic herbicides and insecticides. After WWII ended, from 1948 to 1955 production lines were reduced to 15. Then from 1955 to 1985, further production eliminations reduced production lines to two and fully shut down facility operations within the former industrial area. Operation continued unchanged within the current leased industrial area, producing Ludox colloidal silica and sodium silicate products. In 2000, these operations were leased to Grace Davison and were to remain unchanged. These products have been manufactured for over 100-years and currently remain in production (CH2M Hill 1990).

DuPont managed wastes at the facility according to general industrial practices at the time. Prior to 1970, DuPont utilized the northern waste management area and buffer zone for disposal of industrial waste streams. Liquid wastes were discharged to settling pits or pH neutralization lagoons before discharge to the Grand Calumet River. Pits and lagoons within the northern waste management area eventually discharged to groundwater. Solid waste streams were disposed in piles and then later into the onsite landfill. DuPont began

to modify waste management under new environmental regulations in the 1970's implementing wastewater treatment systems. These systems generated mass amounts of what is believed to be inert filter cake and led to a large increase in solid waste being deposited in the onsite landfill. The current leased industrial area discontinued onsite disposal (landfill) of filter cake prior to 2000. In 1986, all operations were consolidated to a single 30-acre parcel along Kennedy Avenue (CH2M Hill 1990, CH2M Hill 1997, DuPont 2002).

2.7 DUPONT FACILITY ENVIRONMENTAL HISTORY

The following is a brief overview of environmental investigations, actions and activities conducted at the Facility related to current RCRA Corrective Action Cleanup Enforcement:

In the 1980s, former operations and waste management practices were investigated at the Facility during closure of various industrial processes at the facility, as per RCRA requirements. In 1990, CH2M Hill conducted a groundwater assessment and a comprehensive evaluation of former waste management and operational practices. CH2M Hill identified 36 onsite waste management units (WMUs) that have the potential to adversely contaminate the Facility and concluded that onsite groundwater conditions have likely been contaminated. In 1992, CH2M Hill completed a Phase II groundwater assessment that further evaluated groundwater conditions at the Facility and identified offsite contamination to the northern Riley Park neighborhood. Arsenic and other metals were detected above the maximum contaminant levels (MCLs) in groundwater throughout the Facility. Furthermore, Site-related metal contaminants were identified in neighborhood sump pumps and sewer lines.

In 1997, the findings of the CH2M Hill's reports prompted a USEPA Facility investigation and subsequent RCRA Corrective Action Order 3008(h) issued to DuPont for the facility. In 1997, CH2M Hill further evaluated former operational and waste handling practices at the Facility and redefined previously identified WMUs. These environmental risks were further evaluated and characterized as 39 areas of concern (AOCs) as presented in **Table 1** and 41 solid waste management units (SWMUs) as presented in **Table 2**. Throughout the 2000s, these SWMUs and AOCs were systematically evaluated individually though multiple assessment, investigations and studies. Based on sample data collected and exposure pathways characteristics, SWMUs and AOCs were categorized into multiple designations ranging from no further action to remedial actions required. During these investigations, groundwater contamination was further defined, and contamination was found to be associated with multiple SWMUs and AOCs. A hydraulic divide separates groundwater flow into two alternate flowing pools, of which Pool A flows from the central portion of the Facility towards the northern boundary

and Pool B flows from a central portion of the Facility to the southern boundary (into the Grand Calumet River). Within both Pool A and Pool B, arsenic contaminated groundwater plumes were delineated and defined.

In response, DuPont installed a 2,000-foot long permeable reactive barrier (PRB) wall parallel to the northern boundary of the Facility in 2002. This was to prevent groundwater contamination from migrating off-site into the Riley Park neighborhood. This passive remediation system was designed to intercept and sequester dissolved arsenic compounds to mitigate their transport off-site. The second plume was identified within the interior of the former industrial area associated with SWMU 4- Insecticide Disposal Area and flowing southerly into the Grand Calumet River (Pool B). Furthermore, surface fill contaminated with arsenic and lead were further defined throughout the Redevelopment Area and Open Area. In 2012, interim remedial measures (IRM) removed and staged 71,571 cubic yards of contaminated fill associated with SWMUs and AOCs throughout the Buffer zone. Approximately 5,768 cubic yards were found to be potentially classified as hazardous waste and stockpiled separately. In 2014, the USEPA issued the Final Decision Response to Comments document for the Buffer Zone and Natural Area describing final actions, remedies and monitoring requirements selected.

In 2014, Parsons conducted a comprehensive evaluation on groundwater conditions at the Facility to further define onsite contamination and arsenic plumes. This study was followed by a bench scale study conducted in participation with CH2M Hill, the purpose of which was to evaluate the feasibility of in-situ chemical fixation (ISCF) injections recommended in the 2014 Groundwater Evaluation Report. In 2015, a corrective measures study was conducted to evaluate remedial approaches and technology that would achieve corrective action objectives. It was determined that fill Source Areas or “hotspots” are likely contributing to groundwater condition and would be excavated, treated and disposed onsite, contaminated surface fill would be capped with permeable and non-permeable covers, and groundwater plumes would be addressed with ISCF via enhanced sulfate reduction injections and Biowall trenches. In 2015, enhanced sulfate reduction injections were pilot tested within the two (2) arsenic plume areas and found to be initially effective, however further recommendations were proposed to optimize long-term effectiveness.

Parsons completed pilot testing in 2016 of enhanced microbial sulfate reduction injections intersecting arsenic plumes in Pool A and Pool B. These initial pilot tests appeared effective; however, further monitoring was determined to be needed to ascertain long-term effectiveness. Parsons submitted an Addendum to the CMS for the Grace Parcel which outlines proposed remedial actions to achieve the RCRA program corrective action

clean up goals for the Leased Area. This included removing lead contaminated areas that contain an exposure factor greater than 1.0, maintaining existing impermeable barriers (roads, slabs etc.) and permeable capping in location to achieve a residual target cancer risk hazard quotient below $1x10^{-5}$. In 2016, Parsons completed a Long-term Monitoring Report for the Natural Area. This report evaluated groundwater and fill conditions related to protection of human health and ecological resources. Elevated concentrations of zinc were observed in groundwater wells along the southwestern Natural Area/ Buffer Zone area and further zinc delineation would be completed to evaluate mitigative/corrective measures. In 2016, IRM work in the Buffer zone was completed, which included an additional 4,685 cubic yards of fill removed and all IRM stockpiled fill from 2012 and 2015 were treated and disposed within the onsite landfill. The landfill was then stabilized, capped with 1-foot of clay and seeded. In 2017 and early 2018, remedial measures were conducted to address the elevated levels of zinc observed in certain locations and ponds within the southern Buffer zone. These reports are currently being prepared by Parsons and will be discussed in the next CSM update. In early 2018, Parsons submitted a Comprehensive Pilot Study Report discussing performance monitoring of pilot test injection events of enhanced microbial sulfate reduction. Enhancements and long-term optimizations were proposed along with additional pilot testing. Furthermore, full scale groundwater treatment methods and locations were evaluated and outlined. In the summer of 2018, USEPA issued the Final Decision and Response to Comments document designating the final corrective measures based on the recommendations in the 2015 CMS, the 2016 Addendum to the CMS for the Grace Parcel and public comment.

In November 2018, the USEPA issued a RCRA 3008 (h) Administrative Order on Consent for Corrective Measures Implementation Order. This document obligates respondents to satisfy the environmental cleanup requirements mentioned above. Moreover, the Consent Order discussed a portion of land formerly owned by DuPont approximately 9-acres in size identified as the “Annex Area” that was not included in investigatory work previously conducted at the Facility. This past omission obligates respondents to pursue investigative and remedial actions for the Annex Area. Currently, it is understood that an investigative work plan is being prepared by Parsons and investigative work will commence in 2019.

3 SELECTED REMEDIAL ALTERNITIVES

3.1 CORRECTIVE ACTION OBJECTIVES

Corrective Action Objectives (CAOs) are media specific cleanup objectives to address goals for reducing hazards to human health, safety and the environment. CAOs are intended to be as specific as possible but not to unduly limit the range of alternatives that can be developed. These objectives are identified for hazardous substance compounds and specific media which humans and the environment may be exposed to. When the CAOs are developed they address contaminants and media of concern, exposure route and receptors, remediation goal for each exposure route.

The CAOs for the Facility were developed during the Corrective Measures Study (Parsons 2015a) and Addendum to the CMS for the Grace Parcel (Parsons 2016a) in consideration of the nature and extent of known and documented contamination, the potential exposure pathways, current and future receptors, and the current and future land-use. Once CAOs were well-defined based on the Human Health Risk Assessment (HHRA) (Pioneer 2011) and Baseline Ecological Risk Assessment (BERA) (Parsons 2012) findings, site-specific cleanup goals were developed in the CMS to achieve protection of human health and the ecological receptors as discussed below.

3.2 REMEDIAL CLEANUP GOALS

Based on the HHRA and the BERA, several complete exposure pathways were identified for both human and ecological receptors, respectively. This includes approximately 120,720 square feet of Facility surface in the Redevelopment Area and approximately 22,200 square feet located in the open area. Furthermore, incidental and direct contact exposure pathways to human receptors were identified for COCs (primarily lead) in shallow soil within the Leased Area. Cleanup goals were developed during the Corrective Measures Study specifically to address surficial fill contamination and direct contact exposure pathways. Cleanup goals were further defined based on the protection of human health and the environment, potential future land uses, the long-term goals of reducing sitewide contamination and preventing contaminants of concern releases from fill to groundwater. The following cleanup goals were accepted by the USEPA in the issuance of the final decision and respond to comments document:

- Minimize direct contact exposure to contaminated surficial fill.

- Achieve 1x10E^{-5} residual risk from direct contact with fill, and a non-cancer HI<1 across entire Redevelopment Area.
- Remediate identified fill-to-groundwater Source Areas where arsenic concentrations in fill are greater than 1000 mg/kg (part per million).

3.3 SHORT TERM CLEANUP GOALS

Short term cleanup goals have been described as the following:

- Significant reduction in exposure risk (dermal contact, ingestion, inhalation) to receptors from elevated COCs (lead, cadmium and arsenic) within contaminated surface soils by means of permeable barrier cover construction and maintaining existing non-permeable covers (paved areas, roadways).
- Significant reduction in arsenic loading to groundwater within Source Area locations by means of Source Area excavation and In-situ stabilization activities.
- Mitigate potential groundwater contribution/influence on the water quality in the Grand Calumet River.
- Demonstrate measurable groundwater quality improvement resulting from Source Area excavations and preliminary groundwater treatment activities.

3.4 LONG-TERM CLEANUP GOALS

The Facility contains two distinct and well-defined groundwater plumes. One that migrates towards the northern boundary in the direction of the Riley Park Neighborhood (Pool A) and another that migrates south in the direction of the Grand Calumet River (Pool B). Each of the plumes has a different cleanup standard that applies toward remedial goals.

Northern Boundary - Pool A

- The Northern boundary cleanup goal for Arsenic in groundwater was established at the Maximum Contaminant Level (MCL) of 0.010 mg/L for the USEPA Drinking Water Standard.

Southern Boundary - Pool B

- The Southern boundary cleanup goal for Arsenic in groundwater was established at the Indiana Surface Water Quality Standard of 0.148 mg/L.

3.5 REMEDIAL ALTERNATIVES EVALUATION AND SELECTION

Various fill/soil and groundwater remediation treatment techniques and technologies were evaluated and proposed for use at the Facility given the associated CAOs and remedial cleanup goals in the CMS. These technologies were evaluated for their efficiency in achieving overall protection of human health and the environment, attaining media cleanup standards, controlling Source Area releases, and complying with applicable standards for waste management. Additionally, short-term and long-term effectiveness, implementability and costs were factored. The CMS presented the treatment techniques and technologies into 5 separate packaged alternatives. USEPA selected the proposed CMS "Alternative 4" containing final corrective measures to achieve short-term and long-term remedial goals. After a public comment period the final corrective measure and remedies were issued in the Final Decision Response to Comment Document (USEPA 2018a) and are as follows:

3.5.1 Permeable Barrier Cover

Prohibit direct contact exposures to contaminants in the fill through the utilization of engineering controls. The engineering controls included maintaining existing pavement and foundations in the Lease area and by constructing and maintaining a permeable barrier cover in the Open Area and Redevelopment Area.

3.5.2 Source Area Excavation/ Treatment/ Disposal

Excavate fill with concentrations of Arsenic greater than 1,000 mg/kg "hot spots" for off-site disposal. These hot-spots are known to be major sources of the detected groundwater contamination (Source Areas). Modeling predicts that this removal of the Source Areas will result in the decreased arsenic concentrations in the groundwater. In addition, excavation and off-site disposal of Lead contaminated fill to a depth 2 feet bgs in the Lease Area. This is to mitigate direct human contact and achieve a residual target cancer risk of 1×10^{-5} and the lead exposure factor of less than 1.0.

3.5.3 In-Situ Treatment of Saturated Source Area Fill

Treat contaminated in-situ saturated soil within arsenic Source Area excavations (below the water table) where concentrations warrant treatment to further reduce the arsenic source to groundwater.

3.5.4 In-Situ Treatment of Groundwater

Create enhanced microbial sulfate reduction injection treatment zones along the plume flow paths and construct permeable reactive biological barrier walls with a perpendicular orientation to intercept the plume and reduce arsenic solubility. The combination of Source Area remediation and treatment zones transecting plume flow paths is intended to rapidly reduce arsenic concentrations in groundwater, reduce the flux of arsenic to the bio-barriers thus extending their longevity, and to convert existing forms of arsenic in saturated fill/soils into forms that are less soluble and therefore less mobile.

3.5.5 Final Closure of the Onsite Landfill

Proceed with final closure of the landfill. The final closure effort should meet or exceed the Final Closure requirements of Title 329 of Indiana Administrative Code (IAC) Article 10 Rule 37 and shall include the following:

- Installation of a final cover that includes geocomposite layers, a drainage layer and a vegetative cover per the closure requirements.

- Development and implementation of a groundwater monitoring plan.

- Development and implementation of a post-closure care plan in accordance with 329 IAC 10-38 and EPA requirements provided in 40 CFR Parts 264, 265, 270 and 271 including a design, monitoring and post-closure process.

4 SUPPLEMENTAL FIELD ACTIVITIES

4.1 SUPPLEMENTAL FIELD ACTIVITIES

This CMI Work Plan includes additional studies, surveys and investigations that will be undertaken to provide additional information for the remedial design contemplated as part of this work plan and/or for redevelopment. Some of these activities will utilize computer electronic, hydraulic-powered heavy earth moving and drilling equipment. In all cases, the investigation work will progress in accordance with the CMI Health and Safety Plan and the Quality Assurance Project Plan as applicable to equipment and media disturbed, handled and/or sampled.

4.2 HEALTH AND SAFETY CONSIDERATIONS

The Health and Safety Plan (HASP) is included in **Appendix A** and discusses various items related to the health and well-being of investigative, remedial and construction workers. The purpose of the HASP is to assign responsibilities, establish awareness of known hazards, prepare for unknown hazards and provide contingencies to handle related emergencies. The HASP will detail the following topics:

- Project Organization and Safety Management
- Hazard Evaluation
- Worker Protection
- Work Zones
- Site Safety Controls
- Hospital Routes
- Contingency Plans
- Training
- Medical Monitoring
- Sanitation
- Inspections and Monitoring

4.3 COMMUNITY AIR MONITORING PLAN (CAMP)

The Community Air Monitoring Plan (CAMP) developed for this project is intended to protect the surrounding community from potential fugitive dust generated by onsite remedial activities. Air quality will be tested at

one perimeter location upwind and two locations on the downwind perimeter of the Facility during remediation and redevelopment activities. The rationale of the program will be to test air quality along the downwind boundary of the Redevelopment Area and the northern boundary of the Redevelopment Area to provide protection to the adjacent natural areas and residential neighborhoods. Testing will include real-time and time-weighted instruments and techniques. The procedures, protocols, and implementation details are presented in **Appendix B – CAMP**. This testing will be in addition to testing performed at various locations at the Facility for worker health and safety considerations as presented in the Health and Safety Plan.

4.4 QUALITY ASSURANCE AND QUALITY CONTROL

According to the EPA, a Quality Assurance Project Plan (QAPP) describes the activities of an environmental data operations project involved with the acquisition of information generated from direct measurements activities, laboratory testing or compiled from computerized databases and information systems. The QAAP documents the results of a project's technical planning process, providing a clear, concise, and complete plan for the environmental data operation and its quality objectives and identifying key project personnel. The work plan for this project will integrate environmental investigation and remediation activities with redevelopment design and construction, and therefore the QAPP incorporates procedures, protocols and measurements for remedial design elements. The QAPP for this work plan is provided in **Appendix C**.

4.5 BASELINE GROUNDWATER MONITORING

Prior to performing the Source Area soil excavation and stabilization work, baseline groundwater monitoring will be performed. This work can be performed in concert with the geotechnical investigation. The purpose of the groundwater monitoring event shall be for the following objectives:

- Evaluate the efficacy of the 2015 remedial pilot test injection events and measure any changes in geochemistry.
- Evaluate groundwater conditions associated with the Source Areas, to determine whether sulfide mineral (iron/arsenic) precipitation conditions exists, iron oxide complexes/sulfate mineral dissolution conditions exist (arsenic liberation) and determination of potential arsenic dissolution based on future remedial actions.
- Apply the field measurements/laboratory analyses towards updated fate and transport model preparation.

- Confirm the amendment dosage associated with Source Area In-Situ soil Stabilization/Solidification.
- Utilize the field measurements, laboratory analyses and modeling output for optimizing the groundwater remediation work plan.
- Evaluate groundwater samples collected from the proposed and existing remedial supply wells, for chemical of concern (COC) concentrations and chemical/physical properties.
- Screen the monitoring network for non-COC, emerging contaminants.

The following preparatory tasks will be performed to confirm reliable groundwater data essential for proper evaluation prior to the baseline groundwater monitoring event.

4.6 WELL ABANDONMENT

It is anticipated that monitoring wells, PRB wells and piezometers located within and adjacent to Source Areas within the redeveloped/open areas and leased areas of the Facility, will be damaged and/or destroyed during the Source Area fill/soil excavation and ISS work. Said wells and piezometers will be abandoned prior to the baseline groundwater monitoring event. Replacement wells and piezometers will be installed prior to initiating the baseline groundwater monitoring event. It is anticipated that additional wells and/or piezometers will require abandonment, prior to redevelopment work; said well abandonment work will be performed prior to the subsequent groundwater treatment work and will be proposed with future work plans related to groundwater treatment design and implementation. The following wells and piezometers will be abandoned prior to the start of the baseline groundwater monitoring event:

- Monitoring Wells: MW-10, MW-15, MW-16, MW-17, MW-19, MW-20, MW-21, MW-22, MW-28, MW-31S, MW-44, MW-45, MW-48S, MW-48D, MW-49S, MW-49D, MW-50S, MW-50D, MW-51S, MW-51D, MW-56S and MW-56D
- Permeable Reactive Barrier (PRB) Wells: PRB-1, PRB-1S, PRB-2, PRB-2S, PRB-3, PRB-3S, PRB-4, PRB-5, PRB-5S, PRB-5D, PRB-6, PRB-7, PRB-8, PRB-8S, and PRB-9
- Piezometers: P-3, P-6 and P-10

The location of the wells and piezometers selected for abandonment are provided in **Figure 5** and a list of the wells to be abandoned are included on **Table 3**. The wells will be abandoned in accordance with USEPA protocols and procedures as detailed in the QAPP. Additional wells/piezometers may be required to be abandoned in the future, associated with Property redevelopment work; the USEPA will be notified prior to

any future well abandonment(s) as well as potential replacement well installations for groundwater remediation and long-term monitoring purposes.

4.7 WELL PROTECTION AND RETROFITTING

Existing and newly installed monitoring wells/piezometers will be field flagged to prevent damage from construction activities and allow for easier locating (in addition to geo-mapping). In addition, the wells will be retrofitted, where necessary, to allow an extension of the riser to accommodate increases in surface elevation due to the construction of the earthen protective PVC barrier lifts and the subsequent construction. Well retrofitting procedures will be performed by either of the following industry-standard methods:

- Each well to be retrofitted will be inspected at the top of the casing for viable female threading. If viable threading exists, a PVC screw coupling will be threaded on to the top of the existing well casing, examined for proper seating and tightness, then followed by the installation of the additional length of PVC casing to bring the top of the new well assembly above the proposed earthen cap grade.

- If viable threading does not exist at the top of the well casing, then a slip coupling will be employed. A PVC slip coupling will be installed at the top of the well; seal integrity will be inspected to ensure that the seal between the coupling and well casing is tight without the use of adhesives or sealants, and the well casing sits properly within the coupling. An additional length of PVC well casing (identical in composition and diameter as the coupling and existing well casing) will be installed at the open end of the coupling and inspected for seal integrity and seating.

Compacted soil, clay, bentonite, or a mixture of these materials will be installed against and surrounding the extended well riser in one-foot lifts to stabilize the well casing. This process will be repeated up until one-foot beneath the proposed earthen protective barrier grade is achieved. An at-grade locking, eight-inch diameter steel well box with a twelve-inch stainless steel skirt will be installed at the earthen cap grade surrounding the well casing to prevent damage and/or tampering. Prior to installing the well box, the extended casing will be cut to approximately six-inches below the earthen protective barrier grade and a locking well plug installed within the top of the well. After the well box is installed a bentonite slurry will be installed within the well box to approximately three inches below the top of the well casing. A wood surveyor stake equipped with a construction flag will be installed directly adjacent to the well box, to identify the location of the well during subsequent redevelopment work.

4.8 MONITORING WELL INSTALLATION

Additional monitoring wells will be installed proximal to the Source Areas, and within the footprints of reported groundwater plumes downgradient from the Source Areas. The purpose of the well installation work is to enhance the monitoring network and to obtain baseline groundwater quality data prior to the Source Area fill excavation and saturated fill stabilization work. The data obtained from the additional monitoring wells will enhance the Conceptual Site Model for groundwater monitoring data output, groundwater contaminant isoconcentration depictions, and updated contaminant fate and transport modeling calculations. The proposed monitoring well installations with associative locations are presented below:

- Downgradient from Source Areas SA-3, SA-6 and SA-7 and PRB Wall, screened within the shallow section of the water table aquifer: Monitoring Wells MW-21S, MW-22D, MW-22S, MW-22D and MW-24S.
- Approximately adjacent to the eastern and western extent of the PRB Wall, screened within the shallow section of the water table aquifer: PRB Wells PRB-16S and PRB-17S.
- Upgradient from Source Areas SA-3, SA-6 and SA-7, screened within the shallow and deep sections of the water table aquifer: Monitoring Wells MW-19S, MW-62S, MW-62D, MW-63S and MW-63D.
- Upgradient from Source Areas SA-3 and SA-4; screened within the shallow and deep sections of the water table aquifer: MW-64S and MW-64D.
- Downgradient from Source Areas SA-1 and SA-3, and PRB Wall, screened within the shallow section of the water table aquifer: PRB Well PRB-10S.
- Within the estimated footprint of Soil Boring S-5 and to the west of soil boring S-5, screened within the shallow, intermediate and deep sections of the water table aquifer: MW-66S, MW-66I, MW-66D, MW-67S, MW-67I and MW-67D.
- To the east of well cluster MW-61S/D, screened within the shallow and deep sections of the water table aquifer; MW-65S and MW-65D.
- Downgradient form Source Area SA-1, screened within the shallow and deep sections of the water table aquifer: MW-69S, MW-69D, MW-70S, MW-70D
- Along the northwestern extent of the Facility, to the south, east and north of monitoring well cluster MW-23S/D, screened within the shallow and deep sections of the water table aquifer: MW-11S, MW-11D, MW-69S, MW-69D, MW-70S, MW-70D, MW-71S and MW-71D
- Along the western extent of the Facility, potentially downgradient from Source Area SA-8, screened within the shallow section of the water table aquifer: Monitoring Well MW-28S.

- Along the northern extent of the Facility, proximal to Source Area SA-5 and screened within the shallow section of the water table aquifer: Monitoring Well MW-25S.
- Downgradient from Source Areas SA-10 and SA-11 and screened within the shallow, Intermediate and deep sections of the water table aquifer: Monitoring Wells MW-42I, MW-43S, MW-57S, MW-57I, MW-57D, MW-58S, MW-58I, MW-58D, MW-59S, MW-59D, MW-60S, MW-60D, MW-61S and MW-61D.

The proposed monitoring wells are presented in tabular form with estimated well depths and well screen intervals in **Table 4**. The location of the proposed monitoring well installations are provided in **Figure 6A**.

4.9 MONITORING WELL INSTALLATION SPECIFICATIONS

The new monitoring wells will be installed utilizing hollow stem auger or sonic drilling methods. Well components will consist of two-inch I.D. schedule 40 PVC well Riser, two-inch I.D. 20-slot Sch. PVC 40 well screen and schedule 40 PVC pinned well plugs. The "deep" wells will be installed to a terminal depth of the onsite overburden aquifer screened between the aquifer confining layer and five feet above said confining later. The top of well casings for the proposed shallow and deep wells will extend a minimum of 2 feet above Site grade. Number 2 Morie sand will be installed from the terminal depth of the well to 3 feet above the top of the screen, followed by a two-foot thick bentonite seal and completed with grout to 1-foot bgs. The "shallow" wells will be installed to a terminal depth between 10 and 15 feet bgs and with five-foot screen intervals (5 to 10 feet BGS or 10 to 15 feet bgs. The "intermediate" wells will be installed in specific sections of the aquifer between its representative shallow and deep wells, specifically screened across known areas of subsurface impacts identified in historic investigations. Number 2 Morie sand will be installed from the terminal depth of the well to 3 feet above the top of the screen and completed with grout to 1-foot bgs. A locking 'J-plug' will be installed in each of the abovementioned wells and completed to grade with an above-grade steel protective enclosure ("stick-up"). Soil cutting generated from this work will be containerized and stages for subsequent characterization and disposal.

4.10 SUPPLY WELL INSTALLATION SPECIFICATIONS

A source of anoxic groundwater is required for the groundwater treatment. Historic withdrawal and use of onsite groundwater during the 2015 pilot test remedial work was accomplished by installing a dedicated supply well within the northern section of the Facility (Well ID: NSW-1) and utilizing the withdrawal from said

well for remedial solution makeup water to produce stock solutions utilized during the 2015 pilot test remedial injection event.

Three remedial (non-potable) supply wells are proposed to be installed, developed and utilized during the supplementary remedial event:

- Supply Well NSW-2: Well proposed to be installed within the western extent of the northern treatment area
- Supply Well SSW-1: Well proposed to be installed proximal to the northwestern extent of the southern treatment area
- Supply Well SSW-2: Well proposed to be installed proximal to the western extent of the southern treatment area.

The locations of the abovementioned existing and proposed remedial supply wells are presented in **Figure 6B.**

The proposed wells will be installed by hollow stem auger or sonic drilling methods and techniques to a terminal depth approximately 35 feet bgs. The supply wells will be constructed utilizing six-inch I.D, Sch. 40 PVC well riser and 20-slot well screen, with the screen interval between 15 and 35 feet bgs. A filter pack consisting of inert silica (sand (US Mesh size between 20 to 30 mesh) will be installed from the terminal depth of the well to three feet above the well screen, followed by a bentonite seal installed between the sand pack and three feet above the sand pack. High-solids bentonite grout or equivalent will be installed within the remainder of the boring surrounding the well casing to approximately one foot below Site grade. The well will be finished approximately three to five feet above grade and protected within an iron stick-up box secured with a concrete pad installed at site grade. Resultant soil cuttings will be will be handled in a manner similar to the monitoring wells in conformance with IDW containerization, characterization and disposal protocols and procedures specified within this work plan and related QAPP.

A construction schematic of the proposed supply wells is provided in the QAPP**.**

The newly installed remedial supply wells will be developed concurrent with the proposed additional monitoring wells; related purge water will be handled in a manner similar to the monitoring wells in conformance with IDW containerization, characterization and disposal protocols and procedures specified within this work plan and related QAPP. Immediately after development is completed, a groundwater sample

will be collected from each well and analyzed for arsenic content, to confirm the arsenic concentrations are below USEPA requirements (< 5 mg/l) for utilization as remedial makeup water for stock solutions. The analytical results will be reported to USEPA.

After the development work is completed and analytical results from the groundwater samples are reported, a step/drawdown test will be performed on each proposed remedial supply well. The purpose of said test is to investigate the performance of a pumping well under controlled variable discharge conditions. In a step-drawdown test, the discharge rate in the pumping well is increased from an initially low constant rate through a sequence of pumping intervals (steps) of progressively higher constant rates. The tests will be conducted in incremental stages based on the ideal well yield of 25 GPM and each step will be conducted over a two-hour period:

- Step One: 60% of Ideal Pumping Yield – Approximately 15 GPM
- Step Two: 80% of Ideal Pumping Yield – Approximately 20 GPM
- Step Three: 100% of Ideal Pumping Yield – Approximately 25 GPM
- Step Four: 120% of Ideal Pumping Yield – Approximately 30 GPM

A stainless-steel submersible pump with an at-grade flow controller will be utilized for the tests. The pump will be installed within the center of each remedial supply well screen and engaged once water table aquifer measurements are made within the pumping well and within neighboring wells (monitoring/PRB/injection/etc.) Electronic data loggers will be deployed within the test well and surrounding wells to track the change in water table elevation in response to each pumping step. An inline flow meter will be installed within the effluent discharge piping to track the actual groundwater purge rate for each step. Field personnel will measure and record field measurements during each step, in dedicated field notebooks, in conformance with the protocols and procedure cited within the QAPP.

Generated purge water will be handled in a manner similar to the monitoring wells in conformance with IDW containerization, characterization and disposal protocols and procedures specified within this work plan and related QAPP. Pumping and field measurement equipment will be decontaminated in accordance with the protocols and procedures cited within the QAPP and dedicated effluent tubing will be disposed of in accordance with Facility IDW protocols and procedures.

Data obtained from field measurement and downloaded level logger data will be compiled and evaluated utilizing industry standard modeling programs (Aqtesolv, etc.) to identify well yield and related pumping rates to be employed during the preliminary groundwater treatment activities. The Step/Drawdown results will be reported to the USEPA in a technical memorandum.

4.11 WELL SURVEY

A survey of the existing and proposed monitoring wells, permeable reactive barrier (PRB) wells, Injection Wells and within the monitoring network will be performed by an Indiana State-licensed professional surveyor. The purpose of said survey work is to establish reference elevation points at the top of each well casing measured against a standard above mean sea level datum, in order to develop a uniform groundwater elevation and groundwater flow models for the Facility. The northern lip of each well casing will be marked to establish continuity with each water table measurement. Utilizing GPS satellite-based survey equipment, the surveyor will measure and record the latitude and longitudinal plane as well as vertical elevation above mean sea level, for each well at its designated measuring point. A table identifying all existing monitoring wells (well depths and screen intervals) that will remain after well abandonments is provided in **Table 5**. A survey report for the work will be prepared and submitted upon completion. Information on GPS calibration is in the QAPP.

4.12 WELL DEVELOPMENT/RECONDITIONING

Where necessary, pre-existing and newly installed monitoring and supply wells will be developed utilizing industry standard methods. A Well Condition Report will be submitted to the USEPA in supplemental CMI reports to indicate the condition of the wells and indicate what reconditioning was performed. The purpose of the development work is to remove fines, solids and/or suspension from within the wells and from the filter pack surrounding each well screen, in order to provide the best possible groundwater flow through each well and augment viable groundwater quality for future sample collection work. A battery-operated submersible pump connected to unspoiled low-density polyethylene (LDPE) tubing will be deployed into each well. The tubing outlet will be connected to a plastic flow control valve/flow splitter, with a dedicated outlet directing flow via connective tubing to a 55-gallon drum and a separate outlet directing reduced purge flow to a water quality multimeter positioned with a flow-thru cell. Periodic turbidity measurements will be made with the water quality meter, to determine whether the purged groundwater is at or below 50 nephelometric turbidity units (NTUs). A minimum of 3 casing volumes of purged groundwater will be extracted from each well; but is anticipated that additional casing volumes may be required to attain turbidity standard. Depth to water

measurements will be measured with a water-level meter prior to and after the development work. The purged groundwater will be containerized, transported to a designated staging area and consolidated into a polyethylene tank. The contents of the tank will be characterized and managed per the procedures in the QAPP.

The LDPE tubing will be contained and properly discarded after the development work is completed. The submersible pump will be decontaminated after the development work is completed at each well, utilizing an alconox or similar wash, followed by a triple distilled water rinse. The decontamination wash water and rinse water will be incorporated with the containerized development water. Calibration standards and practices for the equipment utilized for this work are presented in the QAPP and safety protocols associated with this work are presented within the HASP.

4.13 WATER LEVEL DATA LOGGING

Upon completion of the well development and reconditioning, automatic water level data loggers will be deployed within selected (existing and proposed) wells and piezometers. The purpose of said water level datalogger deployment is to consistently measure and record changes in the water table elevation, which will assist in forecasting water table elevation at the time Source Area fill excavation/ISS is performed and provide a groundwater elevation and groundwater flow profile for subsequent modeling. A total of 49 vented hydrostatic probes (In-Situ Rugged Troll series or equivalent) will be installed in selected monitoring wells within the network, upon completion of the abovementioned well installation/survey/development work. Said battery operated probes will measure and record water level, water pressure and temperature within the installed well at preset periodic increments. A log of recorded measurements will be periodically downloaded onto a mobile datalogger and the resultant output utilized for groundwater water table and groundwater flow models, as well as incorporated into updated Fate and Transport and Stormwater Recharge models. The following wells were selected for this purpose, based on the well locations proximal to Source Areas and in other areas which would enhance the hydrogeologic comprehension for the Facility. The following existing and proposed monitoring wells and piezometers will be utilized for the water level data acquisition work:

- Monitoring Wells: MW-10S (proposed), MW-10D (proposed), MW-11S (proposed), MW-11D (Proposed), MW-19, MW-19S (proposed), MW-24D, MW-24S (proposed), MW-30S, MW-30D, MW-32S, MW-32D, MW-33S, MW-33D, MW-34S, MW-34D, MW-35S, MW-35D, MW-36S, MW-36D, MW-

37S, MW-37D, MW-38S, MW-38D, MW-39S, MW-39D, MW-40S, MW-40D, MW-41S, MW-41D, MW-46S, MW-46D, MW-47S, MW-47D, MW-53S, MW-53D, MW-54S, MW-54D, MW-55S, MW-55D, MW-57S (proposed), MW-57D (proposed), MW-58S (proposed), MW-58D (proposed), MW-59S (proposed), MW-59D (proposed), MW-60S (proposed), MW-61D (proposed), MW-62S (proposed), MW-62D (proposed), MW-63S (proposed), MW-63D (proposed), MW-64S (proposed),MW-64D (proposed), MW-65S (proposed), MW-65D (proposed), MW-66S (proposed), MW-66D (proposed), MW-67S(proposed), MW-67D (proposed), MW-68S (proposed), MW-68D (proposed), MW-69S (proposed), MW-69D (proposed), MW-70S (proposed), MW-70D (proposed), MW-71S (proposed) and MW-71D (proposed).

- Permeable Reactive Barrier (PRB) Wells: PRB-8, PRB-8S, PRB-10, PRB-10S (proposed), PRB-13, PRB-13S, PRB-14S, PRB-14D, PRB-15S, PRB-15D, PRB-16S (proposed), PRB-16D, PRB-17S (proposed), PRB-17D, PRB-18S, PRB-18D, PRB-19S and PRB-19D
- Piezometers: P-8, P-12, P-15, P-20, P-24

The network wells specified for water level data logging are presented in tabular form in **Table 6** and their locations are indicated in the Hydrogeologic Plan on **Figure 7**. Calibration standards and protocols for the equipment utilized for this work are presented in the QAPP. The wells/piezometers may be required to be abandoned in the future, associated with Property redevelopment work; the USEPA will be notified prior to any future well abandonment required as well as potential replacement well installations for groundwater remediation and long-term monitoring purposes.

4.14 GROUNDWATER SAMPLING

Upon completion of well installation, survey, and development/reconditioning work, and prior to the start of the Source Area unsaturated fill/ saturated fill ISS work, a site-wide baseline groundwater monitoring event will be performed. A total of 91 pre-existing and proposed monitoring wells (including wells to be installed at the direction of the Agency) will be sampled for this monitoring event as presented in tabular form on **Table 7** and locations indicated on **Figure 6B:** Proposed Groundwater Monitoring Well Network. University of Waterloo wells, piezometers, injection wells and any other diagnostic groundwater well will be excluded from this baseline monitoring event. The following wells will be utilized for the baseline monitoring event:

- Monitoring Wells: MW-10S (proposed, MW-10D (proposed), MW-11S (proposed), MW-11D (proposed), MW-15S (proposed), MW-15D (proposed), MW-19S (proposed), MW-19D (proposed),

MW-21S (proposed), MW-21D (proposed) MW-22S (proposed), MW-22D (proposed), MW-23S (proposed), MW-23D, MW-24S (proposed), MW-24D, MW-25S (proposed), MW-25D, MW-30S, MW-30D, MW-34S, MW-34D, MW-35, MW-35D, MW-41S, MW-41D, MW-42S (proposed), MW-42I (proposed), MW-42D (proposed), MW-43S (proposed), MW-43D, MW-46S, MW-46D, MW-47S, MW-47D, MW-52S, MW-52D, MW-53S, MW-53D, MW-54S, MW-54D, MW-55S, MW-55D, MW-57S (proposed), MW-57I (proposed), MW-57D (proposed), MW-58S (proposed), MW-58I (proposed), MW-58D (proposed), MW-59S (proposed), MW-59D (proposed), MW-60S (proposed), MW-60D (proposed), MW-61S (proposed), MW-62D (proposed), MW-63S (proposed), MW-63D (proposed), MW-64S (proposed), MW-64D (proposed) MW-65S (proposed), MW-65D (proposed), MW-66S (proposed), MW-66D (proposed), MW-67S (proposed), MW-67D (proposed), MW-68S (proposed), MW-68D (proposed), MW-69S (proposed), MW-69D (proposed), MW-70S (proposed), MW-70D (proposed), MW-71S (proposed) and MW-71D (proposed)..

- Permeable Reactive Barrier Wells: PRB-10S (proposed), PRB-10D, PRB-13S, PRB-13D, PRB-14S, PRB-14D, PRB-15S, PRB-15D, PRB-16S (proposed), PRB-16D, PRB-17S (proposed), PRB-17D, PRB-18S, PRB-18D, PRB-19S, and PRB-19D.

Water Level loggers will be temporarily removed from wells identified in the groundwater monitoring network, prior to the start of the sample collection work. Sample collection will be performed utilizing USEPA Low Flow/Volume Protocols and Procedures. A solinst or equivalent water level meter will be installed in the well prior to the start of the low-flow purge, to measure physical and geochemical parameters (ORP, pH, Specific Conductivity) will be measured and recorded for groundwater low-flow stability confirmation and utilization for potential iron and sulfate complex mineralization/sorption and/or dissolution conditions within the water table aquifer. Collected groundwater samples will be containerized within laboratory prepared and preserved.

4.14.1 **Groundwater Sampling Procedures**

The USEPA Low-Flow/Volume groundwater purging, and sample collection is a method that reduces well drawdown mixing and formation stress, isolates stagnant water above the well screen, and reduces sample turbidity which improves sample accuracy. Groundwater samples collected by this methodology represents naturally mobile metal constituents in groundwater and not stagnant water within the well casing or mobilized colloids or other impurities generated by high-volume purging. The actual purge volume is based on

stabilization of physical and chemical parameters during said low-flow purging. The procedures to perform low flow groundwater sampling will be implemented in accordance with the details outlined in the QAPP.

At the request of the Agency, emerging contaminant analytes, perfluro-octonoic acid (PFOA) and perfluoro-octane sulfonate (PFOS) will be screened during the baseline monitoring event. Specific protocols and procedures for the collection and analysis of PFOA/PFOS are specified within the QAPP.

Water Level loggers will be temporarily removed from wells identified in the monitoring well network, prior to the start of the sample collection work, and replaced once the sample collection work is completed. Sample collection will be performed utilizing USEPA Low Flow/Volume Protocols and Procedures. The low flow sampling assembly will consist of a certified PFOA/PFOS-free high performance, stainless steel, variable flow rate submersible pump (QED Model Sample Pro Portable MicroPurge Pump or equivalent) with HDPE discharge tubing. The tubing outlet will be connected to the to a water quality multimeter equipped with a flow-thru cell. The pump and tubing will be installed within the well, at or proximal to the middle of the reported well screen interval, a minimum of 2 hours prior to initiating the low-flow minimal volume purge, aquifer stabilization and sample collection work. The purpose of this step is to minimize aquifer disturbance and in-situ well water mixing, pursuant to Federal and State low-flow sample collection protocols and procedures. A Solnist or equivalent water level meter will be installed concurrent with the submersible pump and tubing installation, to measure the extent of water table drawdown due to the resultant low-flow purge.

Prior to connecting the pump effluent tubing to the parameter meter assembly, the pump will be engaged, and flow rate controlled via an at-grade flow controller. After the flow rate is established, the effluent tubing will be connected to the water quality meter/ flow-thru cell assembly and low-volume purging will proceed. Stabilization measurements will be measured and recorded every 5 minutes of pump operation to determine whether parameter stabilization is achieved. The following USEPA water quality stabilization indicator parameter criteria (ASTM Standard D6771-02) will be utilized:

Parameter	Stabilization Criteria
pH	Difference of ± 0.2
Specific Electric Conductance	Difference of ± 3%
Temperature	Difference of 0.5 degrees Celsius
Turbidity	± 10% (when turbidity is greater than 10 NTUs)

Oxidation-Reduction Potential (ORP)	± 20 millivolts (mV)
Dissolved Oxygen (DO)	10% or ± 0.2 mg/l (whichever is greater)

Calibration standards for the equipment utilized and the sampling procedures for this work are presented in the QAPP.

4.15 GROUNDWATER SAMPLING AND ANALYSIS

After aquifer stability is achieved (pursuant to the defined USEPA low-flow sample collection protocols and procedures), groundwater sample collection will proceed. With the pump continuing to operate, the plastic flow control valve/flow splitter will be rotated, directing flow towards the dedicated sample collection outlet, and sample collection will commence. Total metal and additional inorganic parameters will be collected first, followed by the collection of dissolved metal samples. Prior to the collection of dissolved metals samples, a 0.45-micron filter will be installed at the sample collection outlet. Collected groundwater samples will be containerized within laboratory prepared and preserved bottles and glassware, immediately placed within an iced cooler and transported to a certified ELAP accredited environmental laboratory under standard chain of custody protocols and procedure for analyses. The following laboratory analyses will be performed on the resultant groundwater samples:

- Total Arsenic, Lead, Iron, Cadmium, Zinc, Phosphorus and Calcium by USEPA Test Method 6010B.
- Perfluoro octonoic acid (PFOA) and Perfluoro octane sulfuric acid (PFOS) by USEPA Test Method 537 (or other EPA preferred method).
- Speciated Arsenic (As III/As V) by USEPA Test Method 1632.
- Sulfate by USEPA Test Methods 375.3 (or 9056).
- Sulfide by USEPA Test Method 376.1.
- Total Organic Carbon by USEPA Test Method 415.1 (or 9060).
- Alkalinity by USEPA Test Method 310.2.
- Bicarbonate by USEPA Test Method SM 2320 B.
- Chloride by USEPA Test Method 300.0.
- Nitrate by USEPA Test Method 353.1 (or 9056).
- Nitrite by USEPA Test Method 354.1

These analyses and the recorded physical and geochemical parameters (ORP, pH, DO, Specific Conductivity) will be utilized to determine:

- Monitor the progress of the 2016 Pilot Test ISCR injection work.
- Establish baseline metal contaminant concentrations in groundwater prior to the Source Area excavation/ISS work.
- Evaluate potential iron and sulfate complex mineralization/sorption and/or dissolution conditions within the water table aquifer.
- Utilize the field measurements and laboratory analyses for modified ("sliding") Stiff geochemical evaluation, contaminant Fate and Transport model preparation and Stormwater input model calculations.
- Determine whether impacts to onsite groundwater have occurred by emerging contaminants PFOA and/or PFOS.

The sampling and analysis for this activity will comply with USEPA protocols and procedures to demonstrate laboratory reporting duplicity, analysis accuracy and precision as detailed in the QAPP. Based on a review of the baseline monitoring analytical data, recommendations may be made to request the removal of PFOS/PFOA analyses from future groundwater monitoring.

4.16 PNEUMATIC SLUG TESTING

A direct push/percussion (Geoprobe) drilling machine with appurtenances will be mobilized to the Facility and staged at the first PST location. A Geoprobe SP16 Groundwater sampler assembly will be advanced into the saturated soil to a prescribed termination depth. Once at the prescribed depth, the stainless-steel screen associated with the system will be deployed and minimal volume development performed. Once the development is completed, a pressure transducer will be installed to within the water table to a prescribed depth, followed by the above-grade installation of the PST manifold. The transducer cable will be installed to a laptop computer equipped with data logging software, followed by the air-tight completion of the assembly. Pressurized air will be introduced within the PST probe rods and allowed to equilibrate to the substratum. Once equilibrium is reached, a pressure release valve is opened and the resultant change in water table elevation is continuously measured and observed in real time on the data logger laptop. Advantages to this approach include the speed of conducting one or more PST evaluations, consistency of obtained data between multiple tests, and having the potential to conduct a bottom-up approach to determine hydraulic conductivity within different depths of the saturated soil from a single boring location. The proposed PST examinations will

be performed along transects designated within the Facility, to enhance the hydrogeologic conditions of the Facility. The proposed PST transects are presented in **Figure 7:** Hydrogeologic Plan.

Upon completion of the PST work, the data obtained will be incorporated into the hydrogeologic study preformed during Remedial Construction Phase II. Boundary conditions, PST measured hydraulic conductivities (with depth), rainfall infiltration and groundwater flow/flow retardation and diversion parameters will be entered and assimilated into industry-standard model software (Visual MODFLOW with MODPATH particle tracking module, Groundwater VIstas, etc.). The model output will provide an update to the groundwater flow regime, based on the concept plans for redevelopment. It is anticipated that numerous iterations of said model will be prepared to evaluate different redevelopment scenarios and their effect on hydrogeologic conditions at the Facility. This will assist in developing full-scale groundwater treatment contingency plans post building construction.

5 CORRECTIVE MEASURES DESIGN

Corrective measures will be performed by the Contractor in accordance with the USEPA's selected remedial alternatives to achieve remedial cleanup goals for fill/soil and groundwater at the Facility (USEPA 2018a). Remedial design will be based on the results of previous work conducted at the Facility and/or based on additional data which will be generated from the scope of this work plan. The phases of corrective measures are provided as follows in order of sequence.

5.1 PRELIMINARY GROUNDWATER TREATMENT

Groundwater treatment at the Facility will be conducted in both Remedial Construction Phase I and Phase II. Historic pilot test arsenic reduction/sequestration work resulted in a reported six-fold decrease in arsenic concentrations in groundwater. The proposed remedial scope within this work plan will consist of preliminary groundwater treatment within the northern and Southern sections of the Facility.
There are three primary purposes of groundwater treatment within Phase I;

1) To achieve short-term cleanup goals by demonstrating measurable groundwater quality improvement concurrent with the source area removal and saturated soil treatment;
2) Utilize the post-remedial data to evaluate, prepare and implement a full-scale groundwater remedial treatment design; and

   To further evaluate the uncertainties with the technology previously gauged and proposed by Parsons.

The abovementioned uncertainties include long-term decrease and stability of arsenic concentrations in groundwater, evaluation of potential modifications to the proposed full-scale groundwater treatment design; both in approach and injection reagents, and the estimated frequency of repeat remedial injection work after the full-scale implementation. The abovementioned remedial design tasks will be evaluated in Phase I to provide the implementation of an effective full-scale groundwater treatment in Phase II. The scope of work described below for preliminary groundwater treatment was developed and proposed by Parson in the 2018 Comprehensive Pilot Study (CPS).

5.1.1 **Injection Plan**

In 2013, a series of injection wells and groundwater well clusters (specifically designed to monitor the progress of the pilot test remedy) were installed in a series of transects within the northern and southern sections of the Facility. Selected wells within each injection transect were utilized for the pilot injections in 2015. An initial evaluation of the 2015 Pilot Test work revealed a reported six-fold decrease in arsenic concentrations in groundwater, utilizing an in-situ biotic/sulfate reduction approach Existing injection wells will be utilized for this work; additional injection well installation is not anticipated to implement the Phase I groundwater treatment scope of work.

The preliminary groundwater treatment approach proposed for this phase of the work includes a combination of:

- Analyze long-term trends attributed to the pilot injections through the evaluation of data collected from the baseline groundwater sampling event from the 2015 pilot test work.
- Installing remedial (biotic/sulfate reduction) reagents into injection wells that were not utilized for the 2015 pilot test work.
- Conduct four post-remedial groundwater sampling events. Review and evaluate the efficacy of the remedial injection work.
- Determine and differentiate the effect of the different remedial methods (source area removal, saturated soil treatment, and in-situ groundwater injection) on arsenic groundwater concentrations.

Northern Injection Area:
Historic elevated concentrations of arsenic were detected in shallow groundwater within the northern section of the Facility, between the northern property boundary and extending to the permeable reactive wall. The area of elevated arsenic in shallow groundwater corresponds with elevated arsenic concentrations detected in shallow soil samples. Historic arsenic concentrations in deep groundwater range between 0.5 mg/l and 3 mg/l along the northern property line in this area extending from monitoring well MW-53 (west) to monitoring well MW-17D (east).

Eighteen shallow and deep injection wells are proposed for the preliminary groundwater treatment work within the Northern Treatment Area:

- Remedial Transect One (Located proximal to the northern Facility boundary): IW-17S, IW-17D, IW-18D, IW-19D, IW-20S, IW-20D, IW-21S, IW-21D, and IW-22D
- Remedial Transect Two (Located between Remedial Transect One and the PRB Wall): IW-10S, IW-10D, IW-11S, IW-11D, IW-12S, IW-12D, IW-13S, IW-13D, and IW-14D.

Two non-potable Remedial Supply wells are proposed to be utilized to supply solution makeup water for the injection work:

- Existing Supply Well NSW-1, screened between 25 and 35 feet bgs; and
- Proposed Supply Well NSW-2, to be screened between 15 and 35 feet bgs

The locations of the existing and proposed injection wells and remedial supply wells are presented in **Figure 8a.**

Southern Injection Area:
Historic elevated concentrations of arsenic were detected in deep groundwater within the southern section of the Facility, proximal to the southwestern property boundary. The area of elevated arsenic in deep groundwater corresponds with elevated arsenic concentrations detected in deep soil samples and baseline (pre-pilot) groundwater samples. Historic arsenic concentrations in deep groundwater within this area range between 4.6 mg/l and 30 mg/l proximal to the southwestern property line. Historic arsenic concentrations in shallow groundwater in this area are significantly lower with the exception of arsenic samples detected in groundwater samples collected from injection well IW-1S.

Eleven shallow and deep injection wells are proposed for the preliminary groundwater treatment work within the Southern Treatment Area:

- Remedial Transect Three (Located proximal to the southwestern Facility boundary): IW-1S, IW-1D, IW-2S, IW-2D, IW-3S, IW-3D, IW-4D, IW-5D, IW-6D, IW-7S, and IW-7D

Two non-potable Remedial Supply wells are proposed to be installed and utilized to supply solution makeup water for the injection work:

- Proposed Supply Well SSW-1, screened between 15 and 35 feet bgs; and

- Proposed Supply Well SSW-2, to be screened between 15 and 35 feet bgs

The locations of the existing and proposed injection wells and remedial supply wells are presented in **Figure 8b.**

5.1.2 **Remedial Reagent Composition**

Calculations were performed to estimate the potential longevity of iron sulfides created from the North Area 2015 pilot injections. The calculations assume that 100% of the injected substrate biodegraded through sulfate reduction. After a review of the pilot test post-injection groundwater monitoring event data, it was concluded that the quantity of organic carbon in the treatment formulation was identified and reported to result in a 50% increase in sulfate reduction potential which would hypothetically generate a higher quantity of iron sulfides for arsenic sequestration. Based on the calculated arsenic mass flux in deep groundwater and the reported range of arsenic uptake values, it was estimated that the time required for the generated iron sulfides react and precipitate within the saturated stratum is between 0.4 and 40 years.

Emulsified vegetable oil (EVO) will be discontinued due to reported complications observed during the pilot test work. Instead, soluble organic carbon as a mixture of sodium lactate and diluted corn syrup will be utilized as a source of total organic carbon for bacteria to metabolize and drive the sulfate reduction reactions in the saturated substratum. Ferrous sulfate will be injected at a concentration slightly greater (20% increase) than what was applied during the pilot test injection work, in order to precipitate the generated sulfide. Food-Grade corn syrup will be utilized for this work. Due to the viscosity of this material, a stock corn syrup solution, diluted with feed water obtained from the remedial supply wells will be utilized for this work. The stock solution will consist of a manufacturer prepared food grade high fructose corn syrup and make up water obtained from onsite anoxic groundwater. The goal of the dilution is to reduce the viscosity to where the solution may be readily conveyed to the remedial system.

5.1.3 Calculated Reagent Volume

The following reagent component and make-up/push water volumes were calculated based on the mass of arsenic detected within and downgradient from the source area regimes and previously reported within the January 2018, Final Comprehensive Study report. The values presented below represent the reagent component volumes to be utilized for this preliminary groundwater treatment:

Injection Component	Reagent/Water Volume (per well)	Reagent/Water Volume (total)
Ferrous Sulfate (Crown 5%) Solution (60% v/v)	868.3 gals	25,180.7 gals
High Fructose Corn Syrup (5% v/v)	9 gals	252.2 gals
Will Clear Sodium Lactate Solution	37 gals	1,073 gals
Reagent Dilution "Makeup" water	16,000 gals	464,000 gals
Injectate Solution "Push" water	500 gals	14,500 gals

Based on the results of the initial pilot test injections, it is inferred that the injection volumes will yield an ROI of approximately 17 feet. The distance between injection wells is approximately 30 feet. The injection ROI may be modified at specific injection locations to assure that the injection ROIs influence the downgradient monitoring wells.

5.1.4 Reagent Injection Summary

The following preparation and implementation steps will be employed for the preliminary groundwater treatment work:

- A treatment dosage and conveyance trailer (same trailer utilized during the 2015 pilot test work), heated portable storage shipping container, and injectate reagents will be mobilized to the Facility. The stock injectate reagents will be delivered to the Facility in 275-gallon totes, 55-gallon drums and 20-liter carboys and will be staged within the shipping container until ready for use.
- The conveyance trailer will be mobilized to a central location within each treatment zone. A secondary containment area will be established adjacent to the trailer and utilized to stage the raw stock injectant reagents, mix tanks, centrifugal pumps with compressor and ancillary equipment.
- A 25KW or greater output diesel generator will be mobilized to the Facility and will be utilized to provide power to the conveyance trailer. Electrical connections will be made to the trailer power panel and preliminary diagnostic inspections will be performed at each bus within the trailer panel.
- An insulated heater blanket will be installed on the HFCS tote and utilized to reduce the viscosity of the HFCS to improve flow to the mix tank will concurrently increasing solubility of the agent when diluted by makeup water.
- Submersible pumps will be installed within the supply wells and purged at a desired rate of 25 GPM each, in order to provide the makeup water and push water required for the injection work.

- Each of the Injection wells employed during this work will be equipped with a pressure gauge, double ball valves, and bleed/pressure relief valve fittings will be connected to the top of the injection wells.
- In-line solution mixers and flow meters will be installed within the interconnecting piping between the stock totes and mix tanks, to measure and regulate the desired reagent concentrations for each component.
- In-line dosimeters installed within the conveyance trailer will be programmed to provide the desired reagent concentrations to the injection solution stream to the injection wells.

The detailed procedures for the injection work are provided in the QAPP.

5.2 SOURCE AREA EXCAVATIONS

Source removal refers to excavation of contaminated fill and subsequent disposal, thereby removing the highest contaminant concentrations, and the source of contamination to groundwater. When a well-defined, concentrated, continuing source is present, such as highly contaminated fill, source removal is the most effective way to prevent ongoing release of contamination to groundwater.

Based on the arsenic fate and transport conceptual model and modeling results, the removal of arsenic sources to the groundwater would result in measurable groundwater quality improvement within a year close to Source Areas and within five years near the Grand Calumet River (Parsons 2015). Therefore, excavating Source Areas will meet the short-term cleanup goals of near-term improvements in groundwater quality near the source. The removal of fill containing arsenic at concentrations greater than 1,000 mg/kg is predicted to result in decreased arsenic concentrations in groundwater and decreased arsenic loading to groundwater treatment zones, as well as mitigate risk to direct contact (dermal) exposure.

Approximately 47,705 cubic yards of Source Area fill (i.e. arsenic contaminated fill >1,000 mg/kg) are located in the Redevelopment Area of the Facility (Parsons 2015); and 14,042 cubic yards of Lead contaminated fill is located in the Lease Area (Parsons 2016a). The arsenic contaminated fill within the Redevelopment Area and the Lead contaminated fill within the Leased Area, for convention, will herein be referred to as the "Source Areas". These areas will be excavated to the water table at an average depth of approximately 4 feet bgs. There are 20 Source Areas that will be subject to source excavation; 11 in the Redevelopment Area and 9 in the Lease Area. In general, these Source Areas exist at an elevation that approximates +590 feet above mean

seal level. **Figure 9a** indicates the location and horizontal extent of each Source Area excavation. The following tasks will be completed for implementation of Source Area excavation.

5.2.1 Source Area Delineation and Modeling

In 2013, Parsons conducted a comprehensive review of soil and groundwater data collected from 1990 to 2012. All historic soil and groundwater data collected from the Facility (approximately 800 soil and groundwater samples) were used to create isoconcentration gradients or contours of the arsenic contamination. A 10 foot by 10-foot raster grid network was plotted onto to the contours across the PRB Wall and SWMU-4 areas. A triangulated irregular network (TIN) of contoured concentration values were evaluated across each elevation range; including 0-2', 2-4', 4-6', 6-8', and 8-10' below site grade. This mapped the vertical and horizontal distribution of arsenic concentrations within the PRB Wall and SWMU-4 areas.

The Groundwater Evaluation Report (March 2013) indicated a strong association between concentrations of arsenic in groundwater and unsaturated/saturated soil within specific "hot spot" or Source Area locations. A ranged-based ArcMap Zonal Statistical model was applied to the TIN and the raster grid network to determine arsenic mass within these Source Areas. It was estimated that 98,400 kg of arsenic mass was present in soil and groundwater with 76 percent of the mass above the water table in the PRB area. Furthermore, it was estimated that 77,600 kg of arsenic mass was present in soil and groundwater with 67 percent of the mass above the water table within the SWMU-4 area. From this modeling, spatial relationships, results of TCLP/SPLP, LEAF and SEP leaching tests, the Source Areas were determined to be directly contributing to arsenic concentrations in groundwater.

In 2015 during the CMS (Parsons 2015a), the vertical and horizontal arsenic concentration mapping was input to additional arsenic transport modeling in the PRB and SWMU-4 Source Areas utilizing an integrated hydrodynamic model (MODFLOW) and geochemical model (PHREEQC) to evaluate treatment options. It was identified that soil arsenic concentrations of 1,000 mg/kg or higher represent the predominate loading source. Based spatial mapping and additional simulations it was determined that; 26,916 CY in the PRB area and 20,806 CY in the SWMU-4 area of material (As > 1,000 mg/kg) removed from the associated Source Area locations would discontinue stable loading. Inflection analysis was conducted to predict at which volume of Source Area material removal will demonstrate diminishing groundwater concentration reductions. In the PRB area, an inflection point between 10,000 and 20,000 CY demonstrate diminishing groundwater concentration reductions. In the SWMU-4 area an inflection point is observed near 20,000 CY of material removed. These

inflection point volumes project to yield the greatest feasible reduction in source area loading and define a targeted removal approach.

A Ranged ArcMap Zonal Statistical model was applied to the TIN to determine arsenic mass boundaries and create the "Source Areas" identified in the CMS. The Source Areas exist as ArcGIS Shape files geo-referenced to the applicable datum to enable an accurate means of removal. Based on the contouring and statistical evaluation, arsenic concentrations are not present above 1,000 mg/kg outside the defined boundaries of the Source Areas. Removal of unsaturated soils within the pre-determined Source Area boundaries will produce significant reduction in arsenic groundwater concentrations to achieve short-term groundwater remedial goals. Based on extensive arsenic isoconcentration contouring, statistical evaluation and modeling, removal of the Source Areas as defined in the CMS will result in significant removal of arsenic concentrations above 1,000 mg/kg.

5.2.2 **Field Survey - Source Area Excavations**

After clearing and grubbing is completed, a survey crew will delineate the boundaries of each Source Area excavation using GPS based satellite survey equipment. A Trimble Handheld GPS 7X unit with sub-meter accuracy will be utilized for the survey. The handheld GPS unit is accurate down to +/- 1.0 centimeter. It includes a 1.0 GHz processor, 256 MB of RAM, 4GB of onboard storage, a built in 5 MP camera, a sunlight optimized display and an integrated dual-mode cellular modem that enables continuous network and internet access to real time map data and web-based services that increase accuracy and precision. The gps unit will be calibrated and maintained in accordance with the procedures in the QAPP.

Field flag markings will be installed at each Source Area location for visual representation of each area's full horizontal extent of Arsenic concentrations greater than 1,000 mg/kg, and for denoting in-situ stabilization (ISS) areas within saturated fill. These boundaries and locations are based on data provided in the CMS Figures 3.6 and 3.7 (Parsons 2015a). These markers will be used as a guide during excavation and ISS activities. The GPS data obtained from the survey will be later plotted onto a scaled map for representation of the actual areas excavated. Post-excavation boundaries will be surveyed as well to delineate actual excavation extent.

5.2.3 **Underground Utility Marking and Clearing - Source Area Excavations**

Prior to excavation activities, all public utilities will be notified through Indiana's 811 "Call Before You Dig" protocols. In addition, any easement holders will be contacted and notified where Source Area excavations

are within designated easements. The results from the field survey being conducted as part of the subsurface structures and disturbed soils survey will be used to field mark known locations of underground utilities within areas of the Source Area excavation in the PRB area. In addition, prior utility mapping was performed by Parson and will be relied upon and included on applicable figures, for known or presumed locations of underground utilities. The location and position of the permeable reactive barrier on the northern portion of the Facility will be mapped as well.

Where necessary, additional underground surveys will be performed to clear each area of excavation of utilities for safety purposes. The underground utilities and/or structures will be evaluated with sensing equipment within Source Areas and field marked with paint and/or flagging. This will be completed with magnetic locators, ground penetrating radar (GPR) and other geo-sensing equipment. Any located utilities/structures, or anomalous detections will be carefully evaluated using soft dig methods. These results will not be reported as they are for internal use only for health and safety considerations.

5.2.4 **Air Monitoring**

Real-time air monitoring will be performed during Source Area Excavation activities as per the procedures and specifications detailed in the Community Air Monitoring Program contained within the HASP. The monitoring will be performed during soil/fill disturbance including grubbing, excavation, soil/fill mixing during treatment application, truck loading, truck transport, stockpile management and backfilling work. Testing will include real-time and time-weighted instruments and techniques. These results will be used to detect any off-site effects of Facility activities upon the surrounding community. This testing will be in addition to testing performed at various locations at the Facility for worker health and safety considerations as presented in the Health and Safety Plan.

5.2.5 **Dust Control and Suppression**

Dust control will be performed as per the specifications and procedures detailed in the HASP. The primarily control to be used during excavation will be the application of water. If water is determined to provide inadequate control, a suppressant knockdown foam will be applied with a pressure vessel. In no case will excavation of the Source Areas occur where sustained wind is detected at greater than 20 miles per hour. Vehicles and equipment will be used with a strict 15 miles per hour speed limit.

5.3 EXCAVATION OF SOURCE AREAS

The precision excavation of unsaturated soil/fill in designated Source Areas will be completed with the use of hydraulic excavators. Each Source Area that will be excavated is detailed on **Figures 9b, 9c and 9d** in the Redevelopment Area and the Leased Area. Fill removal will be systematically excavated from the Source Areas where arsenic concentrations have been determined to exist above 1,000 mg/Kg as indicated on the CMS Figures 3.6 (SWMU 4 Area) and 3.7 (PRB Area). All excavations will be constructed on a 1:2 slope for safety purposes. This will lead to the excavation of surplus fill that is not considered to be Source Area. This surplus fill will be handled and managed separately for use in Source Area excavation backfill.

The Source Area excavations in the Lease Area will all extend to a maximum depth of 2 feet bgs Excavation within the Redevelopment Area will be conducted as per Parsons Source Area modeling terminal depths or to the groundwater table, whichever is encountered first. The excavation depth will always be limited by the depth of the water table at each Source Area location as no excavation will breach saturated soils. The depth of the water table averages approximately 4 feet bgs in the Source Area locations.

The volume estimations for each Source Area are provided in Cubic Yards on **Table 8**. These estimations were based on the predetermined horizontal and vertical extent of each excavation area. It should be noted that some of the Source Areas on the northern portion of the Facility transect the permeable reactive barrier. Excavation near the permeable reactive barrier will not be performed within 10 feet of the barrier (on either side) to prevent disturbing contaminants absorbed onto the barrier, which could potentially re-mobilize and disperse back into the groundwater if disturbed.

During the Source Area excavations, fill/soil will be placed and staged in stockpiles immediately adjacent to excavation. The fill/soil from the Source Areas were profiled in May 2018 (Parsons 2018b) and were tested to be classified as hazardous waste by toxicity for arsenic, lead and/or cadmium. According to this technical memorandum, fill within these areas was separated into grids and characterized approximately from 0 to 3.5 feet bgs. Of the 20 excavation areas; 11 excavation areas are located in the Redevelopment Area and 9 excavation areas in the Leased Property.

Soil/Fill excavated from the Source Areas will be stockpiled along the outer boundary of the Source Area previously surveyed and marked. Material handling and relocation will be minimized to prevent unnecessary dispersion and to mitigate the potential for cross contamination in other areas of the Facility. Minimizing

fill/soil relocation will also reduce equipment fuel consumption and emissions. Each work and support area will be designated as an "Operating Zone", which will encompass the excavation area, staging area, areas for storage for materials and equipment, decontamination area, treatment area for fill/soil stockpiles and surplus stockpiles (removed from clean areas outside of the Source Area from sloping). All field activities will be documented with excavation logs and a daily photographic log. Final excavations will be photographed and geotagged for inclusion in the CMI Reports (Remediation Report).

In general, the excavation of Source Areas will start in the northwest corner of the Redevelopment Area and progress, as field conditions warrant, to the south and to the east. Upon completion in the Redevelopment Area, work will begin in the Leased Area. The rationale for this sequencing is to accommodate completion of Phase 1 Development Area of the barrier cover.

5.3.1 Source Area Stockpile Management

Fill/soil removed from the excavations will be stockpiled in 1,000 cubic yard piles along the excavation boundary within the Operating Zone. The piles will be managed (tested, treated and disposed of) in accordance with the specifications and procedures detailed within the QAPP.

Within the Operating Zone, longitudinal piles will be created with a length of 80 feet; width of 40 feet and an average height of 8.5 feet. These piles will be constructed on a 6-inch bed of wood chips. Each longitudinal pile will have a 1-foot high LVA product berm surrounding each pile to contain any runoff. The wood chip layer will be sourced from the various piles that exist at the Facility that were created by Chemours, as well as from trees that will be chipped from the clearing operations. The hazardous waste piles will be covered with 6-mil high density polyethylene plastic sheeting after placement to prevent precipitation from infiltrating the stockpile and dispersing contaminants. All stockpiles will be identified with signage as to the date when it was generated. A typical layout of the Source Area Operating Zone is provided in **Figure 10**.

5.4 EX-SITU SOIL TREATMENT

Hazardous fill/soils will be stabilized onsite to reduce leachability of COC's into the environment and treated to meet non-hazardous requirements for toxicity prior to transport for disposal. Based on the demonstration testing and effectiveness for IRM Buffer Zone treatment (Parsons 2016c), the TerraBond® reagent manufactured by Terra Materials will continue to be used for hazardous waste stabilization. The product specification sheet for TerraBond® is provided in the QAPP.

A flow diagram of the process of Source Area fill treatment, testing and disposal is provided in **Exhibit 5**. Each stockpile will be prepared by creating a depression or U-shape contour on the pile. The treatment product will be delivered by truck into this depression or U-shape for mixing. This approach allows minimal chemical additive handling prior to mixing and can provide improved treatment production. TerraBond® treatment additives will be added at a rate of 3% by mass to each pile to reduce leachable metal concentration to below the toxicity guidelines. Dose rates may be adjusted up or down based on the results of toxicity testing of each pile. The estimated soil treatment dosage calculations for the TerraBond® additive is provided in **Table 9**.

Treatment additive will be delivered in tarped end-dump trailers and will be managed carefully to minimize dust. The average delivered truckload weight of TerraBond® is 23 tons. Piles will be sized at approximately 1,000 cubic yards. Each pile will require approximately 2 truckloads of treatment additive. Delivery drivers will be directed to back into the depression or U-shape contour of the pile and deposit the treatment additive within that area. Once the additive is unloaded, the excavator operator will cover the additive with fill/soil from the stockpile and commence mixing. Mixing involves a repetitive folding motion with an excavator bucket to incorporate and evenly mix the fill/soil with the treatment additive. Mixing time is typically 2 hours from the time mixing begins and will be conducted until color uniformity. Once the treated pile has been properly mixed with the stabilization reagent, the material volume will be sampled as described below. Dust mitigation measures will reduce the potential for fugitive dust during the treatment mixing process as detailed in the QAPP.

5.5 STORMWATER EROSION AND SEDIMENT CONTROLS FOR SOURCE AREA EXCAVATIONS

Stormwater erosion and sediment controls will be performed consistent with the SWPPP. For the Source Area material handling and treatment, additional erosion and sediment control measures will be performed, where warranted, in the Operating Zone. These activities will include installation of localized sediment barriers, which are temporary erosion controls intended to minimize the flow of sediment and to prevent the deposition of sediments beyond approved workspaces or into sensitive resources, shall be installed following vegetative clearing operations within the Source Areas for added protection. They may be constructed of materials such as silt fence, staked straw bales or LVA product. Temporary sediment barriers will be inspected daily in areas of active construction to ensure proper functioning and maintenance. In other areas within the Operating Zone, sediment barriers will be inspected and maintained on a weekly basis throughout construction, and within 24 hours following storm events.

5.6 POST-TREATMENT SAMPLING AND WASTE CHARACTERIZATION

Post-treatment sampling and analysis will be performed from each pile to confirm that it has been rendered nonhazardous and that it meets the disposal facilities acceptance criteria. Post-treatment sampling will be conducted using test pits and consist of a randomized single grab sampling procedure from various locations across and within each pile. A ten-point composite sample will be collected from each 1,000 ton volume. This will be done by the 10 aliquots s collected being homogenized in a stainless-steel decontaminated bowl and dividing that sample volume into 3 laboratory provided sampling jars bearing the identical sampling information.

This collection method is consistent with the USEPA recognized stratified random sampling approach for collection of a representative sample of waste piles. All post-treatment samples collected will be containerized and sent to an Indiana accredited Laboratory as per sample procedures, chain-of-custody protocols and health and safety considerations outlined in the QAPP. Initial post-treatment sample analysis that will be performed on 1 of the 2 composite sample containers will consist of the preparation of a leachate sample using USEPA SW-846 Method SW1311.

Analysis will be performed on the leachate sample for the COC (lead, arsenic or cadmium). If the testing of the leachate sample indicates that the sample is no longer classified as hazardous waste for toxicity (demonstrating that the stabilization was effective), the following steps will be initiated. These steps are predicated upon the need to have the successfully stabilized nonhazardous material tested and qualified for off-site disposal.

1. The remaining leachate sample will be analyzed for waste characterization purposes for the following method target analytes:

    - TCLP Metals (the remaining 5 of the 8 RCRA)

2. A second sample volume will be prepared from the composite sample material secured utilizing 4oz Amber Jar with septa will be tested for Total Volatiles.

3. A third sample volume will be prepared from the composite sample material utilizing 8oz clear Jar with septa will be tested for Total Semi-volatiles, PCBs, Total Cyanides and Sulfides.

The above analysis will be performed on the initial 1,000 tons of material to set a material profile with the disposal facility. Based on the initial analysis, COCs will be sampled every additional 1,000 tons of volume.

5.7 DISPOSAL FACILITY ACCEPTANCE PROTOCOLS

The analytical data results from each pile that is successfully stabilized will be submitted to the selected disposal facility for review and approval prior to transport. Notifications will be submitted to USEPA upon receiving acceptance of each pile from the disposal facility.

5.7.1 Transportation and Disposal

The stabilized fill/soils excavated from the Facility, which have been successfully stabilized and rendered non-hazardous will be transported and disposed of at an approved off- site disposal facility. The stabilized waste will be disposed of as non-hazardous solid waste in accordance with applicable local, state, and federal regulations.

5.7.2 Waste Manifesting

The USEPA will be provided notification 24-hours in advance of approved waste pile transportation off-site to the selected disposal facility. Trucks scheduled to export nonhazardous waste will be provided with a waste manifest for each load to act as a transportation charter as detailed in the QAPP and referenced in **Exhibit 6**. The receiving facility will certify acceptance of the load/material. Manifests and weight tickets will be provided as backup in the CMI Reports submitted to the USEPA.

5.7.3 Reporting

All of the data collected during the process of delineating, excavating, stabilizing, transporting and disposing of the Source Area material will be compiled for the CMI Report (Remediation Report).

5.8 IN-SITU SATURATED SOIL STABILIZATION/SOLIDIFICATION (ISS)

Approximately 47,705 cubic yards of Source Area fill /soil (i.e., arsenic concentrations >1,000 mg/kg) are located at the Facility. Excavation of these Source Areas is expected to provide reductions in arsenic concentrations in groundwater. This reduction of pollution source mitigates the risk for direct contact where

fill concentrations are highest relative to a fill cover alone over the Source Areas. The Source Area excavations will extend to the saturated zone, where saturated soil arsenic concentrations are at or above 1,000 mg/kg, to decrease the saturated soil source to groundwater. Where deep saturated soil warrants In-Situ Stabilization/Solidification (ISS) treatment, an excavator will be used to mix amendments within contaminated saturated Source Area soil.

ISS will be performed within the defined Source Areas based on the results and findings of numerous historical investigations and contaminant distribution models, conducted by Chemours/Parsons. Cross sectional arsenic model depictions, as prepared by Chemours/Parson indicate arsenic in unsaturated fill and saturated fill/soil at concentrations above the 1,000 mg/kg threshold, with arsenic dissolution groundwater plumes as a direct result. There are 2 arsenic plumes within the northern portion of the Facility and 4 on the southern portion of the groundwater divide. With the exception of the identified southwest deep arsenic groundwater plume, Chemours/Parsons indicated that the plumes are associated with the dissolution of arsenic, liberated concurrently with ferric iron complex fractions of the unsaturated/saturated soil material, as a direct result of observed iron-reduction redox reactions in groundwater.

Chemours/Parsons stated that arsenic in Source Area saturated soil are primarily associated with noncrystalline materials, iron hydroxides, sulfides, carbonates, and organics. In particular, iron sulfide concentrations in saturated soil samples collected within and adjacent to said Source Ares indicate natural arsenic sequestration with iron sulfides. Chemours/Parson concluded that reductive dissolution of ferric iron hydroxides and related metal complexes within the Source Area is contributing Arsenic leaching to the groundwater.

This is consistent with previous interpretations by Chemours/Parsons and geochemical modeling indicating that the remediation of Source Area unsaturated and saturated soil with arsenic concentrations greater than 1,000 mg/kg will result in reduced dissolution of sorbed arsenic complexes to groundwater. Arsenic concentrations in deep groundwater are typically elevated further from the Source Areas and over an increased distance along the flow path relative to shallow groundwater.

5.8.1 **ISS Treatment Technology**

The chosen remedial method to stabilized contaminated Source Area saturated fill, is to apply and mix into the saturated fill/soil a formulated amorphous ferrous iron (FeS) liquid suspension amendment. The

amendment would induce microbial sulfate reduction and create biogeochemical conditions that favor the formation of minerals (ex. arsenic/iron-sulfides) that incorporate arsenic during precipitation or create kinetically favorable surfaces upon which dissolved arsenic sequesters to. The resultant stabilized minerals would substantially decrease arsenic contributions to downgradient groundwater.

A formulated blend of FerroBlack-Hybrid (FerroBlack-H - ReDox Solutions, LLC., Carmel, IN) or equivalent will be used to stabilize and reduce the potential for dissolution of arsenic from Source Area saturated soil. FerroBlack-H consists of liquid suspended FeS in the form of precipitated pyrite, with additional free sulfide to microbial sulfate reduction and mineralize dissolved arsenic into intermediate and endpoint (Ex. arsenopyrite, orpiment, etc.) complexes which are not affected by iron reduction processes. Specifications product sheets for the remedial ISCR reagent are provided in the QAPP.

5.8.2 **Dosage Calculation Model**

Chemours/Parsons stated that the total volume of contaminated unsaturated soil/fill and saturated soil with concentrations at or exceeding 1,000 mg/kg within the designated Source Areas is estimated to be 47,705 cubic yards, with 16,666 cubic yards comprised of saturated soil. The estimated volume was based on the horizontal and vertical delineation of arsenic source areas calculated from historic fill/soil samples collected and analyzed during numerous investigations. For the purposes of the volume calculations, an estimated water table depth of 4 feet bgs was used to delineate the boundary between unsaturated and saturated fill within each Source Area.

Utilizing historic saturated soil sampling analyses from samples collected within and/or adjacent to the Source Areas, in concert with groundwater in-situ chemical measurements and laboratory analyses, preliminary dosage calculations were prepared by Redox Solutions, LLC. The dosage is intended to maximize microbial sulfate reduction and promote maximum dissolved arsenic mineralization within Source Area fill and underlying soil. A summary of the calculations and related assumptions are presented below:
Assumptions:

- Soil Density of 1.4 tons per cubic yard of soil.
- 16,666 cubic yards of contaminated saturated soil, to be treated via ISS.
- A 3% by mass (% weight contaminated soil / % weight treatment solution) would be able to produce a ferrous sulfide (FeS) to arsenic ratio range between 5:1 and 19:1; ideal for arsenic stabilization.

Calculations:

- 16,666 cubic yards of contaminated saturated soil x 1.4 = 23,380 Tons of impacted saturated soil.
- 23,380 Tons of contaminated saturated soil x 0.3 = 701.4 Tons of formulated FerroBlack-H.

A preliminary estimated amount of 701.4 Tons of formulated FerroBlack-H (or equivalent) will be required to treat an estimated 16,700 cubic yards of arsenic-contaminated, Source Area saturated soil at concentrations at or greater than 1,000 mg/kg, by ISS methods. However, additional in-house bench-scale testing of saturated Source Area soil and groundwater will be required to enhance and refine the above estimated dosage calculations and confirm the actual ISS agent dosages to be installed in saturated soil within each Source Area. The in-house bench testing will be performed directly by the manufacturer.

Approximately 4 to 5 pounds of soil and 2 to 3 gallons of groundwater are required from each Source Area for in-house bench scale testing. The sources of said material will be generated from:

- Soil: Spoils from redevelopment-based geophysical testing (hollow stem auger or sonic drilling methods /split-spoon sample collection) conducted within each of the following ISS Source Areas:
    - Source Area SA-1: 4 -6 feet bgs interval
    - Source Area SA-6: 4 -6 feet bgs, 6 -8 feet bgs and 8 -10 feet bgs intervals
    - Source Area SA-7: 4 -6 feet bgs and 6 -8 feet bgs intervals
    - Source Area SA-8: 4 -6 feet bgs and 6 -8 feet bgs intervals
    - Source Area SA-9: 4 -6 feet bgs interval
    - Source Area SA-10: 4 -6 feet bgs interval
    - Source Area SA-11: 4 -6 feet bgs and 6 -8 feet bgs intervals

- Groundwater: purged well development/reconditioning water, generated from groundwater wells located within or immediately downgradient from each Source Area, or from temporary stainless-steel well points installed within the interior of the geophysical hollow stem auger or sonic assembly:
    - Source Area SA-1: PRB Well PRB-1S
    - Source Area SA-6: PRB Well PRB-2S
    - Source Area SA-7: PRB Well PRB-2S
    - Source Area SA-8: Piezometer P-10 or Temporary Well Point
    - Source Area SA-9: PIezometer P-3 or Temporary Well Point

- Source Area SA-10: Monitoring Wells MW-31S and/or MW-20
- Source Area SA-11: Monitoring wells MW-31S and MW-44

The abovementioned soil and groundwater samples will be collected in bottle ware provided by the manufacturer and immediately delivered to the manufacturer's facility in Carmel, Indiana for in-house dosage optimization testing. The in-house testing will consist of baseline analyses and dosage optimization analyses, with reagent additions at 1.5%, 3% and 4.5%:

Baseline testing will be performed on soil collected from Source Areas with respect to treatment depth intervals and groundwater samples collected from within and downgradient from the Source Areas. Testing will also be performed on in-house prepared slurry samples (1:3 soil:groundwater) utilizing Source Area soil samples with groundwater collected from its associative Source Area.

- Example: Source Area SA-1 Slurry: One-part soil collected from the 4 -6 feet bgs interval within Source Area mixed with 3 parts groundwater collected from PRB well PRB-1S.

The baseline testing will consist of the following parameters:

- Soil: pH, Redox Potential (ORP), total arsenic and sample specific constituents, including potential agent competitive ions.
- Groundwater: pH, ORP, dissolved arsenic and sample specific constituents.
- Soil/Groundwater Slurry: pH, ORP, dissolved arsenic (filtered water from slurry) and sample specific constituents.

Dosage Rate Optimization Testing will be performed on in-house slurry samples (1:3 soil:groundwater) prepared utilizing Source Area soil samples with groundwater collected from its associative Source Area. Each slurry sample will be divided into 4 split samples; one split sample utilized as a control sample and the other three split samples dosed with the agent at 1.5% by weight, 3.0% by weight and 4.5% by weight respectively. Each of the split samples will be mixed on a stir plate for a 72-hour period, with pH and ORP periodically monitored and recorded. After the 72-hour period is completed, the split samples will be allowed to rest for 24-hours, followed by decantation of each sample. Half of the split sample decant water will be analyzed for total arsenic content and the remaining half will be filtered through a 0.45-micron filter and evaluated for

dissolved arsenic content. The results of the testing, as well as the final ISS-agent amendment dosage calculations will be prepared and submitted to the USEPA within a follow-up Technical Memorandum.

5.8.3 ISS Treatment Locations and Depths

The ISS treatment locations and horizontal extent are depicted on **Figure 11:** ISS Location Plan. The depth ranges for each area are also depicted on the figure and range between 4 feet (average depth to the water table) and a terminal depth between 6 and 10 feet bgs, based on the predetermined endpoint of each Source Area.

5.8.4 ISCR Reagent Delivery Methods and Machinery

A track mounted hydraulic crawler excavator (Komatsu Model PC490LC-10 or equivalent) will be utilized for the saturated soil mixing/amendment agent delivery work. The excavator will be mounted with an Allu PMX 500 HD (or equivalent) power mixing head with plunge capability length appropriate to perform the work at the prescribed treatment depths. Individual hydraulic motors within each mixing drum mounted to the head are powered by the excavator hydraulic system and can be adjusted for rotational direction and speed directly by the excavator operator. The hydraulic powered mixing head will have the capability to mix and blend the saturated soil while concurrently applying the ISCR reagent to the saturated soil. An Allu Model PF 7 (or equivalent) pneumatic based pressure feeder will be utilized to mix and convey the ISCR reagent to the excavator mixing head. The pressure feeder is equipped with a Allu DAC (data acquisition control) module, which measures and conveys the ISCR agent at pre-determined and pre-programmed quantities. The system also reports the reagent delivery per pre-programmed grid nodes, with depth.

The Allu Stabilization system is also equipped with a 3D positioning system, which guides the excavator operator with grid-based mixing location, depth and reagent dosage. The system consists of 4 modules, including computer unit with software, touch screen, base station and GPS Sensors (sensors located at top of power mixer at the excavator boom connection and on ISCR the PF 7 mixer). The 3D Positioning System directs the operator when to change locations and feed the prescribed volume of reagent and to thoroughly mix each grid-block of the job matrix. The reagent dosage is recorded within the areal extent of each grid and by dosage depth, utilizing continuous position communications between the GPS sensors and the GPS base station.
The Allu stabilization computer will record and report reagent dosages concurrent with the work, with respect to each treatment grid location and depth. Each ISS area will subsequently be backfilled per the backfilling specifications and procedures details in this CMI Work Plan and the QAPP.

5.8.5 ISS Preparation

The ISCR reagent will be transported to the Facility in 1,000-gallon polyethylene totes and staged adjacent to the respective Source Area(s) within the Operating Zone. The staging area(s) will consist of temporary containment pads (consisting of polyethylene sheeting and timbers) which will contain the reagent totes and related reagent conveyance pumps and appurtenances and prevent against accidental releases to the Facility in the event of equipment/storage failure. The reagent will be conveyed directly from the totes to the PF 7 pressure feeder storage vessel by pneumatic pumps equipped with chemical-resistant pressure hoses.

Prior to initiating the ISS work, a network of interconnecting 25 foot by 25-foot grids encompassing the areal extent of each ISS Source Area will be mapped. GPS coordinate measurements will be collected at each grid node; the resultant measurements will be transferred to the ALLU 3D positioning system, concurrent with dosage calculations within each Source Area grid. The GPS Source Area grid plan as depicted on **Figures 12a and 12b**.

5.9 SOURCE AREA EXCAVATION BACKFILL

Source area excavations will be backfilled with soils that meet the IDEM Regional Screening Levels for Residential Direct Contact Exposure Standard as presented in IDEM IAC, 2018 Screening Level Table A-6. There will be restriction on any detectable concentrations of PCBs set for this surface of the barrier cover. Initially the barrier cover will be constructed in 90,000 square foot cells with a maximum thickness of 2 feet above backfilled Source Areas with LVA product. These cells will be termed “Starter Cells”. The LVA product will be placed in 1-foot lifts and compacted with a vibratory roller to 95% dry density compaction standard. The slope of the 2-foot lift will be “crown” graded away from the Source Area excavation to prevent migration of storm water through the excavation/ISS area. The lifts will be installed and compacted. Completed backfilled excavations will be photographed for inclusion in CMI Reports.

5.9.1 Stormwater Erosion and Sediment Controls

Stormwater erosion and sediment controls will be performed consistent with the SWPPP. At the conclusion of the Source Area removal and backfilling activities, all the backfill areas and those areas that were not subject to Source Area removal will be grubbed of vegetation and immediately covered with permeable earthen barrier cover to prevent any indirect exposure to sitewide fill contaminants through dust dispersion. This placement will be done systematically, in 90,000 square foot application areas and will progress, in general,

from west to east along the Redevelopment Area. Upon each two foot lift of the barrier cover placement over each application area, it will be temporarily seeded for stabilization. Seeding will occur in Spring using oat (*Avena sativa*); in Fall with rye (*Secale cereale).* The oats will be ploughed under in the Fall season as a green fertilizer to receive the following rye seed application; and the rye will be ploughed under in the Spring season as a green fertilizer to receive the following oat seed application. Rye and oat seeding will be applied to backfilled or permeable soil capped areas only, of which soil will meet IDEM soil standards and criteria designated for material acceptance for the Facility. Root systems of the seeding crop are not expected to grow below permeable barrier cover depth of soils. This groundcover from the seeding will eliminate dust generation and provide ground protection against rutting and runoff from stormwater.

Oat and rye offer maximum coverage, require no fertilization, are tolerant to almost any soil conditions, establish ideal root growth for stabilization without interfering with subsequent earthwork activity and out-competes other vegetation for uniformity. Rye is extremely tolerant to cold weather temperature and prevents the establishment of winter-hardy weeds. Neither the rye or oat yield will be harvested, used for pasture or removed for any use. Planting of the seeds will be done by mechanical casting means using a twin-disk spreader and worked into the ground with steel disc harrows.

The rye and oat seed will be locally sourced to ensure that the genotypes will have the best chance to adapt and survive as well as to service indigenous insect and wildlife populations. This is particularly important as no fertilizer will be used for its planting. Once final elevations and contouring is achieved throughout facility areas, a final vegetative cover will be chosen as per IDEM guidance and detailed in the Remedial Construction Phase II – Development Activities.

5.10 REMEDIAL PERFORMANCE MONITORING

The performance groundwater monitoring events will be performed identical to the protocols and procedures as the baseline groundwater monitoring event to the extent practical. The following performance monitoring events are proposed, based on the type of remedial work performed and remedial event completion:

- Post Source Area Removal/ISS (Northern Area): Four monitoring events, conducted one-month, two months, four months and six months after the completion of the work.
- Post Source Area Removal/ISS (Northern Area): Four monitoring events, conducted one-month, two months, four months and six months after the completion of the work.

- Post Preliminary Groundwater Treatment: Three monitoring events, conducted four-months, eight-months and 12-months after the completion of the work.

If the monthly groundwater monitoring schedule overlaps seasonal cold weather periods where ambient temperatures are below 32 degrees Fahrenheit, then monthly events scheduled will be rolled back and continued once ambient temperatures are above that threshold. Please note that due to the compressed timeframe to conduct the abovementioned remedial events, the resultant performance monitoring events are staggered and not concurrent with each remedial event. Please refer to the proposed project schedule presented in **Exhibit 4.**

The purpose of the monitoring events is to monitor and evaluate the efficacy of the Source Area removal work and ISS work, concurrent with the remedial progress related to the preliminary groundwater injection work. The findings of the groundwater quality review will be utilized to validate and optimize the next phase of the work for long-term groundwater treatment design. Applicability of historic groundwater remediation approaches proposed to the USEPA will be assessed based on the data review. Potential revised groundwater treatments methods may be proposed to the USEPA as a result of the data evaluation. Specific examination tasks will include, but not limited to the following tasks:

Scrutinize potential changes in geochemistry and contaminant concentrations in groundwater downgradient from the former Source Areas.

- Evaluate geochemistry/contaminant changes in groundwater for stability and/or rebound.
- Continue to monitor the progress of the 2015 groundwater treatment Pilot Test work, with concurrent examination of potential enhancement and/or diminishment of pilot test efficacy related to the ISS remedy.
- Determination of source-area related groundwater contaminant plume cessation based upon potential stabilization of contaminated saturated soil related to the ISS remedy, with concurrent evaluation of potential contaminant plume rebound over time.

USEPA low-flow groundwater purging, aquifer stabilization and sample collection protocols and procedures, equivalent to the protocols and procedures utilized during the baseline groundwater monitoring event will be employed. Groundwater samples will be collected, recorded, prepared and transported under chain of custody procedure to the environmental laboratory in an identical manner as carried out during the baseline

groundwater monitoring event. Physical and geochemical parameters (ORP, pH, DO, Specific Conductivity) will be measured from each well in the monitoring network and recorded. The following laboratory analyses will be performed on the resultant groundwater samples:

- Total Arsenic, Lead, Iron, Cadmium, Zinc, Phosphorus and Calcium by USEPA Test Method 6010B.
- Speciated Arsenic (As III/As V) by USEPA Test Method 1632.
- Sulfate by USEPA Test Methods 375.3 (or 9056).
- Sulfide by USEPA Test Method 376.1.
- Total Organic Carbon by USEPA Test Method 415.1 (or 9060).
- Alkalinity by USEPA Test Method 310.2.
- Bicarbonate by USEPA Test Method SM 2320 B.
- Chloride by USEPA Test Method 300.0.
- Nitrate by USEPA Test Method 353.1 (or 9056).
- Nitrite by USEPA Test Method 354.1
- PFOA and PFOS by USEPA Test Method 537 (or other EPA preferred method) - (If warranted as per results of Baseline event)

Groundwater samples collected during the first performance monitoring event will be collected from the network of pre-existing and newly installed wells described in Section 4 of this work plan. The removal of wells from the monitoring network by be requested from the Agency, if data obtained from said wells no longer assist in the effectiveness of the remedy, future remedial events and/or long-term monitoring purposes

The sampling and analysis for this activity will comply with USEPA protocols and procedures to demonstrate laboratory reporting duplicity, analysis accuracy and precision as detailed in the QAPP.

5.10.1 **Performance Monitoring Reporting**

Interim reports will be prepared and submitted to the USEPA after each performance monitoring event is completed as per Section 7.4.

5.11 **ENGINEERING AND INSTITUTIONAL CONTROLS**

The CMS establishes the remedy to construct a permeable barrier cover over the exposed fill surface of the Redevelopment Area at the Facility to preclude exposures to sitewide contaminants. The contaminants

representing the greatest potential risk for direct contact exposure for both human and ecological receptors due to their elevated concentrations in fill at the Facility are the inorganic contaminants of arsenic, lead, antimony, thallium and cadmium. Other, inorganic contaminants or lesser potential risk due to concentration, include barium, chromium, cobalt, copper, manganese, selenium, silver, vanadium and zinc. The presence of these contaminants in the fill represents an exposure pathway for occupants down to a depth of approximately 7 feet bgs. The CMS establishes the need to construct an earthen permeable barrier cover to prevent exposure of occupants to these contaminants. The barrier cover is considered an engineering control for the Facility. The point of compliance for direct contact with fill is within the top 1 foot. Institutional controls are imposed to preclude activities that would breach the barrier cover after construction that could result in direct exposure to the contaminants in the subsurface fill. The institutional controls are not addressed in this work plan as they are specified in the RCRA § 3008(h) Administrative Order on Consent (Docket No. RCRA-05-2019-003).

In addition to controlling direct contact exposures to the Facility fill contaminants, the barrier cover will also abate indirect exposures. Indirect exposures include:

- Increased contaminant load on groundwater due to stormwater percolation through the contaminated fill.
- Dust generated from exposed areas of contaminated fill.
- Vapor migration through soil gas transfer.

5.11.1 **Engineering Control – Permeable Barrier Cover**

The engineering control specified under the CMS remedy is a barrier cover of permeable earthen media and impermeable pavements. Barrier covers are capable of limiting human and ecological exposure risks from fill contaminants through physical impediment. The materials used in the construction of barrier covers are permeable and include soil and masonry media imported from off-site. These media can be manufactured on-site to provide the necessary performance criteria for exposure protection (soil and groundwater) and provide for the geotechnical needs of redevelopment. The impermeable pavements of the engineering control are exclusively concrete and asphalt pavement products (building foundations, slabs, walkways, loading docks, driveways and parking lots). The permeable and impermeable barrier cover specifications are integrated to provide maximum benefit for exposure protection and redevelopment. The barrier cover will have a thickness of 6 feet in areas where it is not covered by pavements. This thickness is what is required to avoid

redevelopment work excavation for foundations, drainage pipe installation, elevator pits and truck loading docks from breaching the barrier cover.

All the barrier cover materials have the potential to include wastes to replace one or more of their manufacturing components with no loss to their respective performance criteria; this is conceptually known as beneficial use of waste.

It should be recognized that the ultimate construction of the impermeable barrier cover will change the soil gas conditions within the underlying permeable barrier cover; it will stop water infiltration and increase soil gas airspace. Vapor intrusion will be prevented by the installation of an air-tight high-density polyethylene sheet membrane beneath the building slab and through the careful construction of the permeable barrier cover to promote equilibrium in subsurface soil vapor.

Finally, it should be recognized that capping methods are considered to be "Green and Sustainable Practices" that are consistent with the published USEPA greener cleanup policy, as defined in the Principles for Greener Cleanups (https://www.epa.gov/greenercleanups/epa-principles-greener-cleanups). The capping method will be performed with Touchstone Practices that are discussed in other sections of this document (e.g. clean diesel, clean air, beneficial use).

Soil and Masonry Media.

The soil and masonry media used for the construction of the permeable barrier cover will be sourced from off-site borrow from construction projects within the region. Soil and masonry media include virgin soil, fill, foundry sand, foundry waste and unpainted (no VOC content) mixed masonry (brick, block, asphalt and terracotta tile) and mixtures of these media that are borrow from construction and demolition activities performed at regional construction projects, herein referred to as Donor Sources. To ensure that no new pollution exposures are introduced onto the Facility, the Donor Source will be thoroughly screened and the borrow inspected and tested for quality assurance and quality control. This vetting process is detailed below.

Soil and Masonry Media Processing.

The activities described herein to process materials will be performed in specific areas of the Facility presented on **Figure 13** as Soil and Masonry Media Processing Areas. The maps show the two expected configurations for the processing as redevelopment occurs. These areas are designated as Phase 1 and Phase 2 that directly coordinate with the construction of Phase 1 and Phase 2 Development Areas of the barrier cover. The process

flow diagram for the manufacture of the specified product that will be used for barrier cover cell construction is provided **as Exhibit 7**, LVA Manufacture Process Flow Diagram.

Imported Donor Source material will be tipped from trucks in the tipping area for inspection prior to being placed into the Raw Feed Stockpile. The Raw Feed Stockpile will be limited in size to 100,000 cubic yards. The pile can be measured for management through use of a drone fitted with a GPS-enabled camera. The camera returns measurements that are very precise and that can output detailed GIS derived maps.

Materials from the Raw Feed Stockpile will be fed into a scalping screen configured to "scalp" fragments greater than 3 inches from the material using a vibratory screen deck equipped with 4 inch steel hexagonal punch plates. These fragments are inert brick, block, concrete, stone, etc. The 4 inch minus material is conveyed into a working pile that can be used to blend with other processed materials into LVA product. Materials retained on the screen deck range in diameter from 4 inch to 24 inches. Miscellaneous steel and wood debris are handpicked out of the material prior to crushing. A jaw crusher is utilized to primary crush on oversized material down to a workable size for finer crushing. The jaw crusher is equipped with hydraulically adjustable jaw settings, reverse crushing action to relieve blockages, hydraulic drive enabling the crusher to start under load, and jaw level sensors to control feed rate with minimal intervention. A jaw crusher is designed to create a 6:1 reduction in material size. It crushes material using the compressive force of a high strength steel hinged jaw plate reciprocating back and forth relative to a high strength steel fixed jaw plate. The jaw plates are mounted above a 6-inch slot. Material ranging from sand sized particles to 6 inch in diameter drops through a secondary scalping screen and onto a conveyor belt for a finishing crush. The finishing crush reduces the material at a 6:1 ratio until it is small enough to fit through a 2inch opening at the bottom of the machine. The material will be recirculated until all materials measure less than 2 inch and pass.

The configuration at the Facility will have two primary feeders feeding one finishing screen. The recirculation allows for the product to be created without the need to double handle the material. This process converts the imported fill to a 4 inch minus product that can be easily handled for filling and grading purposes while also producing a valuable product that can be used as an alternative to quarry mined stone and soil aggregate natural resources.

The materials generated from screening and crushing can be used or blended to manufacture a uniform product with low void-space ratios that can be gauged for quality control. This product is considered a Low Void Aggregate (LVA). The LVA will reduce soil gas airspace and promote equilibrium in the permeable barrier

cover after the permeable barriers are subsequently constructed above. Simply stated, the LVA will have lower pore space and very high density due to the angularity of the crushed media and the great distribution of the particle sizes.

The scalper screen can operate at 585 tons per hour for 5 hours a day, for 4 days per week (1-day maintenance). Calculated for 108 days of work, this will generate approximately 270,000 tons of screen process material per year. The crushers will operate at 300 tons/hour for 5 hours a day for 4 days per week (1 day per week is for maintenance). Calculated for 108 days of work, this will generate approximately 324,000 tons of crush process material per year.

5.11.2 **LVA Manufacture and Stockpiling**

The manufactured LVA will be generated and stored in individual conical piles that will be piled to approximate a volume of 5,000 cubic yards as estimated by Field Staff or through use of a drone. These piles, termed "Charge Stockpiles", will be indexed as the volume is satisfied. At the point where one Charge Stockpile is completed to final volume, a new Charge Stockpile will be created. The number of Charge Stockpiles that can be in the processing area will not exceed 12 (60,000 cubic yards). Charge Stockpiles will be subject to testing prior to use in supplying LVA to construct cells of the barrier cover.

Charge Stockpiles that pass the testing specifications for LVA will be approved for use in barrier cover cell construction. Approved piles will be fitted with signs indicating "Approved LVA" that will include the pile index, sampling date and sample identification. If a representative sample is tested and found to be out of compliance with the gradation specifications, the pile will be failed. Failed piles will be fitted with signs indicating "Failed LVA" and the pile index. Such piles will be fed back into the Primary Process Stockpile for re-blending as deemed necessary by the Field Staff.

Charge Stockpile Testing

A representative composite sample of the charge stockpile will be taken for laboratory analysis. The composite sample will be comprised of 5 grab samples obtained from equidistant points of the charge pile that are taken from a depth within the pile that is a minimum of 2 feet from the pile surface. Each charge stockpile sample will be tested using ASTM methods by a competent soil laboratory and compared against the following threshold limits.

TEST Method	DESCRIPTION	THRESHOLD LIMITS FOR PASSING
AASHTO T194-87	Organic Content	0.6%
ASTM 422-63	Fines Content Passing 200 sieve Oversized (>3/4”)	>15% 20% (volume)
ASTM G51-18	Soil pH	≥6
ASTM 698	Modified Proctor (for high-fines soils) – samples should contain <10% oversize.	Optimum Moisture for use in barrier compaction testing (no threshold)

5.11.3 **Stormwater Erosion and Sediment Controls**

Stormwater erosion and sediment controls will be performed consistent with the SWPPP. For processing of soil and masonry media for LVA product manufacture, additional measures will be followed. In that the Raw Feed and LVA stockpiles have the potential to remain stationary for periods of time, the processing area will be surrounded on all sides by an extra perimeter silt fence. Access and egress into these areas, which will require a break in the fence continuity, will be through a construction trackpad measuring 70 feet in width and 30 feet in length. The pad will have a minimum thickness of 6 inches. In that this will be a high traffic area, the track pad will likely require maintenance and refreshment on a weekly basis.

5.11.4 **Permeable Barrier Cover Construction**

Initially, the barrier cover will be constructed in 90,000 square foot Starter Cells with a maximum thickness of 2 feet above backfilled Source Areas. The Starter Cells will always be gently crowned at the surface to direct stormwater away to the edges as indicated on **Figure 14**: Barrier Cover Detail. The crowning will direct stormwater away from the Source Area backfill (ISS mixing zone) to prohibit the addition of excessive infiltrating water that could dilute the completed mixing efforts. The rationale for limiting the Starter Cells to 2 feet is that it affords an open set of options for ground improvement techniques that will be selected from analysis of the data collected in the geotechnical investigation. The Starter Cells will be constructed sitewide until all Source Areas are excavated and backfilled.

During and after the construction of the Starter Cells, the placement of LVA either above the Starter Cells or in areas that were not covered with Starter Cells will be placed in larger areas measuring 1,200 feet by 600 feet (720,000 square feet), herein referenced as “Primary Cells”.

The placement of Primary Cells of the barrier cover will start in the northwest corner of the Redevelopment Area. The elevation of the ground surface, which is nearly flat in topography, in this location is approximately +590 above mean seal level. This is identified as the Phase 1 Development Area and is referenced on Figure 15: Engineering Control Barrier Cover Plan. The cells will be made horizontally contiguous through the entire Phase 1 Development Area to elevation +596. This will represent a barrier cover thickness of 6 feet. Completed lifts within Primary Cells will be gps-tagged, surveyed for elevation and photographed for inclusion within CMI Reports. Compaction will be verified with a field densometer and documented for inclusion in CMI reports. The placement can be measured for management through use of a drone fitted with a GPS-enabled camera. The camera is capable of returning measurements that are very precise and that can output detailed GIS derived maps. It should be noted that the areal extent of subsequent phases (i.e. Phase 2, Phase 3, etc.), has not yet been determined and will likely be construed when the results of the various investigations, surveys and analysis proposed in this work plan are completed. Where densities are found to meet or exceed 95%, the cell will be fitted with signs indicating “passed compaction” that will include the testing date. This data will be compiled by the Project Managers for inclusion in the CMI Reports.

If densities are found to be below 95% compaction, additional compaction methods can be employed to improve the ground surface. This will include making additional passes with the vibratory roller, or addition of lime, aggregate and/or cement. If a cell, or cell portion, cannot be made to pass inspection. It will be excavated back out and the LVA and moved back to the primary feed pile. All occurrences of compaction failures requiring an excavation will be documented in CMI Reports.

5.11.4.1 Placement and Compaction

The barrier cover will be constructed in pieces (cells) from LVA product delivered from the processing area by rubber-tired end loaders. The end loaders will tip loads of LVA and then the loads will be immediately knocked down with a heavy dozer and then immediately rolled with a 10-ton vibratory roller into an 18-inch lift. The roller will compact the lift with two perpendicular passes to form a lift that is approximately 1 foot in thickness and that will have a minimum 95% compaction. The roller can be either a smooth or sheep-footed to create different stormwater sheeting effects. The sheep foot is required in areas where smooth rollers will “pump”

water from the subsurface due to the LVA's fine particle content. The final grade is exacted to 1-foot thickness utilizing a dozer that is gps machine grade control technology enabled. Machine grade control technology is the newest technology that works faster and with more precision to achieve final elevation grade. Such technology reduces operating time emissions and promotes surfaces that promote stormwater infiltration to groundwater that will not generate surface sheet flow. The GPS unit, either hand or drone fitted, will be calibrated and maintained in accordance with the procedures in the QAPP.

The result of the careful blending of construction materials will provide for general overall results of high maximum dry unit weight, lower optimum moisture content, greater shear strength, greater stiffness, lower compressibility, lower air voids and decreased permeability.

Where groundwater wells or piezometers are present in a cell area, the risers and covers will be retrofitted, as necessary, to allow an extension to accommodate anticipated increases in surface elevation.

5.11.4.2 Placement and Compaction Specifications for Permeable Barrier Cover

The barrier cover acts as a semi-pervious hydraulic conductivity layer designed to minimize infiltration of precipitation to protect groundwater and to minimize the transmission of soil vapors to protect interior air quality in the future overlying buildings. Hydraulic conductivity refers to a measure of the barrier media's water-retaining ability when soil pore space is not saturated with water. The targeted measurement of hydraulic conductivity for the barrier cover will be less than 10^{-5} cm/s ($2.8x10^{-2}$ feet per day). Failure of a Primary Cell to measure with a low enough hydraulic conductivity will not result in removal of any portion of the barrier cover cell. A failing result will be used to steer future LVA blend thresholds, compaction methods and grading elevations toward achieving the hydraulic conductivity goals in future Primary Cell applications.

The measured in-place dry density will be taken immediately after soil compaction to confirm it is at, or greater, than the optimum moisture content corresponding to the charge stockpiles.

5.11.4.3 Placement Conditions

Barrier cover placement shall be performed under the supervision of an independent licensed Professional Engineer in the State of Indiana (Civil Engineer). Placement activities will not be performed during the period after November 30 and before April 1, or during any other times when adverse weather conditions exist.

- Rainfall greater than 0.1 inches per hour.
- Temperatures below 20 degrees and above 95 degrees
- Snow conditions
- Squall conditions
- Winds in excess of 35 miles per hour

If Primary Cell surface areas experience desiccation cracks, water can be applied for repairing the surface. If repairs are not feasible with water or if cracks exceed 2 inches in depth, a 6 inch lift will be required to be removed (bladed) at a subsequent date where desiccation conditions do not exist and the lift re-placed.

Compaction and Moisture Measurements

Compaction and moisture testing will be performed on each Primary Cell lift using a nuclear densitometer to demonstrate a minimum of 95% compaction. The densitometer will be operated in accordance with ASTM D2922 and ASTM D3017. The passing results will be recorded by the Civil Engineer and presented in the CMI Reports (technical memorandum). Where compaction rates are measured below 95% compaction, additional compaction passes with the vibratory roller can be made as a remedy. If after such remedy the compaction is still below the 95% requirement, the lift will be required to be removed (bladed) and re-placed.

5.11.4.4 Hydraulic Conductivity Measurements

Measurements of hydraulic conductivity will be performed on a weekly basis as each Primary Cell is being placed. The minimum thickness of the Primary Cell to be tested will be two feet. The surface will always be prepared to be firm, smooth and flat. Measurements will be taken in the field utilizing a Meter Company SATURO brand infiltrometer.

SATURO was designed to be an automated instrument for measuring permeability and field saturated hydraulic conductivity (K_{fs}) in soil. It utilizes a multi-pressure head analysis approach to simplify the corrections for three-dimensional flow from a single ring infiltrometer, allowing for quick measurements of hydraulic conductivity without postprocessing. This automated approach reduces error in the hydraulic conductivity assessment (Reynold and Elrick 1990). It consists of the following components:

- Control unit
- Two insertion rings: 5-cm depth and 10-cm depth
- Driving plate

- Infiltrometer head
- Charging adapter
- Two collapsible water tanks
- Three air and water tubes: 6.4-mm (1/4-in) diameter tube for air output; 9.5-mm (3/8-in) diameter tube for water output; 7.9-mm (5/16-in) diameter tube for water input

The unit retains data for output into an excel database for archiving purposes (.xlsx or .csv). The data will be presented in the CMI Reports (technical memorandum). The data is intended to optimize mix design and compaction goals for the barrier cover.

5.11.4.5 Stormwater Erosion and Sediment Controls

Stormwater erosion and sediment controls will be performed consistent with the SWPPP. For placement of the barrier cover cells, additional measures will be followed. The edges of Primary Cells will be smooth compaction rolled on a 1:2 slope (rise/run) to avoid rutting from stormwater runoff. Where runoff cannot be directed to a retention pond, the downward edge of the Primary Cell will be fitted with hay bales.

At no time will more than 4 cells (either starter or primary) be actively constructed absent seeding or vegetative cover. The construction in cells can and will leave the surface of the Facility with a "patchwork" appearance. The resultant "patches" will often exist at different elevations that will require specific procedures to control erosion from sheet flow between elevation slopes. Accordingly, the following activities will be performed where cell edges exist at different elevations to reduce erosion and runoff.

- Cell surfaces will be rolled with a sheep foot roller to impede sheet flow from achieving velocities that will create rutting or channeling of surfaces and slopes.
- Cell edges will be sloped on a 1 to 2 angle of repose and compaction rolled with a smooth roller to direct sheeting water toward local erosion controls (silt fence, straw bales, sheep foot surfaces or impoundments).
- Where sloping and rolling edges are found to be insufficient to control sheet flow velocities, aggregate and/or mulch can be added to the slopes for stabilization and sheet flow velocity dissipation.
- Inspection in these areas by the SWPPP Coordinator will be heightened.
- As practical, cells will be combined, in areal extent and elevation to reduce the length and magnitude of cell slopes that exist at the Facility.

5.11.4.6 Chemical Quality of Soil and Masonry Media

All of the soil and masonry media or qualified wastes approved for beneficial use will be tested and demonstrated to meet the IDEM Adjusted Legitimate Use Modified Residential Criteria based on the Project Conceptual Site Model. No material impacted by point source contamination will be accepted. There will be a limit of total PCBs set at the more conservative concentration of 2.0 parts per million per USEPA TSCA Policy Decision (pending changes to the PCB manual). The top foot of the barrier will be comprised of materials that meet the IDEM Regional Screening Levels for Residential Direct Contact Exposure Standard as presented in IDEM IAC, 2018 Screening Level Table A-6. There will be restriction on any detectable concentrations of PCBs set for this surface of the barrier cover.

5.11.4.7 Physical Quality

In that the soil fraction of materials used to construct the barrier cover will be coming from regional Donor Sources, variability can be expected in gradation, plasticity, organic content, angularity, porosity and color. For uniformity, Donor Source media will be collected at the Facility and processed with diesel-powered hydraulic sorting and sizing equipment within the designated processing area. This equipment will manufacture the necessary products from the soil and masonry media needed to construct the permeable barrier cover. Quality control testing is performed on the soil and masonry media after sorting and sizing to ensure that the physical and chemical quality of the media meets the specifications for the remedy and is suitable for the selected redevelopment method of building construction. The remedy requires the construction of the physical impediment to prevent direct and indirect exposure to contaminants. On-site sorting and sizing will also provide a greater population of potential Donor Sources (i.e. certain sources will not be considered unsuitable because of one or more physical deficits).

5.11.5 **Indirect Exposures**

5.11.5.1 Dust Generation

The contaminated fill at the Facility currently is stabilized with mature vegetation that has developed over several decades since facility closure. This stabilized fill currently generates minimum dust at the Facility. Source Area excavation will require that this vegetative cover be disturbed. Additionally, the techniques that will be used to excavate, stockpile, chemically stabilize and load out the Source Area fill will disturb a substantial area around each excavation footprint. To create the adequate work area around excavations for

all of these activities, a standard procedure and sequence has been developed to ensure that dust from contaminated fill is not generated. At the conclusion of these procedures, it will be necessary to re-establish a dust free surface. This will be accomplished with the early application of elements of the barrier cover in areas around and between Source Area excavations.

For precision, barrier cover cells placed over backfilled Source Areas, Starter Cells, will always be applied with consistent dimensions that can be readily discerned in the field. The dimensions for application will always be 300 feet wide by 300 feet long (90,000 square feet), with a thickness of 2 feet. These areas will be referred to as “Starter Cells”. Upon completion of each Starter Cell, it will be temporarily seeded for stabilization.

Seeding will occur in Spring using oat (Avena sativa); in Fall with rye (Secale cereale). The oats will be ploughed under in the Fall season as a green fertilizer to receive the following rye seed application; and the rye will be ploughed under in the Spring season as a green fertilizer to receive the following oat seed application. Rye and oat seeding will be applied to backfilled or permeable soil capped areas only, of which soil will meet IDEM Facility soil standards and criteria designated for material acceptance for the Facility. Root systems of the seeding crop are not expected to grow below permeable barrier cover depth of soils. This groundcover from the seeding will eliminate dust generation and provide ground protection against rutting and runoff from stormwater.

Oat and rye offer maximum coverage, require no fertilization, are tolerant to almost any soil conditions, establish ideal root growth for stabilization without interfering with subsequent earthwork activity and out-competes other vegetation for uniformity. Rye is extremely tolerant to cold weather temperature and prevents the establishment of winter-hardy weeds. Neither the rye or oat yield will be harvested, used for pasture or removed for any use. Planting of the seeds will be done by mechanical casting means using a twin-disk spreader and worked into the ground with steel disc harrows.

The rye and oat seed will be locally sourced to ensure that the genotypes will have the best chance to adapt and survive as well as to service indigenous insect and wildlife populations. This is particularly important as no fertilizer will be used for its planting. Once final elevation and contouring is achieved throughout facility areas, a final vegetative cover will be chosen as per IDEM guidance and detailed in the Remedial Construction Phase II – Development Activities.

5.11.5.2 Vapor Migration

Although vapor intrusion in not an expected concern based on COCs at the Facility, to abate potential issues of vapor intrusion into interior buildings and structures, a 20 mil high density polyethylene (HDPE) vapor barrier will be included in building design, and the permeable barrier cover will be constructed of a Low Void Aggregate ("LVA"). The HDPE will be placed in sheets that are connected using high-strength HDPE seam tape. The LVA will be manufactured on-site to consist of crushed concrete, block and brick with varying percentages of soil fractions of sand, trace silt and clay. It will be produced from the proposed soil and masonry media borrow using a multi-step manufacturing process to produce a uniform fill consisting of greater than 15% fines (particles passing No. 200 sieve) and 70% of aggregate that's up to ¾" inches in diameter and less than 20% over ¾" (oversized). The LVA will have a low porosity measured near 0.2, with aggregates providing satisfying bearing capacity and fines filling the void space between the aggregates. A 95% compaction rate is required for the proposed construction; thus, the porosity will be below 0.25.

5.11.5.3 Contaminant Loading to Groundwater

The principal means to address the direct exposures to groundwater contamination is associated with the Source Area removal and chemical fixation, and subsequent treatment of groundwater provided in the CMS remedy. The indirect effects that the permeable reactive barrier cover will have should be viewed only as an enhancement.

As discussed above, the LVA will have a low permeability and, due to the presence of masonry in its production, exhibit pH that is higher than 6.0. This is because weathered concrete and masonry have a pH of approximately 10.5 (Grubb et al. 2004). This will ensure that the barrier will not provide the acidic conditions to increase the solubility of heavy metals in the groundwater. The increased pH will act to reduce metal solubility and provide stabilization of the metals bond with soil and therefore reduce the potential for contaminant load on the groundwater and retard its mobilization. The rate and extent of these reactions will depend on other factors that will change given the variability of the Donor Sources that will be used to manufacture the cover barrier. As such, the benefits and geochemistry can only be generalized. Where the engineering control is completed to include concrete and asphalt pavements, groundwater infiltration will be ostensibly eliminated in those areas.

5.11.6 **Material Acceptance Protocol**

5.11.6.1 Donor Source Imported Soil and Masonry Media Vetting

Vetting and quality control of proposed Donor Sources for the manufacture of LVA product for construction of the permeable barrier cover will be performed in accordance with the procedures outlined in this section.

5.11.6.2 Review Engineer Qualifications

The Review Engineer will be an Indiana licensed Professional Engineer (referred to herein as the "Review Engineer"). The review engineer will have technical staff to assist in data collection and interpretation with a minimum of a Bachelor of Arts/Science Degree in environmental, chemical or life science and at least one year of regulatory review and chemical analysis experience. All technical staff will be familiar with Federal as well as Indiana codes, rules and regulations pertaining to the classification of wastes and identification and management of hazardous wastes.

The Review Engineer will maintain documentation related to Donor Source review, technical justifications for approvals, and other relevant environmental data pertaining to imported soil and masonry media. The data collected and approved by the Review Engineer will be submitted to the USEPA for documentation.

The Review Engineer will be covered with an Errors and Omissions Insurance Policy that will provide for, at a minimum, a $10,000,000 per occurrence coverage for approval decisions concerning Donor Sources.

5.11.6.3 Donor Source Review and Approval

Proposed permeable barrier cover media from Donor Sources will be subject to a vetting process to determine suitability for beneficial reuse and compliance with Federal and IDEM requirements. Donor Sources under consideration will be required to submit a Donor Compliance Package ("DCP") for proposed permeable barrier cover media, including certified laboratory reports, environmental investigation reports, available site geotechnical reports, relevant statistical analysis of sample results (e.g., 95% Upper Confidence Limit), and a completed Donor Source Profile Form (**Exhibit 8**). The Donor Source Profile form will be signed by the generator or its authorized representative to provide and certify the proposed quantity of media, the physical and chemical characteristics of the media, history of the land use of the property, environmental regulatory involvement, and available reports/sample data for media from each Donor Source.

As part of each DCP review, the Review Engineer will evaluate the environmental setting of each proposed Donor Source by: 1) reviewing laboratory analysis; 2) obtaining additional chemical testing consistent with the IDEM Acceptance Criteria; 3) inspecting the Donor Source material at its source location; and 4) reviewing relevant online and private computer database. Following review of a suitable Donor Source, the Review Engineer will issue an approval letter to the Donor Source representative for proposed protective cap media meeting site-specific criteria and IDEM requirements for donor fill. This approval letter will bear the seal of a licensed Professional Engineer. Copies of all approvals and support data will be made available to the USEPA.

5.11.7 **Chemical Acceptance Criteria**

5.11.7.1 Qualitative Standards

All material accepted for import to the Facility will meet IDEM Adjusted Legitimate Use Modified Residential Criteria as set for the Facility by IDEM. No soil and masonry media will be approved for import to the Facility that is classified as hazardous by listing, definition or by characteristics under the RCRA or Toxic Substances Control Act (TSCA). No point source contaminated soil and masonry media will be approved for import to the Facility. No industrial waste, putrescible waste, technologically enhanced naturally occurring radioactive material, friable asbestos containing building material, medical waste, bio-hazardous waste, special waste, Universal Waste, or municipal solid waste will be approved for import to the Facility. Further, there will be no inclusion of any of the wastes detailed above in mixtures or as fractions of the soil and masonry media approved for import to the Facility.

5.11.7.2 Quantitative Standards

The soil and masonry media will be tested on a frequency of no less than one representative sample per one thousand cubic yards of media proposed. Chemical testing will be performed at proposed Donor Sources by an agent or representative of the Review Engineer, or a contracted third-party environmental engineer or consultant (collectively, the "Testing Entity"). Sampling may be conducted ex-situ from cordoned-off stockpiles, or in-situ using test pits or borings collected from demarcated boxes of fixed volumes over the proposed Donor Source borrow. Default sampling protocol will be consistent with the IDEM Site Characterization and Sampling Guidance Revised October 13, 2016 for volatile organic compounds, USEPA Environmental Sampling and Analytical Methods (ESAM) and Soil Sampling (SESDPROC-300-R3). Painted masonry media will be tested exclusively using grab samples.

95% UCL Analysis Methodology

The nature of Donor Site borrow is to have a wide-range distribution of metal concentrations from natural mineral content and ubiquitous concentrations of certain target analytes associated with urban and industrial land uses. The ideal would be for there to be a published background concentration of organic and inorganic analytes for all regional soils, but this is not the case as natural and ubiquitous analytes show great variation. These expected sample-to-sample variabilities can range as much as 600% in a single body of soil and masonry media from a Donor Source that exhibits no point source contamination from pollution (EPA, OSWER, 2002). The variability is also affected by typical statistical issues such as small sample size and small population "N" size. This provides the basis of parametric data analysis for qualifying Donor Sources. Such plans involve means of estimating the standard deviation of target analyte concentrations.

The analysis with the acceptable robustness to provide for conservative Donor Source approval decisions is the 95th percent upper confidence limit (95th UCL) analysis. The 95th UCL is a widely used method for conservative statistical analysis of environmental data. The program used for determining 95th UCL is ProUCL that was developed by the USEPA. ProUCL provides rigorous data processing methods and statistical models that cover the wide-range of variability, distribution, skewness and size of environmental data. All Donor Sites will also be required to provide representative environmental data that is sufficient to generate truly valid 95th UCL for comparison to the IDEM Adjusted Legitimate Use Modified Residential Criteria.

5.11.8 **Donor Source Chemical Testing Protocols**

Proposed permeable barrier cover media from Donor Sources will be sampled and tested in accordance with the following USEPA Test Methods. In general, the sampling scheme of such samples that are used for characterizing large volumes of media is simple random or stratified random.

For grab samples:

- 5035A for purge and trap acquisition.
- 8260 for total volatile organic compounds (TAL/TCL +30).

For composite samples:

- 8270 for total Semi-volatile Organic Compounds (TAL/TCL +30).
- 8082 for total Polychlorinated Biphenyls (PCBs) (speciated TAL/TCL).
- 8081 for total Organochlorine Pesticides (TAL/TCL).

- 8151 for total Herbicides (TAL/TCL).
- 6010 for total Metals (antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, vanadium, zinc).
- 7470 for Mercury
- 7196A/3060A for total Hexavalent Chromium.
- 9045C corrosivity (pH).
- 1311/60 for leachable metals (8 RCRA).

The target analyte list will match that compiled under the current IDEM Remediation Closure Guide, Screening Level Summary Table A-6.

5.11.9 **Physical Acceptance Criteria**

The physical standards used for qualifying soil and masonry media will be on an "as-needed" basis in order to meet the mix design standards for barrier cover construction. The media will be required to be free of vegetation or deleterious inert materials at a concentration that is greater than 1% by volume. As mentioned, mechanical sorting and sizing will eliminate the need to establish standards for acceptance.

5.11.10 **Final Approvals**

When the Review Engineer has completed the vetting process for a Donor Source, notice will be sent to the USEPA. The approval letter will include Notice will include a written approval and all supporting documentation used in the decision including all documents used and reviewed in making the decision. The notice will also bear the seal of a licensed Professional Engineer.

5.11.11 **Quality Management**

5.11.11.1 Scheduling, Notification and Receipt from Donor Source

Each day prior to scheduled transportation of barrier cover media from a given Donor Source, the Review Engineer will email a Transportation and Disposal Notification to the Donor Source representative, the Remedial Engineer, the USEPA, the Project Manager, the Safety Team, and other required parties. The notification will include a project number, Donor Source name & address, material description, transportation

contractor, number of trucks and rounds scheduled, start time, managing company, and a job type (see **Exhibit 9** Sample Transportation and Disposal Notification).

Trucks scheduled to import permeable barrier cover media will be provided with a transport charter for each load to act as a transportation manifest. The charters will be printed on sequentially numbered five-part carbonless forms consisting of white, yellow, pink, goldenrod and blue sheets (see **Exhibit 10** Transportation Charter). Part 1 of the form will require printing of the Donor Source owner's name and address, the Donor Source location and address, a description of the material and, if available, information pertaining to the analysis that represents the specific load of material to be transported (e.g. sample or laboratory analysis identification references). Before each loaded truck leaves the Donor Source location, the Donor Source Owner, or the Owner's legally designated agent, will sign and date Part 1 of the charter on the top sheet of the multi-part form (white sheet). By signing Part 1, the Donor Source Owner/Agent will certify to the following:

By signing in the space below, I hereby certify that the Material coming from the above-named Donor Source owner and location is being moved with the knowledge and consent of the Donor Source owner who is generator. I have been authorized on behalf of the Donor Source owner to witness the proper removal, loading and off-site management of the Material, and to evidence the same by signing this transport charter. I understand that by signing this form, I am acknowledging that the Material has been tested or demonstrated to be free of contaminants at concentrations in excess of the permitted levels of the Receiving Facility listed on Part 3 of this form. Further, I understand that this form is not evidence of the receipt of the Material at the Receiving Facility. This document bears no form field or area in which to list the weight or volume of material being transported. Consequently, this form CANNOT be used to evidence the disposal of the Material. Only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of Material to the Receiving Facility. Further, I certify that if the load is rejected at the Receiving Facility, for any reason, I will accept it back to the Donor Source location, unconditionally.

After signing, the Donor Source Owner/Agent will remove and retain the bottom sheet of the five-part carbonless form (blue sheet).

Upon signature of Part 1, the Transporter company driver will complete Part 2 of the top sheet (white sheet) of the charter identifying the Transporter name, address and permit # (if applicable), the driver name, driver's license expiration date, vehicle registration state, vehicle license plate index and truck #. When the driver has

completed the information required for Part 2, the driver will sign and date a driver certification on the top sheet (white sheet) of the multi-part form at the time of departure from the donor source location. By signing Part 2, the Driver will certify to the following:

By signing in the space below, I hereby certify that the above-named Material was picked up at the Donor Source location listed in Part 1 above. I understand that I am responsible for any deviation in Donor Source location. Further, by signing this form I, as driver for Hauler, am solely responsible for the amount and weight of Material that is being transported as well as the methods and means for its safe travel.

Upon arrival at the Receiving Facility (the Facility), the driver will sign and date a certification on the top sheet (white sheet) of the multi-part form (to the right of his/her first signature). By signing, the Driver will certify to the following:

By signing in the space below, I hereby certify that the above-named Material was delivered without incident from the Donor Source Location listed in Part 1 above to the Receiving Facility listed below and remained secure and unaltered throughout the entire duration of transportation. Further, if the load is rejected, I will immediately return the Material to the Donor Source Location presented in Part 1 above.

After signing the top sheet (white sheet) of the multi-part form, the Driver will present the charter to the receiving Facility (the Facility) representative in the scale house. If the representative confirms that Parts 1 and 2 have been adequately completed, then the load will be scaled. Once on the scale, the load will be inspected by video camera to ensure that it presents as expected and that there are no overt signs of the load having been manipulated in any way. If inspection prompts a rejection, the load will be rejected and processed as described below. If the load is approved, the representative will complete Part 3 of the charter. This includes listing the representative's name that approved the completeness review of the charter Parts and that visually approved the load. Additionally, the representative of the Receiving Facility will indicate the date of receipt and the time of receipt. Finally, the scale ticket reference number will be listed on the charter.

Upon completing Part 3, the Health and Safety Team representative will sign and date a certification on the top sheet (white sheet) of the multi-part form. By signing Part 3, the Receiving Facility representative will certify to the following:

By signing in the space below, I hereby certify that the above-named Material arrived at this Receiving Facility on the date listed. I have advised the Driver listed in Part 2 of this form that this charter can NOT be used to evidence the disposal/beneficial use of the Material; only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of Material to the Receiving Facility.

After signing, the Receiving Facility representative will remove the bottom sheet of the five-part carbonless form (goldenrod sheet) and present it to the driver for his company's use as evidence of having delivered the material to the Receiving Facility. The Receiving Facility will retain the remaining sheets (white, yellow, pink) of the charter at the Facility, which will in turn be paired to a numbered two-part weight receipt from the scale. The Receiving Facility representatives will retain a duplicate of the weight ticket for reconciliation, and the pink sheet of the charter. Following reconciliation, the Donor Source owner will be provided with the yellow sheet of the charter and the second part of the weight ticket. Contractor will retain the white sheet of the charter and a photocopy of the weight ticket as corporate records. Manifests and weight tickets will be provided as backup in the CMI Reports submitted by the USEPA.

Loads rejected due to inadequate or inaccurate execution of the charter Parts 1 and or 2 will be directed back to the Donor Source location. At such time, the Receiving Facility representative will mark Part 3 of the top sheet (white sheet) of the charter "rejected" and retain the bottom sheet (goldenrod sheet) on site. The balance of the sheets will be provided back to the driver for use in the return trip to the Donor Source location for remedy.

Loads that are rejected from inspection, either while in the truck or after tipping, will immediately be reloaded onto the transport vehicle and returned to the Donor Source location. At such time, the Receiving Facility representative will mark Part 3 of the top sheet (white sheet) of the charter "rejected" and retain the bottom sheet (goldenrod sheet) at the Facility. The balance of the sheets will be provided back to the driver for use in the return trip to the Donor Source location for remedy. All sheets of the scale ticket will be marked "rejected" as well. In all cases, rejections will be listed in a log and retained as a corporate record.

5.11.12 **Load Inspection**

Tipped loads will be inspected by the Health and Safety Team and Field Staff at the Facility within the Soil and Masonry Media Processing Area. Inspection will be performed to ensure that the materials received match the expected appearance of the materials from the data contained within the approved DCP. This means that

the Field Staff and Health and Safety Team will be familiar with the DCP and approvals issued by the Review Engineer. Further, any materials exhibiting any indications of a point source pollution, excessive debris or standing liquids will be rejected.

In addition to an inspection, the Health and Safety Team will utilize a photo-ionization detection meter to detect organic vapors at concentrations that are in excess of 50 Parts Per Million. Materials yielding PID results greater than 100 PPM will be rejected.

5.11.13 **On-Site Scale Protocols**

Trucks entering the Facility will proceed to a queuing area (see **Figure 16)** that is off the road and subsequently directed across a certified scale prior to unloading, and all trucks will require an empty (tare) weight reading during initial Site visit and at set intervals thereafter to maintain quality control. Each project scale operator will maintain a valid public Weighmaster license. A scale calibration notification will be automatically prompted by computer on a monthly basis and will be implemented as required. The scale will be licensed by Lake County Weights and Measures Department.

5.11.14 **Transportation Weight Safety Policy**

Drivers transporting donor material for construction of the permeable barrier cover must be scaled prior to tipping for weight verification. Title, 9 Article 20 of Indiana State Law establishes that the maximum gross weight is 80,000 pounds. To thwart the occurrence of violations to the law, a weight policy will be in affect at the scale. Under the policy, drivers of loads scaled in excess of 80,0000 pounds will be given an “overweight warning”.

The first overweight measurement will result in a verbal warning and will be annotated in an electronic systems database for that specific driver; the second consecutive overweight measurement will result in a verbal warning and will be annotated in an electronic database for that specific driver; on a third consecutive overweight violation a written warning will be printed onto the specific scale ticket and will be annotated in an electronic database for that specific driver. After a third consecutive overweight measurement, the driver will enter a “penalty box” area of the Facility for a duration of two hours and annotated in an electronic database for that specific driver. Any further consecutive violations will result in the driver being barred from the Facility indefinitely.

5.11.15 **Stormwater Erosion and Sediment Controls**

Stormwater erosion and sediment control activities will be consistent with the SWPPP. However, additional measures will be taken where certain conditions apply to the work plan activities. These conditions and the additional measures that are prescribed are as follows.

Placement of barrier cover within 300 feet of the Calumet River or the Natural Area, herein the "protected areas", will require the following additional erosion and sediment control measures. The protected area includes all FEMA flood areas.

- There will be no fueling of equipment.
- Straw bales, in addition to the perimeter silt fence, will be placed between the work area and the protected areas.
- Inspections will be performed by the SWPPP Coordinator daily at the beginning and conclusion of the work day.
- No material stockpiles will be allowed to be present in the protected area.
- All placed material will be rolled and compacted to sheet water away from the protected area.

5.11.16 **Air Emission Compliance**

Air emission compliance controls and activities will be consistent state and federal regulations. All diesel-powered equipment will be in compliance with USEPA Tier 4 Final, Nonroad Compression Ignition Exhaust Emission Standards. Compliance with be documented using USEPA VERIFY for equipment model years with A-D engine technology categories.

Annual throughput of sorting and sizing equipment utilized on-site shall be submitted as a running total in CMI Reports. Each source or process will be described by subdivision and maintained for the 12-month period on a monthly rolling total basis.

5.11.17 **Air Emission Permitting**

The emissions of particulate generated from the operation of this crushing and screening plant will not require permitting with IDEM, Office of Air Quality due to the type of activities and potential emissions for air contaminants (see Exhibit 11 for Air Emission Inventory). The emissions rate potential from an air inventory

of sources has identified that the operations are exempt. State rules found in Title 326, Article 2-1.1-3 of the Indiana Administrative Code list exempt units, processes and operations and thresholds. Units or operations that are not exempt require an approval for construction and operation. There are three primary types of approvals in Indiana: registrations; State operating permits (general and source-specific); permit-by-rule operating permit; and Title V permits, which are issued for pollution control at large sources under Title V of the Federal Clean Air Act.

6 DEVELOPMENT ACTIVITIES

6.1 CLEARING AND GRUBBING

A majority of the Source Areas maintain overgrowth of scrub vegetation, trees and high grasses, all of which all will impede work activities. Clearing zones of 90,000 square feet in size will be designated for clearing and grubbing to establish a safe and productive work area for access routes, Source Area excavation operations, and stockpile management and treatment. The existing piles of trees and wood chips located in the Buffer Zone, as well as living trees, stumps and brush will be cut, and chipped in place to reduce disturbing the underlying fill, provide a temporary dermal barrier for potentially contaminated surface fill and mitigate emissions. These activities will be completed by use of field crews with hand equipment (i.e. chainsaws, brush mowers, string trimmers) and heavy machinery (Bulldozers, Skid-steer Mulchers, Trucks). Brush piles generated will be chipped or ground into mulch for future use at the Facility. Recycling these brush piles for various future uses would include laydown areas, temporary dermal barrier over contaminated surfaces, organic matter for bio wall construction etc. Community air monitoring and emission controls, where appropriate, will be performed during grubbing/subsurface disturbance activities.

6.2 SUBSURFACE STRUCTURES AND DISTURBED FILL SURVEY

The redevelopment of the Facility requires that the subsurface be free of large impermeable slabs, pavements, foundations and conduits and areas of disturbed unconsolidated fill that may exist from previous industrial structures and/or operations. Such areas will require demolition, filling (conduits) and or ground improvement activities to accommodate the requisite weight bearing loads.

Such areas were tentatively identified with the necessary level of precision by a historic records study and verified through field survey. The historic records study included the analysis of aerial photographs and East Chicago City Building Department Records that date back to 1927 (ECDPW 1974, ECDPW 1982). The study of historic records allowed for correlation of former building footprint (slabs, pavements, foundations and conduits) locations with current surface conditions shown on aerial photographs. In many cases the noted existing condition of the ground surface or vegetation as shown on current aerials and contour maps allowed for finer inference-based adjustments in locating the tentatively identified areas. Based on this historical study a Tentatively Identified Subsurface Structures Map was developed and is presented on **Figure 16. This** will be directly loaded onto a handheld GPS unit and used to guide surveyors and or drones. Once in the general area, the investigator will be able to search the ground surface for signs of subsurface structures and/or disturbed

fill/soils. Where indications are confirmed or refuted, the surveyor will trigger the GPS unit to mark the exact location of the structure or area and to name that location with respect to the index locations. The surveyor will also be able to use the unit to photograph and geotag the photograph for future use and analysis. The GPS unit is accurate down to +/- 1.0 centimeter. The GPS unit that will be used is the Trimble Geo 7x handheld. It includes a 1.0 GHz processor, 256 MB of RAM, 4GB of onboard storage, a built in 5 MP camera, a sunlight optimized display and an integrated dual-mode cellular modem that enables continuous network and internet access to real time map data and web-based services that increase accuracy and precision. The procedures for calibrating the GPS instrumentation are provided in the QAPP.

A steel rebar hand-probe will be used to hit the ground where vegetation is too dense to confirm or refute if a concrete structure and or disturbed fill area is present. The hand-probe that will be used to "feel" for concrete pavements that may be masked with a shallow mineral or vegetative cover. If no concrete structures or disturbed fill is noted by the surveyor's activities, a hydraulic excavator will be used to confirm the finding. If the excavator identifies something at depth that was not noted from hand-probing, then survey will continue with the aid of a hydraulic excavator.

Surveyors will keep notes of all findings made, including identifying any previously unidentified structures or conditions discovered in the field. The field notes will include information on the surveyor, the time/date the survey occurred, the weather/temperature at the time of the survey and any comments relating to structures. Comments will be inclusive of information that identifies if positively identified structures are horizontally contiguous and make note of their continuity. The notes will identify if the structures will impede water flow if buried. Surveyors will understand that absence of a slab (or presence of a wooden floor) does not indicate the absence of footings and conduits. Findings will be presented in an Interim Report (discussed in Section 7.4) and a subsequent former slab/ concrete removal work plan will be provided.

6.3 GEOTECHNICAL INVESTIGATION

The proper design of buildings, pavements, drainage features and the permeable earthen barrier cover (engineering control) that will be constructed at the Facility, requires geotechnical data on the subsurface soil and fill materials. This includes such information as soil gradation, classification (Unified Soil Classification System), plasticity, transmissivity and porosity. The testing will be performed in accordance with the American Society of Testing and Materials (ASTM) methods in absence of an equivalent USEPA test method. The Preliminary Geotechnical Investigation will be performed to acquire data that can be used for design of ground improvement criteria, determine construction design and techniques, and for beneficial use considerations.

Methods will be consistent with state of the practice for geotechnical investigations and engineering principles.

6.3.1 Boring Construction

The subsurface investigation will consist of thirty-seven supervised soil borings performed in accessible areas across the Facility. The borings will be performed with drill rig, using hollow stem augers or sonic drilling methods in accordance with *ASTM D6151/D6151M: Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling* and *ASTM D1452/D1452M-16: Standard Practice for Soil Exploration and Sampling by Auger Borings* or *ASTM D6914/D6914M: Standard Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices*. The locations of proposed geotechnical borings are provided on **Figure 17**. Borings will be advanced to between 25 and 65 feet bgs or refusal, whichever occurs first.

6.3.2 Field Sampling Plan

All field work will be performed under the full-time observation of a geotechnical engineer/technician. The representative will maintain continuous logs of the borings as the work proceeds in accordance with *ASTM D5434-12: Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock* and identify the materials encountered in accordance with *ASTM D2487-17: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)* and *ASTM D2488-17: Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)*.

Soil samples suitable for identification purposes will be extracted from the borings in accordance with *ASTM D1586/1586M- 18: Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils, ASTM D1587/D1587M-18: Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes,* and *ASTM D6519-16: Standard Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler*.

6.3.3 Analytical Methods

All soil samples will be brought to a designated soils laboratory following the guidelines of ASTM D4220/4220M-14: Standard Practices for Preserving and Transporting Soil Samples. Soil samples will be selected for further evaluation and laboratory testing, as deemed appropriate. Laboratory Test methods will be performed in accordance with the ASTM methods. These methods do not have USEPA Test Method

Equivalents for the necessary applications. The following tests and methods may be utilized for analysis of the geotechnical samples acquired under the geotechnical field sampling plan:

- ASTM G187-18: Standard Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method.
- ASTM D4972-18/ASTM G51-18: Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing.
- ASTM C1580: Standard Test Method for Water-Soluble Sulfate in Soil.
- AASHTO T 291: Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil.
- ASTM D4427-18: Standard Classification of Peat Samples by Laboratory Testing.
- ASTM D854-14: Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer.
- ASTM D4318-17e1: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- ASTM D2974-14: Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
- ASTM D2216: Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
- ASTM D1140-17: Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing.
- ASTM D6913/D6913M-17: Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
- ASTM D7928-17: Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis.
- ASTM D8037/D8037M-16: Standard Practice for Direct Push Hydraulic Logging for Profiling Variations of Permeability in Soils.
- ASTM D5084: Standard Triaxial Permeability (Hydraulic Conductivity) / Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
- ASTM D2434-68(2006): Standard Test Method for Permeability of Granular Soils (Constant Head) (WITHDRAWN STANDARD 2015).
- ASTM D2435/D2435M-11: Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading.
- ASTM D4546-14e1: Standard Test Methods for One-Dimensional Swell or Collapse of Soils.
- ASTM D4829-11: Standard Test Method for Expansion Index of Soils.

- ASTM D3080/D3080M-11: Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.
- ASTM D2166/D2166M-16: Standard Test Method for Unconfined Compressive Strength of Cohesive Soil.
- ASTM D2850-15: Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils.
- ASTM 4767-11: Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils.
- ASTM D448-01(2013) - Standard Guide for Sampling Groundwater Monitoring Wells.
- ASTM D6089-15: Standard Guide for Documenting a Groundwater Sampling Event.
- ASTM D6771 – 18: Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations.

Upon completion of the preliminary geotechnical investigation and subsequent laboratory testing the geotechnical engineer will provide a report containing a summary of the subsurface data, observations, and recommendations regarding the following:

- Description of the Facility and topography.
- Groundwater observations.
- 'N' Values (Blow counts).
- Boring and monitoring well location plan and soil boring and monitoring well logs.
- Ground improvement criteria.
- Determination of construction design and techniques.
- Beneficial use considerations.
- Any additional comments/concerns.
- Recommendations for additional investigations, as required.

The analysis of these samples will not be subject to the QA/QC.

6.3.4 Structural Design Analysis

The data generated from the geotechnical sample analysis will be studied to determine a structural design (foundation, wall, pavement and utility conduit) specification. The main goal of structural design is to ensure that structures built at the Facility are not subject to differential settlement that could lead to failure. It also

requires consideration for ground improvement activities that could include a compensated mat foundation (e.g. controlled modulus columns), driven piles and pile caps, dynamic compaction with wick drains and/or surcharging.

The design specifications will be presented in a report entitled Structural Design Specification Report. The report will identify how the foundation design and ground improvement technique (if necessary) will dovetail to the demands of the remediation and the pollution contamination at the Facility (e.g. integration with the earthen cap engineering control). Additionally, the report will propose "green" design and implementation practices to reduce the occurrence of the removal of subsurface fill/soils, contact of workers with contaminated media, integrating with remedies contained within the CMI WP, situating foundation components away from groundwater, avoiding the creation and propagation of dust and avoiding the generation of stormwater runoff, minimizing vehicle and engine emissions and preventing the migration of contaminants into interior building areas (USEPA 2015).

6.3.5 Geotechnical Reporting

The data that will be generated from the geotechnical investigation will be submitted as an Interim Report (see section 7.3).

6.4 GARY ROAD ACCESS

Currently ECGP is working with the City of East Chicago Planning Board and Mayors Office to obtain roadway access to Gary Road. This is anticipated to be conducted during Phase I Remedial Construction, however, relies on property acquisition and City approval. ECGP will inform USEPA on progress and related earthwork.

6.5 BENEFICIAL USE DETERMINATION STUDY FOR SOLID WASTE LANDFILL

The management of non-hazardous residuals, debris, and by-products represent a challenge because of their volume and necessity for safe management, and an opportunity as a result of the tremendous materials recovery potential. In 2003, USEPA estimated that approximately 7.6 billion tons of industrial waste is generated each year. If used correctly, many of these materials can act as a substitute for virgin resources, including in the manufacture of new products, as fuel for energy recovery, or utilization as a construction product. The term commonly used to describe the practice of utilizing these wastes in a productive fashion is "beneficial use" (USEPA 2013). The beneficial use of waste materials represents a shift to materials management as opposed to waste management and focuses on decreasing the amount of materials that are

disposed, which may have numerous benefits, including decreasing the use of virgin materials in products or processes and potentially reduced lifetime greenhouse gas (GHG) emissions.

The Solid Waste Landfill contains non-hazardous filter cake that is classified under IDEM as waste meeting Type IV restricted waste criteria (329 IAC 10-9-4). This waste should be considered for beneficial use rather than classified as a waste, and the footprint of the landfill should be considered for beneficial redevelopment. This process is deemed seeking a beneficial use determination.

There are many unique waste materials that have been subject to beneficial-use requests and determinations at different states. Although several investigators have presented information regarding wastes that may be beneficially used, several recent efforts compiled information that included fairly extensive lists of wastes that have been subject to beneficial-use approvals or are beneficial use-related. For example, the Association of State and Tribal Solid Waste Management Officials (ASTSWMO) published two reports that summarized surveys that were conducted to identify beneficial use procedures in different U.S. states and territories, which included a listing of many wastes that have been the subject of a beneficial use requests. USEPA (1994) published guidance regarding recycling and reuse of materials found at Superfund sites, which included a compendium of waste materials and technologies that are also commonly used as part of state beneficial use programs. The types of wastes included in a beneficial use program vary among states based on the generators located in or near a given state, as well as the regulatory scheme used in the state.

Among those broad categories and specific examples of waste materials receiving beneficial use determinations is industrial process wastes including inert industrial sludges, filter media and foundry sands in encapsulated ingredients and aggregates and unencapsulated fill material and amendments. In the case of the filter cake in the Solid Waste Landfill, a study of its chemical and physical qualities will be performed to identify and propose a suitable on-site beneficial use as an ingredient, aggregate, fill or amendment.
The Indiana Department of Environmental Management (IDEM) governs beneficial use of non-hazardous solid waste via the Indiana Administrative Code. The sampling will comply with analysis will comply with IDEM under IC 13-19-3-7 for a “legitimate use” or case-by-case Beneficial Use Determination. The analysis will also comply with RCRA, 40 CFR Part 261 and USEPA State of the Practice guidelines (USEPA 2013).

6.5.1 Beneficial Use Reporting

The physical data collected from the investigation will be presented in a report entitled, Beneficial Use Analysis. It will present the physical data collected from the investigation, a compilation of the chemical data

collected from previous investigations of the landfill, proposed beneficial uses for the filter cake and performance criteria comparisons. The comparisons will provide product specifications and demonstrate the ability of the filter cake to suitably (legitimately) substitute some or all of the product component materials. It will determine if proposed reuses are predetermined or case specific within the IDEM regulations. The report will include analysis to determine if the proposed beneficial uses constitute direct exposure or indirect exposure risks to groundwater, stormwater and or air quality. This study will be a determining factor in the closure design process for the solid waste landfill at the Facility. All of the data collected will be presented in the CMI Report (Supplemental Investigation Report).

7 PROJECT ADMINISTRATION

7.1 CONCEPTUAL SITE MODEL UPDATE REPORTS

A Conceptual Site Model (CSM) will be updated at least every 5 years from the execution of the Administrative Order on Consent. Furthermore, the CSM will be updated within 60 days upon discovery of a release or threat of a release of hazardous substances. A CSM update report will include a summary of activities performed since the last CSM update, evaluate and discuss the nature and extent of contamination at the Facility, and exposure pathways and receptors.

7.2 COMMUNITY PARTICIPATION PLAN

A Community Participation Plan was developed in accordance with the RCRA Public Participation Manual (USEPA 2017) between the USEPA and East Chicago Gateway Partners to operate and maintain community outreach during the process of remediation, construction and development. The Community Participation Plan is provided in **Appendix D**.

7.3 INTERIM REPORTING

Technical memorandums or supplemental reports will be submitted to the USEPA and present the findings and results of activities implemented as part of the supplemental field work or development related activities during the construction phases of the remedial actions. These memorandums or supplemental reports will contain a summarized narrative of activities and evaluation of collected data to support design and discuss conditions encountered and may request approvals with USEPA for deviations from the CMI Work Plan, where appropriate.

7.4 CORRECTIVE MEASURES IMPLEMENTATION WORK PLAN: REMEDIAL CONSTRUCTION PHASE II

This work plan will be prepared and submitted after Source Area removal/ISS activities, preliminary groundwater treatment and subsequent performance monitoring. Performance evaluation of Source Area removal/ ISS and comprehensive findings related to preliminary groundwater treatment will provide means to accurately design a full-scale groundwater treatment remedy that satisfies the Administrative Order on Consent prior to building construction. This work plan will include design plans and specifications, design strategy and basis, constructability of the design, remedial technology utilizing qualitative and quantitative

flow sheets, operation and maintenance plans and system/remedy performance monitoring plans. Furthermore, will discuss potential development influences on the full-scale groundwater treatment and potential contingencies.

7.5 LANDFILL CLOSURE AND LONG-TERM MONITORING REPORT

A landfill closure and long-term monitoring report will be prepared and submitted after evaluation of the comprehensive findings of the supplemental field sampling work plan related to redevelopment, including geotechnical investigation, subsurface surveys, structural design analysis, beneficial use determination study and approval of development plans.

7.6 FINAL REMEDY CONSTRUCTION COMPLETION REPORT

A final remedy completion report will be prepared and submitted after remedy construction activities have been completed pursuant to the Order on Consent and Project schedule. This report will include details for all supplemental field sampling activities, remedial design activities and remedy construction activities, professional engineer certifications of construction completeness.

7.7 LONG-TERM MONITORING AND MAINTENANCE PLAN REPORT

A long-term monitoring and maintenance plan will be prepared and submitted within the final remedy construction completion report. This report will include frequency-based monitoring of groundwater conditions and along the northern and southern compliance points, evaluation of geochemical and contaminant trends.

7.8 PERMITTING

All necessary permits will be procured from local, county, state and federal agencies for approval as required for the remediation, construction and development activities. Progress related to permit acquisition will be communicated in quarterly progress reports to the USEPA. Permits that are expected to be required are:

- IDEM Rule 5 Stormwater General Permit (SWPPP) and Notification (Future Submission)
- USEPA Class V UIC Permit
- Indiana DNR Construction in a Floodway Permit

- *No Change* in Effective Cross-Sectional Flow Area

- City Planning /Construction Permits. The City of East Chicago permits will be determined by the City Planning Board after Facility remediation activities are approved by USEPA, and may include:
  - Excavation Permit
  - Grading Plan
  - Site Plan (interim - Phase 1)
  - Above Ground Storage Tank Permits
  - Demolition Permits
  - Electric Service
  - Road Signs

7.9 TIMELINE AND SCHEDULE OF REPORTING

A reporting schedule for submittals is provided in the Project Schedule in **Exhibit 4**. This is presented as a Gantt chart with phased remedial activities and associated reporting requirements. Due to the nature of field activities, timeframes and deadlines associated with task completion may be subject to change under the approval of the USEPA.

7.10 EMAIL CORRESPONDENCE, HARDCOPY SUBMITTALS, DOCUMENT RESOURCE AND ONLINE PORTAL

Parties involved will communicate frequently in good faith to ensure the completion of activities discussed in the Administrative Order on Consent. Email correspondence between parties will be recorded and retained for use of authorization, and/or guidance. If in this instance an email correspondence is relied upon, it will be included within applicable report or memo as an exhibit. If a draft report or final report is submitted via email, a read and delivery receipt will be request for all parties. The final version of all applicable reports and submittals will be made available online in accordance with the Community Participation Plan.

7.11 QUARTERLY PROGRESS REPORTS

Quarterly progress reports will be generated and submitted to the USEPA by the 15th day of the month after the end of each quarter. These progress reports will include overall CMI progress, work performed within the described time frame, description of all data collected, conditions encountered, problem resolution, community participation activities, personnel changes, project outlook and project schedule updates.

Furthermore, progress reports will attach copies of daily reports, inspection reports, and all laboratory reports during the reporting period.

7.12 GREEN REMEDIATION BEST MANAGEMENT PRACTICES

Best management practices will be followed where possible for green practices related to Facility work investigation, remediation and construction activities. The scope of the CMI Work Plan and ancillary documents contemplate green practices throughout the phases of the work, including the some of the following:

- Utilization of direct push/percussive-based pneumatic drilling methods to eliminate drill cutting wastes.
- Use of recycled soil and masonry media an alternative to quarry mined stone and soil aggregate natural resources in the construction of the earthen permeable barrier cover (cap).
- Recycling of trees and brush for use in generating a mulch-like and wood-chip media for use in erosion and sediment control, for dust control and for demarcation barrier for hazardous material stabilization.
- Performance of Source Area “hot spot” stabilization near the excavation to eliminate the dispersion of hazardous waste from loading and stockpiling activities.
- Sustainable revegetation program that will utilize locally sourced seed and will not require fertilization that could negatively affect ground and surface water quality.
- The use of gps machine grade control technology enabled equipment that will increase diesel-powered heavy equipment efficiency and therefore decrease diesel combustion emissions.
- Exclusive utilization of Tier 4 diesel engine fitted equipment that will meet Final, Nonroad Compression Ignition Exhaust Emission Standards. Utilization of USEPA Verify software for program management.
- Application of the USEPA SmartWay Transport Partnership Program to identify, quantify and document reduced emissions from truck traffic entering and exiting the Facility.
- Utilization of ultra-low sulfur content diesel fuel in all site diesel-powered equipment and vehicles to reduce diesel combustion emissions at the Facility.
- Utilization of weights and elaborate vetting and tracking system to provide precision in the receipt of soil and masonry media that will be used to construct the permeable earthen barrier cover.

- The utilization of smart administrative procedures including the use of video conferencing, where practical, proper pre-planning techniques, electronic application support (e.g. Smartsheets, Microsoft Project) and digital media submittals of deliverables in lieu of paper.
- The utilization of GPS and GIS instrumentation, including drones, to increase the precision of boundary measurements and provide calculations for areas, volumes and elevations. Also, to evidence soil stabilization mixing rates and to create vehicle geogrids.
- The utilization of beneficial use "legitimate use" alternatives for waste disposal instead of landfills. The beneficial use of waste materials represents a shift to materials management as opposed to waste management and focuses on decreasing the amount of materials that are disposed, which may have numerous benefits, including decreasing the use of virgin materials in products or processes and potentially reduced lifetime greenhouse gas (GHG) emissions. All work in this regard will be in compliance with the USEPA State of the Practice guidelines (USEPA 2013).
- The use of remote sensing technologies to avoid unnecessary ground disturbance and promote the precise use of heavy equipment. Such technologies include in-situ data loggers, ground penetrating radar.
- The air monitoring devices that will be used for the community air monitoring program will utilize solar power as a primary drive.
- Truck and engine idling will be monitored and minimized to reduce diesel combustion emissions at the Facility.

8 REFERENCES

1. CH2M Hill 1990 - Phase I Groundwater Assessment, Former DuPont East Chicago Facility, East Chicago, Indiana, February 1990
2. CH2M Hill 1997 - Current Conditions Report, Former DuPont East Chicago Facility, East Chicago, Indiana, October 1997.
3. DuPont 2002 - Final Phase I RCRA Facility Investigation (RFI) Report, Former DuPont East Chicago Facility, East Chicago, Indiana, October 2002.
4. East Chicago Department of Public Works (ECPDW) 1974 - Storm Sewers Map 3886, East Chicago Works, East Chicago Department of Public Works, Last Revised July 25, 1974
5. ECPDW 1982 - Outside Lines and Sanitary Sewers. Map 3045, East Chicago Works, East Chicago Department of Public Works, July 31, 1945, Last Revised March 17, 1982
6. Grubb et al. 2007 – Testing the pH of Concrete, American Concrete Institute Convention, San Francisco, CA, Concrete International Publication, April 2007.
7. IDEM 2016 – Site Characterization and Sampling Guidance, Updated October 13, 2016.
8. IDEM 2019 – Indiana Administrative Code Title 327 Water Pollution Control Division, Former DuPont East Chicago Facility, Article 2, Updated January 16, 2019.
9. Parsons 2012 - Baseline Ecological Risk Assessment (BERA), Former DuPont East Chicago Facility, East Chicago, Indiana, February 2012.
10. Parsons 2014a - Groundwater Evaluation, Former DuPont East Chicago Facility, East Chicago, Indiana, March 2014.
11. Parsons 2015a - Corrective Measure Study (CMS), Former DuPont East Chicago Facility, East Chicago, Indiana, March 2015.
12. Parsons 2016a - Addendum to the Corrective Measures Study for the Grace Parcel, Former DuPont East Chicago Facility, East Chicago, Indiana, October 2016.
13. Parsons 2016b – Interim Remedial Measures Completion Report, Former DuPont East Chicago Facility, East Chicago, Indiana, December 2016.
14. Parsons 2018a - Final Comprehensive Pilot Test Study Report, Former DuPont East Chicago Facility, East Chicago, Indiana, January 2018.
15. Parsons 2018b – Technical Memorandum: CMS Excavation Areas Soil Profiling, Former DuPont East Chicago Facility, East Chicago, Indiana, May 29, 2018.
16. Pioneer 2011- Human Health Risk Assessment (HHRA), Former DuPont East Chicago Facility, East Chicago, Indiana, September 2011.
17. USEPA 2002- Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites, Office of Emergency and Remedial Response USEPA, Washington DC, September 2002.

18. USEPA 2013 – Beneficial Use of Waste Materials: State of Practice 2012 – USEPA Office of Research and Development, September 14, 2013.
19. USEPA 2014a- Final Decision Response to Comments for the Natural Area and Buffer Zone, DuPont East Chicago Site, Chicago, Illinois, September 2014.
20. USEPA 2015 - OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, USEPA Office of Solid Waste and Emergency Response, June 2015
21. USEPA 2018a - Final Decision Response to Comments - The Western Portion/ Industrial Area of the Former DuPont East Chicago Facility, Chicago, Illinois, July 18, 2018
22. USEPA 2018b - RCRA 3008(h) Administrative Order on Consent for Corrective Measures and Implementation Order - DuPont East Chicago Site, Indiana, November 16, 2018.
23. Historic Photographs "Untitled". Photographer Unknown, September 4, 1927, 1950, 1978; Aerial Images. EDR, 1939, 1954, 1959, 1964, 1967, 1970, 1973, 1978, 1983, 1987, 1992, 1998
24. USEPA 1991 - Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, PA/600/4-89/034. March 1991
25. ASTM D5092-04 - Standard Practice for Design and Installation of Groundwater Monitoring Wells
26. An, Xue-LIang, et. al., Oxidative Dissolution of amorphous FeS and Speciation of Secondary Fe Minerals: Effects of pH and As (III) Concentration, Chemical Geology 462 (2017) 44-54
27. Zhou, Jimel, et. al., Adsorption Kinetic and Species Variation of Arsenic for As(V) removal by Biologically Mackinawite (FeS), Chemical Engineering Journal 354 (2018) 237-244
28. Jeong, H. Y., et, al., Aerobic Oxidation of Mackinawite (FeS) and its Environmental Implication for Arsenic Mobilization, Geochemical Engineering 74 (2010) 3182-3198
29. Schoonen, M.A.A, Mechanisms of Sedimentary Pyrite Formation, The Geological Society of America - Special Paper 379 (2004), 117-134
30. Morse, J.W., et. al, Adsorption and Coprecipitation of Divalent Metals with Mackinawite (FeS), Geochimica et Cosmochimica Acta 57 (1993), 3635-3640
31. Chirita, Paul, et. al., Oxidation of FeS by Oxygen-Bearing Acidic Solutions, Journal of Colloid and Interface Science 321 (2008) 84-95
32. Bostick, B.C., et. al, Arsenite Sorption on Troilite (FeS) and Pyrite (FeS2), Geochimica et Cosmochimica Acta 67 (2003), 909-921
33. Blanchard, Marc, et. al., Arsenic Incorporation into FeS2 Pyrite and its influence on Dissolution: A DFT Study, Geochimica et Cosmochimica Acta 71 (2007), 624-630
34. Baskin, M.B., et. al., Determination of Arsenic Removal Efficiency by Ferric Ions Using Response Surface Methodology, Journal of Hazardous Materials 166 (2009), 796-801

35. Pallier, Virginie, et. al., Effect of Organic Matter on Arsenic Removal During Coagulation/Flocculation Treatment, Journal of Colloid and Interface Science 342 (2010) 26-32

FIGURES

Former DuPont East Chicago Facility

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Figure 3b: Site Geologic Cross Sections
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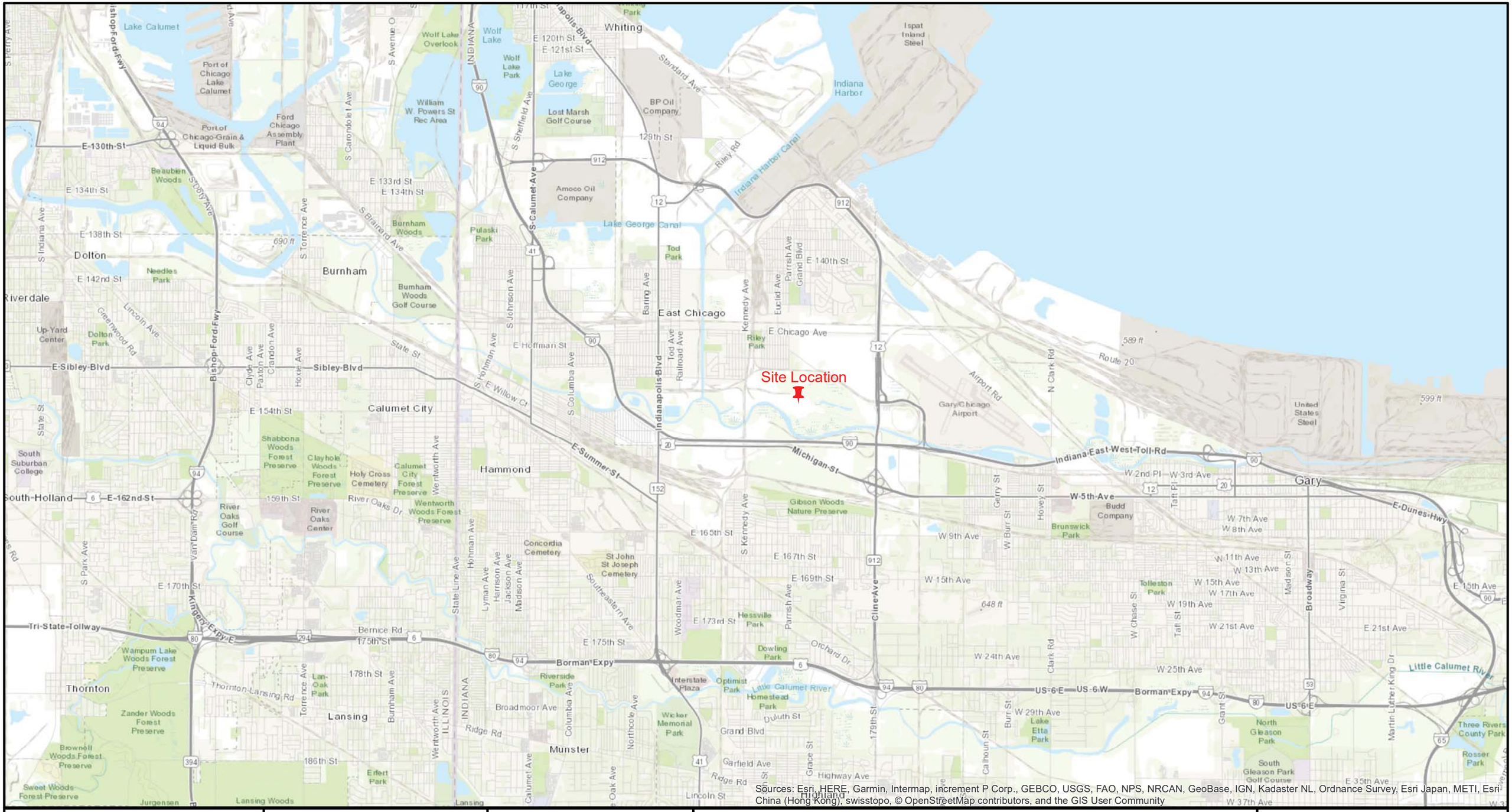

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

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0 2,200 4,400 8,800 Feet

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Map Reference:

Legend

Site Location

Base Map Source: USGS Topographic Map Highland & Whiting Quadrangles

Figure :1 Facility Location Map



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Property Boundary

Figure: 2
Facility Map



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0 212.5 425 850 Feet

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Map Reference:

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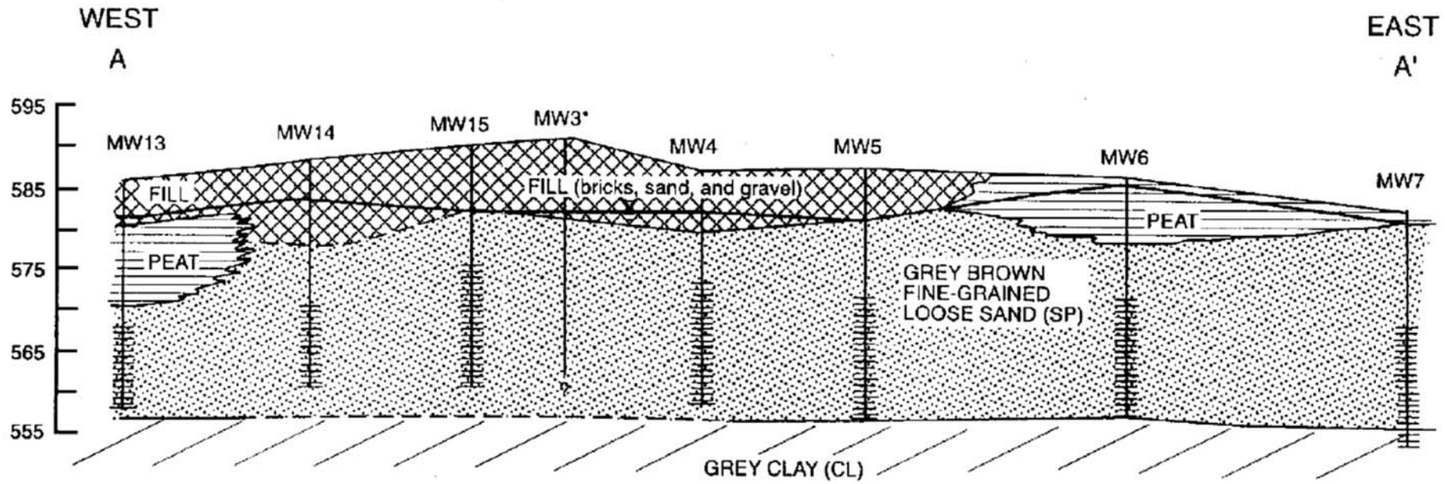
- Groundwater Monitoring Well
- Property Boundary

Figure :3A Site Geologic Cross Section



LEGEND

* Well construction and lithologic data are not available, these are approximate depths of U.S. EPA wells.

Water elevations are measured on June 18, 1990.

Groundwater elevation

Well screened interval

MW4 Monitoring well ID

Interpolated lithologic boundary

The depth and thickness of the subsurface strata indicated on the cross section were generalized from and interpolated between borings. Information on actual subsurface conditions exists only at the specific locations and dates indicated. Soil conditions and water levels at other locations may differ from conditions occurring at the boring locations. Also, the passage of time may result in a change in the conditions at these boring locations.

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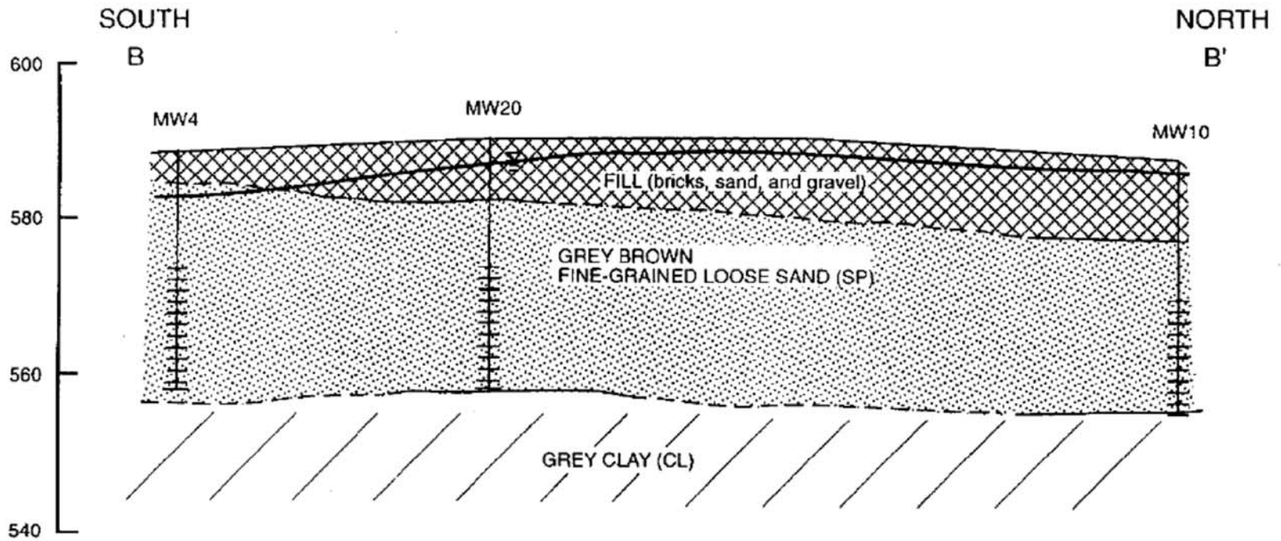
Figure :3B Site Geologic Cross Section (A-A')



LEGEND

Water elevations measured on June 18, 1990.

- Groundwater elevation
- Well screened interval
- MW4 — Monitoring well ID
- Interpolated lithologic boundary

The depth and thickness of the subsurface strata indicated on the cross section were generalized from and interpolated between borings. Information on actual subsurface conditions exists only at the specific locations and dates indicated. Soil conditions and water levels at other locations may differ from conditions occurring at the boring locations. Also, the passage of time may result in a change in the conditions at these boring locations.

HORIZONTAL SCALE IN FEET

0 200 400

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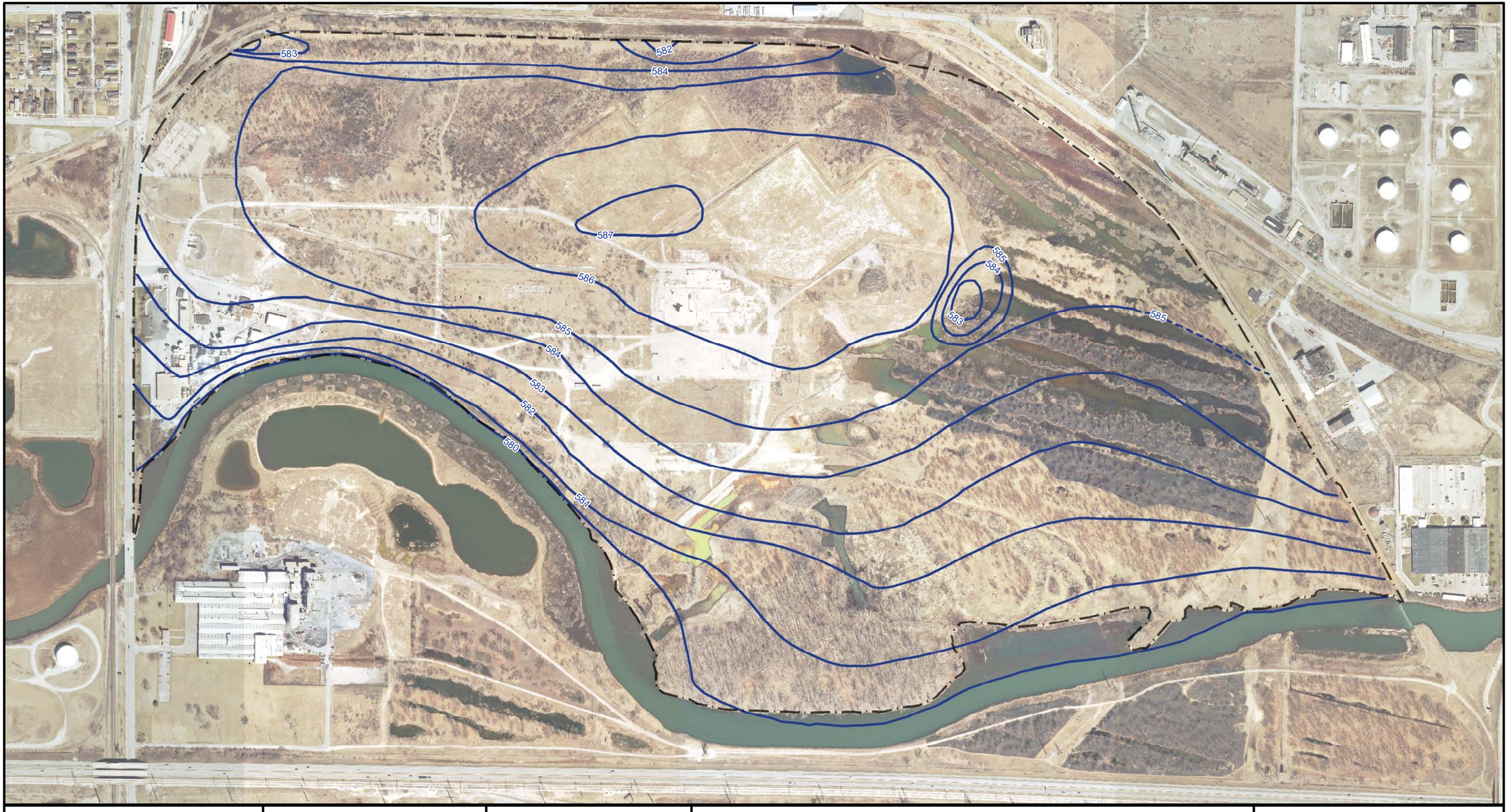
Figure :3C Site Geologic Cross Section (B-B')



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Scale:

0 205 410 820 Feet

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Map Reference:

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- Property Boundary
- DASH, JUN_2012
- SOLID, JUN_2012

Figure : 4 Groundwater Elevation Contour Map



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Scale:
0 120 240 480 Feet

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Map Reference:

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- Proposed Well Abandonments
- Property Boundary
- PRB, SWMU4 & Leased Area Source Areas

Figure 5: Proposed Well Abandonment



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Map Reference:

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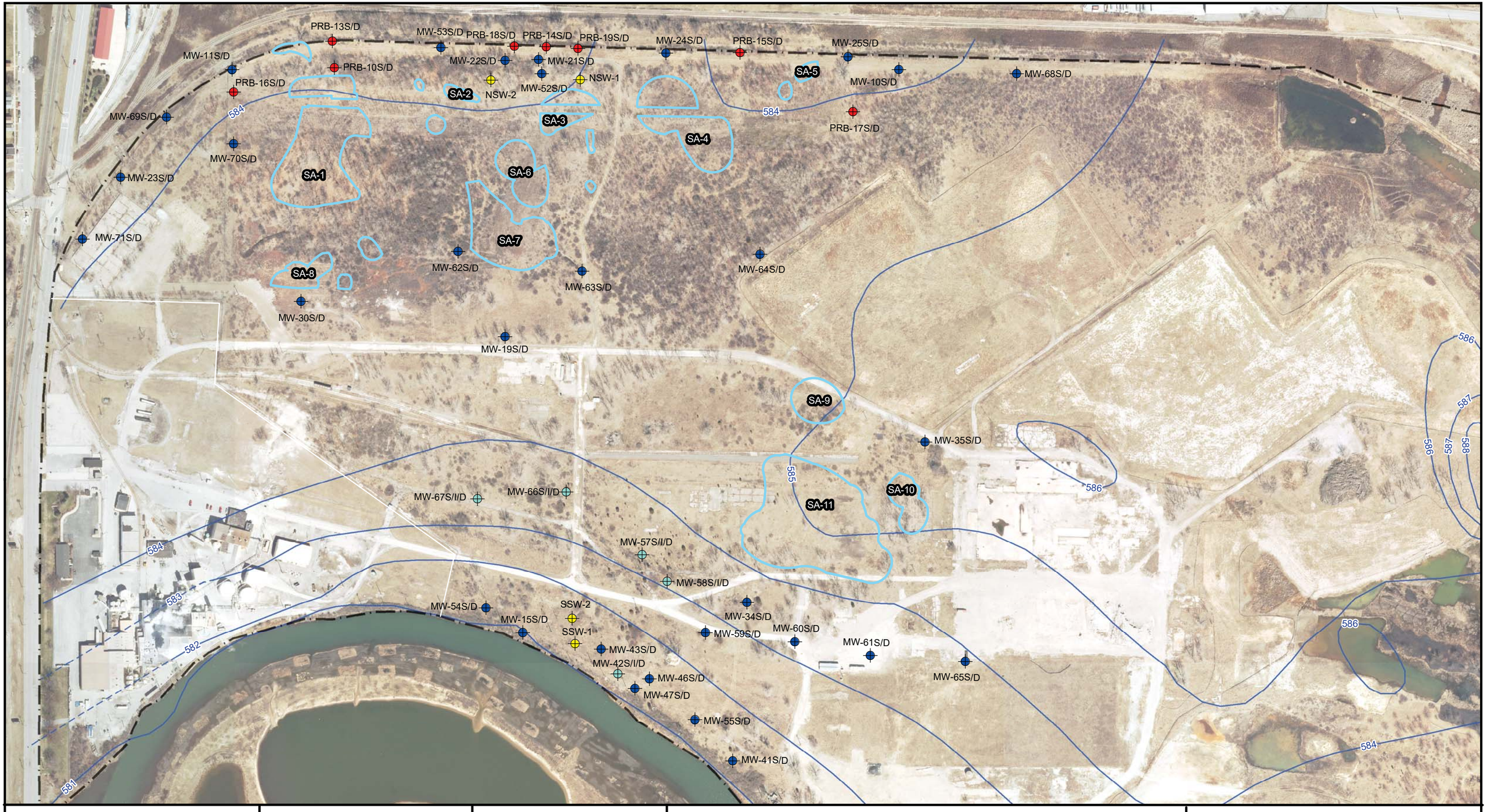
- Proposed (Non-Potable) Remedial Supply Well
- Proposed Groundwater Monitoring Well Cluster (Shallow, Intermediate & Deep)
- Proposed Shallow Groundwater Monitoring Well
- Proposed Intermediate Groundwater Monitoring Well
- Proposed Groundwater Monitoring Well Cluster (Shallow & Deep)
- Property Boundary

Figure 6A: Proposed Groundwater Monitoring Well Installation



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Scale:
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Map Reference:

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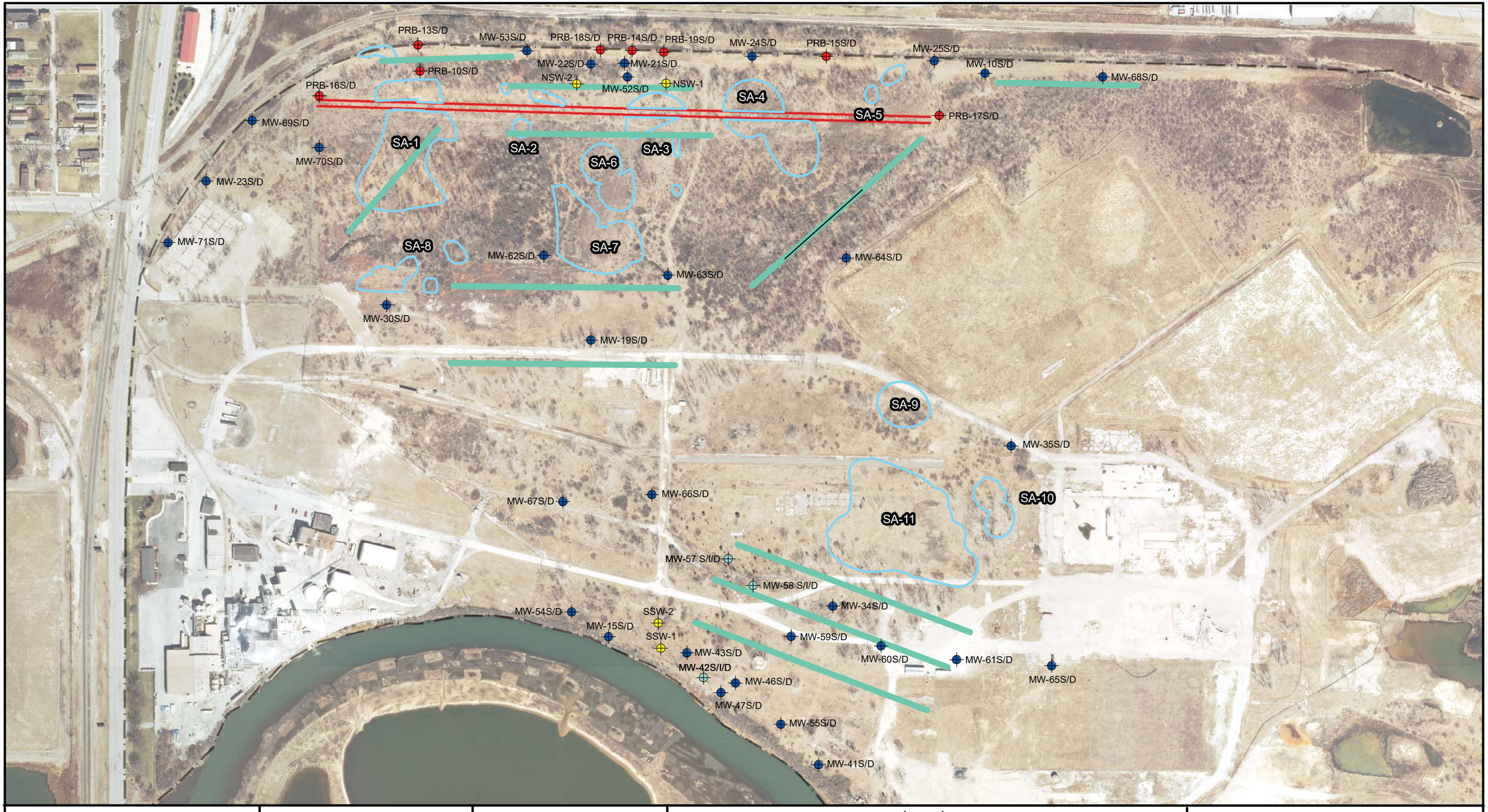
- Existing & Proposed Groundwater Well Cluster (Shallow & Deep)
- Existing & Proposed Reactive Wall Well Cluster (Shallow & Deep)
- Existing & Proposed Groundwater Well Cluster (Shallow, Intermediate & Deep)
- Proposed (Non-Potable) Remedial Supply Well
- Property Boundary
- Source Areas

Figure 6B: Proposed Groundwater Monitoring Well And Remedial Supply Well Network



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Scale:
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Map Reference:

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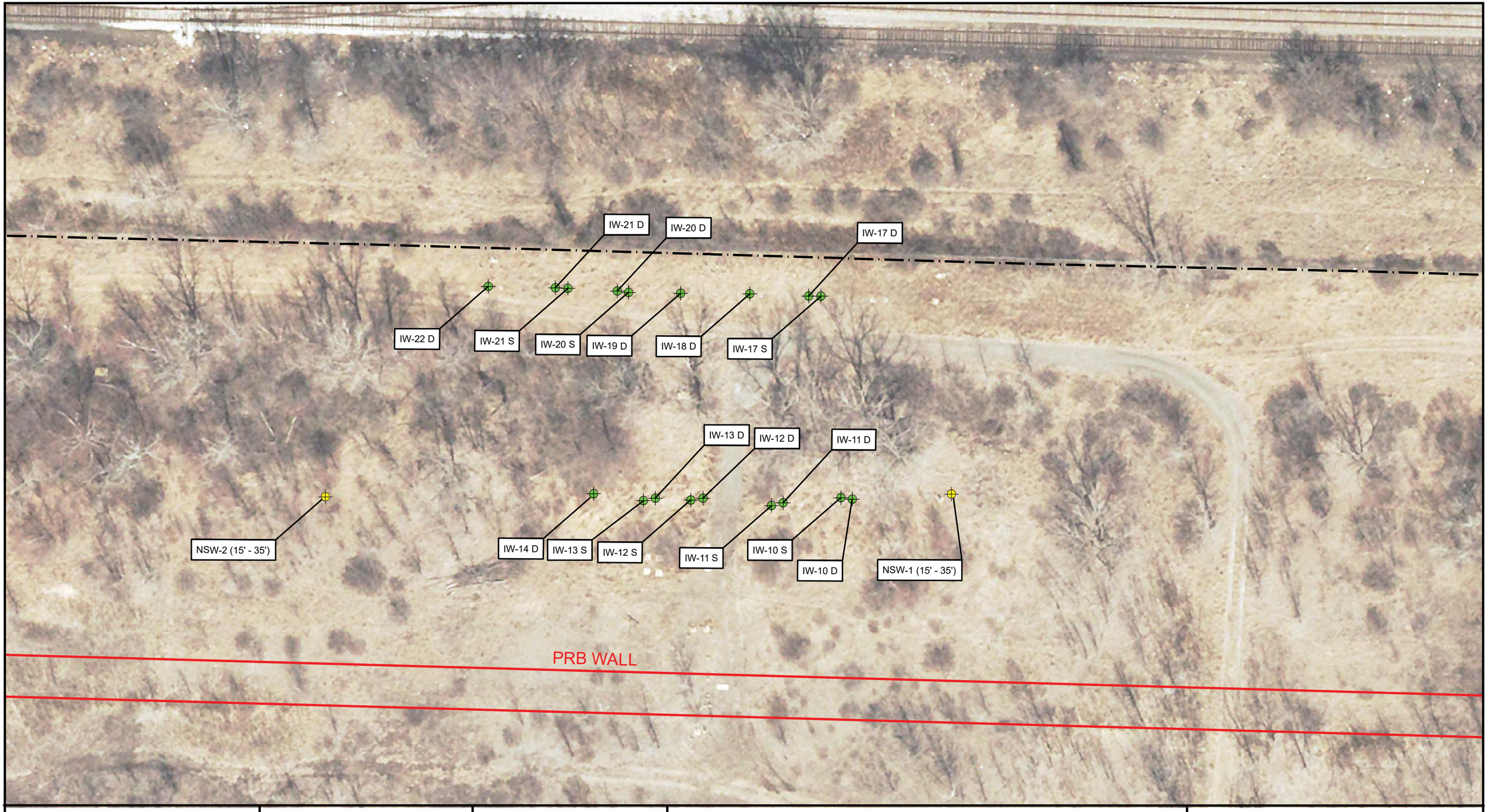
- Existing & Proposed Groundwater Well Cluster (Shallow & Deep)
- Existing & Proposed Reactive Wall Well Cluster (Shallow & Deep)
- Existing & Proposed Groundwater Well Cluster (Shallow, Intermediate & Deep)
- Proposed (Non-Potable) Remedial Supply Well
- Pneumatic Slug Test Transect
- Source Areas
- Property Boundary
- PRB WALL

Figure 7:

Hydrogeologic Plan



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Scale:
0 15 30 60 Feet

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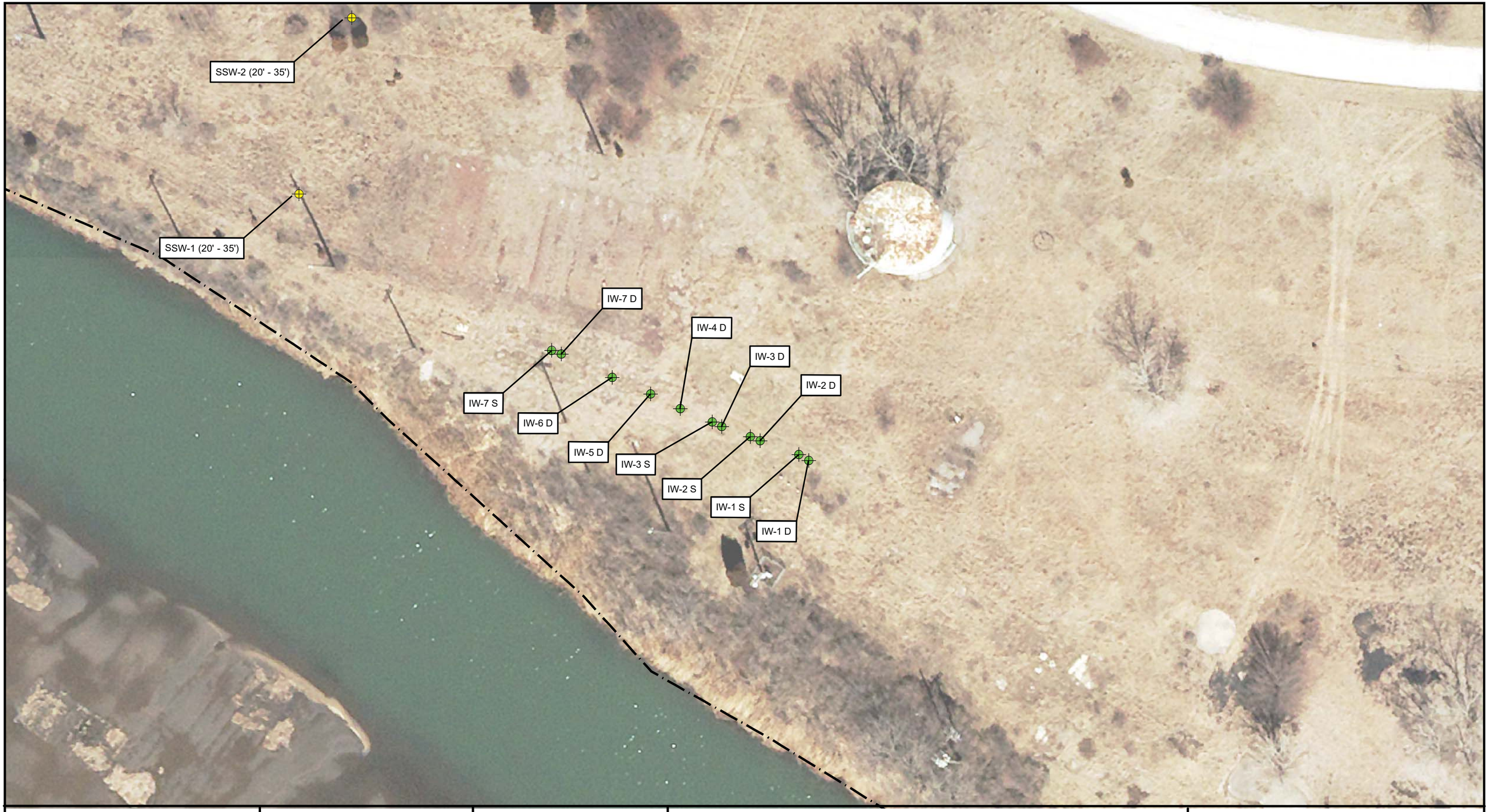
Map Reference:

Legend

- Property Boundary
- Existing Injection Wells
- Proposed Remedial (Non-Potable) Supply

Figure 8a - Northern Groundwater Treatment Area



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Scale:
0 15 30 60 Feet

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Map Reference:

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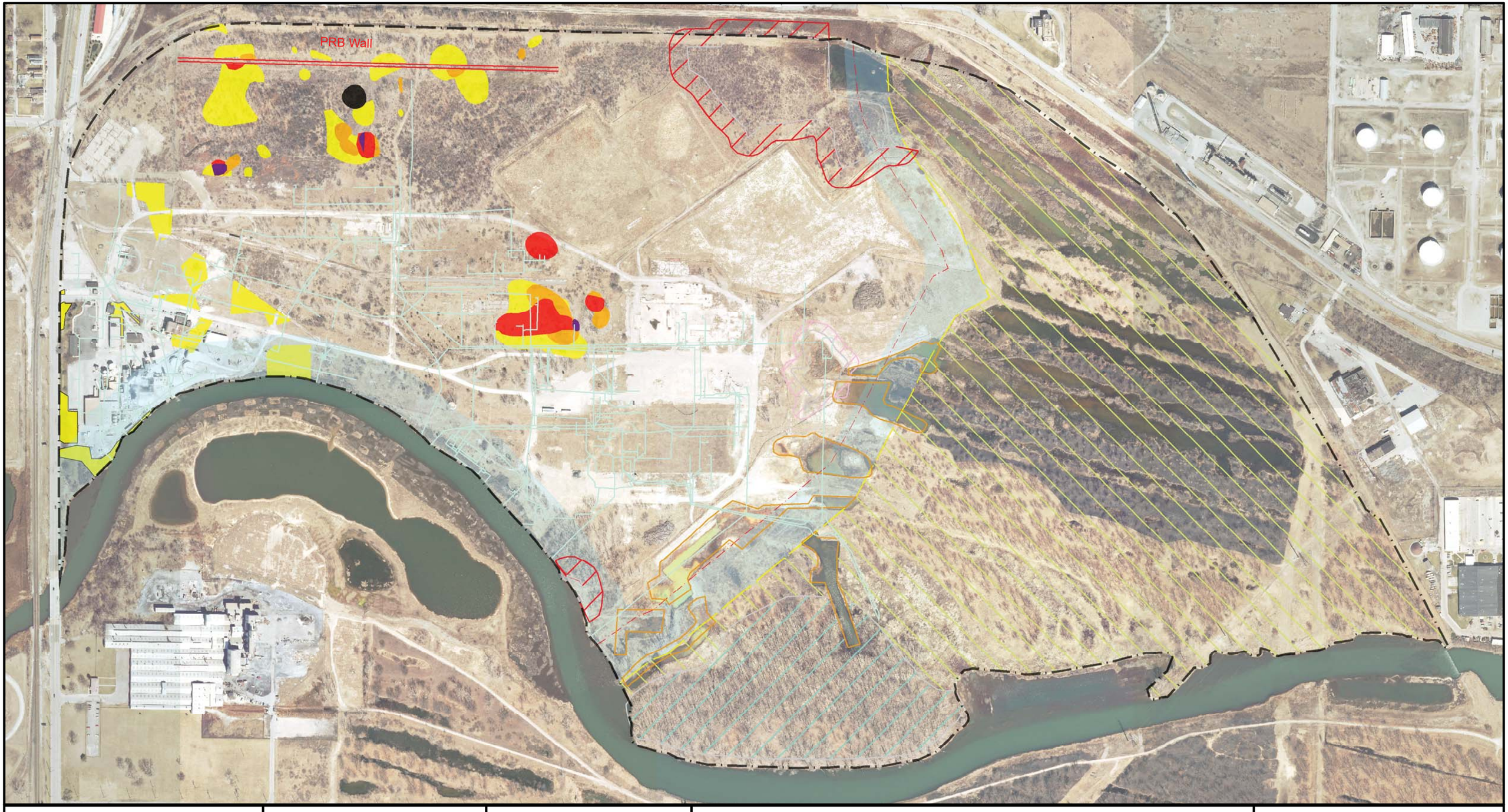
- Property Boundary
- Existing Injection Wells
- Proposed Remedial (Non-Potable) Supply

Figure 8b - Southern Groundwater Treatment Area



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Scale:
0 190 380 760 Feet

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Map Reference:

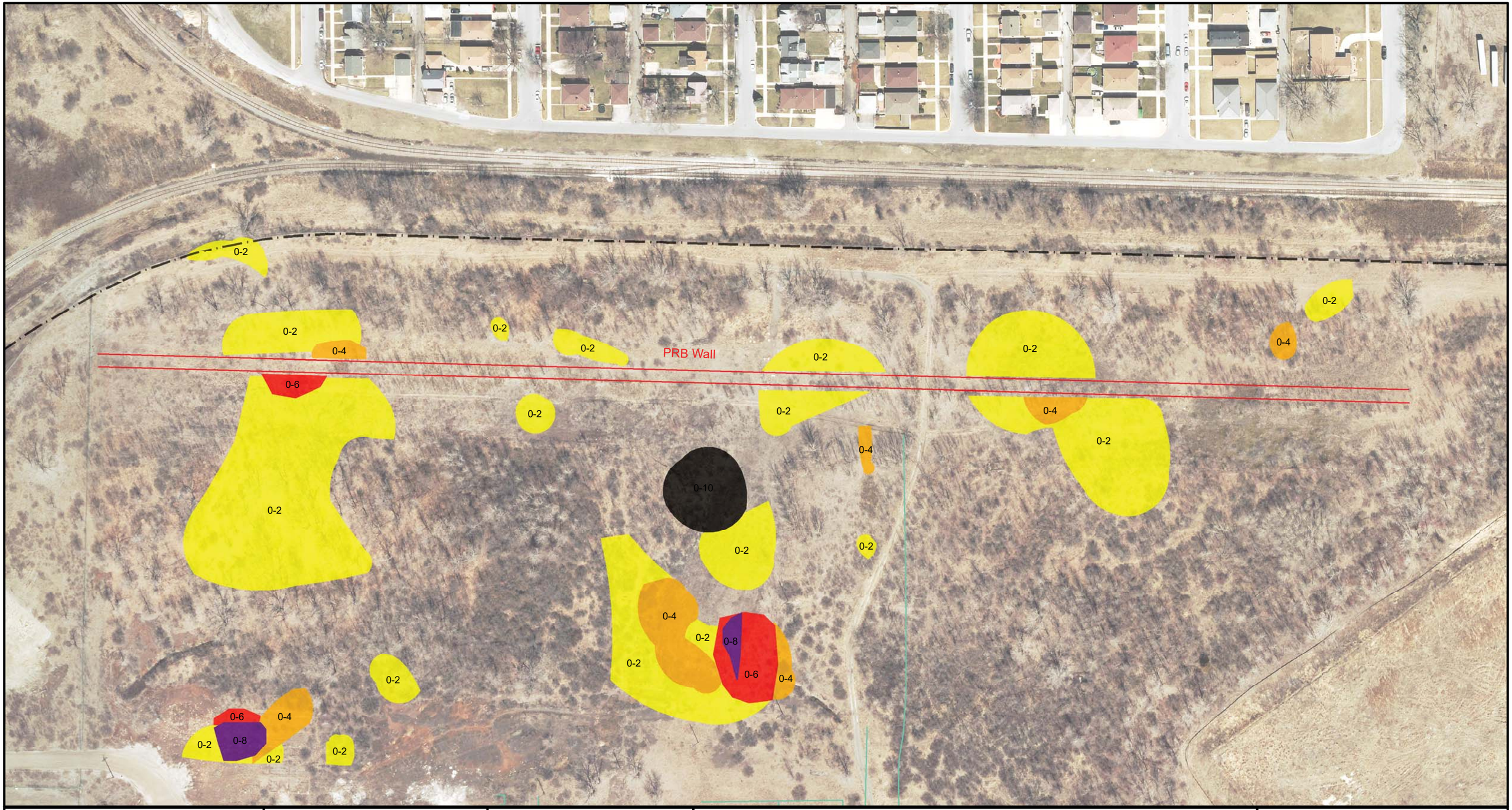
Legend

- Underground Utilites
- Excavated_Ponds
- 100 Foot Wetland Buffer Line
- Wetland (10.30 Acres)
- 100 Foot Wetland Buffer Polygon
- 50 Foot Wetland Buffer Line
- 50 Foot Wetland Buffer Polygon
- Forested Wetland Complex (23.76 Acres)
- Conservation Easement Buffer
- Conservation Easment
- Due and Swale Complex
- 300 Foot Protected Area

Depth of Removed Arsenic (Concentration > 1,000 mg/kg)

- 0-2
- 0-4
- 0-6
- 0-8
- 0-10

Figure : 9A Source Area Location Map (Site Overview)



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Scale:
0 55 110 220 Feet

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Map Reference:

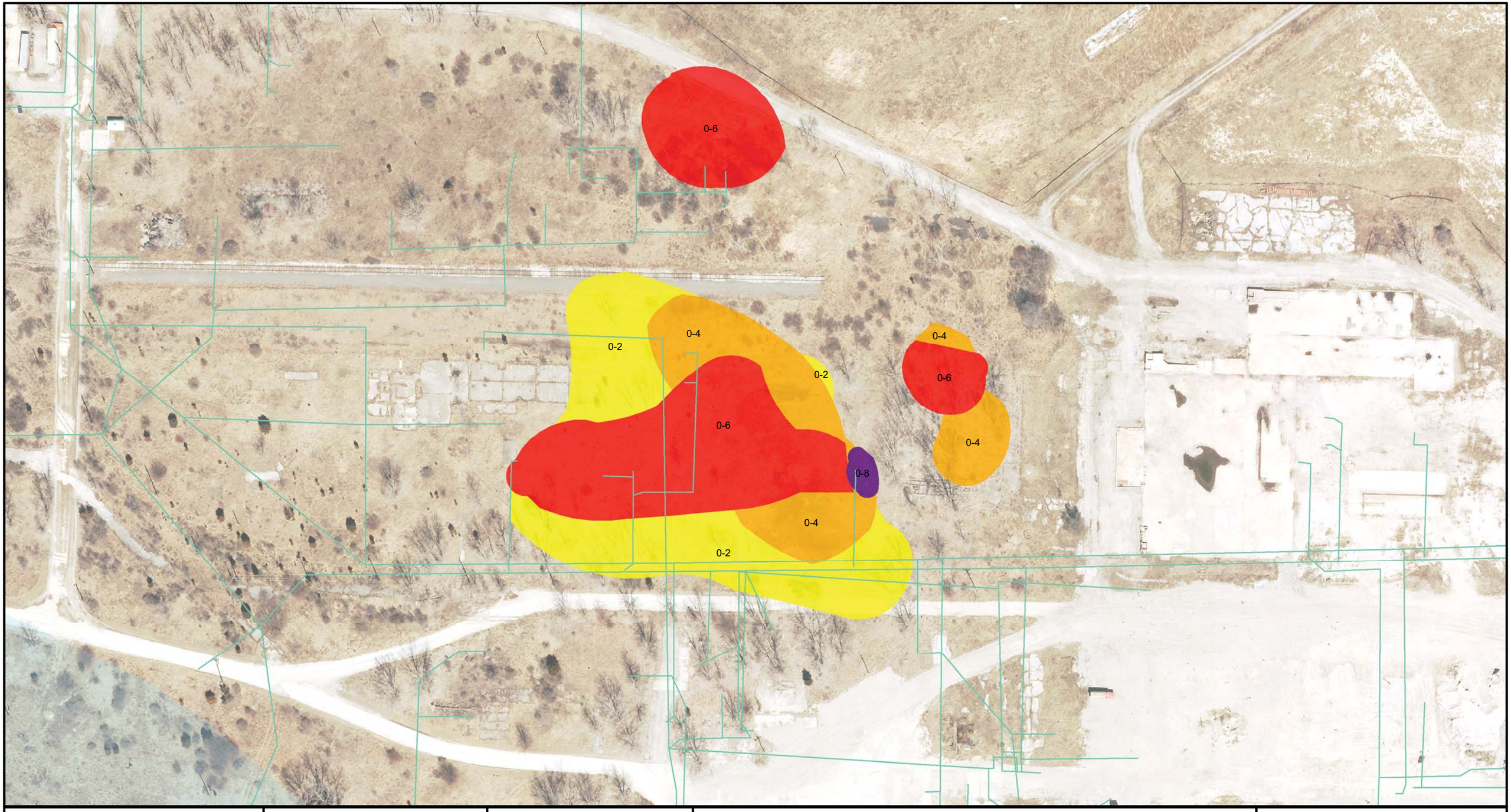
Legend

- Property Boundary
- Underground Utilites
- 300 Foot Protected Area

Depth of Removed Arsenic (Concentration > 1,000 mg/kg)

- 0-2
- 0-4
- 0-6
- 0-8
- 0-10

Figure : 9B Source Area Location Map (PRB Excavation)



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Scale:
0 40 80 160 Feet

Prepared By: LR | Reviewed By: KK

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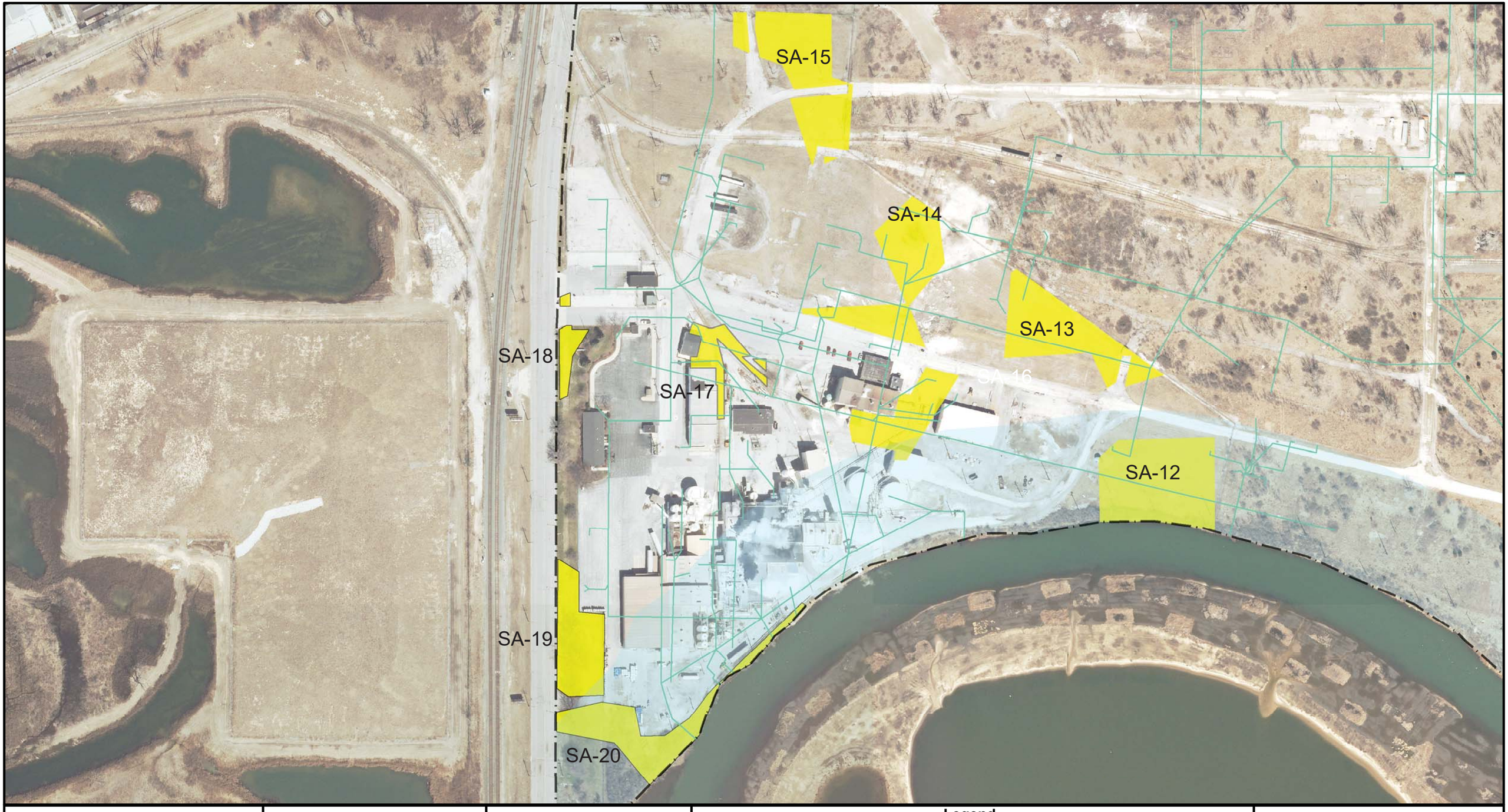
Map Reference:

Legend

Underground Utilites
300 Foot Protected Area

Depth of Removed Arsenic (Concentration > 1,000 mg/kg)
0-2
0-4
0-6
0-8
0-10

Figure : 9C Source Area Location Map (SWMU-4 Excavation)



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Scale:
0 70 140 280 Feet

Prepared By: LR | Reviewed By: KK

N
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S

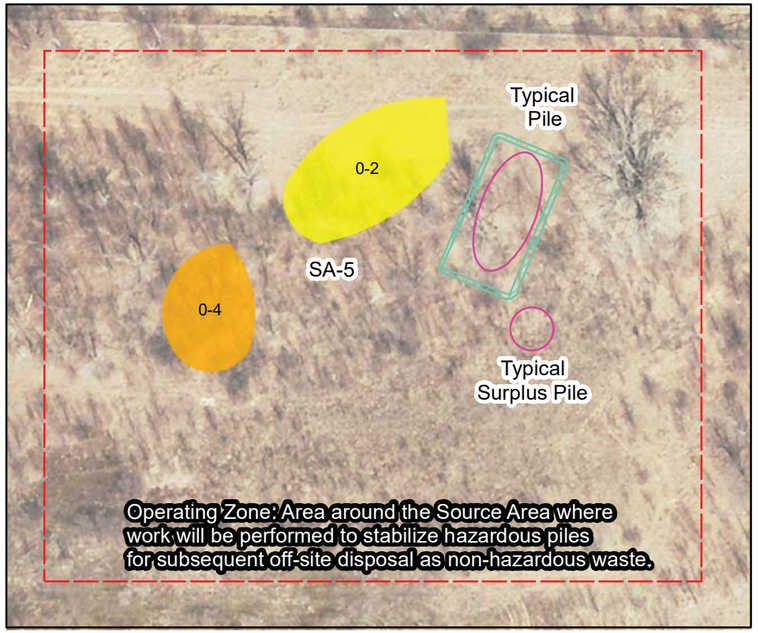
Map Reference:

Legend

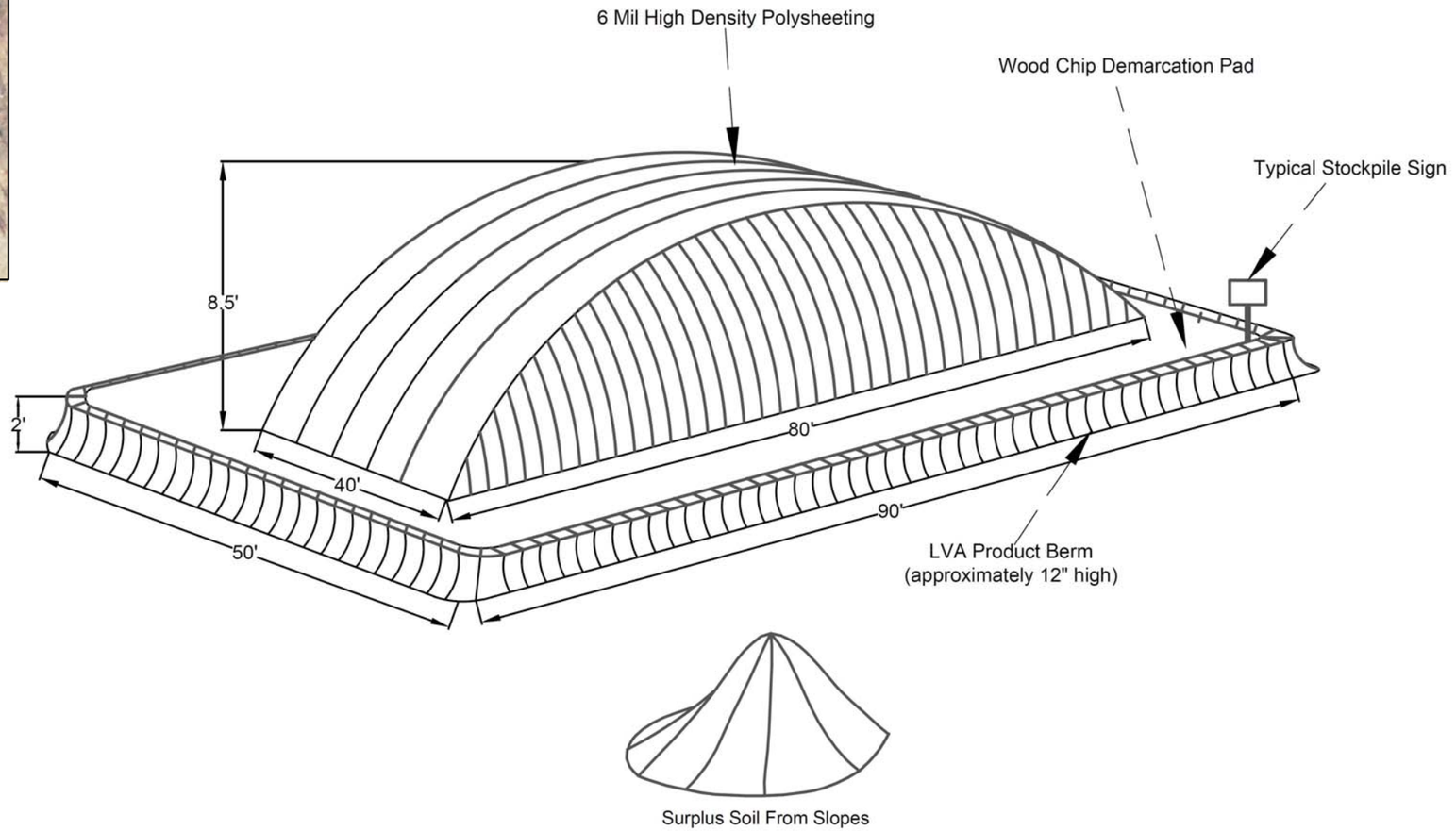
- Underground Utilites
- Excavated_Ponds
- 100 Foot Wetland Buffer Line
- Wetland (10.30 Acres)
- 100 Foot Wetland Buffer Polygon
- 50 Foot Wetland Buffer Line
- 50 Foot Wetland Buffer Polygon
- Forested Wetland Complex (23.76 Acres)
- Conservation Easement Buffer
- Conservation Easment
- Due and Swale Complex
- 300 Foot Protected Area

Depth of Removed Arsenic (Concentration > 1,000 mg/kg)
- 0-2

Figure : 9D Source Area Location Map (Lease Areas)



Typical Pile Detail



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Scale: 0 25 50 100 Feet

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Notes:

Proposed pile locations are approximate and may be adjusted in the field based on Site conditions.

Figure : 10
Source Area
Operating Zone



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Map Reference:

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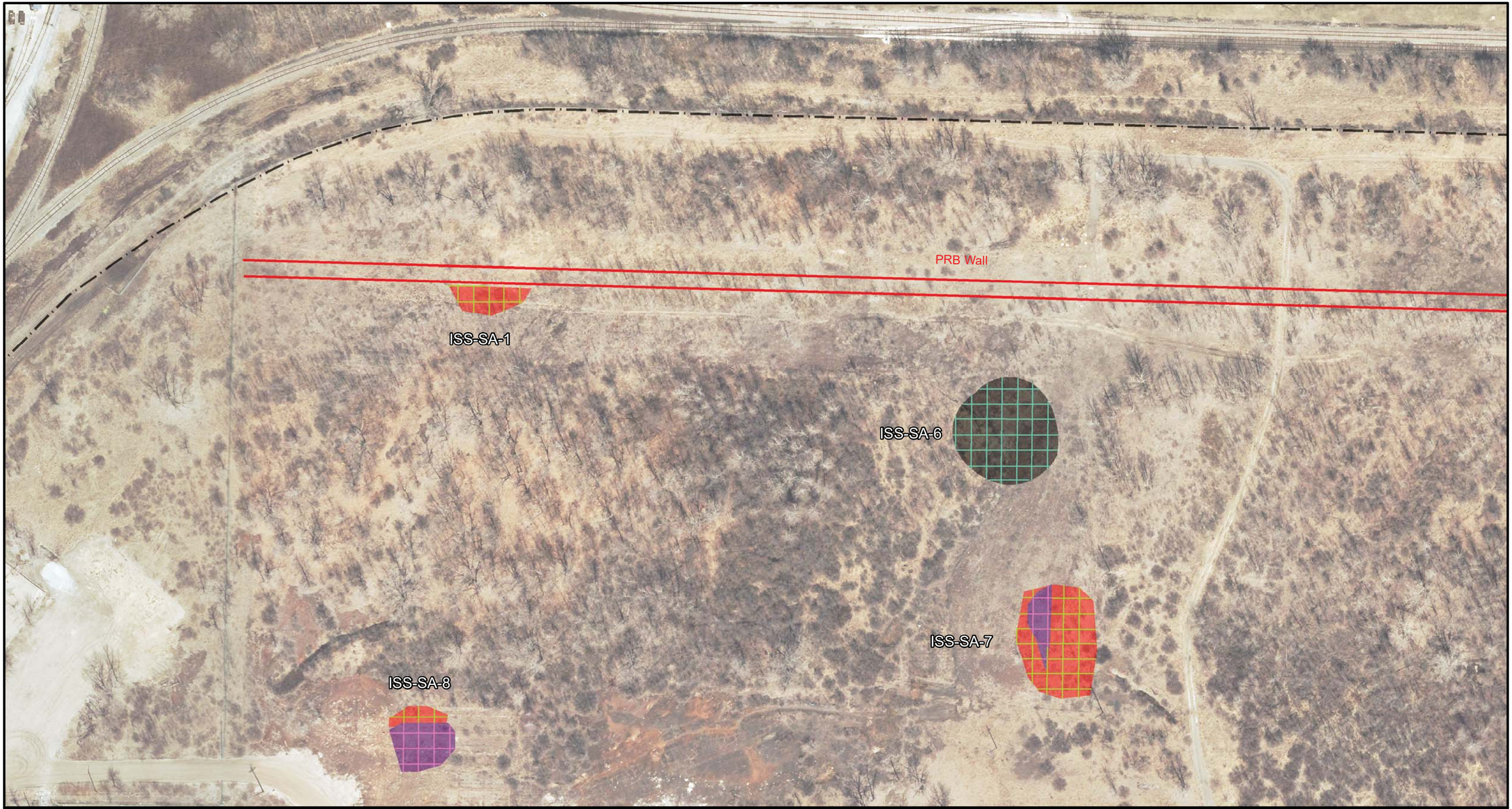
Property Boundary

4-6' BSG
4-8' BSG
4-10' BSG

Figure :11
In-Situ Stablization Plan



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Scale:
0 40 80 160 Feet

Prepared By: LR | Reviewed By: KK

N
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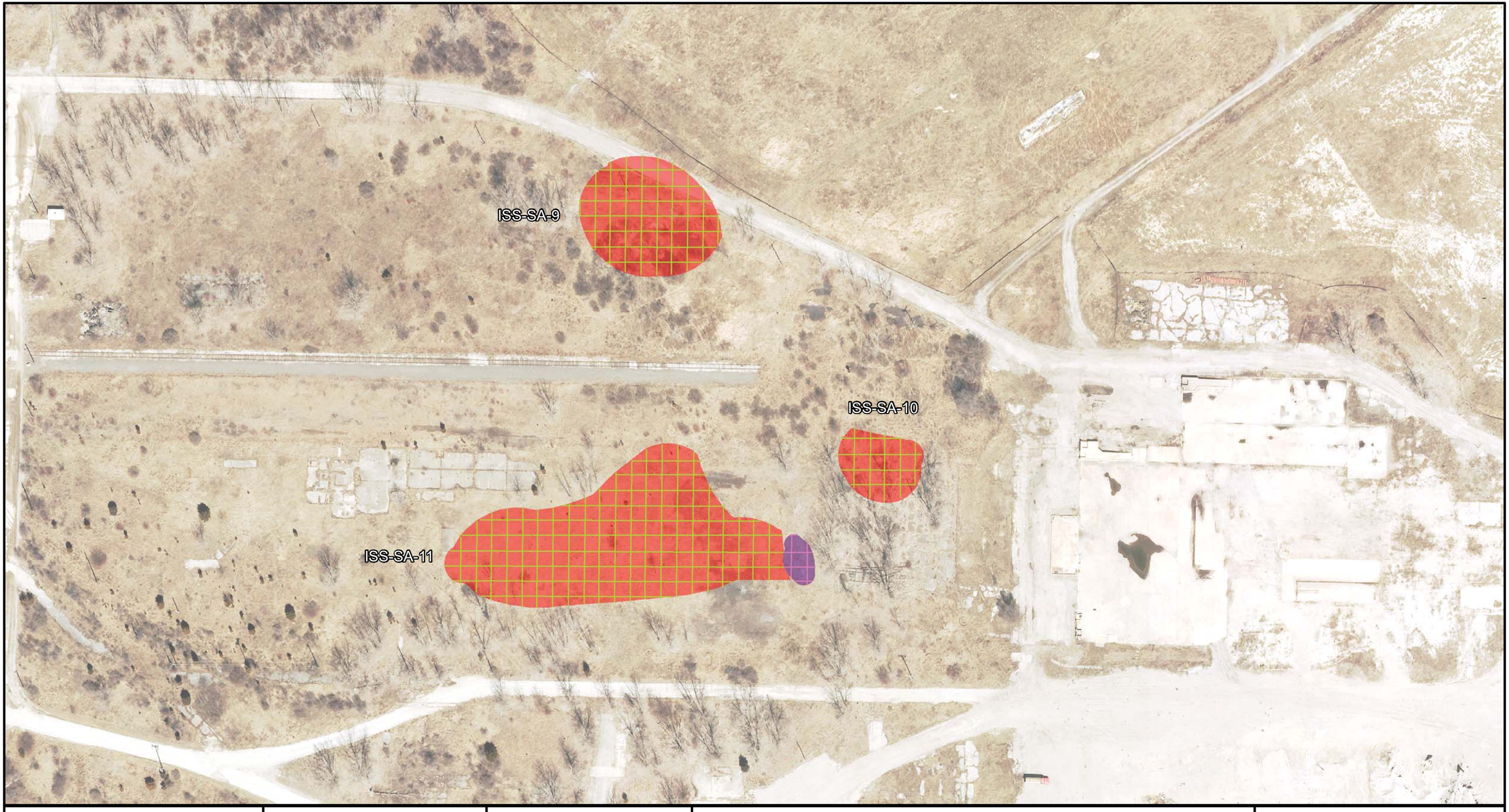
Map Reference:

Legend

- ISS Grid (4-10' BSG)
- ISS Grid (4-8' BSG)
- ISS Grid (4-6' BSG)
- 4-6' BSG
- 4-8' BSG
- 4-10' BSG

Figure :12A
PRB Source Area
ISS Grid Plan



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FAX (631) 269-1599

Scale:
0 40 80 160 Feet

Prepared By: LR | Reviewed By: KK

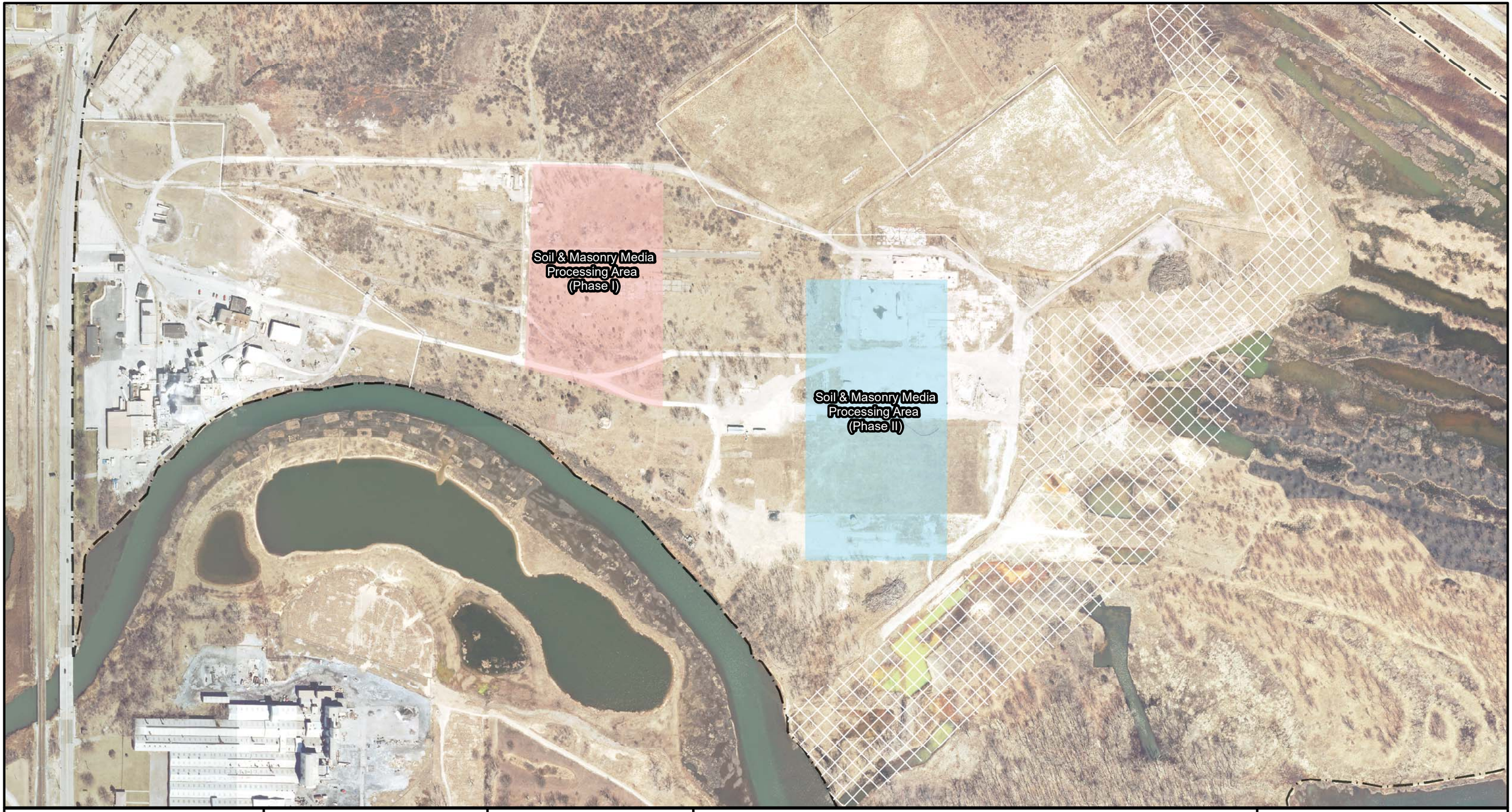
N
W E
S

Map Reference:

Legend

- ISS Grid (4-6' BSG)
- ISS Grid (4-8' BSG)
- 4-6' BSG
- 4-8' BSG

Figure :12B SWMU-4 Source Area ISS Grid Plan



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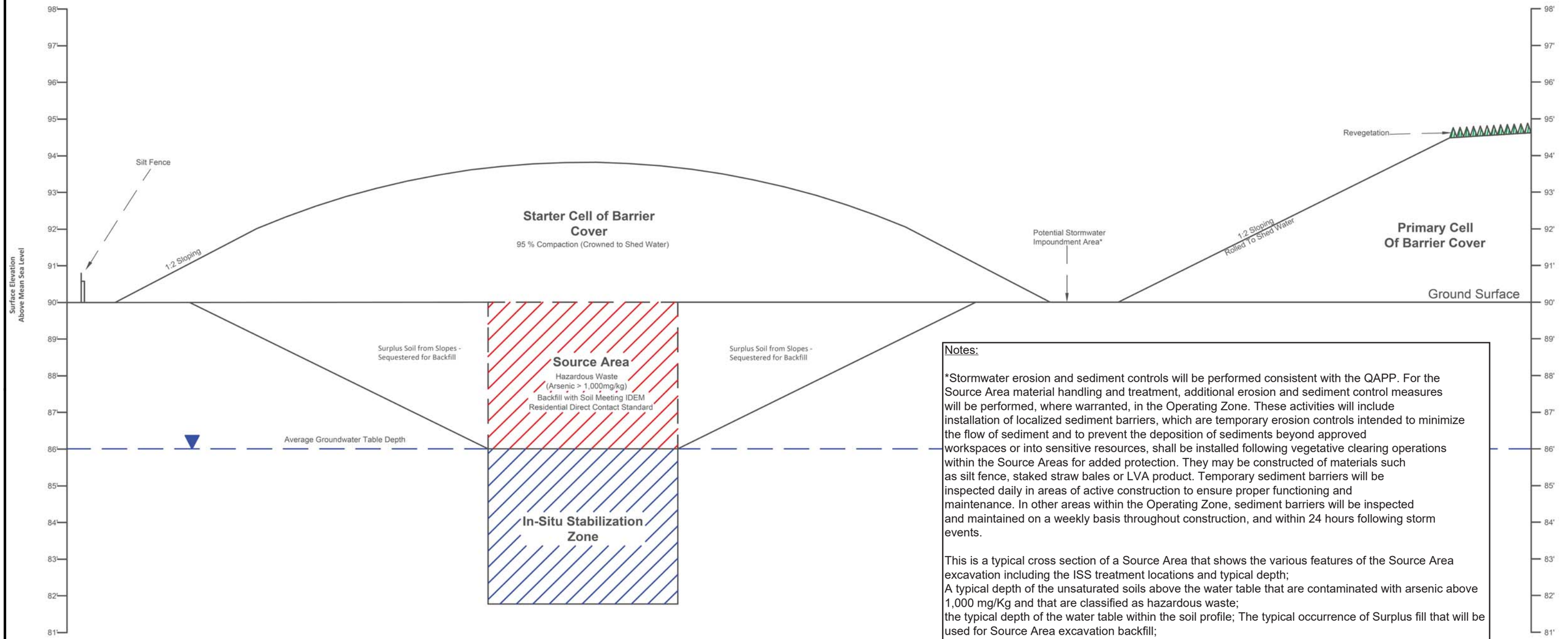
Map Reference:

Legend

Property Boundary

Figure : 13
Soil and Masonry Media Processing Areas



Notes:

*Stormwater erosion and sediment controls will be performed consistent with the QAPP. For the Source Area material handling and treatment, additional erosion and sediment control measures will be performed, where warranted, in the Operating Zone. These activities will include installation of localized sediment barriers, which are temporary erosion controls intended to minimize the flow of sediment and to prevent the deposition of sediments beyond approved workspaces or into sensitive resources, shall be installed following vegetative clearing operations within the Source Areas for added protection. They may be constructed of materials such as silt fence, staked straw bales or LVA product. Temporary sediment barriers will be inspected daily in areas of active construction to ensure proper functioning and maintenance. In other areas within the Operating Zone, sediment barriers will be inspected and maintained on a weekly basis throughout construction, and within 24 hours following storm events.

This is a typical cross section of a Source Area that shows the various features of the Source Area excavation including the ISS treatment locations and typical depth;
A typical depth of the unsaturated soils above the water table that are contaminated with arsenic above 1,000 mg/Kg and that are classified as hazardous waste;
the typical depth of the water table within the soil profile; The typical occurrence of Surplus fill that will be used for Source Area excavation backfill;
The placement of a Starter Cell with crowned surface to cover and protect the backfilled Source Area ISS zone from excessive stormwater infiltration;
The placement of a Primary Cell in lifts to an elevation that is 5 feet above ground surface;
the use of revegetation on a Primary Cell that is dormant for greater than 10 months and;
The ability to create surface water impoundment areas through strategic placement of barrier cover cells.

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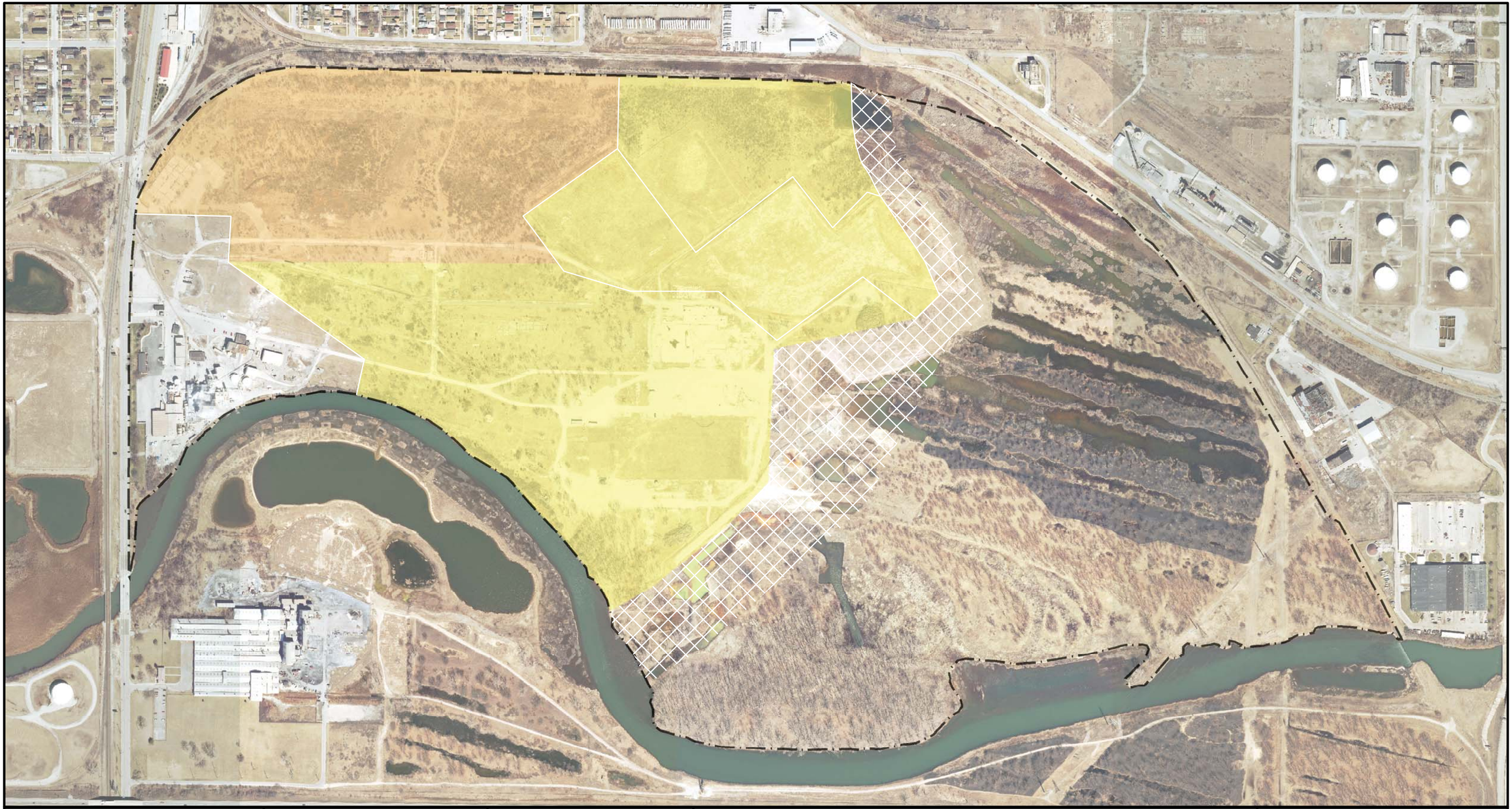
N
W E
S

Map Reference:

Figure: 14 Barrier Cover Detail



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Scale:

0 210 420 840 Feet

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S

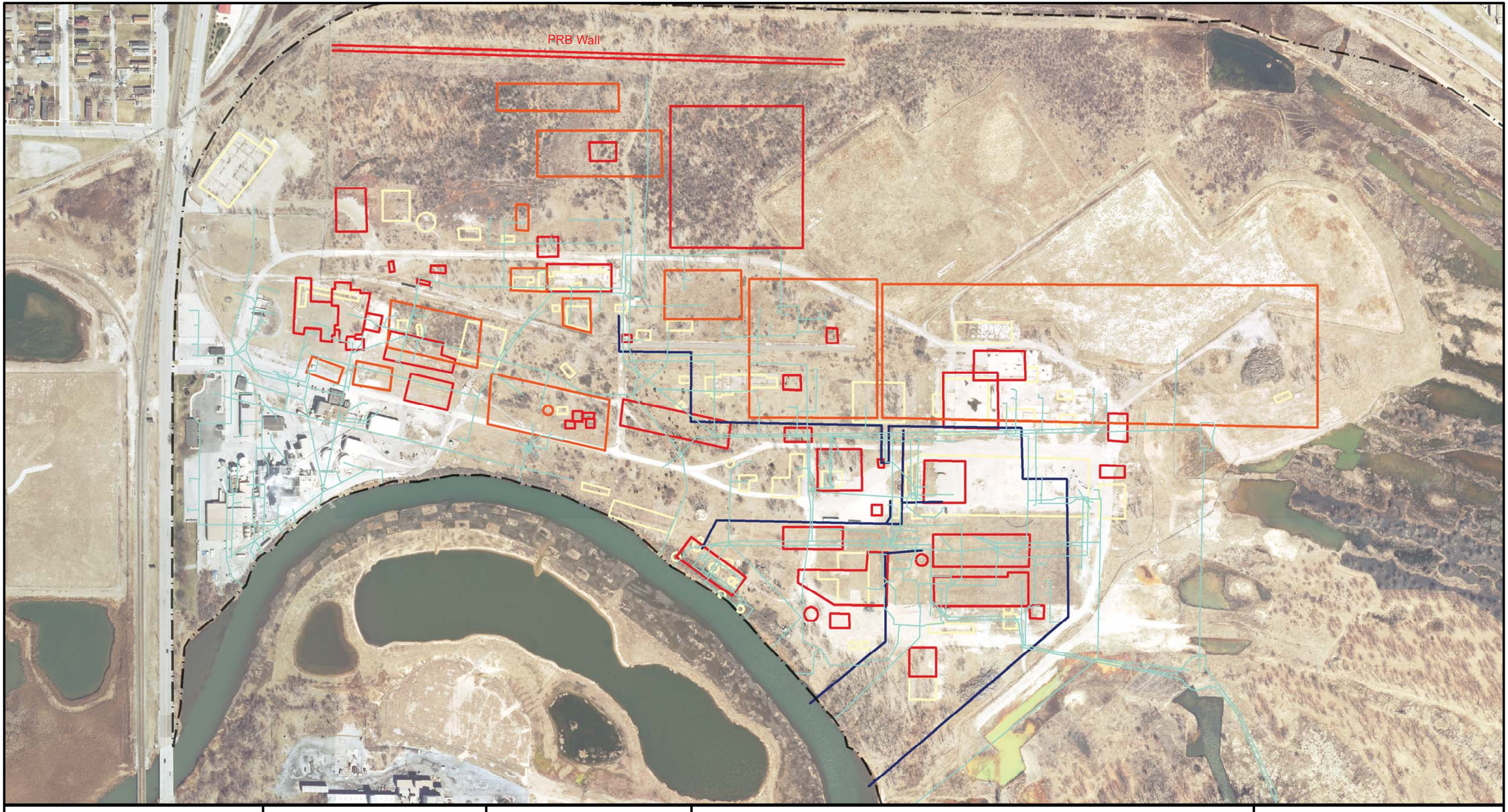
Map Reference:

Legend

Phase I *(Defined)*

Phase II *(Undefined)*

Figure : 15
Engineering Control Barrier Cover Plan



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N
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S

Map Reference:

Legend

- Property Boundary
- Underground Utilites
- Blue
- Tentatively_idenified_stuctures_orange
- Red
- Yellow

Figure :16 Tentatively Identified Subsurface Structures



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N
W E
S

Map Reference:

Legend

- Property Boundary
- Proposed Geotechnical Boring

Figure 17: Geotechnical Boring Plan

TABLES

Former DuPont East Chicago Facility

Table 1: Areas of Concern (AOCs) Solid Waste Management Units (SWMUs)
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Table 3: Proposed Well Abandonments
Table 4: Proposed Well Installations
Table 5: Existing Monitoring Wells
Table 6: Proposed Water Level Data Logging Wells
Table 7: Proposed Groundwater Monitoring Well Network
Table 8: Estimated Source Area Volume Calculations
Table 9: Ex-Situ Soil Treatment Dosage Calculations

TABLE 1
AREA OF CONCERN (AOCs)
Former DuPont East Chicago Facility

AOC ID	NAME/ DESCRIPTION	CURRENT ASSOCIATED AREA
1A	Vehicle Loading and Unloading Areas (With Reported Spills) – Silica Area North	Current Leased Industrial Area
1B	Vehicle Loading and Unloading Areas (With Reported Spills) – Silica Area South	Current Leased Industrial Area
1C	Vehicle Loading and Unloading Areas (With Reported Spills – Contact No.1	Former Industrial Area
1D	Vehicle Loading and Unloading Areas (With Reported Spills – FSA/Reagent Area	Former Industrial Area
1E	Vehicle Loading and Unloading Areas (With Reported Spills – Sulfamic Acid Area	Former Industrial Area
1F	Vehicle Loading and Unloading Areas (With Reported Spills – Freon Area	Former Industrial Area
1G	Vehicle Loading and Unloading Areas (With Reported Spills – Contact No.3	Former Industrial Area
2A	Railroad Loading and Unloading Areas (With Reported Spills) – Contact No. 3 North	Former Industrial Area
2B	Railroad Loading and Unloading Areas (With Reported Spills) – Contact No. 3 South	Former Industrial Area
2C	Railroad Loading and Unloading Areas (With Reported Spills) – Sulfamic Acid Area South	Former Industrial Area
2D	Railroad Loading and Unloading Areas (With Reported Spills) – FSA/Reagent Area	Former Industrial Area
2E	Railroad Loading and Unloading Areas (With Reported Spills) – AgChem Area North	Former Industrial Area
2F	Railroad Loading and Unloading Areas (With Reported Spills) – Zinc Chloride Area	Former Industrial Area
2G	Railroad Loading and Unloading Areas (With Reported Spills) – Sulfamic Acid Area	Former Industrial Area
3A	Aboveground Storage Tanks (With Reported Spills) – Freon Areas South	Former Industrial Area
3B	Aboveground Storage Tanks (With Reported Spills) – Freon Areas North	Former Industrial Area

TABLE 1
AREA OF CONCERN (AOCs)
Former DuPont East Chicago Facility

AOC ID	NAME/ DESCRIPTION	CURRENT ASSOCIATED AREA
3C	Aboveground Storage Tanks (With Reported Spills) – Sulfamic Acid Area	Former Industrial Area
3D	Aboveground Storage Tanks (With Reported Spills) – FSA/ Reagents Area	Former Industrial Area
3E	Aboveground Storage Tanks (With Reported Spills) – Contact No. 3	Former Industrial Area
3F	Aboveground Storage Tanks (With Reported Spills) – Powerhouse	Former Industrial Area
3G	Aboveground Storage Tanks (With Reported Spills) – AHF Area	Former Industrial Area
3H	Aboveground Storage Tanks (With Reported Spills) – Contact No. 1	Former Industrial Area
3I	Aboveground Storage Tanks (With Reported Spills) – Zinc Chloride Area	Former Industrial Area
3J	Aboveground Storage Tanks (With Reported Spills) – AgChem Area	Former Industrial Area
4	Tank Car Neutralization Pit	Former Industrial Area
5	Beneath Former Contact 1	Former Industrial Area
6	Zinc Crude Milling Area	Former Industrial Area and Current Leased Industrial Area
7	Former Commercial Packing House	Former Industrial Area
8	Former Powerhouse Pit	Current Leased Industrial Area
9	Open Sanitary Ditch	Waste Management Area
10A	Former Underground Petroleum Storage Tanks – Front Gate	Current Leased Industrial Area
10B	Former Underground Petroleum Storage Tanks – Contact No. 3	Former Industrial Area

TABLE 1
AREA OF CONCERN (AOCs)
Former DuPont East Chicago Facility

AOC ID	NAME/ DESCRIPTION	CURRENT ASSOCIATED AREA
10C	Former Underground Petroleum Storage Tanks – Central Shops	Former Industrial Area
10D	Former Underground Petroleum Storage Tanks – AgChem	Former Industrial Area
10E	Former Underground Petroleum Storage Tanks – Contact No. 2	Former Industrial Area
10F	Former Underground Petroleum Storage Tanks – Trial Ore Roaster Tank 1	Former Industrial Area
10G	Former Underground Petroleum Storage Tanks – Powerplant No. 2	Former Industrial Area
10H	Former Underground Petroleum Storage Tanks – Trail Ore Roaster Tank 2	Former Industrial Area
11	Ditch and Associated Materials	Former Industrial Area
12	Area East of Freon Area South of ASTs	Former Industrial Area
13	Conoco Area	Former Industrial Area
14	Former Insecticide Warehouse	Former Industrial Area
GW A	Groundwater Pool A	Waste Management Area
GW B	Groundwater Pool B	Former Industrial Area

TABLE 2

SOLID WASTE MANAGMENT UNITS (SWMUs)

Former DuPont East Chicago Facility

SWMU ID	NAME/ DESCRIPTION	CURRENT ASSOCIATED AREA
1A	Stoker Grate Ash Landfill	Waste Management Area
1B	Calcium Sulfate and TSP Area	Waste Management Area
1C	Rubble Fill Area	Waste Management Area
1D	Silica/ Calcium Sulfate Area	Waste Management Area
1E	Calcium Fluoride Area	Waste Management Area
1F	Zinc Mud Area	Waste Management Area
1G	General Refuse Area	Waste Management Area
1H	PCB Storage Area in Rubble Fill Area	Waste Management Area
1I	Misc Pits and Piles North	Waste Management Area
1J	Misc Pits and Piles South	Waste Management Area
1K	Spill Areas South of Stoker Grate Ash Landfill	Waste Management Area
1L	New Landfill	Waste Management Area
2A	Coal and Ash Pile Far West	Former Industrial Area
2B	Coal and Ash Pile West	Former Industrial Area
2C	Coal and Ash Pile East	Former Industrial Area
2D	Coal and Ash Pile Far East	Waste Management Area
3	Disposal Area Near Former Chrome Outfall	Former Industrial Area
4	Insecticide Disposal Areas	Former Industrial Area
5	PCB Electrical Storage Yard	Former Industrial Area

TABLE 2
SOLID WASTE MANAGMENT UNITS (SWMUs)
Former DuPont East Chicago Facility

SWMU ID	NAME/ DESCRIPTION	CURRENT ASSOCIATED AREA
6A	Waste Solvent Tank	Former Industrial Area
6B	AgChem Drum Storage	Former Industrial Area
6C	Reagent Drum Storage	Former Industrial Area
6D	Flue Dust Storage from Adhesives Building	Current Leased Industrial Area
6E	Flue Dust Storage near North Warehouse	Former Industrial Area
7	Abandoned Chemical Storage Building “The Morgue”	Former Industrial Area
8	Zinc Roaster Sinter Area	Former Industrial Area
9A	Northwest Incinerator	Former Industrial Area
9B	Incinerator West of Freon Warehouse	Former Industrial Area
10	HCL Neutralization Pits	Waste Management Area
11	Sulfamic Acid Pits	Former Industrial Area
12	Antimony Pentachloride Settling Pit	Waste Management Area
13	Colloidal Silica Settling Pits	Current Leased Industrial Area
14	Former Chrome Outfall and Impound	Former Industrial Area
15	Former Wastewater Treatment Outfall 002	Former Industrial Area
16	Environmental Control Wastewater Treatment System Outfall 003	Current Leased Industrial Area
17	Process Sewers	Former Industrial Area and Current Leased Industrial Area

TABLE 2

SOLID WASTE MANAGMENT UNITS (SWMUs)

Former DuPont East Chicago Facility

SWMU ID	NAME/ DESCRIPTION	CURRENT ASSOCIATED AREA
18	Sanitary Sewers	Former Industrial Area and Current Leased Industrial Area
19	Building Maintenance Areas	Former Industrial Area and Current Leased Industrial Area
20	I-90 Fill Area	Natural Area
21	Lead Arsenate Sludge Disposal Area	Not Indicated
22	River Intake Canal	Former Industrial Area

TABLE 3
PROPOSED WELL ABANDONMENTS
Former DuPont East Chicago Facility

Well Type	Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
Monitoring Well	MW-10	30	15.0 - 30.0	15
Monitoring Well	MW-11	30	15.0 - 30.0	15
Monitoring Well	MW-15	30	15.0 - 30.0	15
Monitoring Well	MW-16	32	17.0 - 32.0	15
Monitoring Well	MW-17	33	18.0 - 33.0	15
Monitoring Well	MW-19	33	18.0 - 33.0	15
Monitoring Well	MW-20	32	17.0 - 32.0	15
Monitoring Well	MW-21	33.5	8.5 - 33.5	25
Monitoring Well	MW-22	33.5	8.5 - 33.5	25
Monitoring Well	MW-31S	14.23	8.73 - 13.73	5
Monitoring Well	MW-44	25.5	18.0 - 23.0	5
Monitoring Well	MW-45	25.5	18.0 - 23.0	5
Monitoring Well	MW-48S	15	10.0 - 15.0	5
Monitoring Well	MW-48D	35	30.0 - 35.0	5
Monitoring Well	MW-49S	15	10.0 - 15.0	5
Monitoring Well	MW-49D	35	30.0 - 35.0	5
Monitoring Well	MW-50S	15	10.0 - 15.0	5
Monitoring Well	MW-50D	35	30.0 - 35.0	5
Monitoring Well	MW-51S	15	10.0 - 15.0	5
Monitoring Well	MW-51D	35	30.0 - 35.0	5
Monitoring Well	MW-56S	20	15.0 - 20.0	5
Monitoring Well	MW-56D	35	30.0 - 35.0	5
PRB Well	PRB-1	40	30.0 - 40.0	10
PRB Well	PRB-1S	15	10.0 - 15.0	5
PRB Well	PRB-2	32	22.0 - 32.0	10
PRB Well	PRB-2S	14.5	9.5 - 14.5	5
PRB Well	PRB-3	34.28	24.28 - 34.28	5
PRB Well	PRB-3S	15	10.0 - 15.0	5
PRB Well	PRB-4	38.76	28.76 - 38.76	10
PRB Well	PRB-5	32.09	22.09 - 32.09	10
PRB Well	PRB-5S	Not Available	Not Available	Not Available
PRB Well	PRB-5D	Not Available	Not Available	Not Available
PRB Well	PRB-6	35.27	25.27 - 35.27	10
PRB Well	PRB-7	34.15	24.15 - 34.15	10
PRB Well	PRB-8	33.19	23.19 - 33.19	10
PRB Well	PRB-8S	15	10.0 - 15.0	5
PRB Well	PRB-9	34.78	24.78 - 34.78	10
Piezometer	P-3	35.5	19.1 - 35.5	16.4
Piezometer	P-6	30	13.6 - 30.0	16.4
Piezometer	P-10	31.8	Not Available	Not Available

Notes:

TABLE 4

PROPOSED WELL INSTALLATIONS

Former DuPont East Chicago Faclity

Well Type	Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
Monitoring Well	MW-10S	15	10.0 - 15.0	5
Monitoring Well	MW-10D	34	29.0 - 34.0	5
Monitoring Well	MW-11S	15	10.0 - 15.0	5
Monitoring Well	MW-11D	32	27.0 - 32.0	5
Monitoring Well	MW-15S	15	10.0 - 15.0	5
Monitoring Well	MW-15D	35	30.0 - 35.0	5
Monitoring Well	MW-19S	15	10.0 - 15.0	5
Monitoring Well	MW-19D	33	28.0 - 33.0	5
Monitoring Well	MW-21S	15	10.0 - 15.0	5
Monitoring Well	MW-21D	34	29.0 - 34.0	5
Monitoring Well	MW-22S	15	10.0 - 15.0	5
Monitoring Well	MW-22D	33	28.0 - 33.0	5
Monitoring Well	MW-23S	15	10.0 - 15.0	5
Monitoring Well	MW-24S	15	10.0 - 15.0	5
Monitoring Well	MW-25S	15	10.0 - 15.0	5
Monitoring Well	MW-28S	15	10.0 - 15.0	5
Monitoring Well	MW-42I	32	27.0 - 32.0	5
Monitoring Well	MW-43S	15	10.0 - 15.0	5
Monitoring Well	MW-57S	20	15.0 - 20.0	5
Monitoring Well	MW-57I	27	22.0 - 27.0	5
Monitoring Well	MW-57D	35	30.0 - 35.0	5
Monitoring Well	MW-58S	20	15.0 - 20.0	5
Monitoring Well	MW-58I	27	22.0 - 27.0	5
Monitoring Well	MW-58D	35	30.0 - 35.0	5
Monitoring Well	MW-59S	20	15.0 - 20.0	5
Monitoring Well	MW-59D	35	30.0 - 35.0	5
Monitoring Well	MW-60S	20	15.0 - 20.0	5
Monitoring Well	MW-60D	35	30.0 - 35.0	5
Monitoring Well	MW-61S	20	15.0 - 20.0	5
Monitoring Well	MW-61D	35	30.0 - 35.0	5
Monitoring Well	MW-62S	33	28.0 - 33.0	5
Monitoring Well	MW-62D	15	10.0 - 15.0	5
Monitoring Well	MW-63S	33	28.0 - 33.0	5
Monitoring Well	MW-63D	15	10.0 - 15.0	5
Monitoring Well	MW-64S	33	28.0 - 33.0	5
Monitoring Well	MW-64D	15	10.0 - 15.0	5
Monitoring Well	MW-65S	20	15.0 - 20.0	5
Monitoring Well	MW-65D	35	30.0 - 35.0	5
Monitoring Well	MW-66S	20	15.0 - 20.0	5
Monitoring Well	MW-66I	27	22.0 - 27.0	5
Monitoring Well	MW-66D	35	30.0 - 35.0	5
Monitoring Well	MW-67S	20	15.0 - 20.0	5

TABLE 4

PROPOSED WELL INSTALLATIONS

Former DuPont East Chicago Faclity

Monitoring Well	MW-67I	27	22.0 - 27.0	5
Monitoring Well	MW-67D	35	30.0 - 35.0	5
Monitoring Well	MW-68S	15	10.0 - 15.0	5
Monitoring Well	MW-68D	34	29.0 - 34.0	5
Monitoring Well	MW-69S	15	10.0 - 15.0	5
Monitoring Well	MW-69D	32	27.0 - 32.0	5
Monitoring Well	MW-70S	15	10.0 - 15.0	5
Monitoring Well	MW-70D	32	27.0 - 32.0	5
Monitoring Well	MW-71S	15	10.0 - 15.0	5
Monitoring Well	MW-71D	32	27.0 - 32.0	5
PRB Well	PRB-10S	15	10.0 - 15.0	5
PRB Well	PRB-16S	15	10.0 - 15.0	5
PRB Well	PRB-17S	15	10.0 - 15.0	5
Supply Well	NSW-2	35	15.0 - 35.0	20
Supply Well	SSW-1	35	15.0 - 35.0	20
Supply Well	SSW-2	35	15.0 - 35.0	20

Notes:

Proposed "Shallow" Water Table Wells

Proposed "Intermediate" Water Table Wells

Proposed "Deep" Water Table Wells

TABLE 5

EXISTING MONITORING WELLS

Former DuPont East Chicago Faclity

Well Type	Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
Injection Well	IW-1S	25	15.0 - 25.0	10
Injection Well	IW-1D	34.5	24.5 - 34.5	10
Injection Well	IW-2S	25	15.0 - 25.0	10
Injection Well	IW-2D	35	25.0 - 35.0	10
Injection Well	IW-3S	25	15.0 - 25.0	10
Injection Well	IW-3D	36	26.0 - 36.0	10
Injection Well	IW-4S	25	15.0 - 25.0	10
Injection Well	IW-4D	36	26.0 - 36.0	10
Injection Well	IW-5S	25	15.0 - 25.0	10
Injection Well	IW-5D	36.5	26.5 - 36.5	10
Injection Well	IW-6S	25	15.0 - 25.0	10
Injection Well	IW-6D	36	26.0 - 36.0	10
Injection Well	IW-7S	25	15.0 - 25.0	10
Injection Well	IW-7D	Not Available	Not Available	Not Available
Injection Well	IW-8S	25	15.0 - 25.0	10
Injection Well	IW-8D	36	26.0 - 36.0	10
Injection Well	IW-9S	25	15.0 - 25.0	10
Injection Well	IW-9D	37	27.0 - 37.0	10
Injection Well	IW-10S	25	15.0 - 25.0	10
Injection Well	IW-10D	35	25.0 - 35.0	10
Injection Well	IW-11S	25	15.0 - 25.0	10
Injection Well	IW-11D	35	25.0 - 35.0	10
Injection Well	IW-12S	25	15.0 - 25.0	10
Injection Well	IW-12D	35	25.0 - 35.0	10
Injection Well	IW-13S	25	15.0 - 25.0	10
Injection Well	IW-13D	35	25.0 - 35.0	10
Injection Well	IW-14S	25	15.0 - 25.0	10
Injection Well	IW-14D	35	25.0 - 35.0	10
Injection Well	IW-15S	25	15.0 - 25.0	10
Injection Well	IW-15D	35	25.0 - 35.0	10
Injection Well	IW-16S	25	15.0 - 25.0	10
Injection Well	IW-16D	35	25.0 - 35.0	10
Injection Well	IW-17S	25	15.0 - 25.0	10
Injection Well	IW-17D	35	25.0 - 35.0	10
Injection Well	IW-18S	25	15.0 - 25.0	10
Injection Well	IW-18D	35	25.0 - 35.0	10
Injection Well	IW-19S	25	15.0 - 25.0	10
Injection Well	IW-19D	35	25.0 - 35.0	10
Injection Well	IW-20S	25	15.0 - 25.0	10
Injection Well	IW-20D	35	25.0 - 35.0	10
Injection Well	IW-21S	25	15.0 - 25.0	10
Injection Well	IW-21D	35	25.0 - 35.0	10
Injection Well	IW-22S	25	15.0 - 25.0	10
Injection Well	IW-22D	35	25.0 - 35.0	10
Monitoring Well	MW-3	29.2	24.2 - 29.2	5

TABLE 5

EXISTING MONITORING WELLS

Former DuPont East Chicago Faclity

Well Type	Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
Monitoring Well	MW-3S	15	10.0 - 15.0	5
Monitoring Well	MW-4	29	14.0 - 29.0	15
Monitoring Well	MW-5	31	16.0 - 31.0	15
Monitoring Well	MW-6	30	15.0 - 30.0	15
Monitoring Well	MW-8	29	14.0 - 29.0	15
Monitoring Well	MW-9	29.5	14.5 -29.5	15
Monitoring Well	MW-10	33.5	18.5 - 33.5	15
Monitoring Well	MW-11	31.4	16.4 - 31.4	15
Monitoring Well	MW-12	32	17.0 - 32.0	15
Monitoring Well	MW-13	29	19.0 - 29.0	10
Monitoring Well	MW-14	28	18.0 - 28.0	10
Monitoring Well	MW-15	30	15.0 - 30.0	15
Monitoring Well	MW-16	32	17.0 - 32.0	15
Monitoring Well	MW-17	33	18.0 - 33.0	15
Monitoring Well	MW-18	33.5	18.5 - 33.5	15
Monitoring Well	MW-19	33	18.0 - 33.0	15
Monitoring Well	MW-20	32	17.0 - 32.0	15
Monitoring Well	MW-21	33.5	8.5 - 33.5	25
Monitoring Well	MW-22	33.5	8.5 - 33.5	25
Monitoring Well	MW-23	31	21.0 - 31.0	10
Monitoring Well	MW-24	34	24.0 - 34.0	10
Monitoring Well	MW-25	30	20.0 - 30.0	10
Monitoring Well	MW-26	34	24.0 - 34.0	10
Monitoring Well	MW-27	35	25.0 - 35.0	10
Monitoring Well	MW-28	32	22.0 - 32.0	10
Monitoring Well	MW-30	14.2	8.7 - 13.7	5
Monitoring Well	MW-30D	28.45	22.95 - 27.95	5
Monitoring Well	MW-31S	14.23	8.73 - 13.73	5
Monitoring Well	MW-31D	31.04	25.54 - 30.54	5
Monitoring Well	MW-32S	14.36	8.86 - 13.36	5
Monitoring Well	MW-32D	36.38	30.88 - 35.88	5
Monitoring Well	MW-33S	13.73	8.23 - 13.23	5
Monitoring Well	MW-33D	30.62	25.12 - 30.12	5
Monitoring Well	MW-34S	15	9.5 - 14.5	5
Monitoring Well	MW-34D	33	27.5 - 32.5	5
Monitoring Well	MW-35S	16	9.5 - 14.5	5
Monitoring Well	MW-35D	33	27.5 - 32.5	5
Monitoring Well	MW-36S	15	9.5 - 14.5	5
Monitoring Well	MW-36D	31	25.5 - 30.5	5
Monitoring Well	MW-37S	15	9.5 - 14.5	5
Monitoring Well	MW-37D	26.5	21.0 - 26.0	5
Monitoring Well	MW-38S	15	9.5 - 14.5	5
Monitoring Well	MW-38D	31	25.5 - 30.5	5
Monitoring Well	MW-39S	15	9.5 - 14.5	5
Monitoring Well	MW-39D	33	27.5 - 32.5	5

TABLE 5

EXISTING MONITORING WELLS

Former DuPont East Chicago Faclity

Well Type	Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
Monitoring Well	MW-40S	15	9.5 - 14.5	5
Monitoring Well	MW-40D	27.5	22.0 - 27	5
Monitoring Well	MW-41S	15.25	10.25 - 15.25	5
Monitoring Well	MW-41D	31.5	26.5 - 31.5	5
Monitoring Well	MW-42S	19.5	14.5 - 19.5	5
Monitoring Well	MW-42D	41	36.0 - 41.0	5
Monitoring Well	MW-43	36	28.0 - 33.0	5
Monitoring Well	MW-44	25.5	18.0 - 23.0	5
Monitoring Well	MW-45	25.5	18.0 - 23.0	5
Monitoring Well	MW-46S	17	12.0 - 17.0	5
Monitoring Well	MW-46D	36	31.0 - 36.0	5
Monitoring Well	MW-47S	17	12.0 - 17.0	5
Monitoring Well	MW-47D	17	12.0 - 17.0	5
Monitoring Well	MW-48S	15	10.0 - 15.0	5
Monitoring Well	MW-48D	35	30.0 - 35.0	5
Monitoring Well	MW-49S	15	10.0 - 15.0	5
Monitoring Well	MW-49D	35	30.0 - 35.0	5
Monitoring Well	MW-50S	15	10.0 - 15.0	5
Monitoring Well	MW-50D	35	30.0 - 35.0	5
Monitoring Well	MW-51S	15	10.0 - 15.0	5
Monitoring Well	MW-51D	35	30.0 - 35.0	5
Monitoring Well	MW-52S	15	10.0 - 15.0	5
Monitoring Well	MW-52D	35	30.0 - 35.0	5
Monitoring Well	MW-53S	15	10.0 - 15.0	5
Monitoring Well	MW-53D	35	30.0 - 35.0	5
Monitoring Well	MW-54S	20	15.0 - 20.0	5
Monitoring Well	MW-54D	37	32.0 - 37.0	5
Monitoring Well	MW-55S	20	15.0 - 20.0	5
Monitoring Well	MW-55D	35	30.0 - 35.0	5
Monitoring Well	MW-56S	20	15.0 - 20.0	5
Monitoring Well	MW-56D	35	30.0 - 35.0	5
PRB Well	PRB-1	40	30.0 - 40.0	10
PRB Well	PRB-1S	15	10.0 - 15.0	5
PRB Well	PRB-2	32	22.0 - 32.0	10
PRB Well	PRB-2S	14.5	9.5 - 14.5	5
PRB Well	PRB-3	34.28	24.28 - 34.28	5
PRB Well	PRB-3S	15	10.0 - 15.0	5
PRB Well	PRB-4	38.76	28.76 - 38.76	10
PRB Well	PRB-5	32.09	22.09 - 32.09	10
PRB Well	PRB-5S	Not Available	Not Available	Not Available
PRB Well	PRB-5D	Not Available	Not Available	Not Available
PRB Well	PRB-6	35.27	25.27 - 35.27	10
PRB Well	PRB-7	34.15	24.15 - 34.15	10
PRB Well	PRB-8	33.19	23.19 - 33.19	10
PRB Well	PRB-8S	15	10.0 - 15.0	5

TABLE 5

EXISTING MONITORING WELLS

Former DuPont East Chicago Faclity

Well Type	Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
PRB Well	PRB-9	34.78	24.78 - 34.78	10
PRB Well	PRB-10	35.31	25.31 - 35.31	10
PRB Well	PRB-11	35.44	25.44 - 35.44	10
PRB Well	PRB-11S	Not Available	Not Available	Not Available
PRB Well	PRB-12	34.33	24.33 - 34.33	10
PRB Well	PRB-13	33.09	23.09 - 33.09	10
PRB Well	PRB-13S	14.5	9.5 - 14.5	5
PRB Well	PRB-14	30.6	20.6 - 30.6	10
PRB Well	PRB-14S	14.75	9.75 - 14.75	5
PRB Well	PRB-15	33.82	23.82 - 33.82	10
PRB Well	PRB-15S	15.25	10.25 - 15.25	5
PRB Well	PRB-16	34.78	24.78 - 34.78	10
PRB Well	PRB-17	35.36	25.36 - 35-36	10
PRB Well	PRB-18S	14.5	9.5 - 14.5	5
PRB Well	PRB-18D	29.75	24.75 - 29.75	5
PRB Well	PRB-19S	14	9.0 - 14.0	5
PRB Well	PRB-19D	29.5	24.5 - 29.5	5
Piezometer	P-3	35.5	19.1 - 35.5	16.4
Piezometer	P-4	35	12.0 - 35.0	23
Piezometer	P-5	31	14.6 - 31.0	16.4
Piezometer	P-6	30	13.6 - 30.0	16.4
Piezometer	P-8	31	11.3 - 31.0	19.7
Piezometer	P-9	32	12.3 - 32.0	19.7
Piezometer	P-10	31.8	not available	not available
Piezometer	P-11	34	9.0 - 34.0	25
Piezometer	P-12	34	9.0 - 34.0	25
Piezometer	P-14	34	9.0 - 34.0	25
Piezometer	P-15	34	9.0 - 34.0	25
Piezometer	P-16	34	9.0 - 34.0	25
Piezometer	P-17	34	9.0 - 34.0	25
Piezometer	P-20	16	11.0 - 16.0	5
Piezometer	P-21	19	14.0 - 19.0	5
Piezometer	P-22	16	11.0 - 16.0	5
Piezometer	P-23	14	9.0 - 14.0	5
Piezometer	P-24	12	8.0 - 12.0	4
Piezometer	P-25	16	11.0 - 16.0	5
Piezometer	P-26	10	5.0 - 10.0	5
Piezometer	P-29	8	3.0 - 8.0	5
PIezometer	P-30	10	5.0 - 10.0	5
Piezometer	P-31	8	3.0 - 8.0	5

TABLE 6

PROPOSED WATER LEVEL DATA LOGGING WELLS

Former DuPont East Chicago Facility

Well Type	Updated Well ID	Historic Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
Monitoring Well	MW-10S	-	15	10.0 - 15.0	5
Monitoring Well	MW-10D	-	34	29.0 - 34.0	5
Monitoring Well	MW-11S	-	15	10.0 - 15.0	5
Monitoring Well	MW-11D	-	32	27.0 - 32.0	5
Monitoring Well	MW-19S	-	15	10.0 - 15.0	5
Monitoring Well	MW-19D	-	33	18.0 - 33.0	15
Monitoring Well	MW-23S	-	15	10.0 - 15.0	5
Monitoring Well	**MW-23D**	**MW-23**	31	21.0 - 31.0	10
Monitoring Well	MW-24S	-	15	10.0 - 15.0	5
Monitoring Well	**MW-24D**	**MW-24**	34	24.0 - 34.0	10
Monitoring Well	**MW-30S**	**MW-30**	14.2	8.7 - 13.7	5
Monitoring Well	MW-30D	MW-30D	28.45	22.95 - 27.95	5
Monitoring Well	MW-32S	MW-32S	14.36	8.86 - 13.36	5
Monitoring Well	MW-32D	MW-32D	36.38	30.88 - 35.88	5
Monitoring Well	MW-33S	MW-33S	13.73	8.23 - 13.23	5
Monitoring Well	MW-33D	MW-33D	30.62	25.12 - 30.12	5
Monitoring Well	MW-34S	MW-34S	15	9.5 - 14.5	5
Monitoring Well	MW-34D	MW-34D	33	27.5 - 32.5	5
Monitoring Well	MW-35S	MW-35S	16	9.5 - 14.5	5
Monitoring Well	MW-35D	MW-35D	33	27.5 - 32.5	5
Monitoring Well	MW-36S	MW-36S	15	9.5 - 14.5	5
Monitoring Well	MW-36D	MW-36D	31	25.5 - 30.5	5
Monitoring Well	MW-37S	MW-37S	15	9.5 - 14.5	5
Monitoring Well	MW-37D	MW-37D	26.5	21.0 - 26.0	5
Monitoring Well	MW-38S	MW-38S	15	9.5 - 14.5	5
Monitoring Well	MW-38D	MW-38D	31	25.5 - 30.5	5
Monitoring Well	MW-39S	MW-39S	15	9.5 - 14.5	5
Monitoring Well	MW-39D	MW-39D	33	27.5 - 32.5	5
Monitoring Well	MW-40S	MW-40S	15	9.5 - 14.5	5
Monitoring Well	MW-40D	MW-40D	27.5	22.0 - 27.0	5
Monitoring Well	MW-41S	MW-41S	15.25	10.25 - 15.25	5
Monitoring Well	MW-41D	MW-41D	31.5	26.5 - 31.5	5
Monitoring Well	MW-46S	MW-46S	17	12.0 - 17.0	5
Monitoring Well	MW-46D	MW-46D	36	31.0 - 36.0	5
Monitoring Well	MW-47S	MW-47S	17	12.0 - 17.0	5
Monitoring Well	MW-47D	MW-47D	36	31.0 - 36.0	5
Monitoring Well	MW-53S	MW-53S	15	10.0 - 15.0	5
Monitoring Well	MW-53D	MW-53D	35	30.0 - 35.0	5
Monitoring Well	MW-54S	MW-54S	20	15.0 - 20.0	5
Monitoring Well	MW-54D	MW-54D	37	32.0 - 37.0	5
Monitoring Well	MW-55S	MW-55S	20	15.0 - 20.0	5
Monitoring Well	MW-55D	MW-55D	35	30.0 - 35.0	5
Monitoring Well	MW-57S	-	20	15.0 - 20.0	5
Monitoring Well	MW-57I	-	27	22.0 - 27.0	5
Monitoring Well	MW-57D	-	35	30.0 - 35.0	5

TABLE 6

PROPOSED WATER LEVEL DATA LOGGING WELLS

Former DuPont East Chicago Faclity

Well Type	Updated Well ID	Historic Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
Monitoring Well	MW-58S	-	20	15.0 - 20.0	5
Monitoring Well	MW-58I	-	27	22.0 - 27.0	5
Monitoring Well	MW-58D	-	35	30.0 - 35.0	5
Monitoring Well	MW-59S	-	20	15.0 - 20.0	5
Monitoring Well	MW-59D	-	35	30.0 - 35.0	5
Monitoring Well	MW-60S	-	20	15.0 - 20.0	5
Monitoring Well	MW-60D	-	35	30.0 - 35.0	5
Monitoring Well	MW-61S	-	20	15.0 - 20.0	5
Monitoring Well	MW-61D	-	35	30.0 - 35.0	5
Monitoring Well	MW-62S	-	15	10.0 - 15.0	5
Monitoring Well	MW-62D	-	33	28.0 - 33.0	5
Monitoring Well	MW-63S	-	33	28.0 - 33.0	5
Monitoring Well	MW-63D	-	15	10.0 - 15.0	5
Monitoring Well	MW-64S	-	15	10.0 - 15.0	5
Monitoring Well	MW-64D	-	33	28.0 - 33.0	5
Monitoring Well	MW-65S	-	20	15.0 - 20.0	5
Monitoring Well	MW-65D	-	35	30.0 - 35.0	5
Monitoring Well	MW-66S	-	20	15.0 - 20.0	5
Monitoring Well	MW-66I		27	22.0 - 27.0	5
Monitoring Well	MW-66D	-	35	30.0 - 35.0	5
Monitoring Well	MW-67S	-	20	15.0 - 20.0	5
Monitoring Well	MW-67I		27	22.0 - 27.0	5
Monitoring Well	MW-67D	-	35	30.0 - 35.0	5
Monitoring Well	MW-68S	-	15	10.0 - 15.0	5
Monitoring Well	MW-68D	-	34	29.0 - 34.0	5
Monitoring Well	MW-69S	-	15	10.0 - 15.0	5
Monitoring Well	MW-69D	-	32	27.0 - 32.0	5
Monitoring Well	MW-70S	-	15	10.0 - 15.0	5
Monitoring Well	MW-70D	-	32	27.0 - 32.0	5
Monitoring Well	MW-71S	-	15	10.0 - 15.0	5
Monitoring Well	MW-71D	-	32	27.0 - 32.0	5
PRB Well	PRB-8S	PRB-8S	15	10.0 - 15.0	5
PRB Well	**PRB-8D**	**PRB-8**	33.19	23.19 - 33.19	10
PRB Well	PRB-10S	-	15	10.0 - 15.0	5
PRB Well	**PRB-10D**	**PRB-10**	35.31	25.31 - 35.31	10
PRB Well	PRB-13S	PRB-13S	14.5	9.5 - 14.5	5
PRB Well	**PRB-13D**	**PRB-13**	33.09	23.09 - 33.09	10
PRB Well	PRB-14S	PRB-14S	14.75	9.75 - 14.75	5
PRB Well	**PRB-14D**	**PRB-14**	30.6	20.6 - 30.6	10
PRB Well	PRB-15S	PRB-15S	15.25	10.25 - 15.25	5
PRB Well	**PRB-15D**	**PRB-15**	33.82	23.82 - 33.82	10
PRB Well	PRB-16S	-	15	10.0 - 15.0	5
PRB Well	**PRB-16D**	**PRB-16**	34.78	24.78 - 34.78	10
PRB Well	PRB-17S	-	15	10.0 - 15.0	5
PRB Well	**PRB-17D**	**PRB-17**	35.36	25.36 - 35-36	10

TABLE 6

PROPOSED WATER LEVEL DATA LOGGING WELLS

Former DuPont East Chicago Faclity

Well Type	Updated Well ID	Historic Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
PRB Well	PRB-18S	PRB-18S	14.5	9.5 - 14.5	5
PRB Well	PRB-18D	PRB-18D	29.75	24.75 - 29.75	5
PRB Well	PRB-19S	PRB-19S	14	9.0 - 14.0	5
PRB Well	PRB-19D	PRB-19D	29.5	24.5 - 29.5	5
Piezometer	P-8	P-8	31	11.3 - 31.0	19.7
Piezometer	P-12	P-12	34	9.0 - 34.0	25
Piezometer	P-15	P-15	34	9.0 - 34.0	25
Piezometer	P-20	P-20	16	11.0 - 16.0	5
Piezometer	P-24	P-24	12	8.0 - 12.0	4

Notes:

Existing/Proposed "Shallow" Water Table Wells

Existing/Proposed "Intermediate" Water Table Wells

Existing/Proposed "Deep" Water Table Wells

Water Table Wells that are Screened within the "Shallow" and "Deep" Regimes

Proposed Monitoring Well Installation

TABLE 7

PROPOSED GROUNDWATER MONITORING WELL NETWORK

Former DuPont East Chicago Faclity

Well Type	Updated Well ID	Historic Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
Monitoring Well	MW-10S	-	15	10.0 - 15.0	5
Monitoring Well	MW-10D	-	34	29.0 - 34.0	5
Monitoring Well	MW-11S	-	15	10.0 - 15.0	5
Monitoring Well	MW-11D	-	32	27.0 - 32.0	5
Monitoring Well	MW-15S	-	15	10.0 - 15.0	5
Monitoring Well	MW-15D	-	35	30.0 - 35.0	5
Monitoring Well	MW-19S	-	15	10.0 - 15.0	5
Monitoring Well	MW-19D	-	33	28.0 - 33.0	5
Monitoring Well	MW-21D	-	34	29.0 - 34.0	5
Monitoring Well	MW-21S	-	15	10.0 - 15.0	5
Monitoring Well	MW-22D	-	33	28.0 - 33.0	5
Monitoring Well	MW-22S	-	15	10.0 - 15.0	5
Monitoring Well	MW-23S	-	15	10.0 - 15.0	5
Monitoring Well	**MW-23D**	**MW-23**	31	21.0 - 31.0	10
Monitoring Well	MW-24S	-	15	10.0 - 15.0	5
Monitoring Well	**MW-24D**	**MW-24**	34	24.0 - 34.0	10
Monitoring Well	MW-25S	-	15	10.0 - 15.0	5
Monitoring Well	**MW-25D**	**MW-25**	30	20.0 - 30.0	10
Monitoring Well	**MW-28S**	**-**	15	10.0 - 15.0	5
Monitoring Well	**MW-28D**	MW-28	32	22.0 - 32.0	10
Monitoring Well	**MW-30S**	**MW-30**	14.2	8.7 - 13.7	5
Monitoring Well	MW-30D	MW-30D	28.45	22.95 - 27.95	5
Monitoring Well	MW-34S	MW-34S	15	9.5 - 14.5	5
Monitoring Well	MW-34D	MW-34D	33	27.5 - 32.5	5
Monitoring Well	MW-35S	MW-35S	16	9.5 - 14.5	5
Monitoring Well	MW-35D	MW-35D	33	27.5 - 32.5	5
Monitoring Well	MW-41S	MW-41S	15.25	10.25 - 15.25	5
Monitoring Well	MW-41D	MW-41D	31.5	26.5 - 31.5	5
Monitoring Well	MW-42S	MW-42S	19.5	14.5 - 19.5	5
Monitoring Well	MW-42I	-	32	27.0 - 32.0	5
Monitoring Well	MW-42D	MW-42D	41	36.0 - 41.0	5
Monitoring Well	MW-43S	-	15	10.0 - 15.0	5
Monitoring Well	**MW-43D**	**MW-43**	36	28.0 - 33.0	5
Monitoring Well	MW-46S	MW-46S	17	12.0 - 17.0	5
Monitoring Well	MW-46D	MW-46D	36	31.0 - 36.0	5
Monitoring Well	MW-47S	MW-47S	17	12.0 - 17.0	5
Monitoring Well	MW-47D	MW-47D	17	31.0 - 36.0	5
Monitoring Well	MW-52S	MW-52S	15	10.0 - 15.0	5
Monitoring Well	MW-52D	MW-52D	35	30.0 - 35.0	5
Monitoring Well	MW-53S	MW-53S	15	10.0 - 15.0	5
Monitoring Well	MW-53D	MW-53D	35	30.0 - 35.0	5
Monitoring Well	MW-54S	MW-54S	20	15.0 - 20.0	5

TABLE 7

PROPOSED GROUNDWATER MONITORING WELL NETWORK

Former DuPont East Chicago Faclity

Well Type	Updated Well ID	Historic Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
Monitoring Well	MW-54D	MW-54D	37	32.0 - 37.0	5
Monitoring Well	MW-55S	MW-55S	20	15.0 - 20.0	5
Monitoring Well	MW-55D	MW-55D	35	30.0 - 35.0	5
Monitoring Well	MW-57S	-	20	15.0 - 20.0	5
Monitoring Well	MW-57I	-	27	22.0 - 27.0	5
Monitoring Well	MW-57D	-	35	30.0 - 35.0	5
Monitoring Well	MW-58S	-	20	15.0 - 20.0	5
Monitoring Well	MW-58I	-	27	22.0 - 27.0	5
Monitoring Well	MW-58D	-	35	30.0 - 35.0	5
Monitoring Well	MW-59S	-	20	15.0 - 20.0	5
Monitoring Well	MW-59D	-	35	30.0 - 35.0	5
Monitoring Well	MW-60S	-	20	15.0 - 20.0	5
Monitoring Well	MW-60D	-	35	30.0 - 35.0	5
Monitoring Well	MW-61S	-	20	15.0 - 20.0	5
Monitoring Well	MW-61D	-	35	30.0 - 35.0	5
Monitoring Well	MW-62S	-	15	10.0 - 15.0	5
Monitoring Well	MW-62D	-	33	28.0 - 33.0	5
Monitoring Well	MW-63S	-	33	28.0 - 33.0	5
Monitoring Well	MW-63D	-	15	10.0 - 15.0	5
Monitoring Well	MW-64S	-	15	10.0 - 15.0	5
Monitoring Well	MW-64D	-	33	28.0 - 33.0	5
Monitoring Well	MW-65S	-	20	15.0 - 20.0	5
Monitoring Well	MW-65D	-	35	30.0 - 35.0	5
Monitoring Well	MW-66S	-	20	15.0 - 20.0	5
Monitoring Well	MW-66I		27	22.0 - 27.0	5
Monitoring Well	MW-66D	-	35	30.0 - 35.0	5
Monitoring Well	MW-67S	-	20	15.0 - 20.0	5
Monitoring Well	MW-67I		27	22.0 - 27.0	5
Monitoring Well	MW-67D	-	35	30.0 - 35.0	5
Monitoring Well	MW-68S	-	15	10.0 - 15.0	5
Monitoring Well	MW-68D	-	34	29.0 - 34.0	5
Monitoring Well	MW-69S	-	15	10.0 - 15.0	5
Monitoring Well	MW-69D	-	32	27.0 - 32.0	5
Monitoring Well	MW-70S	-	15	10.0 - 15.0	5
Monitoring Well	MW-70D	-	32	27.0 - 32.0	5
Monitoring Well	MW-71S	-	15	10.0 - 15.0	5
Monitoring Well	MW-71D	-	32	27.0 - 32.0	5
PRB Well	PRB-10S	-	15	10.0 - 15.0	5
PRB Well	**PRB-10D**	PRB-10	35.31	25.31 - 35.31	10
PRB Well	PRB-13S	PRB-13S	14.5	9.5 - 14.5	5
PRB Well	**PRB-13D**	**PRB-13**	33.09	23.09 - 33.09	10

TABLE 7

PROPOSED GROUNDWATER MONITORING WELL NETWORK

Former DuPont East Chicago Faclity

Well Type	Updated Well ID	Historic Well ID	Reported Well Depth (ft. BSG)	Reported Screen Interval (ft. BSG)	Reported Screen Length (Ft.)
PRB Well	PRB-14S	PRB-14S	14.75	9.75 - 14.75	5
PRB Well	**PRB-14D**	**PRB-14**	30.6	20.6 - 30.6	10
PRB Well	PRB-15S	PRB-15S	15.25	10.25 - 15.25	5
PRB Well	**PRB-15D**	**PRB-15**	33.82	23.82 - 33.82	10
PRB Well	**PRB-16D**	**PRB-16**	34.78	24.78 - 34.78	10
PRB Well	PRB-16S	-	15	10.0 - 15.0	5
PRB Well	**PRB-17D**	**PRB-17**	35.36	25.36 - 35-36	10
PRB Well	PRB-17S	-	15	10.0 - 15.0	5
PRB Well	PRB-18S	PRB-18S	14.5	9.5 - 14.5	5
PRB Well	PRB-18D	PRB-18D	29.75	24.75 - 29.75	5
PRB Well	PRB-19S	PRB-19S	14	9.0 - 14.0	5
PRB Well	PRB-19D	PRB-19D	29.5	24.5 - 29.5	5

Notes:

Existing/Proposed "Shallow" Water Table Wells

Existing/Proposed "Intermediate" Water Table Wells

Existing/Proposed "Deep" Water Table Wells

Proposed Monitoring Well Installation

TABLE 8

ESTIMATED SOURCE AREA VOLUME CALCULATIONS

Former DuPont East Chicago Faclity

			CMS Excavation Area Soil Profiling		VS.	CMS			CMS
Location at Site	**Area Number**	**Sum Area Square Feet**	**Depth (Estimated Depth of Max. As or Pb Concentration for Waste Profiling & Disposal Costs)**	**Cubic Yards**	**VS.**	**Depth (Dependent on As Concentration > 1000 mg/Kg)**	**Cubic Yards to Excavate**		**ISS Cubic Yards**
PRB	1	87237.30	3.00	9683.34		Depth Range: Excavation = 0 to 6 ft bgs ISS = 6 to 10 ft bgs	6462.02		
	2	7019.68	3.00	779.18			519.98		
	3	15418.89	3.00	1711.50			1142.14		
	4	47405.21	3.00	5261.98			3511.50		
	5	4982.26	3.00	553.03			369.06		
	6	23655.36	3.50	3063.37			3504.50		2860.45
	7	50214.74	3.00	5573.84			7439.22		
	8	18969.77	3.00	2105.64			3967.63		1276.44
			PRB CY Total:	28,731.88	**VS.**		26,916.04		4,136.89
SWMU 4	9	19479.34	3.50	2522.58		Depth Range: Excavation = 0 to 4 ft bgs ISS = 4 to 10 ft bgs	1442.91		1879.32
	10	15899.17	3.00	1764.81			2355.43		626.49
	11	132306.85	3.00	14686.06			17007.90		10023.06
			SWMU 4 CY Total:	18,973.44	**VS.**		20,806.24		12,528.87
			PRB + SWMU 4 CY Total:	47,705.32			47,722.28		16,665.76
Grace	12	56.30	2.00	3040.00		No source areas with concentrations of Arsenic > 1000 mg/kg, thus no excavation proposed in CMS			
	13	32.57	1.50	1319.00					
	14	44.02	2.00	2377.00					
	15	33.98	2.00	1835.00					
	16	23.65	2.00	1277.00					
	17	11.31	2.00	611.00					
	18	5.63	2.00	304.00					
	19	20.81	2.00	1124.00					
	20	39.91	2.00	2155.00					
			Grace CY Total:	14,042.00	**VS.**		0.00		0.00
			All Areas Grand CY Total:	61,747.32	**VS.**		47,722		16,666

Volume calculations provided by Parson based on data within the Technical Memorandum dated May 29, 2018, CMS dated March 2015 and an Addendum to the CMS dated October 2016

TABLE 9

EX-SITU SOIL TREATMENT DOSAGE CALCULATIONS

Former DuPont East Chicago Facility

Lead Hazardous Grid				
Excavation Area	Grid	What Metals is TCLP Hazardous	Soil Volume (CY)	Approx. Mass in Tons (Assume 1.4 tons/CY)
1	1A	lead	2500	3500
1	1C	lead	2500	3500
1	1D	lead	2500	3500
2	2	lead	2500	3500
3	3	lead	2500	3500
4	4A	lead	2500	3500
4	4B	lead	2500	3500
6	6A	lead	2500	3500
7	7A	lead	2500	3500
8	8	lead	2500	3500
11	11B	lead	2500	3500
11	11C	lead	2500	3500
11	11E	lead	2500	3500
12	12A	lead	2500	3500
13	13	lead	2500	3500
14	14	lead	2500	3500
Totals	**16 grids**	lead	**40000**	**56000**
			*** Estimated TerraBond Dose Rate**	**3%**
			Estimated Tons of TerraBond for lead only grids	**1680**

Lead and Cadmium Hazardous Grids				
Excavation Area	Grid	What Metals is TCLP Hazardous	Soil Volume (CY)	Approx. Mass in Tons (Assume 1.4 tons/CY)
6	6B	lead & cadmium	2500	3500
7	7B	lead & cadmium	2500	3500
Totals	**2 grids**	lead & cadmium	**5000**	**7000**
		*** Estimated TerraBond Dose Rate**		**3%**
		*** Estimated Tons of TerraBond for lead + cadmium Grids**		**210**
		Estimated Additional TerraBond-FBA Dose Rate		**2%**
		Estimated Tons of TerraBond-FBA lead + cadmium Grids		**140**

Arsenic Hazardous Grid				
11	11f	arsenic	2500	**3500**
			Estimated FerroBlack Dose Rate	**2%**
			Estimated Tons of FerroBlack for arsenic only Grid	**70**

Estimated Total Cubic Yards Treated	**47,500**
Estimated Soil Tons Treated	**66,500**
*** Total Estimated TerraBond Tons**	**1,890**
*** Total Estimated TerraBond FBA Tons**	**140**
*** Total Estimated FerroBlack Tons**	**70**

*Notes:

* Hazardous Grid Identification and Quantities taken from Parson May, 29, 2018 Technical Memorandum
* Assumed soil density 1.4 tons/CY
* Potentially Hazardous Grids 1B, 5, 9, 11A, and 11D are not included in this estimate (additional potenital quantity of 17,500 tons)
* Dosages and volumes provided by Remedium Services Group, LLC (dba Terra Materials) based on Data collected from Parsons Technical Memorandum dated May 29, 2018.

EXHIBITS

Former DuPont East Chicago Facility

Exhibit 1: CMI Phased Remedial Design Approach Diagram
Exhibit 2: Project Sequencing Flow Diagram
Exhibit 3: Project Organization Chart
Exhibit 4: Project Schedule
Exhibit 5: Soil Treatment and Disposal Process Diagram
Exhibit 6: Waste Manifest
Exhibit 7: LVA Manufacture Process Flow Diagram
Exhibit 8: Donor Source Profile Form
Exhibit 9: Sample Transportation and Disposal Notification
Exhibit 10: Transportation Charter
Exhibit 11: Air Emission Inventory

PHASED REMEDIAL APPROACH DIAGRAM

Construction & Redevelopment Progression

Corrective Measures Implementation Process

Mobilization/Clearing
- Equipment Mobilization
- Clearing and Grubbing

Survey Work
- GPR / Markouts
- Well Viability
- SA Boundaries GIS/GPS
- TOC / Elevation Survey

Baseline Groundwater Sampling
- Install/ Development
- Sampling
- Data Logger Install

Geotechnical Investigation
- Geotech Borings
- ISS Optimization/ Dosage

Landfill BUD Study
- Landfill Evaluation
- Geotechnical
- LVA Application

Permeable Barrier Cover
- Equipment Mobilization
- Material Import
- LVA Processing
- Placement/ Compaction

Preliminary Groundwater Treatment
- Equipment Mobilization
- ISCF Injections
- ROI Eval/ Optimization

Source Areas Work
- Remedial Excavation
- ISS of Saturated Soils
- Material Treatment
- Loadout/ Disposal

Concrete Removal
- Slab/ Subsurface Survey
- Concrete Removal
- LVA Processing

Performance Monitoring
- Monitoring SA work
- Monitoring Preliminary Groundwater Treatment
- Short-term Goal Evaluation

Remedial Construction Phase I

Full-Scale Groundwater Treatment
- Treatment System Installation
- Biowall Installation

Hydrogeologic Study
- Fate and Transport
- Development Influences
- Treatment Contingencies
- Full-scale Modifications

Final Permeable Barrier Cover Grading
- Placement/ Compaction
- Final Grading/ Elevations
- Seeding/ Stabilization

Full-Scale Performance Monitoring
- Routine Sampling
- Operation and Maintence
- Long-term Goal Evaluation

Landfill Closure
- Landfill Modification
- Landfill IDEM Closure

Building Construction
- Foundation/ Slab Construction
- Vapor Barrier Install
- Hydraulic Control Systems

Long-term Monitoring and Maintence Period
- Long-term Performance Monitoring / Evaluation of Achieving Long-term Goals
- Long-term Maintence of Groundwater Treatment Systems
- Contingency/ Modification of Groundwater Treatment due to Development
- Landfill Long-term Monitoring

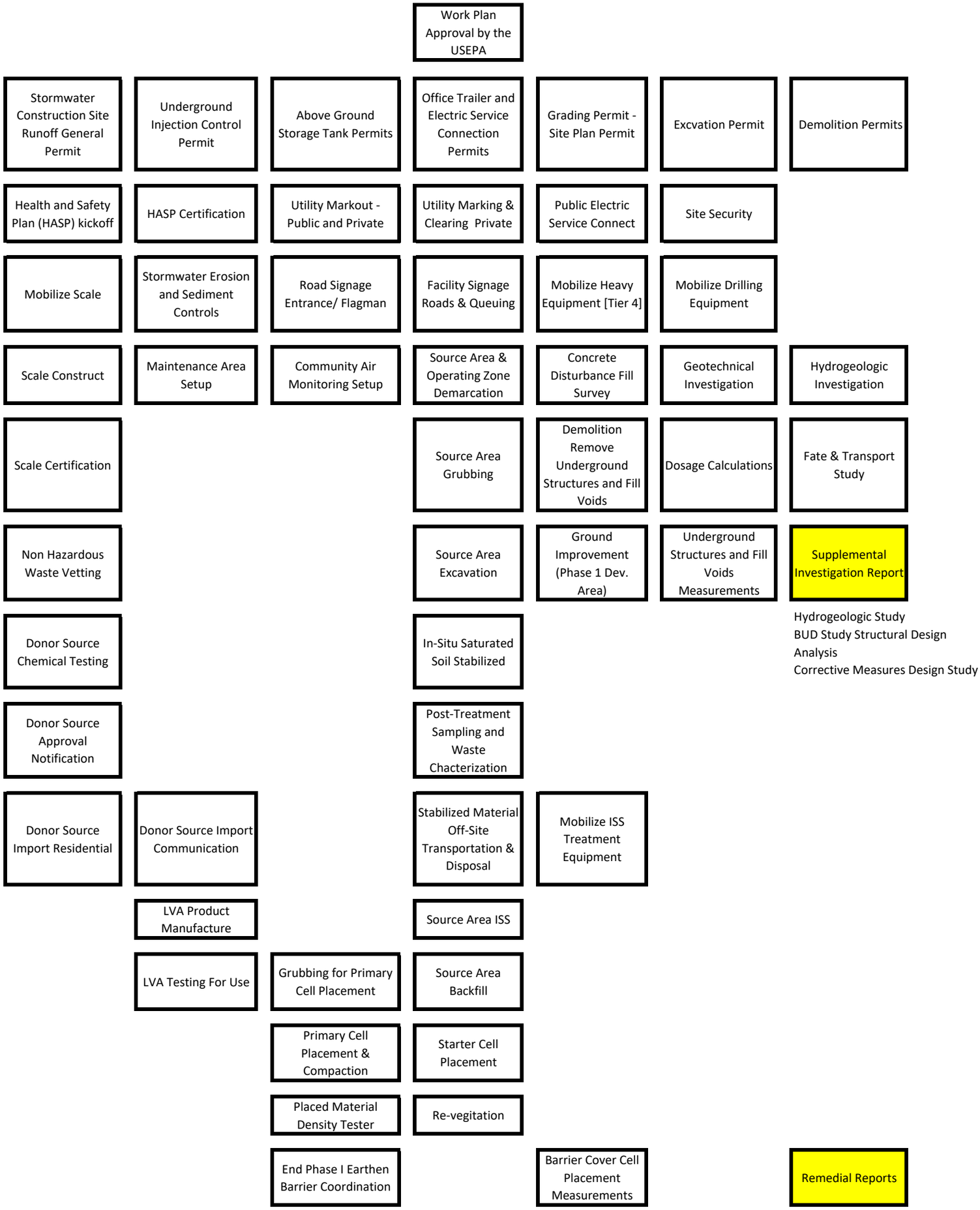
Remedial Construction Phase II

Remedial Tasks

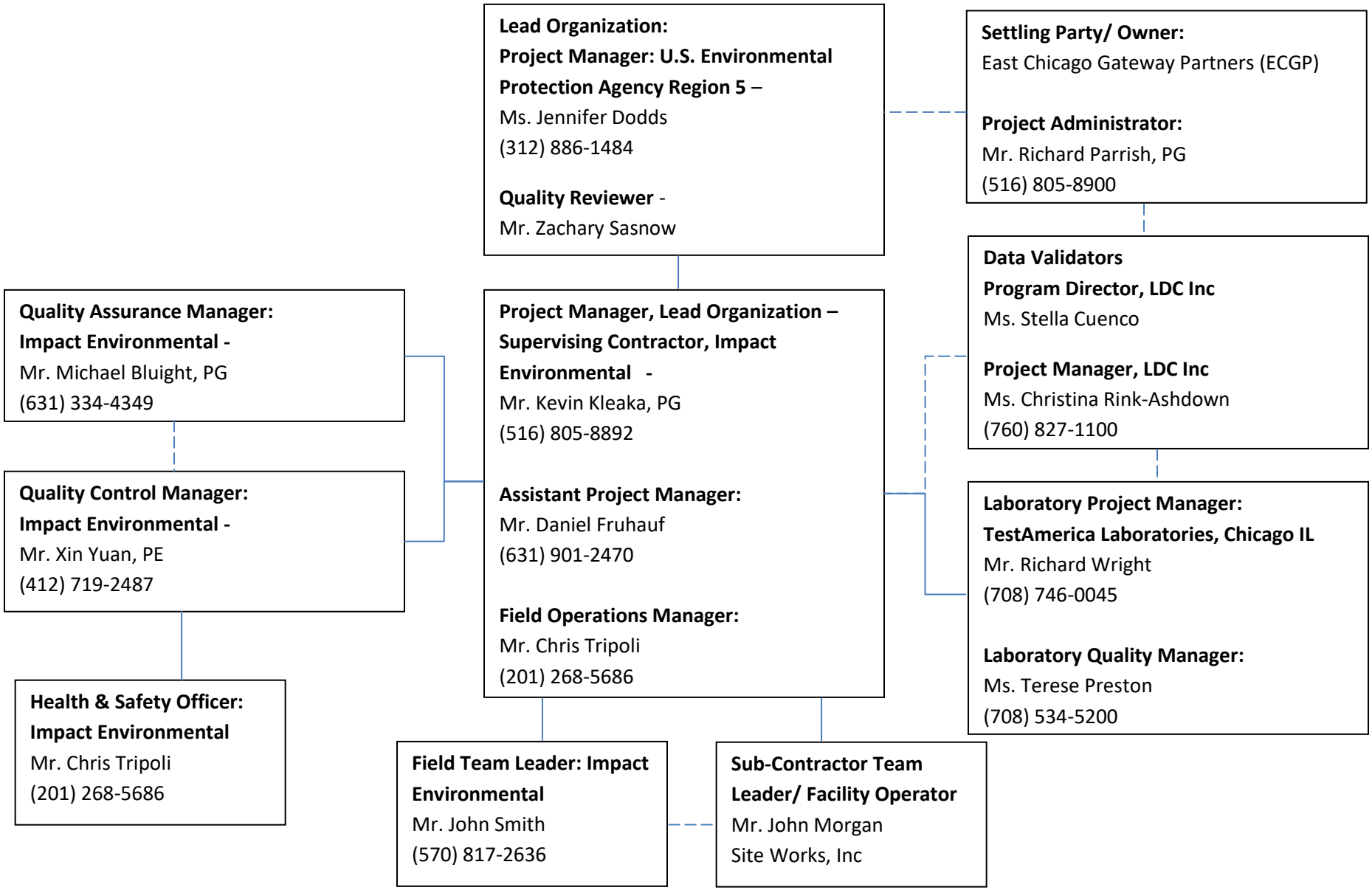
Development Tasks

PROJECT SEQUENCING FLOW DIAGRAM

Former DuPont East Chicago Facility



Project Organization and Project Team



Project Team List

QAPP Recipients	Title	Organization	Telephone Number	E-mail Address
Jennifer Dodds	Project Manager	EPA, Region 5	Office: (312) 886-1484	dodds.jennifer@epa.gov
Mr. Zachary Sasnow	Quality Reviewer	EPA, Region 5	Office: (312) 886-1484	None
Richard Parish	Project Administrator	ECGP	Office: (631) 805-8900	rich@impactenvironmental.com
Kevin Kleaka	Project Manager	Impact Environmental	Office: (631) 269-8800 x129	kkleaka@impactenvironmental.com
Daniel Fruhauf	Assistant Project Manager	Impact Environmental	Office: (631) 269-8800 x141	dfruhauf@impactenvironmental.com
Chris Tripoli	Field Operations Manager	Impact Environmental	Office: (201) 268-5686	ctripoli@impactenvironmental.com
Michael Bluight	Quality Assurance Manager	Impact Environmental	Office: (516) 269-8800 x118	mbluight@impactenvironmental.com
Xin Yuan	Quality Control Manager	Impact Environmental	Office: (516) 269-8800 x111	xyuan@impactenvironmental.com
Richard Wright	Laboratory Project Manager	TestAmerica Laboratories, Inc	Office: (708) 746-0045	Richard.Wright@testamericainc.com
Terese Preston	Laboratory Quality Manager	TestAmerica Laboratories, Inc	Office: (708) 534-5200	Terese.Preston@testamericainc.com
Christina Rink-Ashdown	Data Validator	LDC	Office: 760-827-1100	Crink-ashdown@lab-data.com

East Chicago Field Activity Schedule

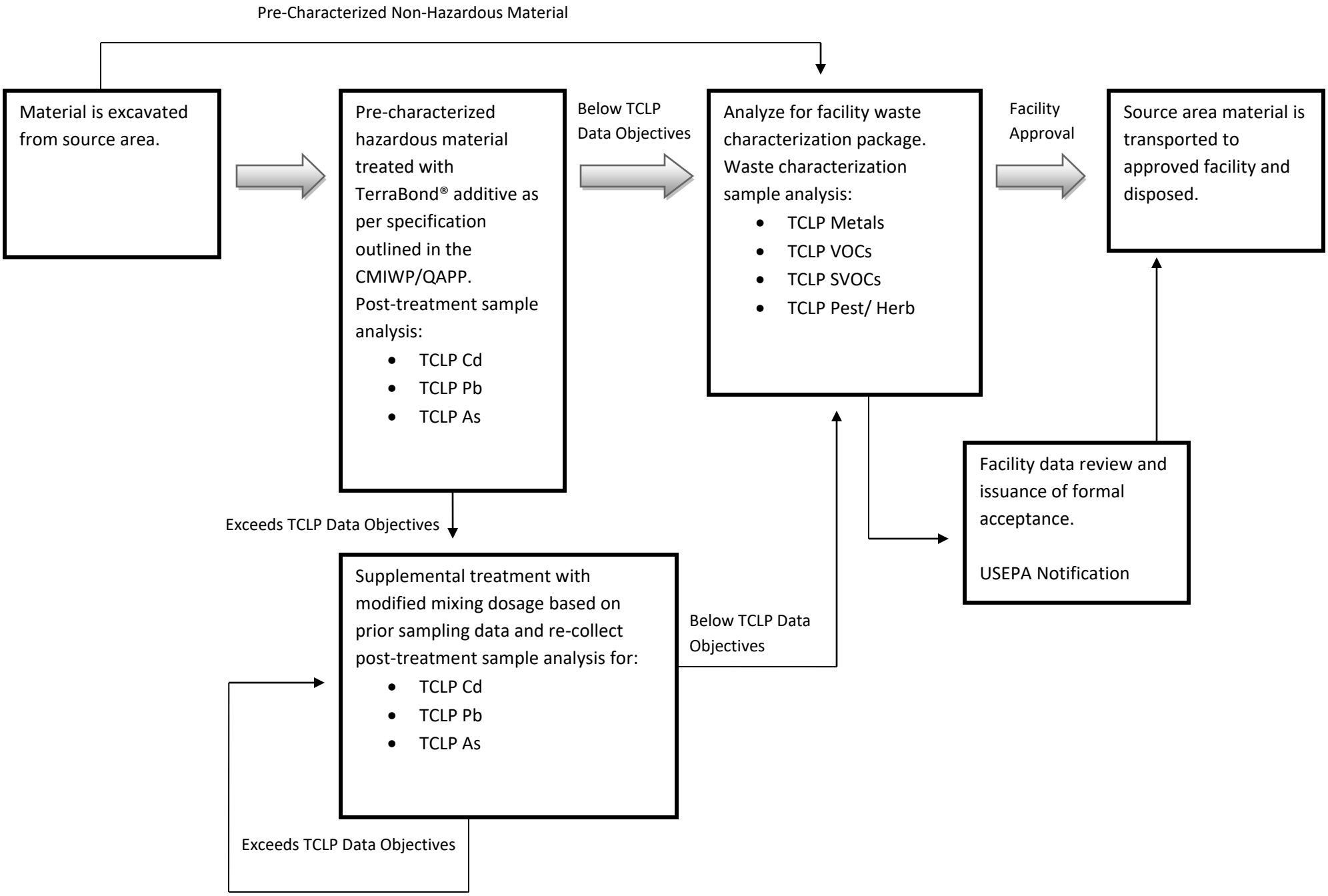
	Task Name
1	Soil: Permeable Cover and Source Area Soil Excavation, In-situ Stabilization of Saturated Soil and Excavated Soil Treat
2	Site Reconnaissance/ IDW Areas, Site Mobilization
3	Surface Grubbing and Clearing
4	Baseline Groundwater Monitoring Event
5	Site Reconnaissance/ Well Viability Survey
6	Markouts and GPR for Well Install Locations
7	Well Installation and Development
8	Top of Casing Survey
9	Baseline Groundwater Sample Collection
10	Source Area Excavation, Treatment & Disposal
11	Source Area GPS Boundary Marking
12	Equipment Mobilization/ Site Prep
13	Public/ Private Utility Markout/ GPR Survey
14	Source Area Excavations
15	Excavation of Northern Source Areas
16	Excavation of Southern Source Areas
17	Excavation of Leased Area Source Areas
18	On-site Soil Treatment Prior to Disposal Off-site
19	Load out/ Off-site Disposal of Contaminated Soil
20	Backfill Source Area locations/ Regrading / Compaction
21	Source Area Saturated Soil In-Situ Stabilization
22	Equipment Mobilization/ Feeding System
23	In-situ Stabilization of Northern Saturated Soil
24	In-situ Stabilization of Southern Saturated Soil
25	Northern Source Area Removal/ ISS Treatment Performance Monitoring
26	1st Northern Performance Monitoring Event
27	2nd Northern Performance Monitoring Event
28	3rd Northern Performance Monitoring Event
29	4th Northern Performance Monitoring Event
30	Southern Source Area Removal/ ISS Treatment Performance Monitoring
31	1st Southern Performance Monitoring Event
32	2nd Southern Performance Monitoring Event
33	3rd Southern Performance Monitoring Event
34	4th Southern Performance Monitoring Event
35	Permeable Soil Cover
36	Equipment Mobilization/ Site Prep/ Scales
37	Importation of Material
38	LVA Manufacturing and Production
39	Soil/ LVA Placement and Compaction
40	Groundwater: In-situ Chemical Fixation via Enhanced Sulfate Reduction Injections and Bio-Wall
41	Install Data Loggers
42	Continuous Water Level Data Logging
43	Preliminary Groundwater Treatment (CPS 6.0)/ Full Scale Implementation
44	Preliminary Groundwater Treatment (CPS 6.0) Mobilization
45	Northern PGT Injections (CPS 6.0)
46	Southern PGT Injections (CPS 6.0)
47	Pneumatic Slug Testing (PST)
48	PGT (CPS 6.0) Performance Monitoring
49	1st PGT Performance Monitoring Event (4mo.)
50	2nd PGT Performance Monitoring Event (8 mo.)
51	3rd PGT Performance Monitoring Event (12 mo.)
52	Full Scale Injection/ Groundwater Treatment Mobilization
53	Full Scale Injection System Assembly and Testing
54	Full Scale Injection/Monitoring Well Installation and Development
55	Northern Enhanced Microbial Sulfate Reduction Injections
56	Southern Enhanced Microbial Sulfate Reduction Injections
57	Bio-Wall Barrier Installation
58	Groundwater Treatment Performance Monitoring
59	1st Performance Monitoring Event
60	2nd Performance Monitoring Event
61	3rd Performance Monitoring Event
62	4th Performance Monitoring Event
63	Contingency GW Treatment
64	Site Redevelopment / Construction Activities
65	Markouts/ Geotechnical Investigation
66	Gary Road Access/ Improvement
67	Equipment Mobilization/Setup
68	Access Roadway Construction
69	Phase 2 Mobilization of LVA/ Cap Construction Operations
70	Concrete Survey
71	Concrete Survey Work
72	Ground Penetrating Radar Survey
73	Concrete Removal/ Underground Demo
74	Equipment Mobilization/Setup
75	Concrete Sampling
76	Soil Excavation/Concrete Removal
77	Decontamination/ Underground Utility Demo
78	Solid Waste Landfill Closure
79	Landfill Modification for Redevelopment
80	BUD Investigation Study
81	Excavation, Relocation, Grading and Compaction
82	Final Solid Waste Closure
83	Clay Cap/ Drainage/Geo and Seeding
84	Building Construction (est. March 2023)
85	Geotechnical Stabilization/ Compaction and Surcharging
86	Construction Equipment Mobilization
87	Building 1 Slab/ Foundation Construction (+Vapor Barrier)
88	Building 2 Slab/ Foundation Construction (+Vapor Barrier)
89	Building 3 Slab/ Foundation Construction (+Vapor Barrier)
90	Building 1 Vertical Construction
91	Building 2 Vertical Construction
92	Building 3 Vertical Construction

Q2 2019 Apr May Jun | Q3 2019 Jul Aug Sep | Q4 2019 Oct Nov Dec | Q1 2020 Jan Feb Mar | Q2 2020 Apr May Jun | Q3 2020 Jul Aug Sep | Q4 2020 Oct Nov Dec | Q1 2021 Jan Feb Mar | Q2 2021 Apr May Jun | Q3 2021 Jul Aug Sep | Q4 2021 Oct Nov Dec | Q1 2022 Jan Feb Mar | Q2 2022 Apr May Jun | Q3 2022 Jul Aug Sep | Q4 2022 Oct Nov Dec | Q1 2023 Jan Feb Mar | Q2 2023 Apr May Jun | Q3 2023 Jul Aug Sep | Q4 2023 Oct Nov Dec | Q1 2024 Jan Feb Mar | Q2 2024 Apr May Jun | Q3 2024 Jul Aug Sep

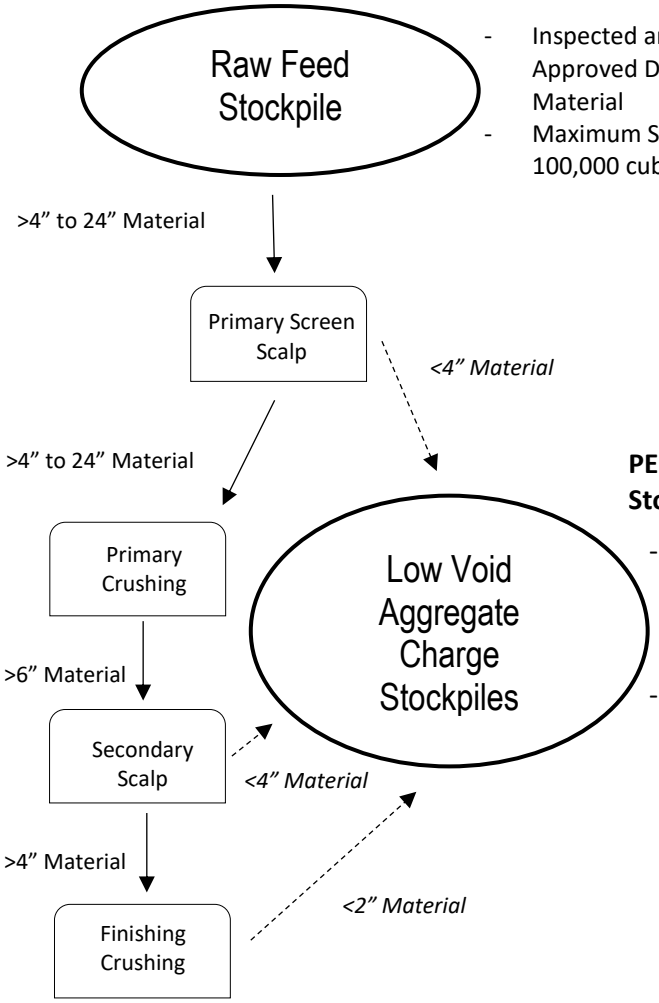
Schedule as of 6/21/19 - Subject to Change with EPA approval

SOIL TREATMENT AND DISPOSAL FLOW DIAGRAM

Former DuPont East Chicago Facility



DONOR SOURCE MATERIAL ACCEPTANCE PROTOCOL



- Inspected and Approved Donor Source Material
- Maximum Storage 100,000 cubic yards

PERFORMANCE CRITIERIA - LVA Charge Stockpile Testing

- Tested to determine use in Barrier Cover Cells
- Maximum Storage 60,000 cubic yards

NON HAZARDOUS WASTE MANIFEST

#

GENERATOR

Site Owner (Generator) Name & Address:
Former DuPont East Chicago -RCRA Closure Site
East Chicago Gateway Partners, LLC
8 The Green - Suite B
Dover, DE 19901

Site Location & Address:
5135 Kennedy Avenue
East Chicago, IN 46312
p/o Lake County Parcel Numbers: 45-03-33-251, 276 and 300

Certification: *By signing in the space below, I hereby certify that the waste coming from the above-named Site is being moved with the knowledge and consent of the Site Owner. I have been authorized on behalf of the Site Owner and waste generator to witness the proper removal, loading and off-site management of the waste, and to evidence the same by signing this transport charter. I understand that by signing this form, I am acknowledging that the waste has been tested or demonstrated to be free of contaminants at concentrations in excess of the permitted levels of the Receiving Facility listed on Part 3 of this form. Further, I understand that this form is not evidence of the receipt of the waste at the Receiving Facility. This document bears no form field or area in which to list the weight or volume of waste being transported. Consequently, this form CANNOT be used to evidence the disposal of the waste. Only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of waste to the Receiving Facility. Further, I certify that if the load is rejected at the Receiving Facility, for any reason, I will accept it back to the Site.*

Description of Non Hazardous Waste - Material/Classification:

Associated Testing (Optional):

Site Owner Authorized Agent Name | Signature of Site Owner/Agent | Shipment Date | Shipment Time

TRANSPORTER

Transporter Name, Address and Permit # (if applicable):

Driver Name (PRINT):

Driver License Expiration Date:

Vehicle License #/State: Truck#:

Certification: By signing in the space below, I hereby certify that the above-named waste was picked up at the location listed in Part 1 above. I understand that I am responsible for any deviation in waste location. Further, by signing this form I, as driver for Hauler, am solely responsible for the amount and weight of waste that is being transported as well as the methods and means for its safe travel.

Certification: *By signing in the space below, I hereby certify that the above-named waste was delivered without incident from the Site listed in Part 1 above to the Receiving Facility listed below and remained secure and unaltered throughout the entire duration of transportation. Further, if the load is rejected, I will immediately return the waste to the Site location presented in Part 1 above.*

Driver Signature for Certification | Date

Driver Signature for Certification | Date

RECEIVING FACILITY

Receiving Facility Name:

Facility Address:

Name of Authorized Recipient:

Date of Receipt:

Time of Receipt:

SCALE TICKET NUMBER:

Certification: *By signing in the space below, I hereby certify that the above-named waste arrived at this Receiving Facility on the date listed. I have advised the Driver listed in Part 2 of this form that this charter CANNOT be used to evidence the disposal/beneficial use of the waste; only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of waste to the Receiving Facility.*

Name of Receiving Facility Agent | Signature of Receiving Facility Agent | Receipt Date

DONOR SOURCE APPLICATION FORM

EAST CHICAGO LOGISTICS CENTER REDEVELOPMENT PROJECT, EAST CHICAGO, IN

(PLEASE PRINT OR TYPE – ATTACH ADDITIONAL SHEETS IF NECESSARY)

PROJECT INFORMATION

1) NAME, ADDRESS AND TELEPHONE NUMBER OF DONOR SOURCE OWNER/GENERATOR:

NAME: _____ ADDRESS:
TEL: _____

2) SOURCE NAME AND PHYSICAL LOCATION OF DONOR SOURCE (INCLUDE LOT AND BLOCK):

NAME: _____ ADDRESS:
LOT: _____ BLOCK: _____

3) VOLUME SUBJECT OF THIS APPLICATION:

_____

4) DESCRIBE BOTH CURRENT AND HISTORIC LAND USES OF THE SITE FROM WHICH THE MATERIAL WAS GENERATED, THE PROCESS BY WHICH THE MATERIAL WAS GENERATED AND/OR THE CHARACTERISTICS OF THE MATERIAL.

5) DESCRIBE ANY REGULATORY (ENVIRONMENTAL) INVOLVEMENT IN THE PROJECT.

6) DESCRIBE THE OPERATIONAL CONTROLS TO BE TAKEN DURING THE HANDLING AND TRANSPORTATION OF THE MATERIAL TO MINIMIZE ENVIRONMENTAL AND HUMAN IMPACTS:

7) DEFINE THE TYPE OF SOLID WASTE – IF MIXTURE, INCLUDE EACH COMPONENTS % OF THE WHOLE:

□ VIRGIN CLEAN FILL – INCLUDING UNCONTAMINATED INERT ROCK, SOIL GRAVEL, AND SAND. _____%

□ RECYCLED MASONRY - CRUSHED BRICK, CONCRETE, BROKEN GLASS (NO DEMOLITION WASTE OR DELETERIOUS MATERIAL). _____%

□ CONSTRUCTIONS BORROW - MEETING FACILITY ACCEPTANCE CRITERIA – INCLUDING SOIL, GRAVEL, BRICK, AND CONCRETE MATERIAL FROM CONSTRUCTION PROJECTS (NO DEMOLITION WASTE OR DELETERIOUS MATERIAL). _____%

□ OTHER, DESCRIBE -

_____

_____ _____%

8) INDICATE THE ITEMS CONSIDERED FOR REFERECE WITH THIS APPLICATION:

☐ A SITE MAP OF THE LOCATION OF THE SITE OF ORIGIN (Donor Source Location).

☐ A SAMPLING PLAN FOR ALL SAMPLES THAT WILL BE OBTAINED FROM THE PROPOSED MATERIAL, INCLUDING A SITE MAP DEPICTING SAMPLE LOCATIONS, SAMPLING FREQUENCY AND COMPOSTING FREQUENCY.

☐ ALL LABORATORY REPORTS PREPARED BY THE COMMERCIAL TESTING LABORATORY, INCLUSIVE OF CHAIN OF CUSTODY DOCUMENTATION.

☐ ANY TABULATED SUMMARY SPREADSHEETS SUMMARIZING THE DATA ON THE LAB REPORTS.

☐ ALL AVAILABLE ENVIRONMENTAL OR GEOTECHNICAL REPORTS WITH RESPECT TO THE SITE AND OR SITES THAT WHERE THE WASTE WAS GENERATED.

9) NAME, ADDRESS AND TELEPHONE NUMBER OF THE LABORATORY:

NAME: _____

ADDRESS: _____

LAB NO.: _____

10) LIST THE SAMPLE NAMES/ID#'S FOR ALL SAMPLES INCLUDED OR REFERENCED WITHIN THE LABORATORY REPORT(S) AND SUBMITTED FOR CONSIDERATION AS PART OF THIS APPLICATION (ATTACH ADDITIONAL SHEET IF NECESSARY)**:**

11) LIST THE SAMPLE NAMES/ID#'S FOR ALL SAMPLES INCLUDED OR REFERENCED WITHIN THE LABORATORY REPORT(S) AND <u>NOT</u> SUBMITTED FOR CONSIDERATION AS PART OF THIS APPLICATION (ATTACH ADDITIONAL SHEET IF NECESSARY)**:**

12) INFORMATION OF THE COMPANY THAT PERFORMED THE SAMPLING:

NAME: _____ ADDRESS:

TEL: _____

13) IS THE PROPOSED MATERIAL CLASSIFIED AS A HAZARDOUS WASTE BY TOXICITY OR BY DEFINITION?

☐ YES ☐ NA ☐ NO

CHAIN OF PAYMENT

IN ORDER, STARTING WITH THE OWNER/GENERATOR AND ENDING WITH THE COMPANY TO BE BILLED FOR LOADS OF WASTE RECEIVED, PROVIDE THE CHAIN OF PAYMENT. THIS INFORMATION WILL NOT BE USED TO CIRCUMVENT ANY PARTIES INVOLVED IN THE TRANSACTION.

OWNER/, NAME AND CONTACT #:

IF APPLICABLE, TIER 1 CONTRACTOR/BROKER, NAME AND CONTACT #:

BILLING ENTITY, NAME AND CONTACT #:

CERTIFICATION

I CERTIFY UNDER PENALTY OF LAW THAT I AM THE OWNER/GENERATOR OF THE SOLID WASTE REFERENCED WITHIN THIS APPLICATION, AND THAT I HAVE PERSONALLY EXAMINED AND AM FAMILIAR WITH THE INFORMATION SUBMITTED IN THIS DOCUMENT AND ALL ATTACHMENTS AND THAT, BASED ON MY INQUIRY OF THOSE INDIVIDUALS IMMEDIATELY RESPONSIBLE FOR OBTAINING THE INFORMATION, I BELIEVE THAT THE INFORMATION IS TRUE, ACCURATE AND COMPLETE.

I AM AWARE THAT THERE ARE SIGNIFICANT PENALITIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBLITY OF FINES AND IMPRISONMENT. I UNDERSTAND THAT, IN ADDITION TO CRIMINAL PENALITIES, I MAY BE LIABLE FOR A CIVIL ADMINISTRATIVE PENALTY PURSUANT TO APPLICABLE LAW AND THAT SUBMITTING FALSE, INACCURATE, OR INCOMPLETE INFORMATION MAY BE GROUNDS FOR DENIAL, REVOCATION, OR TERMINATION OF ANY SOLID WASTE FACILITY PERMIT, LICENSE, OR OTHER OPERATING AUTHORITY FOR WHICH I MAY BE SEEKING APPROVAL OR NOW HOLD.

NAME AND ADDRESS OF OWNER /GENERATOR (PERSONAL OR CORPORATE):

NAME: _____

ADDRESS: _____

TEL: _____

PRINTED NAME OF OWNER/GENERATOR: _____

SIGNATURE OF OWNER/GENERATOR: _____ DATED _____

Project #" Job #"; "*Site Address*" Transportation & Disposal Notification for "*Date*"

This is a transportation notification/confirmation for a project. It is intended as a courtesy and does not represent substantive information with respect to the project. Information contained herein should be verified by telephone. Further, receipt of this notice does not guarantee acceptance into the referenced facility.

PJT #	SITE ADDRESS	MATERIAL	FACILITY	TRUCKER	# TRUCKS	RDS	START TIME	COMPANY MANAGING	JOB TYPE

This email is intended to be reviewed in HTML format. If your device is unable to accept HTML formatted email, please notify accordingly

TRANSPORT CHARTER – NOT FOR USE AS SCALE TICKET

#

GENERATOR

Donor Source Owner & Address:

Donor Source Location & Address:

Certification: By signing in the space below, I hereby certify that the Material coming from the above-named Donor Source owner and location is being moved with the knowledge and consent of the Donor Source owner who is the generator. I have been authorized on behalf of the Donor Source owner to witness the proper removal, loading and off-site management of the Material, and to evidence the same by signing this transport charter. I understand that by signing this form, I am acknowledging that the Material has been tested or demonstrated to be free of contaminants at concentrations in excess of the permitted levels of the Receiving Facility listed on Part 3 of this form. Further, I understand that this form is not evidence of the receipt of the Material at the Receiving Facility. This document bears no form field or area in which to list the weight or volume of material being transported. Consequently, this form CANNOT be used to evidence the disposal of the Material. Only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of Material to the Receiving Facility. Further, I certify that if the load is rejected at the Receiving Facility, for any reason, I will accept it back to the Donor Source location, unconditionally.

Description of Material/Classification:

Associated Testing (Optional):

Donor Source Authorized Agent Name | Signature of Donor Source Owner/Agent | Shipment Date | Shipment Time

TRANSPORTER

Transporter Name, Address and Permit # (if applicable):

Driver Name (PRINT):

Driver License Expiration Date:

Vehicle License #/State: Truck#:

Certification: By signing in the space below, I hereby certify that the above-named Material was picked up at the Donor Source location listed in Part 1 above. I understand that I am responsible for any deviation in Donor Source location. Further, by signing this form I, as driver for Hauler, am solely responsible for the amount and weight of Material that is being transported as well as the methods and means for its safe travel.

Certification: By signing in the space below, I hereby certify that the above-named Material was delivered without incident from the Donor Source Location listed in Part 1 above to the Receiving Facility listed below and remained secure and unaltered throughout the entire duration of transportation. Further, if the load is rejected, I will immediately return the Material to the Donor Source Location presented in Part 1 above.

Driver Signature for Certification | Date

Driver Signature for Certification | Date

RECEIVING FACILITY

Receiving Facility Name:

Facility Address:

Name of Authorized Recipient:

Date of Receipt:

Time of Receipt:

SCALE TICKET NUMBER:

Certification: By signing in the space below, I hereby certify that the above-named Material arrived at this Receiving Facility on the date listed. I have advised the Driver listed in Part 2 of this form that this charter can NOT be used to evidence the disposal/beneficial use of the Material; only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of Material to the Receiving Facility.

Name of Receiving Facility Agent | Signature of Receiving Facility Agent | Receipt Date

AIR EMISSION INVENTORY TOTALS

Sum of Potential Emissions (PTE)

ENGINE EMISSIONS FROM EQUIPMENT - From AP42/USEPA Office of Transportation and Air Quality EPA-420-B-16-022

					Exhaust Emission Standards [g/Kw-hr]			Annual Emission Rate Potential [grams]			Annual Emission Rate Potential [tons]		
Name	Make/Model	Horsepower	Kw	EPA Tier Code	NMHC	Nox	PM	VOC	NOx	PM	VOC	NOx	PM
Finishing Screen	C4.4 205	129	96.20	Tier 4 Final	0.19	0.4	0.02	11844	24934	1247	0.01	0.03	0.001
Finishing Screen	C4.4 205	129	96.20	Tier 4 Final	0.19	0.4	0.02	11844	24934	1247	0.01	0.03	0.001
Scalper Screen	CAT 206	173	129.01	Tier 4 Final	0.19	0.4	0.02	15883	33438	1672	0.02	0.04	0.002
Scalper Screen	CAT 206	173	129.01	Tier 4 Final	0.19	0.4	0.02	15883	33438	1672	0.02	0.04	0.002
Dozer	Komatsu D65	217	161.82	Tier 4 Final	0.19	0.4	0.02	19923	41943	2097	0.02	0.05	0.002
Jaw Crusher	C9.3-2650	300	223.71	Tier 4 Final	0.19	0.4	0.02	27543	57986	2899	0.03	0.06	0.003
Jaw Crusher	C13 -3055	440	328.11	Tier 4 Final	0.19	0.4	0.02	40397	85046	4252	0.04	0.09	0.005
Excavator	Kamatsu 360	257	191.64	Tier 4 Final	0.19	0.4	0.02	23595	49674	2484	0.03	0.05	0.003
Excavator	Kamatsu 360	257	191.64	Tier 4 Final	0.19	0.4	0.02	23595	49674	2484	0.03	0.05	0.003
Excavator	Kamatsu 360	257	191.64	Tier 4 Final	0.19	0.4	0.02	23595	49674	2484	0.03	0.05	0.003
Excavator	Kamatsu 490	359	267.71	Tier 4 Final	0.19	0.4	0.02	32960	69389	3469	0.04	0.08	0.004
Wheel Loader	Kamatsu WA500	353	263.23	Tier 4 Final	0.19	0.4	0.02	32409	68230	3411	0.04	0.08	0.004
Wheel Loader	Kamatsu WA500	353	263.23	Tier 4 Final	0.19	0.4	0.02	32409	68230	3411	0.04	0.08	0.004
Dozer	D61PXi-23 SN 30739	168	125.28	Tier 4 Final	0.19	0.4	0.02	15424	32472	1624	0.02	0.04	0.002
Dozer	D61PXi-23 SN 30872	168	125.28	Tier 4 Final	0.19	0.4	0.02	15424	32472	1624	0.02	0.04	0.002
Vibratory Roller	Hamm H11	25	18.64	Tier 4 Final	0.19	0.4	0.02	2295	4832	242	0.00	0.01	0.000
Vibratory Roller	Hamm H11	25	18.64	Tier 4 Final	0.19	0.4	0.02	2295	4832	242	0.00	0.01	0.000
Articulated Dump	Komatsu HM400	473	352.72	Tier 4 Final	0.19	0.4	0.02	43426	91424	4571	0.05	0.10	0.005
Articulated Dump	Komatsu HM400	473	352.72	Tier 4 Final	0.19	0.4	0.02	43426	91424	4571	0.05	0.10	0.005
SUBTOTAL											**0.48**	**1.01**	**0.05**

EMISSIONS FROM SOIL ANDMASONRY MEDIA SCREENING - From USEPA AP-42 11.19.1 Sand And Gravel Processing

	Emission Factors (pounds/ton processed)			Annual Production (tons)	Annual Emission Rate Potential [pounds]			Annual Emission Rate Potential [tons]		
Process	NMHC	Nox	PM		VOC	NOx	PM	VOC	NOx	PM
Sand handling, transfer, and storage	0	0	0.0013	624000	0	0	811.2	0	0	0.406
SUBTOTAL								**0**	**0**	**0.41**

EMISSIONS FROM CONCRETE CRUSHING - From AP-42 11.19.2-2 for Crushed Stone

	Emission Factors (pounds/ton processed)			Annual Production[1] (tons)	Annual Emission Rate Potential [pounds]			Annual Emission Rate Potential [tons]		
Process	NMHC	NOx	PM		VOC	NOx	PM	VOC	NOx	PM
Tertiary crushing	0	0	0.0013	624000	0	0	811.2	0	0	0.41
Conveyor Transfer	0	0	0.003	624000	0	0	1872	0	0	0.94
Truck Unloading - conveyor crushed	0	0	0.00008	624000	0	0	49.92	0	0	0.02
Truck Loading - fragments	0	0	0.00008	624000	0	0	49.92	0	0	0.02
SUBTOTAL								**0**	**0**	**1.39**

AIR EMISSION INVENTORY TOTALS

Sum of Potential Emissions (PTE)

EMISSIONS FROM STOCKPILES - From USEPA AP-42 13.2.4 Aggregate Handling And Storage Piles

	Emission Factors (pounds/ton stored)			Storage Limit[2] (tons)	Annual Emission Rate Potential [pounds]			Annual Emission Rate Potential [tons]		
	NMHC	NOx	PM[3]		NMHC	NOx	PM	NMHC	NOx	PM
Stockpiles - maximum	0	0	0.00041	1248000	0	0	511.68	0	0	0.256
SUBTOTAL								**0**	**0**	**0.26**

EMISSIONS FROM VEHICLE TIRES - From USEPA AP-42 13.2.2 Unpaved Roads										
	Emission Factors (pounds/vehicle mile traveled)			Annual Truck Traffic (miles)	Annual Emission			Annual Emission Rate Potential [tons]		
	NMHC	NOx	PM[3]	All Vehicles[3]	VOC	NOx	PM	VOC	NOx	PM
Laden Truck Traffic	0	0	0.07164	15600	0	0	1117.58	0	0	0.56
Wheeled Equipment (loaders)	0	0	0.08157	3000	0	0	244.71	0	0	0.12
SUBTOTAL								**0**	**0**	**0.56**

SUM OF POTENTIAL EMISSIONS

		ANNUAL EMISSIONS [PTE] [tons]		
SUBTOTAL SOURCE		**VOC**	**NOx**	**PM**
EQUIPMENT		0.48	1.01	0.05
SCREENING		0.00	0.00	0.41
CONCRETE CRUSHING		0.00	0.00	1.39
STOCKPILES		0.00	0.00	0.26
VEHICLE TIRES		0.00	0.00	0.56
TOTALS		**0.48**	**1.01**	**2.66**

Notation 1 - Assumes maximum rate for LVA production.

Notation 2 - Data for calculation: Particle size multiplier "k", 0.74; mean wind speed "U", 5 mph; material moisture content "M", 7%

Notation 3 - Data for calculation: emperical constants "k",0.15; "a", 0.9; "b" 0.45; "c""d" na; surface silt "s" 2.6; vehicle weight - laden "W" 30 tons; moisture (trucks)/ 45 tons (wheeled equipment); "M" 3%; speed "S" 20 mph; emission factor "C" NA; size factor "E" 0.106734336; days "P" 120

Notation 4 - Total traffic for all trucks and routine wheeled heavy equipment: 0.75 mile per truck entering and exiting; 8 miles per day per wheeled equipment (loader) operating

NOTE: VOCS are non methane total hydrocarbons

ATTACHMENTS

Former DuPont East Chicago Facility

Attachment A: Health and Safety Plan
Attachment B: Community Air Monitoring Plan (CAMP)
Attachment C: Quality Assurance Project Plan
Attachment D: Community Participation Plan

Attachment A

Health and Safety Plan

Former DuPont East Chicago Facility

Health and Safety Plan

Former DuPont East Chicago Facility, Indiana

EPA ID: IND 005174354

! dzƎdzăű y, 2019

Prepared for:

East Chicago Gateway Partners, LLC
5135 Kennedy Avenue
East Chicago, Indiana 46312

Prepared by:

Impact Environmental Indiana, LLC
170 Keyland Court
Bohemia, New York 11716

IE Project #11300

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Figure 2 – Air Monitoring Map

APPENDIX:

Appendix A – Acknowledgment Statement
Appendix B – MSDS Sheets
Appendix C – Driller Safety Handbook
Appendix D – Excavation and Trenching Handbook
Appendix E – Project Start Briefing Form
Appendix F - Respirator Medical Examination Questionnaire
Appendix G – Dust Control and Suppression Handbook
Appendix H – Employee Accident Report
Appendix I - OSHA 300 Forms
Appendix J – Near Miss/ Incident Report Form

1 INTRODUCTION

This Site Health and Safety Plan (HASP) sets forth the requirements to be followed during the implementation of the design, construction and operation of corrective measures at the former DuPont East Chicago Facility, herein referred to as the "The Facility", pursuant to the RCRA § 3008(h) Administrative Order on Consent (Docket No. RCRA-05-2019-003) executed by E.I. du Pont Nemours and Company (DuPont), Chemours Company FC, LLC (Chemours) and East Chicago Gateway Partners, LLC (ECGP) on November 16, 2018 with the United States Environmental Protection Agency, Region 5 (USEPA 2018b). The applicability of this HASP extends to Impact Environmental and subcontractors.

During development of this HASP, consideration was given to current safety and health standards defined by the United States Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), and the National Institute for Occupational Safety and Health (NIOSH). Specifically, the following reference sources have been utilized in the development of this HASP:

- OSHA Regulations: 29 CFR 1910 and 1926;
- USEPA Standard Operating Safety Guides, June 1992;
- NIOSH Pocket Guide to Chemical Hazards, August 2006; and,
- American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values for Chemical Substances and Chemical Agents, 2014;

In addition to the above-referenced documents, IEC has established a comprehensive and realistic Safety, Health, and Environmental Program based on past experience, sound engineering practice, employee training, and enforcement of safety and health regulations to prevent unreasonable safety and health risks.

This document is not, nor does it purport to be, a complete description of safety and health requirements applicable to work performed at the Facility. Rather, the HASP is a general overview of the compliance policies and work practices applicable to the primary tasks and hazards associated with the environmental corrective action activities at the Facility, as well as a recitation of minimum safety and health compliance obligations for subcontractors and workers at the Facility. All subcontractors of any tier operating at the worksite are obligated to implement and maintain comprehensive safety and health plans for their own employees and to ensure that their employees comply with applicable safety and health requirements. All subcontractors operating at the worksite should refer to the applicable specific OSHA Standards for detailed

requirements. All companies or agencies with employees working at the Facility will be required to acknowledge compliance with the provisions contained in this HASP prior to accessing the Facility.

1.1 PURPOSE

The objective of this HASP is to define the requirements and designate protocols to be followed on-site while implementing Facility-wide remediation and investigations. These activities include, but are not limited to:

- Geotechnical investigations
- Sitewide Clearing and Grubbing
- Source Area Soil Excavation, Treatment and Disposal
- In-Situ Stabilization of Saturated Soil In-Situ Stabilization Application
- Hydrogeologic Study
- Ground Improvement
- Earthen Barrier Cover Construction
- Groundwater Treatment, Design and Construction
- Performance and Long-Term Monitoring
- Operations & Maintenance

In general, the primary objective is to ensure the well-being of on-site workers and the community surrounding the Facility. To accomplish this, Impact Environmental personnel and approved subcontractors of any tier shall acknowledge and adhere to the policies and procedures established herein. Accordingly, personnel assigned to the field activities at the Facility shall read this HASP and sign the Agreement and Acknowledgment Statement (**Appendix A**) to certify that they have read, understood, and agrees to abide by its provisions. A copy of this HASP will be available to anyone that requests it at the Facility. Other personnel (e.g. government officials, administrators, bank inspectors, assessors, etc.) that will have limited exposure to the Facility during the above noted work will be instructed on how to reduce the probability of exposure to Facility contaminants but will not be required read the HASP.

1.2 FACILITY DESCRIPTION

The Facility is approximately 440 acres in size and is identified as 5215 Kennedy Avenue, East Chicago, Indiana. The Facility is bound on the north by the Riley Park neighborhoods and various commercial properties, the

south by the East Branch of the Grand Calumet River, the east by commercial properties (including the City of East Chicago Solid Waste Transfer Station), and the west by Kennedy Avenue and the former USS Lead Refinery (Superfund Site currently under cleanup under CERCLA authority). Currently the majority of the property remains vacant, fenced and unused. The Facility has been divided into the following five areas as mentioned in previous Facility investigations and reports and is presented in **Figure 1**:

- The Redevelopment Area: This area consists of approximately 155 acres and encompasses the former manufacturing area located within the central and western portion of the property. Future industrial and/or commercial use is anticipated for this area.
- The Open Area: This area consists of approximately 50 acres and includes an approximately 25-acre solid waste landfill. The former landfill operated during historical manufacturing operations however discontinued use in 2002. A majority of the landfill consists of filter cake derived from waste water treatment systems at the Facility. North of the landfill location is approximately 25 acres of wooded areas and wetlands.
- The Buffer Zone: This area is located directly east of the open and redevelopment area and separates these portions from the adjacent natural area. The buffer zone area is approximately 200 feet wide and extends across the width of the property oriented north to south occupying approximately 20 acres. Buffer area is intended to provide additional protection to the natural area and its resources. Vegetation and habitat management will continue to support the health of the natural area. The buffer zone area has undergone various IRM to mitigate the migration of contamination into the natural area.
- The Natural Area: This area is approximately 172 acres and has remained undeveloped retaining its unique dune and swale habitat. The natural area is managed by The Nature Conservancy for habitat and wildlife preservation and is protected from future development.
- The Active Manufacturing Area (Leased Area): This area consists of approximately 30 acres leased and managed by WR Grace Industries. This area is the only remaining portion of the Facility that maintains manufacturing operations. These operations consist of manufacturing silica products and has remained nearly unchanged for 110 years.
- The Annex Area: This area is approximately 10 acres in size and consists primarily of wetlands. This parcel has not been previously investigated due to ownership discrepancies and is situated along the northeastern boundary of the Facility.

1.3 SCOPE OF WORK

This HASP shall support the activities scoped as part of the CMI Workplan; including the following:

- Geotechnical investigations
- Sitewide Clearing and Grubbing
- Source Area Soil Excavation, Treatment and Disposal
- In-Situ Stabilization of Saturated Soil ISS Application
- Hydrogeologic Study
- Ground Improvement
- Earthen Barrier Cover Construction
- Building Construction
- CMI Groundwater Treatment Design and Construction
- Performance Monitoring
- Operations & Maintenance
- Long-Term Monitoring

2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The procedures of this HASP apply for any person that will enter the work zone of the Facility or a portion of the Facility during sampling or construction activities, until completion of all CMI activities. Construction contractors and subcontractors of any tier will perform the construction/development portion of the work in accordance with the approved OSHA-compliant site-specific HASP.

2.1 ENVIRONMENTAL PERSONNEL AND RESPONSIBILITIES

Impact Environmental or subcontractors of any tier involved with the following activities will be considered "Environmental Personnel":

- Sampling of native soil/fill material or groundwater for physical or chemical analysis
- Performing surveys
- Supervision/performing excavation activities
- Performing field screening activities
- Performing air quality monitoring
- Loading of native soil/fill onto vehicles
- Managing and tracking waste transportation vehicles
- Processing of native soil/fill into components
- Transporting of native soil/fill across the Facility
- Cleaning or decontaminating equipment or personnel
- Installation or execution of CMI Remedial Items

For this document, "Construction Personnel" is the term given for those employees of contractors and subcontractors of any tier performing activities associated with Facility construction and development only, other than those performed by the Environmental Personnel. This designation does not preclude that Construction Personnel will traverse or work upon native soil/fill material, rather, it infers that it will not involve performing tasks that will create an obvious route of exposure to potential contaminants without exercising mitigative measures discussed herein. Construction Personnel will receive instruction to limit the potential for exposure to these contaminants.

2.2 KEY PERSONNEL

A list of the pertinent key personnel authorized to be present at the Facility is as follows:

Title / Company	Name	Telephone Number
Project Administrator & Director of Training / *Impact Environmental*	Richard Parrish	(O) 631-269-8800 x 101 (C) 631-805-8900
Project Manager/ *Impact Environmental*	Kevin Kleaka	(O) 631-269-8800 x 129 (C) 516-805-8892
Facility Health & Safety Officer/ *Impact Environmental*	Chris Tripoli	(O) 631-269-8800 x 129 (C) 516-805-8892
Project Scientist */ Impact Environmental*	Daniel Fruhauf	(O) 631-269-8800 x 141 (C) 631-901-2470
Field Team Leader/ *Impact Environmental*	John Smith	(O) 631-269-8800 x148 (C) 570-817-2636

2.2.1 Project Administrator

The Project Administrator directs and oversees all aspects of the project in compliance with contractual and technical requirements. The Program Administrator will monitor and control subcontractors to achieve optimal performance and ensure safe, high quality performance that complies with all requirements. Specific duties will include:

- Oversee Project Manager compliance with expected timeline and financial factors;
- Direct training and quality compliance of the Facility Health and Safety Officer (HSO) to ensure appropriate field personnel are supervised under health and safety compliance;

2.2.2 Project Manager

The Project Manager will be responsible for implementing the project and obtaining any necessary personnel or resources for the completion of the project. Specific duties will include:

- Coordinating project activities with the Health and Safety Officer (HSO) and serving as the primary liaison with USEPA and subcontractors. The Project Manager will prepare all correspondence, submittals and other documentation required for the project and coordinate schedules;
- The Project Manager prepares reports and documentation, supervises environmental personnel, and reviews and approves procurement and subcontract activities to reduce the risk of loss due to employee injury, regulatory non-compliance, general liability or damage;
- Selecting a HSO and the appropriate field personnel for the work to be undertaken at the Facility, ensuring that the HSO enforces all health and safety compliance; and,
- Ensuring that the tasks assigned are being completed as planned and on schedule;
- Providing authority and resources to ensure that the HSO is able to implement and manage safety procedures discussed herein.

2.2.3 Health and Safety Officer

The HSO shall be responsible for the implementation of the HASP at the Facility. Specific duties will include:

- Monitoring the compliance during ground-intrusive activities and other environmental-related activities during construction for the routine and proper use of the PPE by field personnel that have been designated for each task;
- Audit the effectiveness of the HASP; Routinely inspecting PPE and clothing to ensure that it is in good condition and is being stored and maintained properly;
- Stopping work at the Facility or changing work assignments or procedures if any operation that may expose workers or the public to fugitive dust particulates and/or unanticipated environmental conditions (e.g., spills, petroleum-contaminated soil, etc.) generated during ground-intrusive activities;
- Monitoring personnel who enter and exit the Facility and all controlled access points.
- Reporting any signs of fatigue, work-related stress, or chemical exposures to the Project Manager;
- Dismissing field personnel from the Facility if their actions or negligence endanger themselves, co-workers, or the public, and reporting the same to the Project Manager;
- Reporting any accidents, near-misses or violations of this HASP to the Project Manager and documenting the same for the project in the records;
- Knowledge of emergency procedures, evacuation routes, and the telephone numbers of the ambulance, local hospital, poison control center, fire and police departments;

- Ensuring that all Environmental Personnel have signed the personnel agreement and acknowledgments form contained in this HASP;
- Coordinate upgrading and downgrading PPE as necessary due to changes in exposure levels, monitoring results, weather, and other field conditions;

2.2.4 Project Scientist

The Project Scientist will be responsible for field sampling activities, reporting, field operations monitoring, and monitoring. Specific duties will include, but are not limited to:

- Schedule and notify parties of field sampling activities;
- Coordinate with the Project Manager all monitoring and sampling activities;
- Support and guide field team members;
- Conduct technical and historical research;
- Develop and establish technical protocols with the Quality Assurance Manager;
- Document field sampling activities;
- Coordinate activities between environmental staff and laboratory staff;
- Report on completeness of Corrective Measure Implementation
- Monitor and consult on exposure risks with the HSO; and,
- Support the decision-making process with the Project Manager based on analytical data and field conditions.

2.2.5 Field Team Leader

The Field Team Leader will be responsible for field operations and safety. Specific duties will include, but are not limited to:

- Scheduling with the subcontractors;
- Coordinating with the HSO in determining protection levels;
- Documenting field activities;
- Coordinate activities between environmental and construction personnel;
- Coordination with waste management contractors; and,
- Review and approval of waste disposal facilities.

In the event that the Project Manager and the HSO are not present, the Field Operations Leader will assume all responsibility of the HSO.

2.2.6 Subcontractors

Subcontractors utilized during activities at the Facility will be provided a copy of the plan prior to commencing work. The HSO will verify subcontractor employee training and will monitor and enforce compliance with the established plan and standard operating procedures. As with all Facility safety meetings.

IEC will continually monitor a subcontractor's safety performance. IEC will observe subcontractors for hazards or unsafe practices that are both readily observable and occur in common work areas. The HSO will note subcontractor work practices on the daily Quality Control Report. If non-compliance or unsafe conditions or practices are observed, the subcontractor safety representative will be notified, and corrective action will be required. The subcontractor will determine and implement necessary controls and corrective actions. If repeat non-compliance/unsafe conditions are observed, the subcontractor will be required to stop affected work until adequate corrective measures are implemented.

2.3 PERSONNEL TRAINING

All environmental personnel, at a minimum, must complete an initial 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training course and, a current eight-hour refresher course (as required annually after initial 40-hour training completion). Construction Personnel that will not be in direct contact with exposure pathways are only required to prove they have read and understood the procedures presented in this HASP.

On-site managers and supervisors of Environmental Personnel are directly responsible for employees engaged in hazardous substance operations and have received an initial 40-hour HAZWOPER training course and, a current eight-hour refresher course (as required annually after initial 40-hour training completion). These training requirements comply with the OSHA Hazardous Waste Operations and Emergency Response Regulation, 29 CFR 1910.120. The HSO will conduct an on-Site training meeting for Environmental personnel and observers that could potentially be exposed to Facility material during field activities. Training meetings will be provided routinely for new project personnel. This program will cover specific health and safety equipment and protocols and potential problems inherent to each project operation. The Facility Health and

Safety Officer will be present for all field activities being performed. This will include insuring the use of proper PPE and air quality monitoring.

3 HEALTH AND SAFETY RISK EVALUATION

The anticipated major risks and hazards presented in this section is not intended to be complete listing of all potential risks that may be encountered during the project. The general risks that this HASP addresses during implementation of a site-wide remedies and other supplemental investigations will include, but are not limited to:

- Chemical hazards;
- Physical Hazards; and,
- Biological Hazards.

3.1 CHEMICAL HAZARDS

Soil data collected from 1991 to present has been evaluated and a well-defined horizontal and vertical distribution of primary chemicals of concern (COC) across the Facility has been established. The primary COC list for soil and groundwater consist of arsenic, lead, cadmium and zinc (metals). Lead and arsenic are the two primary COCs at the Facility. The following table is provided to present primary COCs and associated characteristics and exposure paths.

Primary COC Chemical Name Synonyms (trade name) (CAS No.)	OSHA PEL ACGIH TLV Facility AEL ACGIH STEL NIOSH IDLH Skin Designation	Characteristics	Route of Exposure	Symptoms of Exposure
Arsenic (inorganic) (7440-38-2)	PEL: 0.01 mg/m^3 TLV: 0.01 mg/m^3 AEL: N/E STEL: N/E IDLH: 5 mg/m^3(CA) Skin: No	Silvery-gray or tin-white brittle, odorless solid.	INH ABS CON ING	Symptoms include ulceration of nasal septum, gastrointestinal disturbances, respiratory irritation, and peripheral neuropathy. Potential occupational carcinogen.
Cadmium (elemental) (7440-43-9)	PEL: 0.005 mg/m^3 TLV: 0.01 mg/m^3 AEL: 0.005 mg/m^3 STEL: N/A IDLH: 9 mg/m^3(CA) Skin: No	Silver-white, blue-tinged lustrous, odorless solid. Air odor threshold: N/D	INH ING	Symptoms include pulmonary edema, cough, tight chest, head pain, chills, muscle aches, vomiting, and diarrhea. Potential occupational carcinogen.

Lead (Elemental & inorganic as Pb) (7439-92-1)	PEL: 0.05 mg/m^3 TLV: 0.05 mg/m^3 AEL: 0.05 mg/m^3 STEL: N/E IDLH: 100 mg/m^3 Skin: No	A heavy, gray ductile soft solid.	INH ING CON	Accumulative poison may cause weakness, insomnia, facial pallor, anorexia, malnutrition, constipation, abdominal pain, anemia, gingival lead line, paralysis of wrists and ankles, hypertension, and kidney disease.
Zinc Oxide (Zinc dust) (1314-13-2)	PEL: 5 mg/m^3 TLV: 10 mg/m^3 AEL: N/E STEL: N/E IDLH: 500 mg/m^3 Skin: No	Fine white odorless particulate. Air odor threshold: N/A	INH	Irritant to eyes, nose, throat, and skin. Symptoms include metal fume fever, blurred visions, chills, nausea, muscle ache, fever, and tight chest.

3.1.1 Pathways of COCs

Dermal contact with contaminated soil and groundwater, and inhalation/ingestion of airborne dust are the primary possible exposure routes for the activities specified in this HASP.

The dermal contact route of exposure could result from contact with contaminated groundwater or soil during the sampling/ handling of: contaminated soil, groundwater and decontamination fluids. Worker exposure will be minimized through the use of proper PPE, low- volume, discrete soil sampling equipment, worker training in proper handling of contaminated sample media, and proper decontamination methods.

The inhalation/ingestion of contaminated airborne dust will be controlled through the use of minimal disturbance, discrete soil sampling equipment, dust suppression, wetting the soils with water during excavation or other soil disturbance activities and the level of respiratory protection will be upgraded if necessary based on instrument results. If field conditions indicate dust suppression is necessary, the HSO will initiate dust suppression controls including misting of loose sample material with water or stop work until weather conditions (wind) are appropriate to continue work.

3.1.2 Onsite Chemical Storage

The CMI SOW will require the use, storage and handling of support chemical materials including but not limited to; Diesel fuel, TerraBond Powder Stabilizer and FerroBlack Liquid Stabilizer manufactured by Terra Materials Inc.

All chemical storage will remain within a designated "Chemical Storage Areas" equipped with secondary containment measures and spill response kits. These designated areas will be fenced and locked after working day hours. Storage materials will be inventoried, and usage monitored by log sheets.

Spill prevention measures will be discussed in further detail within the Facility Stormwater Pollution Prevention Plan (SWPPP). Spill response kits including; absorbent material, specific PPE, spill booms and other applicable items will be adjacent to chemical storage at all times.

3.1.3 Material Safety Data Sheets

A Material Safety Data Sheet (MSDSs) must be provided to the HSO for any materials or products that will be imported to accomplish the work. Prior to use, the HSO must review the MSDS and approve that product for use. In addition, plant-specific approval requirements may apply. Materials or products may include decontamination solutions, fuel for equipment operation, preservative for sample containers, etc.). All labeling and storage of hazardous materials must be in accordance with regulatory requirements. MSDS are included in **Appendix B.**

3.2 PHYSICAL HAZARDS

The primary physical hazards include working on, with, in or near heavy equipment, combustibles, heavy machinery, and vehicles, or adverse weather conditions.

3.2.1 Explosion and Fire

As this HASP is intended to be site-specific only, this Section is not, nor does it purport to be, a comprehensive recitation of safety and health requirements applicable to explosion and fire hazards during the project duration. Rather, the subcontractors and workers at the Facility must refer to OSHA's Fire Protection and Prevention Standard, set forth at 29 C.F.R. § 1910 part 1926.35, as well as all supporting OSHA Compliance Directives and Letters of Interpretation, for complete information on safety and health

compliance obligations where said plan prescribes additional or requires more protective measures, controls or procedures.

Although the potential for fire explosion is minimal, sources of risk do exist. These sources include gasoline for portable equipment, diesel fuel for heavy equipment and combustible debris. The following are basic fire preventive measures to take:

- During equipment operation, periodic vapor concentration measurements shall be taken with an explosimeter or combustimeter. If at any time the vapor concentrations exceed 10% of the lower explosive limit (LEL), then the HSO or designated field worker shall immediately shut down all operations.
- Only approved safety cans shall be used to transport and store flammable liquids.
- Use of flammable storage cabinets.
- All gasoline and diesel-driven engines requiring refueling shall be shut down and allowed to cool prior to filling.
- Smoking shall not be allowed during any operations within the work area in which petroleum products or solvents in free-floating, dissolved, or vapor forms, or other flammable liquids may be present.
- No open flame or spark is allowed in any area containing petroleum products or other flammable liquids.

3.2.2 Heavy Equipment and Vehicle Traffic

All personnel must remain aware of those field activities that involve the use and movement of heavy equipment and vehicles. This category includes all operations that utilize moving equipment: loaders, excavators, dozers, trucks and drill rigs. Personnel will wear high visibility reflective vests when working around equipment and vehicles. It is essential that all employees at the Facility exercise extreme caution during operation of equipment and machinery to avoid physical injury to themselves or others. When working around heavy equipment, pedestrian (ground worker) traffic must assume the operator cannot see you. Pedestrians must not proceed without first making eye contact with the operator and receiving acknowledgment that the operator is aware of the pedestrian presence.

Supplemental equipment can be items such as cones, flags, barricades, and/or caution tape. A traffic flow pattern will be established for vehicles entering and exiting the Facility. Drivers of waste transportation

vehicles will only exit vehicles in designated areas. During this time, drivers will only be allowed to inspect the placement of waste loads and cover their trailers.

3.2.3 Drilling

Drilling of various types, include but not limited to, direct push, sonic, rotary, and hollow stem auger may be used during the certain components of work. Drill rigs and associated equipment will be inspected prior to on-site use and daily throughout drilling project tasks. An inspection checklist will confirm that the drill rig meets all requirements including a kill switch, and fire extinguisher. All high-pressure air hoses will be inspected daily to ensure the integrity of the hose and that each hose joint is secured with safety chain/whipchecks. Hoses will be placed away from worker's activities and out of worker's walking paths. Only qualified trained operators (driller) will operate equipment. A spotter will be used to position the drill rig and will communicate any moving pedestrian or truck traffic. **Appendix C** provides the **Driller Safety Handbook**, which provides safety requirements addressing drilling operations, drilling equipment safety checklists and proper procedures.

3.2.4 Pinch points

Personnel must always be aware of limb or body position in close proximity to moving equipment to reduce pinch point hazards. Wear appropriate hand protection to protect hands. Only trained competent persons will operate equipment with dangerous pinch points (drill rig, skidsteer).

3.2.5 Excavation Activities

It is the responsibility of the HSO and each supervisor to implement and maintain the procedures and steps set forth in the **Excavation and Trenching Safety Handbook** presented in **Appendix D**. All employees working in and around an open excavation must be trained in the recognition of hazards associated with trenching and excavating. In general, the primary hazard encountered during soil excavation is the cave in of excavation sides with possible burial or crushing of workers. Causes of cave in may include (a) absence of shoring, (b) misjudgment of stability, (c) defective shoring, and (d) undercut sides. Other potential hazards include falling during access/egress, while monitoring or dismounting equipment, or stumbling into excavation. Flammable atmospheres may also be encountered in excavation.

Each personnel involved with excavation and trenching work is responsible to comply with all applicable safety procedures and requirements of this HASP. The competent person assigned to any

excavation/trenching activities provides oversight and collects data to determine the effectiveness of protective systems, PPE, and personnel safety. The competent person must be trained in accordance with the most recent version of the OSHA Excavation Standard, and all other programs that may apply and must demonstrate a thorough understanding and knowledge of the programs and the hazards associated. Observations or concerns will be freely conveyed to the HSO from any competent person working around excavation activities. All other employees working in and around the excavation must be trained in the recognition of hazards associated with trenching and excavating.

General Requirements

Before any work is performed and before any employees enter the excavation, the competent person must inspect or complete, at a minimum, the following:

- All overhead hazards (surface encumbrances) that create a hazard to employees must be removed or supported to eliminate the hazard;
- A competent person will inspect all excavations and trenches daily, prior to employee exposure or entry, and after any rainfall, soil change, or any other time needed during the shift. The competent person must take prompt measures to eliminate any and all identified or anticipated hazards;
- Adequate protective systems shall be utilized to protect employees. This can be accomplished through sloping, shoring, or shielding. The use of raised berms, caution signs, and caution tape will be instituted to protect personnel at the Facility.
- If a trench or excavation is four feet or deeper and not maintaining a 1:1 slope; stairways, ramps, or ladders shall be used as a safe means of access and egress. For trenches, the employee must not have to travel any more than 25 feet of lateral travel to reach the stairway, ramp, or ladder;
- Walkways shall be provided where employees or equipment are required or permitted to cross over excavations. Guardrails and midrails, which comply with 1926.502(b), shall be provided where walkways are six feet or more above lower levels;
- Workers must be supplied with and wear any PPE deemed necessary by the HSO for protection from specific hazards;
- Employees shall not work in excavations in which there is accumulated water, or in excavations, in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline;

- If water is controlled or prevented from accumulating by the use of water removal equipment, a competent person must ensure proper operation and shall monitor the water removal equipment and operations;
- All soil piles will be stored a minimum of two feet from the sides of the excavation. The soil pile must not block the safe means of egress; and,
- No personnel shall be permitted underneath loads handled by lifting or digging equipment. Workers shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any falling materials.

3.2.6 Ground Clearing and Grubbing

Clearing activities include the cutting of all timber, brush, shrubs and fallen timber except trees or other vegetation that is designated for preservation. Retain and protect from damage any trees and shrubs that are outside the limits of the required clearing. Conduct reconnaissance throughout clearing area for potential obstructions or unknown structures. For clearing follow, the below guidelines:

- Workers using hand tools (chainsaws, brush mowers or string trimmers) must be operating at a minimum distance of 75 feet from the nearest active heavy machinery (Bulldozers, Skid-steer Mulchers).
- At all times be aware of personnel or equipment use in the area – distances and hazards.
- Heavy equipment including Skid-steer Mulchers and other mulching equipment will project wood chips around and forward of target cuts – always be aware of what is beyond your cut.
- Be aware of uneven ground, pits and other trip and fall hazards – equipment use should be on stable ground before cuts.
- Tree stumps are to be ground in place at or below Facility grade during grubbing activities.
- All fallen timber, shrubs and other vegetation are to be mulched in place and spread evenly to reduce dust emissions.
- Fallen timber that cannot be mulched in place are to be cut into sections and transported to a designated wood/log pile.

If a pit, buried structure, semi-buried structure, pipeline or other form of structure is encountered during activities – immediately discontinue work and inform the Field Team Leader for evaluation.

Grubbing activities include the grinding and mulching of fallen timber, surface roots, low brush, grasses and tree stumps. These activities should be conducted in a manner that controls dust emissions as per HASP BMPs. For grubbing follow, the below guidelines:

- At all times be aware of personnel or equipment use in the area – distances and hazards.
- For surface stripping and mulching be aware of rocks, concrete foundations/slabs or other obstructions on the ground surface.
- Low brush and high grasses should be mulched to surface.
- Heavy equipment including Skid-steer Mulchers, chippers and other equipment will project wood chips around and forward of cuts – always be aware of the throw area.
- Be aware of uneven ground, pits and other trip and fall hazards – equipment use should be on stable ground before cuts.
- Tree stumps are to be ground at or below grade
- All fallen timber, shrubs and other vegetation are to be mulched in place and spread evenly to reduce dust emissions.
- Timber that is too large to mulch in place will be stockpiled in current brush piles located within the Buffer Zone to be chipped for future uses.

3.2.7 Material Handling

Various materials and equipment may be handled manually during project operations. Care should be taken when lifting and handling heavy or bulky items to avoid back injuries. The heaviest object one person may lift is 50 pounds, team lift with two people is limited to 80 pounds total. The size, shape, and weight of the object to be lifted must be considered. The following fundamentals address the proper lifting techniques that are essential in preventing back injuries:

- Mechanical lifting devices are the preferred way to move materials.
- The anticipated path to be taken by the lifter should be considered for the presence of slip, trip, and fall hazards.
- The feet will be placed far enough apart for good balance and stability (typically shoulder width).
- The worker will get as close to the load as possible. The legs will be bent at the knees.
- The back will be kept as straight as possible and abdominal muscles should be tightened.
- Twisting motions should be avoided when performing manual lifts.
- To lift the object, the legs are straightened from their bending position.

- A worker will never carry a load that cannot be seen over or around. When placing an object down, the stance and position are identical to that for lifting. The legs are bent at the knees and the object lowered. When two or more workers are required to handle the same object, workers will coordinate the effort so that the load is lifted uniformly and that the weight is equally divided between the individuals carrying the load. When carrying the object, each worker, if possible, will face the direction in which the object is being carried. In handling bulky or heavy items, the following guidelines will be followed to avoid injury to the hands and fingers:
- A firm grip on the object is essential; leather gloves will be used if necessary.

  The hands and object will be free of oil, grease, and water which might prevent a firm grip, and the fingers will be kept away from any points that could cause them to be pinched or crushed, especially when setting the object down.

  The item will be inspected for metal slivers, jagged edges, burrs, and rough or slippery surfaces prior to being lifted. Sheet piling will be removed from transportation trailers with either an excavator (rigging), a loader with fork attachment, or crane. Care shall be giving to pinch points and struck by hazards when lifting, moving, and stacking sheets. Tag lines shall be used if rigging is utilized to handle sheets. A spotter shall be used to keep personnel clear of equipment movements if a loader is used.

3.2.8 Noise Exposure

As this HASP is intended to be an site-specific only, this Section is not, nor does it purport to be, a comprehensive recitation of safety and health requirements applicable to noise hazards. Rather, the subcontractors and workers at the Facility must refer to OSHA's Occupational Noise Exposure Standard, set forth at 29 C.F.R. § 1910 part 1926.52, as well as all supporting OSHA Compliance Directives and Letters of Interpretation, for complete information on safety and health compliance obligations if said plan prescribes additional or requires more protective measures, controls or procedures.

A hearing conservation program shall be established daily, and hearing protection shall be provided to the employees where sound pressure levels exceed 85 decibels (dB[A]) steady-state expressed as a time-weighted average (TWA) or 140 dB(A) impulse. Hearing protection shall be worn where sound pressure levels in areas and/or on equipment exceeds 90 dB(A). It is usually safe to assume that if you need to shout to be heard at arm's length, the noise level is at 90 dB(A) or above.

3.2.9 Temperature Hazards

As this HASP is intended to be site-specific only, this Section is not, nor does it purport to be, a comprehensive recitation of safety and health requirements applicable to temperature stresses. Rather, the subcontractors and workers at the Facility must refer to OSHA's Technical Manual (TED 1-0.15A), Section III – Chapter 4 (1999) as well as all supporting OSHA Compliance Directives and Letters of Interpretation, for complete information on safety and health compliance obligations.

Since climatic changes cannot be avoided, work schedules will be adjusted to provide time intervals for intake of juices, juice products, and water in an area free from contamination and in quantities appropriate for fluid replacement to prevent heat stress conditions from occurring.

3.2.9.1 Heat Stress

Heat stress may occur even in moderate temperature areas and may present any or all of the following:

Heat Rash Result of continuous exposure to heat, humid air, and chafing clothes. Heat rash is uncomfortable and decreases the ability to tolerate heat.

Heat Cramps Result of the inadequate replacement of body electrolytes lost through perspiration. Signs include severe spasms and pain in the extremities and abdomen.

In the event of occurrence, perform the following actions: 1) move worker to a cool place; 2) cool with sponge, water and fan; and 3) if worker if alert, offer fluids water, clear juice, or a sports drink containing salt and sugar (avoid supplemental salt tablets). Worker shall not return to work until symptoms have subsided.

Heat Exhaustion Result of increased stress on the vital organs of the body in the effort to meet the body's cooling demands. Signs include shallow breathing; pale, cool, moist skin; profuse sweating; and dizziness. In the event of an occurrence, perform the following actions:

- get medical aid immediately as this can progress to a serious illness;
- remove worker to a cool location;
- sponge with cool water and fan unless worker starts to shiver;
- if alert and not nauseated, give fluids (i.e., clear juice, sports drinks or water).

Heat Stroke Result of overworked cooling system. Heat stroke is the most serious form of heat stress. Body surfaces must be cooled and medical help must be obtained immediately to prevent severe injury and/or death. Signs include red, hot, dry skin, absence of perspiration, nausea, dizziness and confusion, strong, rapid pulse that could lead to coma or death. **Heat stroke is a legitimate medical emergency. Dial 911 and immediately transport a victim to the nearest medical facility with an emergency room.**

3.2.9.2 Heat Stress Prevention

The following activities may prevent Heat Stress:

- Replace body fluids (water and electrolytes) lost through perspiration. Solutions may include water or commercial mixes such as "Gatorade". Employees must be encouraged to drink more than the amount required in order to satisfy thirst.
- Use cooling devices to aid the natural body cooling mechanism. Cooling occurs through evaporation of perspiration and limited body contact with heat-absorbing protective clothing. Utilize fans and air conditioners to assist in evaporation. Long, cotton underwear may absorb perspiration and, if possible, limit contact with heat retaining protective clothing (i.e., coated Tyvek suits).
- Conduct non-emergency response activities in the early morning or evening during very hot weather.
- Provide shelter against heat and direct sunlight to protect personnel. Take frequent breaks in shaded areas.
- Rotate workers utilizing protective clothing during hot weather.
- Acclimatize workers to weather conditions; establish a work regime that will provide adequate rest periods, with personnel working in shifts.

3.2.10 Cold Exposure Hazards

Work schedules will be adjusted to provide sufficient rest periods in a heated area for warming up during operations conducted in cold weather. Also, thermal protective clothing such as wind and/or moisture resistant outerwear is recommended to be worn.

If work is performed continuously in the cold at or below -7 ºC (20 ºF), including wind chill factor, heated warming shelters (tents, cabins, company vehicles, rest rooms, etc.) shall be made available nearby and the worker should be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. Symptoms that include heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, irritability, or euphoria, are indicators for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing shall be removed and the remainder of the clothing loosened to permit sweat evaporation. A change of dry work clothing should be provided as necessary to prevent workers from returning to their work with wet clothing.

Dehydration, or the loss of body fluids, occurs in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to the extremities. Warm sweet drinks and soups should be provided at the Facility to provide caloric intake and fluid volume. The intake of coffee should be limited because of a diuretic and circulatory effect (adapted from TLV's and Biological Exposure Indices 1988-1989, ACGIH).

3.3 BIOLOGICAL HAZARDS

Biohazards in the work place/construction activity can come in many forms; Infectious agents, cell cultures, microorganisms, plants, fungi, invertebrate animals, medical waste and biological tissue and insects. Biohazards in each case can increase human health risks through human contact or ingestion.

Occupational Health and Safety Awareness will be practiced through the constant observation and monitoring of the Facility to identify and treat human contact and/or ingestion with biohazards.

In addition to the observation and monitoring of biohazards, protective clothing (long sleeve shirts, gloves, eyewear may be worn.

3.3.1 Poisonous Plants

Poisonous plants, such as poison ivy and poison oak, are present or believed to be present on-site. Inspect work areas prior to entering. Wear Tyvek® coveralls and gloves to protect skin from contact with poisonous plants. Remove coverall and gloves from the inside out to avoid contact with potentially contaminated clothing. Use poisonous plant barrier creams and cleansers as needed.

3.3.2 Rabid Animals

Avoid any animal acting in an uncharacteristic manner, especially skunks, feral dogs and cats, and raccoons. If bitten by any animal, go to the hospital immediately.

3.3.3 Mosquitoes

Mosquitoes may be present and may be carriers of malaria, yellow fever, encephalitis, West Nile Fever and other diseases. Wear mosquito repellant as necessary, especially to areas not protected by clothing. Drain pooled or standing water if possible. Be aware of the mosquito-borne illnesses in your area.

3.3.4 Stinging Insects

If stung by a bee, carefully removed the stinger by gently scraping with a finger nail (do not squeeze). Wash the area with soapy water and apply a cold (ice) compress to decrease absorption and spreading of the venom. If excessive swelling or redness appears, seek immediate medical attention. (Note: Allergic reactions to bee stings can be life threatening; therefore, identify susceptible persons prior to project start-up. See form in **Appendix E**.

3.3.5 Ticks

Ticks can infect humans with bacteria, viruses, and parasites that can cause serious illness such as Lyme disease or Rocky Mountain Spotted Fever. The Facility is in an area of the Country that is listed as having a "moderate Risk" for predicted Lyme disease transmission. Reduce chances of getting a tickborne disease

by using repellents, checking for ticks, and showering after working in the vegetated area. If you have a tick bite followed by a fever or rash, seek medical attention.

Field workers should check clothing for ticks. Ticks may be carried into the house on clothing. Any ticks that are found should be removed. Tumble dry clothes in a dryer on high heat for 10 minutes to kill ticks on dry clothing after you come indoors. If the clothes are damp, additional time may be needed. If the clothes require washing first, hot water is recommended. Cold and medium temperature water will not kill ticks effectively.

Field workers should perform "tick checks" before leaving the Facility. Conduct a full body check upon return from the vegetative work area, which even includes grass areas around the work area. Use a hand-held or full-length mirror to view the body for ticks:

- Under the arms
- In and around the ears
- Inside belly button
- Back of the knees
- In and around the hair
- Between the legs

Field workers should shower soon after being outdoors. Showering within two hours of coming indoors has been shown to reduce the risk of getting Lyme disease. Showering may help wash off unattached ticks and it is a good opportunity to do a tick check.

3.3.5.1 What to Do if You Find an Attached Tick

Remove the attached tick by grasping with tweezers, as close to the skin as possible, and pulling it straight out. If this is difficult to perform seek immediate medical attention at a hospital or clinic.

Watch for signs of illness such as rash or fever in the days and weeks following the bite and see a health care provider if these develop.

4 WORKER PROTECTIONS

4.1 FACILITY MANAGEMENT AND PLANNING

All activities presented herein will occur from 7:00 a.m. to 6:00 p.m., Monday through Friday. Herein this will be considered working day hours.

To limit exposure of the Facility workers to the detected contaminants, the Facility will be divided into four operable zones. The zones will be defined as: the exclusion zone (the area where contaminated media is being disturbed by any means); the contaminant reduction zone (an area at least 100 feet away from the exclusion zone in which personal protective equipment is removed); and, the support zone (area where equipment is stored and considered clean from contaminants).

4.2 WORK ZONE DEFINITIONS

Work and support areas shall be established based on ambient air data and proposed work areas. They shall be established in order to contain contamination within the smallest areas possible and shall ensure that each employee has the proper PPE for the area or zone in which work is to be performed.

4.2.1 Exclusion Zone (EZ)

It is within this zone that the investigative, remedial or other field activities are performed that may disturb contaminated media in some form. No one shall enter this zone unless the appropriate PPE is donned. The location of this zone will change as work activity locations change.

4.2.2 Contaminant Reduction Zone (CRZ)

It is within this zone that the decontamination process is undertaken. Personnel and their equipment must be adequately decontaminated before leaving this zone for the support zone. This zone will be set up between the EZ (no less than 100 feet away) and the Facility boundary.

4.2.3 Support Zone (SZ)

The support zone is considered to be uncontaminated; as such, protective clothing and equipment are not required but should be available for use in emergencies. All equipment and materials are stored and

maintained within this zone. Protective clothing is put on within the SZ before entering the EZ or the CRZ. The SZ will be established in a safe environment at least 100 feet away from the CRZ.

4.3 PERSONAL PROTECTIVE EQUIPMENT

This Section is not, nor does it purport to be, a comprehensive recitation of safety and health requirements applicable to personal protective equipment. Rather, contractors, subcontractors and workers at the Facility must refer to OSHA's Personal Protective Equipment Standard, set forth at 29 C.F.R. § 1910.Part 1926.28(a) as well as supporting OSHA Compliance Directives and Letters of Interpretation, for complete information on safety and health compliance obligations.

The purpose of personal protective clothing and equipment (PPE) is to shield or isolate individuals from the chemical, physical, and biological hazards that may be encountered on-site when engineering and other controls are not feasible or cannot provide adequate protection. Careful selection and use of adequate PPE should protect the health of on-site workers. No single combination of PPE is capable of protecting against hazards. Therefore, PPE should be used in conjunction with, not in place of, other protective methods, such as engineering controls and safe work practices.

4.3.1 Levels of Protection

The HSO will determine whether a level of protection should be upgraded or downgraded. Changes in the level of protection will be recorded in the dedicated Facility logbook along with the rationale for the changes (see Section 4.3.2 for additional information on PPE upgrades). Modified Level D PPE will be the minimum requirement during the field survey investigative activities and remedial construction.

4.3.1.1 Level D Personal Protective Equipment

All initial Facility access and activities will be done in Level D attire. Level D protection is sufficient under conditions where no contaminants are present or those activities that do not pose a potential threat of unexpected inhalation of or contact with hazardous levels of hazardous substances.

- Hard hat
- Safety glasses (as appropriate)
- Steel toe and shank boots
- Fluorescent vest
- Hearing protection (as appropriate)

- Modified Level D Personal Protective Equipment
- Hard hat
- Safety glasses
- Steel toe and shank boots
- Fluorescent vest
- Nitrile "N-Dex" inner gloves
- Latex outer boots (chemical resistant)
- Polyethylene coated Tyvek suit
- Hearing protection (as appropriate)

4.3.2 Level C Personal Protective Equipment

Level C protection, as described in this plan, will be available at a minimum for those activities that hazardous soil excavation and treatment. Level C protection equipment should be readily available. Consistent with OSHA training, prior to donning Level C.

- Buddy system required
- Full face respirator with NIOSH approved OV/AG/HEPA combination cartridges (MSA GMCH)
- Saranex coated Tyvek Suit
- Inner Nitrile "N-Dex" gloves
- Outer Nitrile (NBR) gloves
- Steel toe and shank boots
- Outer boots (chemical resistant)
- Hard hat
- Hearing protection (as appropriate)

4.3.2.1 Respirator Requirements

The OSHA respiratory protection standard, 29 CFR 1910.134, under paragraph (f)(2), requires fit testing for employees using tight fitting respirators including filtering face piece respirator. The fit test must be performed before the respirator is used and must be repeated at least annually and whenever a different respirator face piece is used or a change in the employee's physical condition could affect the respirator fit.

The user seal check is a separate requirement under paragraph (g)(1)(iii) and must be performed each time the employee dons the respirator. Employers must adhere to the recommendations of the respirator's manufacturer; different manufacturers recommend different procedures.

4.3.2.2 Medical Surveillance

OSHA requires a medical evaluation to determine whether each employee required to wear a respirator is physically able to wear a respirator and perform the work. This evaluation can be a medical examination or an evaluation of employee responses to the OSHA Respirator Medical Evaluation Questionnaire located in **Appendix F** of the Respiratory Protection Standard. Either method must be performed by a physician or other licensed healthcare professional. A medical examination may be necessary whenever the employee gives a positive response to questions 1 through 8 in **Appendix F**, Part A, Section 2.

4.3.3 Personal Use Factors and Equipment Change Out Schedule

Prohibitive or precautionary measures should be taken as necessary to prevent workers from jeopardizing safety during equipment use.

At this time no respirators are anticipated to be required. However, if necessary, respiratory protective equipment used will be approved by NIOSH/MSHA. Respirator cartridges will be changed once per eight-hour shift at a minimum. This can be accomplished at the end of the workday during respirator decontamination. If respirators are required to be worn at the Facility, they must be replaced once every four hours. If odor breakthrough is detected while wearing the respirator or if breathing becomes difficult, change cartridges immediately. A filter change-out schedule is provided below.

Field Worker	Work Area	Filter Type	Replacement Rate
Screener	EZ – near work	MSA GMC-H	Every 4 Hours
Laborer	EZ – near work	MSA GMC-H	Every 2 Hours
	SZ, CRZ	MSA GMC-H	Every 8 Hours
Equipment Operator	EZ	MSA GMC-H	Every 4 Hours
	SZ, CRZ	MSA GMC-H	Every 8 Hours
Administrator	EZ	MSA GMC-H	Every 4 Hours
	SZ, CRZ	MSA GMC-H	Every 8 Hours

When utilizing protective garments such as Tyvek suits, gloves, and booties, seams between protective items will be sealed with duct tape. Contact with contaminated surfaces, or surfaces suspected of being

contaminated, should be avoided. This includes walking through, kneeling in, or placing equipment in puddles, mud, discolored surfaces, or on drums and other containers. Eating, smoking, drinking, and/or the application of cosmetics in the immediate work area is prohibited. Ingestion of contaminants or absorption of contaminants into the skin may occur.

The use of contact lenses on the Facility is strongly advised against. Contact lenses may trap contaminants and/or particulate between the lens and eye, causing irritation. However, when glasses are not available, contact lenses are preferred over faulty vision. When contact lenses are worn, safety glasses and/or goggles must be worn while at the Facility. Wearing contact lenses with a respirator in a contaminated atmosphere is prohibited under 29 CFR ss1910.134 (e)(5)(iii).

4.4 AIR EMISSION PREVENTION AND MONITORING

The potential for generation of dust emissions during activities associated with the CMI scope of work must be adequately addressed to prevent exposure to Facility workers and off-site communities. Dust control and generation prevention as well as best management practices (BMPs) are presented in **Appendix G – Dust Control and Prevention Safety Handbook**. The Community Air Monitoring Plan (CAMP) which is provided in the CMI Work Plan will focus on perimeter air monitoring to protect and inform the surrounding community. The CAMP is provided as an appendix to the CMI Work Plan. This HASP is provided specifically for worker protections to prevent exposure to dust emissions and/or airborne COCs as detailed in the following sections.

4.4.1 Airborne Media/ Contaminants

Particulates (Dust)/Aerosols

Suspended particulate is particulate matter 10 micrometers (0.01mm) or less in diameter that is a mixture of solid particles and liquid droplets. Total suspended particulate will be directly measured and reported as a mass per volume of air – micrograms per cubic meter (ug/m^3). The instrument that will be used for these measurements will be a TSI model 8530, Dust Track II. The instrument uses light-scattering laser photometry and can detect dust, smoke fumes and mists. The dust metering can detect concentrations from 0.01 mg/m3 up to 400 mg/m3 in real-time. The instrument can be monitored remotely using telemetry unit.

Organic Vapors

Organic vapors include volatile, non-methane, and semi-volatile organic hydrocarbon compounds. These compounds are potentially emitted from vehicle use, fossil-fuel combustion equipment use (saws, hydraulic earth moving, sizing and sorting equipment, etc.) or from soil contaminants. Organic vapors will be directly measured and reported on a part per million basis (ppm). The instrument that will be used for these measurements is the Rae Systems model 3000, MiniRae. The instrument uses photo-ionization detection and can detect total non-methane volatile organic compounds at concentrations from 0.0 to 15,000 parts per million. The instrument can be monitored remotely using telemetry unit.

Inorganics

Lead, arsenic, cadmium, zinc and crystalline silica are contaminants of concern that are present in Facility soils that can be put into air from activities associated with remediation efforts (source removal, vehicle traffic, concrete breaking, grubbing, etc.). These contaminants are also potentially contained in soil and masonry media that will be used to construct the permeable earthen barrier cover. The results of inorganics testing will be indirectly measured and reported as a mass per volume of air – micrograms per cubic meter (ug/m^3). The instrument used for this will be a GilAir Plus. The instrument has a variable flow rate that ranges between 20cc/min to 5,000 cc/min. It is fitted with a technology that can perform both high-flow constant pressure and constant flow, and low-flow constant pressure and constant flow.

4.4.2 Monitoring/ Sampling Equipment

Monitoring shall be performed within the work area onsite in order to detect the presence and relative levels of toxic substances or respirable dust. The data collected throughout monitoring shall be used to determine the appropriate levels of PPE. The table below specifies the real-time monitoring equipment, which will be used for this project.

Real-time Air Monitoring Station (Enclosure)		
INSTRUMENT	**MANUFACTURER/ MODEL***	**USE AND SUBSTANCES DETECTED**
Photo Ionization Detector (PID)	RAE Systems Mini-RAE or Multi-RAE (min. 10.6 eV bulb)	To be used as general screening tool during sample collection or VOC monitoring Organic vapors
Real-time Particulate Air Monitor	TSI Incorporated model, DustTrak II 8530 Aerosol Monitor	To be used as general particulate monitor. Used along Facility upwind perimeter boundary and downwind of the work zone (EZ) to monitor fugitive dust levels. Aerosols, mist, dust, including respirable dust
Air Sampling Pump	Sensidyne GilAir Plus Air Sampling Pump	To be utilized for 8 hour collection on cartridge sampler Respirable dust, metal particulates, crystalline silica

Personal Sample Pump		
INSTRUMENT	**MANUFACTURER/ MODEL***	**USE AND SUBSTANCES DETECTED**
Air Sampling Pump	Sensidyne GilAir Plus Personal Air Sampling Pump	To be continuously used on workers within the work zone (EZ) for cartridge sampler to assess exposure risks Respirable dust, metal particulates, crystalline silica

Weather Station		
INSTRUMENT	**MANUFACTURER/ MODEL***	**USE AND DATA**
Portable Housed Meteorological Station	WEATHERPAK Campbell Scientific (or equivalent)	To continuously collect meteorological data for upwind/ downwind orientation adjustments Wind speed, Barometric Pressure, precipitation

4.4.2.1 Monitoring Equipment Calibration

All instruments used will be calibrated at the beginning and end of each work shift, in accordance with the manufacturer's recommendations. If the owner's manual is not available, the personnel operating the equipment will contact the applicable office representative, rental agency or manufacturer for technical

guidance for proper calibration. Calibration Procedures can be referenced within the QAPP. In General, calibration of the VOC and PM10 instrumentation will occur in accordance with each of the equipment manufacturer's calibration and quality assurance requirements. The VOC and PM10 monitors will be calibrated at least daily, and calibrations will be recorded in the field activity logbook.

4.4.2.2 Weather Conditions

Meteorological conditions will be monitored continuously through the use of a weather station installed at a location central to the Facility. The station will monitor temperature, barometric pressure and wind speed. The instrumentation can be monitored remotely using a telemetry unit. The data can be used in concert with emission data collected under the air monitoring program.

4.4.3 Monitoring Procedures

Based on prevailing wind patterns observed by the onsite meteorological station, upwind and downwind orientations will be established. During the performance of remedial and investigative field activities, airborne fugitive particulate emissions will be measured at the upwind property line and 100-300 feet downwind of the Facility EZ (Work Area). The measurements will be made using a portable particulate monitoring device (DustTrak II Aerosol Monitor 8530). The monitoring device can detect airborne particulate (PM-10) at concentrations ranging from 1 to 1000 micrograms per cubic meter (ug/m3). Detected concentrations are logged within the instrument memory and can be retrieved using Microsoft Windows-based software provided by the manufacturer. Retrieved data can be imported into standard PC-based spreadsheet and database software for analysis and report presentation. **Figure 2** indicates air monitoring equipment positioning based on wind direction and work location.

At a minimum, where the particulate monitoring device is used, the following information will be logged.

- Instrument type and detection range
- Control settings
- Reading locations
- Atmospheric conditions
- Calibration Records – To be performed a minimum of once per day.

Should field conditions warrant personal sampling (breathing zone) to better assess chemical exposures experienced by EZ workers, the HSO, under the direction of a Certified Industrial Hygienist (CIH), will be responsible for specifying the monitoring required. Real time monitoring of EZ workers or within five

working days after the receipt of monitoring results, the HSO will notify each employee, in writing, of the results that represent that employee's exposure risk. Copies of air sampling results will be maintained in the HSO project files.

4.4.3.1 Testing and Monitoring Frequency

Direct, real-time, analysis of particulate and organic vapors will be performed 24-hours a day from within two (one upwind and one downwind of work zone) portable enclosed units. The units will be hardwired to electric service and/or will have a 40-hour battery. Results will be compiled via telemetry directly to a web-based portal. The telemetry unit is a Netronix Thiamis unit. Data will be compiled onto a database that can be used to generate measurements that can be used on a real-time basis to adjust remedial activities and, where necessary, rapidly deploy emission control measures to safeguard off-site receptors. Adjustments can include equipment optimization, activity rate reductions and/or shut-down of equipment or operations. Additionally, the direct measurement data will be used to prompt testing for speciated inorganics.

Personal air-sampling devices may be worn by select field personnel to evaluate the lead and arsenic levels within excavation zones and verify PPE levels are adequate. Arsenic and lead will be analyzed by an American Industrial Hygiene Association (AIHA) approved laboratory. Any personnel working *within* an excavation will be equipped with Level C personal protection until data from personal air-sampling devices indicate that it is not needed however this is not anticipated.

The HSO will be responsible for determining the frequency of sampling and administering the program in coordination with a CIH. In general, samples will be obtained once the initial intrusive activity commences to characterize potential worker exposures. Periodic monitoring may be conducted when work begins on a different portion of the work area, a different type of operation is being initiated, or if employees are working with materials known to contain lead and arsenic at locations where sampling was not performed previously.

Personal air-sampling pumps will be fitted with a filter cassette collection device and will be worn during the initial stages of excavation by a representative on the onsite work force. A personal air-sampling pump will be the GilAir Plus (or equivalent). The filter cassette is a 37-mm, 5-micron, pre-weighed Poly Vinyl Chloride-type unit. The representative number of samples will be based on the number of workers involved in the excavation activity, the specific work tasks being performed, and the judgment of the onsite HSO. If warranted, air samples will be collected in the workers' breathing zone for the duration of

the excavation work. NIOSH Method 7300 will be used for arsenic and lead analysis. The findings will be reviewed, and filter sample results will be shared via electronic submission. Testing for crystalline silica will involve using a variable speed pump and aluminum cyclone in conformance with ISO 7708.1195. This will be done in areas of LVA manufacturing and crushing operations. The pumps will be calibrated, and leak tested and then run at a rate of 2.5 liters per minute for 480 minutes (8 hours), resulting in a 1200 L sample. Analysis for crystalline silica will be collected on a cartridge filter and performed by a commercial testing laboratory using x-ray diffraction. All sample collection will include field blanks and will be handled under an active chain-of-custody procedure.

4.4.3.2 Action Levels

An action level is a point at which work must cease or increased protection is required due to the concentration of contaminants in the work area or other environmental conditions. The concentration level (above background level) and the ability of the PPE to protect against that specific contaminant determine each action level. The action levels are based on concentrations in the breathing zone.

If during handling of the soil/ fill the total downwind PM-10 particulate level is 0.5 milligrams per cubic meter (mg/m3) for 15 minutes or 0.2 mg/m3 greater than background (upwind perimeter) for the 1-hour period or if airborne dust is observed leaving the work area, then the investigative activities must immediately stop, and the dust suppression techniques listed in the attached Dust Control and Prevention Handbook will be employed.

Detection of odors is subjective, the HSO will be charged with the responsibility of making a determination if measures are required to abate odors. Since the contaminant concentrations in the soil/fill are generally below the odor threshold, the odor sources during the Facility will be the operation of diesel engines associated with hydraulic equipment.

If ambient levels are measured which exceed the action levels in areas accessible to unprotected personnel, necessary control measures (barricades, warning signs, and mitigative actions to limit, etc.) must be implemented prior to commencing activities at the specific work area.

Personnel should also be able to upgrade their level of protection if they so feel inclined at the discretion of the HSO.

Reasons to upgrade:

- Known or suspected presence of dermal or airborne hazards.
- Occurrence or likely occurrence of gas, vapor, or dust emission.
- Change in work task that will increase the exposure or potential exposure to hazardous materials.

Below is a table of monitoring procedures with applicable action levels and designated responses. (will be under the guidance of a CIH).

Monitoring Procedures, Action Levels and Response

PARAMETER	LOCATION AND INTERVAL	ACTION LEVEL	RESPONSE
Hydrocarbons, VOCs, SVOCs (Total by PID)	Continuous in the worker's breathing zone or in the immediate work area for sustained reading of 2 minutes in duration.	< 1 ppm	Level D work and continue monitoring (not applicable for initial assessment of unknown drums or containers.
		> 1 ppm	Contact the SSO, and if no potential for change in conditions exist (drum/container activities increasing airborne levels) continue as normal.
		> 5 ppm	Contact the HSO, If continuous – Stop Work. HSO continue work and don Level C (GME/P100 cartridges or equivalent chemical cartridge combined with P100) with continue monitoring. Address source activity.
Dust Particulates	Continuous during all intrusive activities. Monitoring at Facility boundary.	< .5 mg/m^3	Continue Level D work and continue monitoring.
	Continuous during all intrusive activities. Personal Air pump monitoring within the breathing zone.	> .5 mg/m3 (or .2 above upwind reading for 1 hour) > 5 mg/m^3 (Sustained for more than 2 minutes)	Upgrade to modified Level D PPE (PM-10 dust mask). Contact the HSO, implement dust suppression measures. . Temporarily cease work operations, contact the PM and HSO to discuss improving Facility mitigation measures.

Inorganic Airborne Contaminants	Continuous during intrusive activities involving contaminated materials. Personal Air pump monitoring within the breathing zone.	Lead - < 0.3 mg/m3 Arsenic - < 0.1 mg/m3 Crystalline silica - < 50 ug/m3 (TWA 8hr)	Continue Level D work and continue monitoring.
		Lead - > 0.3 mg/m^3 Arsenic - > 0.1 mg/m^3 Crystalline silica - > 50 ug/m^3 (TWA 8hr)	Contact the PM and HSO, implement mitigation measures, and consider modification level of PPE (minimum GME/P100 cartridges or equivalent chemical cartridge combined with P100) and continue monitoring.

4.4.4 Air Emissions and Management

The following types of equipment are intended to be utilized for the scope of work on a recurring basis for a period that will exceed 108 days in a year. If additional equipment is added, this inventory will be updated and the resulting changes in emissions considered with respect to notice and permitting requirements.

- Soil and masonry media sorting, sizing and processing.
- Soil and masonry media stockpiling.
- Vehicle traffic.
- Excavation, handling and placement of fill, soil and masonry materials.

A certified mechanic and support staff will be at the Facility during all soil and masonry media processing activities to maintain optimum equipment operational efficiency. Additionally, all breather filters that are part of the engine operating system will be replaced as prescribed by the manufacturers specifications. No equipment will be modified or "rigged" to circumvent engine air emissions apparatus or performance processes.

Fuel Quality

All fuel used for on-road and off-road diesel engines will be ultra low sulfur content (Grade No. 2-D S15 or Grade No. 1-D S15, as prescribed by the manufacturer). These fuels insure that all diesel combustion emissions are near zero for sulfur and particulate.

Low-Idle Management

Idling means the operation of an engine in the operating mode where the engine is not engaged in gear, where the engine operates at a speed at the revolutions per minute specified by the engine manufacturer, or when the accelerator is fully released and there is no load on the engine. It is in this operational state where many diesel engines generate maximum emissions. While many legally operating trucks employ technology that prevents emissions from this operational state (e.g. auto engine shut-off, electric fired heaters, advanced electrification), there are many trucks that legally remain in use that do not have such advanced technology that have been "grandfathered" for use. As such, all trucks will be required to shut-off engines while in the queuing area for import or export of media from the Facility. Further, no trucks will be loaded while idling. All heavy equipment used on the

Facility (e.g. excavators, loaders) will be operated in shifts to coordinate lunch and coffee break times to prevent inefficiencies. These practices will be strictly enforced by members of the Health and Safety Team.

Conditional Operations

All earth disturbance and or LVA manufacture processing activities will cease if the wind direction has a northerly component and if sustained wind speed (averaged over 1-minute) exceeds 15 miles per hour. All operations will stop at the Facility if wind gusts exceed 40 miles per hour more than twice within a half-hour period.

Spray Bar Systems

The mechanical sorting and sizing equipment will be fitted with manufacturer installed spray bars that provide a mist of water at shaking, crushing and conveyance points on the equipment. The spray bars have anti-foul nozzles that deliver a uniform mist that does not impede sorting and sizing operations. The system uses water only and does not require the addition of chemical surfactants, tackifiers or mollifiers.

5 GENERAL SAFETY AND HEALTH PROVISIONS

This Section is not, nor does it purport to be, a comprehensive recitation of safety and health requirements applicable to general safety and health provisions. Rather, contractors, subcontractors and workers at the Facility must refer to OSHA's General Safety and Health Provision Standard, set forth at 29 C.F.R. § 1910 subparts C and G, as well as supporting OSHA Compliance Directives and Letters of Interpretation, for complete information on safety and health compliance obligations.

5.1 SAFETY PRACTICES / STANDING ORDERS

The following are important safety precautions that will be enforced during work activities.

- Eating, drinking, chewing gum or tobacco, smoking, or practice that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in areas designated as contaminated.
- Hands and face must be thoroughly washed upon leaving the work area and before eating, drinking, or any other activity.
- Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as possible after the protective garments are removed.
- No excessive facial hair that interferes with the effectiveness of a respirator will be permitted on personnel required to wear respiratory protection equipment. The respirator must seal against the face so that the wearer receives air only through the air purifying cartridges attached to the respirator. Fit testing shall be performed prior to respirator use to ensure the wearer obtains a proper seal.
- Contact with potentially contaminated surfaces should be avoided whenever possible. One should not walk through puddles; kneel on the ground; lean, sit, or place equipment on drums, containers, vehicles, or the ground.
- Medicine and alcohol can potentate the effect from exposure to certain compounds
- Prescribed drugs and alcoholic beverages should not be consumed by personnel involved in the project.
- Personnel and equipment in the work areas should be minimized, consistent with effective Facility operations.
- Work areas for various operational activities should be established.

- Procedures for leaving the work area must be planned and implemented prior to going to the Facility. Work areas and decontamination procedures must be established on the basis of prevailing Facility conditions.
- Respirators will be issued for the exclusive use of one worker and will be cleaned and disinfected after each use.
- Safety gloves and boots shall be taped to the disposable, chemical-protective suits as necessary.
- All unsafe equipment left unattended will be identified by a "DANGER, DO NOT OPERATE" tag.
- Noise mufflers or earplugs may be required for Facility personnel working around heavy equipment. This requirement will be at the discretion of the Facility Safety Officer. Disposable, form-fitting plugs are preferred.
- Cartridges for air-purifying respirators in use will be changed daily at a minimum.

5.1.1 Buddy System

Facility personnel will employ the buddy system when working under certain circumstances, such as enclosed spacing. Under the buddy system, each Facility worker is responsible for monitoring the well-being of another worker. No one will work alone when the buddy system is implemented. At no time will fewer than two employees be present at the Facility if activities are underway.

5.1.2 Facility Communications Plan

Mobile telephone and/or two-way radios will be used to communicate between the work parties at the Facility. The following standard hand signals will be used in case of failure of radio communication:

- Hands on top of head = Need assistance
- Thumbs up = OK, I am alright, I understand
- Thumbs down = No, negative

Personnel in the Exclusion Zone should remain in constant radio communication or within sight of the Field team leader. Any failure of radio communication will require the team leader to evaluate whether personnel should leave the zone.

5.1.3 Retention of Records

The following records will be maintained on-Site and in corporate records for no less than three years.

- Fit test results
- OSHA Training Certification
- Medical Questionnaire and/or Medical Clearance
- Medical Data Sheets
- Accident Report Form

6 DECONTAMINATION PLAN

Personnel involved in work activities at the Facility may be exposed to compounds in a number of ways, despite the most stringent protective procedures. Facility personnel may come in contact with vapors, gases, mists, particulates in the air, or other Facility media while performing work duties. Use of monitoring instruments and Facility equipment can also result in exposure and transmittal of hazardous substances.

In general, decontamination involves scrubbing with a detergent water solution followed by clean water rinses. All disposable items shall be disposed of in a dry container. Certain parts of contaminated respirators, such as harness assemblies and leather or cloth components, are difficult to decontaminate. If grossly contaminated, they may have to be discarded. Rubber components can be soaked in detergent and water and scrubbed with a brush. In addition to being contaminated, respirators, non-disposable protective clothing, and other personal articles must be sanitized or replaced before they can be used again if they become soiled from exhalation, body oils, and perspiration. The manufacturer's instructions should be followed in sanitizing the respirator masks.

The HSO will be responsible for the proper maintenance, decontamination, and sanitizing of respirator equipment that may be used on-Site. The decontamination zone layout and procedures should match the prescribed levels of personal protection. The following procedures have been established to provide Facility personnel with minimum guidelines for proper decontamination. Personnel leaving the point of operations designated as the EZ must follow these minimum procedures. The decontamination process shall take place within the contaminant reduction zone.

6.1 MINIMUM DECONTAMINATION PROCEDURE

Personnel leaving the point of operations should remove or change outer gloves. At a minimum, boots shall be cleaned of accumulated soil/fill. Outer boots must be properly washed where gross contamination is evident or disposed of. If Tyvek suits are being utilized, they should be removed or changed. Personnel should remove the Tyvek suits so that the inner clothing does not come in contact with contaminated surfaces. After Tyvek removal, personnel shall remove and discard outer Nitrile gloves. Personnel shall then remove the respirator, where applicable. Respirators shall be disinfected between uses with towelettes or other sanitary methods. Potable water, at a minimum, will be present so that Facility personnel can thoroughly wash hands and face after leaving the point of operations.

The HSO will monitor decontamination procedures to ensure their effectiveness. Modifications of the decontamination procedure may be necessary as determined by the Facility Safety Officer's observations.

6.2 STANDARD DECONTAMINATION PROCEDURE

The following decontamination procedures should be implemented during Facility operations for the appropriate level of protection.

6.2.1 Level B

Segregated equipment drop	Deposit equipment (tools, sampling devices, notes, monitoring instruments, radios, etc.) used at the Facility onto plastic drop cloths.
Boot covers and glove wash	Outer boots and outer gloves should be scrubbed with a decontamination solution of detergent and water or replaced.
Rinse off boot covers and gloves	Decontamination solution should be rinsed off boot covers and gloves using generous amounts of water. Repeat as many times as necessary.
Tape removal	Remove tape from around boots and gloves and place into container with plastic liner.
Boot cover removal	Remove disposable boot covers and place into container with plastic liner.
Outer glove removal	Remove outer gloves and deposit in container with plastic liner.
Suit / safety boot wash	Completely wash splash suit, SCBA, gloves, and safety boots. Care should be exercised that no water is allowed into the SCBA regulator. It is suggested that the SCBA regulator be wrapped in plastic.
Suit / safety boot rinse	Thoroughly rinse off decontamination solution from protective clothing.
Tank or canister changes	This is the last step in the decontamination procedure for those workers wishing to change air tanks and return to the EZ. The worker's air tank or cartridge is exchanged, new outer glove and boot covers are donned, and joints taped.
Removal of safety boots	Remove safety boots and deposit in container with a plastic liner.
SCBA backpack removal	Without removing the face piece, the SCBA backpack should be removed and placed on a table. The face piece should then be disconnected from the remaining SCBA unit and then proceed to the next station.

Splash suit removal	With care, remove the splash suit. The exterior of the splash suit should not come in contact with inner layers of clothing.
Inner glove wash	The inner gloves should be washed with a mild decontamination solution (detergent / water).
Inner glove rinse	Generously rinse the inner gloves with water.
Face piece removal	Without touching the face with gloves, remove the face piece. The face piece should be deposited into a container that has a plastic liner.
Inner glove removal	Remove the inner glove and deposit into a container that has a plastic liner.
Field wash	Wash hands and face thoroughly. If highly toxic, skin corrosive, or skin absorbent materials are known or suspected to be present, a shower should be taken.

6.2.2 Level C and Level D

The decontamination procedure for Level C and Level D will be satisfied with the Minimum procedures outlined in Section 6.1.

6.2.3 Equipment Decontamination

Equipment traversing the Facility and exiting the Facility will be subjected to a decontamination protocol. At a minimum the protocol will consist of an inspection of the truck fenders, tires and mud flaps for accumulated soil/fill, and removal of accumulations using hand tools (brush, broom and scrapers). If deemed necessary by the Health and Safety Officer, this inspection will be performed over a thirty by fifteen-foot area that has been filled with ¾ inch crushed recycled concrete aggregate to facilitate the removal of soil/fill accumulations from the tires, and to immobilize soil/fill removed from the truck body In addition to the above protocols, a truck wash system will be installed at the Facility exits for automated decontamination of truck tires and undercarriages.

At the conclusion of the use of each piece of equipment at the Facility, it will be decontaminated with an Alconox / water solution followed by a clean water rinse within the Contaminant Reduction Zone. The rinsate will be allowed to charge into the Facility ground.

7 EMERGENCY RESPONSE / CONTINGENCY PLANS

7.1 PRE-EMERGENCY PLANNING

In order to properly prepare for emergencies, Material Safety Data Sheets (MSDS) will be maintained on-Site for the type of contaminants to which workers may be exposed. Based upon the past experience, these contaminants typically consist of a mixture of inorganic compounds. The MSDS for both products are presented in **Appendix B**.

In the event a suspected or known hazardous substance or substance container is encountered during Remedial activities, a contingency plan will be triggered (see Section 8).

7.2 EMERGENCY CONTACT INFORMATION

In the event of an accident or emergency situation, emergency procedures will be executed. Said procedures can and will be executed by the first person to observe an accident or emergency situation. The Project Field Manager will be notified about the situation immediately after emergency procedures are implemented.

7.2.1 Emergency Contacts

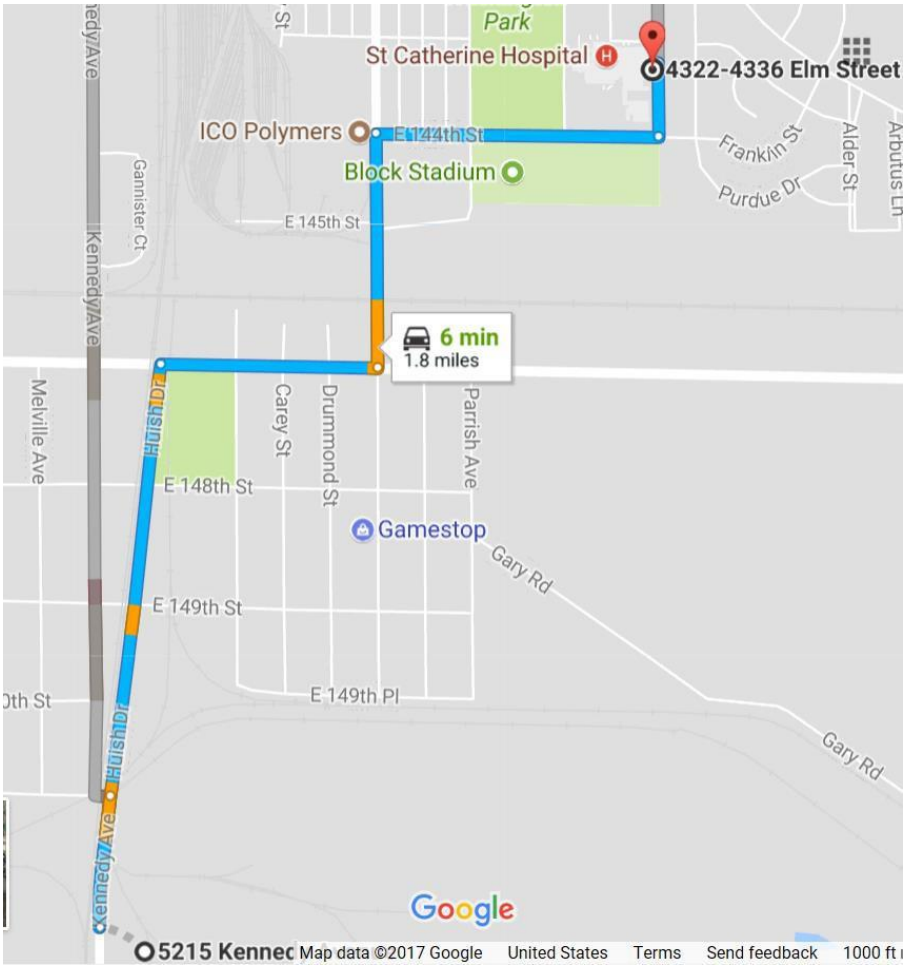
Contact	Emergency Number	Non- Emergency Number
St. Catherine Hospital	911	(219) 392-1700
East Chicago Police Department	911	(291) 391-8400
Fire Department:	911	(291) 391-8472
National Industrial Maintence	(219) 398-6660	N/A
Poison Control Center:	800-336-6997	N/A
National Response Center:	800-424-8802	N/A
USEPA (24-hour hotline):	800-424-9346	N/A

7.2.2 Hospital Route

Directions to Nearest Hospital from Project location, St. Catherine Hospital, presented below:

EMERGENCY ROOM ON ELM STREET BETWEEN E 144th and 143rd STREETS.

- Exit Facility to the Right [North] onto Kennedy Avenue
- Continue on Kennedy Avenue [North] for 0.2 Miles
- Bear Right [North] and Continue to Huish Drive
- Continue on Huish Drive for 0.6 Miles
- Turn Right [East] onto E Chicago Avenue
- Continue on E Chicago Avenue for 0.3 Miles
- Turn Left [North] onto Euclid Avenue
- Continue of Euclid Avenue for 0.3 Miles
- Turn Right [East] onto E 244th Street
- Continue on E 144th Street for 0.4 Miles
- Turn Left [North] onto Elm Street – Emergency Room is 500 feet on the left.



7.3 UTILITY EMERGENCIES / INITIATING SUBSURFACE INVESTIGATION

Where necessary, utility markouts will be called in via the one call center or to the individual companies listed below.

Utility	Contact Number	Company
Mark Out One-Call Center	811	No-Cuts
Gas Company:	800-634-3524	NIPSCO
Water Company:	219-391-8469	East Chicago Water Co.
Electric Company:	800-464-7726	NIPSCO

8 CONTINGENCY/ EVACUATION PLAN

This Section is not, nor does it purport to be, a comprehensive recitation of safety and health requirements applicable to emergency procedures. Rather, contractors, subcontractors and workers at the Facility must refer to OSHA's Employee Emergency Action Plan Standard, set forth at 29 C.F.R. § 1910 Part 1926.35(a), as well as supporting OSHA Compliance Directives and Letters of Interpretation, for complete information on safety and health compliance obligations.

If an unknown substance or substance container (storage tank) is encountered during remedial/development activities, the following contingency plan will be triggered.

- The HSO, Project Manager and Field Operations Leader will be notified and an Exclusion Zone (the aerial extent of which will be determined by the above safety staff) will be established.
- The Facility owner will be notified.
- All staff will be evacuated from the Exclusion Zone.
- The IDEM, as well as any other Government regulatory agency whose need may be prompted by the particular situation, will be notified.
- Upon arrival of the IDEM or Government regulatory agency representative(s), Facility control will transfer to the appropriate Government personnel.

It may be possible that a situation could develop and the emergency could necessitate the evacuation of personnel from the Facility. If such a situation develops, an audible alarm shall be given for Facility evacuation (consisting of an air horn). Personnel shall evacuate the Facility in a calm and controlled fashion and regroup at a predetermined location. The route of evacuation will be dependent on wind direction, severity, type of incident, etc. The Facility must not be re-entered until back-up help, monitoring equipment, and/or personal protective equipment are on hand and the appropriate regulatory agencies have been notified.

8.1 EMERGENCY MEDICAL TREATMENT PROCEDURES

This Section is not, nor does it purport to be, a comprehensive recitation of safety and health requirements applicable to medical treatment and first aid. Rather, contractors, subcontractors and workers at the Facility must refer to OSHA's Medical Services and First Aid Standard, set forth at 29 C.F.R. § 1910 Part 1926.23 and 1926.50, as well as supporting OSHA Compliance Directives and Letters of Interpretation, for complete information on safety and health compliance obligations.

All injuries, no matter how slight, will be reported to the Facility safety supervisor immediately. The safety supervisor will complete an accident report for incidents (**Appendix H**).

Some injuries, such as severe lacerations or burns, may require immediate treatment. Unless required due to immediate danger, seriously injured persons should not be moved without direction from attending medical personnel.

8.1.1 Standard Procedures for Injury

- Notify the Facility Safety Officer, Project Manager, and the Police of accidents, incidents, and near emergency situations.
- If the injury is minor, trained personnel should proceed to administer appropriate first aid.
- Telephone for ambulance/medical assistance if necessary. Whenever possible, notify the receiving hospital of the nature of physical injury or chemical overexposure. If no phone is available, transport the person to the nearest hospital. Refer to the map in section 11.2.1.
- When transporting an injured person to a hospital, bring this Health and Safety Plan with the attached MSDS to assist medical personnel with diagnosis and treatment.

8.1.2 Chemical Overexposure

In cases of chemical overexposure, follow standard procedures as outlined below for poison management, first aid, and, if applicable, cardiopulmonary resuscitation. Different routes of exposure and their respective first aid/poison management procedures are outlined below.

Ingestion	Do not induce vomiting unless prompted by a health professional.
Inhalation / Confined	Do not enter a confined space to rescue someone who has been
Inhalation / Other	Move the person from the contaminated environment. Initiate CPR if necessary. Call or have someone call for medical assistance. Refer to MSDS for additional specific information. If necessary, transport the victim to the nearest hospital as soon as possible.

Skin Contact / Non- Caustic Contaminant	Wash off skin with a large amount of water immediately.
Skin Contact / Corrosive Contaminant	Wash off skin with a large amount of water immediately.
Eyes	Hold eyelids open and rinse the eyes immediately with large amounts

8.1.3 First Aid for Injuries Incurred During Field Work

A first aid kit and an emergency eyewash will be available on-Site. Field crews, when performing field operations, will carry portable first aid kits that include emergency eye wash stations.

8.1.4 First Aid Equipment List

The first aid kit(s) kept at the Facility will consist of a weatherproof container with individually sealed packages for each type of item. The kit will include at least the following items:

- Gauze roller bandages, 1-inch and 2-inch
- Gauze compress bandages, 4-inch
- Gauze pads, 2-inch
- Adhesive tape, 1-inch
- Bandage, 1-inch
- Butterfly bandages
- Triangular bandages, 40-inch
- Ampules of ammonia inhalants
- Antiseptic applicators or swabs
- Burn dressing and sterilized towels
- Surgical scissors
- Eye dressing
- Portable emergency eye wash
- Emergency oxygen supply
- Alcohol
- Hydrogen peroxide
- Clinical grade thermometer
- Tourniquet

8.1.5 Other Emergency Equipment

One portable fire extinguisher with a rating (ratio) of 20 pound A/B/C and one portable fire extinguisher with a rating of 2A will be conspicuously and centrally located between the restricted and non-restricted zones. In addition, similar extinguishers of the same size and class will be located in the Facility office trailer so that maximum travel distance to the nearest unit shall not exceed 50 feet. Portable extinguishers will be properly tagged with inspection dates and maintained in accordance with standard maintenance procedures for portable fire extinguishers. Field personnel will be trained in fire extinguisher use before field operations begin.

An emergency at part of the Facility, such as fire or chemical release, might require that some appropriately trained Facility workers direct traffic on or near the Facility. The following safety equipment to be used for traffic should be kept readily available at the Facility:

- Reflective/fluorescent vests
- Flares
- Traffic cones (and flags, or the equivalent, as needed)
- Hazard tape (barricades as needed)
- Working flashlights

8.2 RECORD OF INJURIES INCURRED ON-SITE

8.2.1 Occupational Injuries and Illnesses Form (OSHA 300)

All occupational injuries and illnesses that are required to be recorded under the Occupational Safety and Health Act will be registered on OSHA Form 300 (see **Appendix I**). The Facility safety supervisor will record occupational injuries and illnesses within 48 hours of occurrence, as required by statute.

8.2.2 Employer's First Report of Injury

The Facility safety supervisor for accidents involving work injury at the Facility will complete this form (**Appendix J**). Follow-up procedures will include investigation of each accident or near-miss by the safety supervisor to assure that no similar accidents occur in the future.

8.2.3 Confidentially and Acceptance by Organization

By receipt of this HASP, the Recipient agrees to hold and treat this HASP and its contents in the strictest confidence. The Recipient will not, directly or indirectly, disclose or communicate or permit anyone else to disclose or communicate any information about this CIM or any of its contents or the fact that they have received this CIM or any part thereof to any person, firm or entity without the prior written consent of the Owner. The Recipient will not use or permit this CIM to be used in any manner detrimental to the interests of the parties, the Owner or their affiliates or for any other purpose than a proposed business transaction.

The HASP shall not be copied, reproduced or distributed, in whole or in part, to other parties at any time without the prior written consent of the Impact Environmental. It is made available to the Recipient for information purposes only and upon the express understanding that such Recipients will use it only for the purposes set forth herein. Upon request, the Recipient will promptly return the HASP. By signing below the signer represents that he/she is the authorized agent of the representing company and that the firm and all of its employers, subcontractors or agents will comply with the terms and conditions of this health and safety plan. Signature and his/her company further acknowledge and agrees that it has read the plan and has no questions or concerns with respect to its scope or content.



IMPACT ENVIRONMENTAL
170 KEYLAND COURT
BOHEMIA, NEW YORK 11716
TEL (631) 269-8800
FAX (631) 269-1599

Scale:
0 190 380 760 Feet

Prepared By: LR	Reviewed By: KK

N
W E
S

Map Reference:

Legend

Property Boundary

Figure :1
Facility Location Map



IMPACT ENVIRONMENTAL
170 KEYLAND COURT
BOHEMIA, NEW YORK 11716
TEL (631) 269-8800
FAX (631) 269-1599

Scale:
0 155 310 620 Feet

Prepared By: LR | Reviewed By: KK

N
W E
S

Map Reference:

Legend

- Mobile Air Monitoring Station Without Telemetry
- Real Time Air Monitoring Station with Telemetry
- Weather Station
- Property Boundary

Figure :2
Air Monitoring Map

ATTACHMENTS

Former DuPont East Chicago Facility

Appendix A – Acknowledgment Statement
Appendix B – MSDS Sheets
Appendix C – Driller Safety Handbook
Appendix D – Excavation and Trenching Handbook
Appendix E – Project Start Briefing Form
Appendix F - Respirator Medical Examination Questionnaire
Appendix G – Dust Control and Suppression Handbook
Appendix H – Employee Accident Report
Appendix I - OSHA 300 Forms
Appendix J – Near Miss/ Incident Report Form

Attachment A

Acknowledgment Statement

Former DuPont East Chicago Facility

Acknowledgment Statement

Health and Safety Plan

5215 Kennedy Avenue, East Chicago, Indiana

By signing the space provided below you are agreeing that you have fully read and fully understand the contents of the enclosed HASP and agree to conduct yourself in accordance to the procedures and protocols described. You also agree to notify the site HSO of anyone conducting themselves or creating a manner or creating a condition or situation on-site that is prohibited within the HASP. Furthermore, by signing this form, you are acknowledging that you have had the opportunity to ask and have received the answer to any questions about the content of the HASP or intimidation thereof.

Name	Company	Signature/Date

Name	Company	Signature/Date

Attachment B

MSDS Sheets

Former DuPont East Chicago Facility

MSDS SHEETS

Trichloroethylene Material Safety Data Sheet - MSDS

---

1. GENERAL INFORMATION

Synonyms: Trichloroethene; TCE; acetylene trichloride; Ethinyl trichloride
CAS No.: 79-01-6
Molecular Weight: 131.39
Chemical Formula: C2HCl3

---

2. COMPOSITION OF INGREDIENTS

Ingredient	CAS No	Percent
Trichloroethylene	79-01-6	100%

---

3. HAZARDS IDENTIFICATION

Emergency Overview

WARNING! HARMFUL IF SWALLOWED OR INHALED. AFFECTS HEART, CENTRAL NERVOUS SYSTEM, LIVER AND KIDNEYS. CAUSES SEVERE SKIN IRRITATION. CAUSES IRRITATION TO EYES AND RESPIRATORY TRACT. SUSPECTED CANCER HAZARD. MAY CAUSE CANCER. Risk of cancer depends on level and duration of exposure.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate (Poison)
Flammability Rating: 1 - Slight
Reactivity Rating: 1 - Slight
Contact Rating: 3 - Severe
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: Blue (Health)

Potential Health Effects

Inhalation:
Vapors can irritate the respiratory tract. Causes depression of the central nervous system with symptoms of visual disturbances and mental confusion, incoordination, headache, nausea, euphoria, and dizziness. Inhalation of high concentrations could cause unconsciousness, heart effects, liver effects, kidney effects, and death.
Ingestion:
Cases irritation to gastrointestinal tract. May also cause effects similar to inhalation. May cause coughing, abdominal pain, diarrhea, dizziness, pulmonary edema, unconsciousness. Kidney failure can result in severe cases. Estimated fatal dose is 3-5 ml/kg.
Skin Contact:
Cause irritation, redness and pain. Can cause blistering. Continued skin contact has a defatting action and can produce rough, dry, red skin resulting in secondary infection.
Eye Contact:
Vapors may cause severe irritation with redness and pain. Splashes may cause eye damage.
Chronic Exposure:
Chronic exposures may cause liver, kidney, central nervous system, and peripheral nervous system effects. Workers chronically exposed may exhibit central nervous system depression, intolerance to alcohol, and increased cardiac output. This material is linked to mutagenic effects in humans. This material is also a suspect carcinogen.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders, cardiovascular disorders, impaired liver or kidney or respiratory function, or central or peripheral nervous system disorders may be more susceptible to the effects of the substance.

----

4. FIRST AIDE MEASURES

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
Ingestion:
Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Call a physician.
Skin Contact:
Immediately flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention. Wash clothing before reuse. Thoroughly clean shoes before reuse.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Note to Physician:

Do not administer adrenaline or epinephrine to a victim of chlorinated solvent poisoning.

---

5. FIRE FIGHTING MEASURES

Fire:
Auto ignition temperature: 420C (788F)
Flammable limits in air % by volume:
lel: 8; uel: 12.5
Explosion:
A strong ignition source, e. g., a welding torch, can produce ignition. Sealed containers may rupture when heated.
Fire Extinguishing Media:
Use water spray to keep fire exposed containers cool. If substance does ignite, use CO2, dry chemical or foam.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece operated in the pressure demand or other positive pressure mode. Combustion by-products include phosgene and hydrogen chloride gases. Structural firefighters' clothing provides only limited protection to the combustion products of this material.

---

6. ACCIDENTAL RELEASE MEASURES

Ventilate area of leak or spill. Remove sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

---

7. HANDLING AND STORAGE

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from source of heat or ignition. Isolate from incompatible substances. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe warnings and precautions listed for the product.

---

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Airborne Exposure Limits:

Trichloroethylene:

-OSHA Permissible Exposure Limit (PEL):

100 ppm (TWA), 200 ppm (Ceiling),

300 ppm/5min/2hr (Max)

-ACGIH Threshold Limit Value (TLV):

50 ppm (TWA) 100 ppm (STEL);

listed as A5, not suspected as a human carcinogen.

Ventilation System:

A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded and engineering controls are not feasible, wear a supplied air, full-face piece respirator, air lined hood, or full-face piece self-contained breathing apparatus. Breathing air quality must meet the requirements of the OSHA respiratory protection standard (29CFR1910.134). This substance has poor warning properties. Where respirators are required, you must have a written program covering the basic requirements in the OSHA respirator standard. These include training, fit testing, medical approval, cleaning, maintenance, cartridge change schedules, etc. See 29CFR1910.134 for details.

Skin Protection:

Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact. Neoprene is a recommended material for personal protective equipment.

Eye Protection:

Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

---

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:

Clear, colorless liquid.

Odor:

Chloroform-like odor.

Solubility:

Practically insoluble in water. Readily miscible in organic solvents.

Specific Gravity:

1.47 @ 20C/4C
pH:
No information found.
% Volatiles by volume @ 21C (70F):
100
Boiling Point:
87C (189F)
Melting Point:
-73C (-99F)
Vapor Density (Air=1):
4.5
Vapor Pressure (mm Hg):
57.8 @ 20C (68F)
Evaporation Rate (BuAc=1):
No information found.

---

10. STABILITY AND REACTIVITY

Stability:
Stable under ordinary conditions of use and storage. Will slowly decompose to hydrochloric acid when exposed to light and moisture.
Hazardous Decomposition Products:
May produce carbon monoxide, carbon dioxide, hydrogen chloride and phosgene when heated to decomposition.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Strong caustics and alkalis, strong oxidizers, chemically active metals, such as barium, lithium, sodium, magnesium, titanium and beryllium, liquid oxygen.
Conditions to Avoid:
Heat, flame, ignition sources, light, moisture, incompatibles

---

11. TOXICOLOGICAL INFORMATION

Toxicological Data:
Trichloroethylene: Oral rat LD50: 5650 mg/kg; investigated as a tumorigen, mutagen, reproductive effector.
Reproductive Toxicity:
This material has been linked to mutagenic effects in humans.

NTP	Carcinogen

Ingredient	Known	Anticipated
Trichloroethylene (79-01-6)	No	Yes

IARC Category - 2A

---

12. ECOLOGICAL INFORMATION

Environmental Fate:
When released into the soil, this material may leach into groundwater. When released into the soil, this material is expected to quickly evaporate. When released to water, this material is expected to quickly evaporate. This material has an experimentally-determined bioconcentration factor (BCF) of less than 100. This material is not expected to significantly bioaccumulate. When released into the air, this material may be moderately degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to have a half-life between 1 and 10 days.
Environmental Toxicity:
The LC50/96-hour values for fish are between 10 and 100 mg/l. This material is expected to be slightly toxic to aquatic life.

---

13. DISPOSAL CONSIDERATIONS

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

---

14. TRANSPORTATION INFORMATION

Domestic (Land, D.O.T.)

Proper Shipping Name: TRICHLOROETHYLENE
Hazard Class: 6.1
UN/NA: UN1710
Packing Group: III
Information reported for product/size: 4L

International (Water, I.M.O.)

Proper Shipping Name: TRICHLOROETHYLENE
Hazard Class: 6.1
UN/NA: UN1710
Packing Group: III
Information reported for product/size: 4L

---

15. OTHER INFORMATION

NFPA Ratings: Health: **2** Flammability: **1** Reactivity: **0**
Label Hazard Warning:
WARNING! HARMFUL IF SWALLOWED OR INHALED. AFFECTS HEART, CENTRAL NERVOUS SYSTEM, LIVER AND KIDNEYS. CAUSES SEVERE SKIN IRRITATION. CAUSES IRRITATION TO EYES AND RESPIRATORY TRACT. SUSPECT CANCER HAZARD. MAY CAUSE CANCER. Risk of cancer depends on level and duration of exposure.
Label Precautions:
Do not get in eyes, on skin, or on clothing.
Do not breathe vapor.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
Keep away from heat and flame.
Label First Aid:
If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. In all cases call a physician. Note to physician: Do not administer adrenaline or epinephrine to a victim of chlorinated solvent poisoning.
Product Use:
Laboratory Reagent.
Revision Information:
MSDS Section(s) changed since last revision of document include: 3.

Disclaimer:

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*
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11.1.1 *1,2-Dichloroethane Material Safety Data Sheet - MSDS*

---

1. GENERAL INFORMATION

Synonyms: Ethylene dichloride; dichloroethylene; 1,2-Bichloroethane
CAS No.: 107-06-2
Molecular Weight: 98.96
Chemical Formula: ClCH2CH2Cl
Product Codes:
J.T. Baker: 9302, H076
Mallinckrodt: 4966, 5338

---

2. COMPOSITION

Ingredient	CAS No	Percent
Ethylene Dichloride	107-06-2	90 - 100%

---

3. HAZARDS IDENTIFICATION

Emergency Overview

WARNING! FLAMMABLE LIQUID AND VAPOR. HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN. AFFECTS CENTRAL NERVOUS SYSTEM, LIVER, KIDNEYS, AND CARDIOVASCULAR SYSTEM. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. POSSIBLE CANCER HAZARD. MAY CAUSE CANCER BASED ON ANIMAL DATA. Risk of cancer depends on duration and level of exposure.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 3 - Severe (Poison)
Flammability Rating: 3 - Severe (Flammable)
Reactivity Rating: 2 - Moderate
Contact Rating: 3 - Severe
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES; CLASS B EXTINGUISHER
Storage Color Code: Red (Flammable)

Potential Health Effects

Inhalation:
Inhalation of vapors irritates the respiratory tract. May cause headache, weakness, cyanosis, nausea, vomiting, and diarrhea. These symptoms may be followed by central nervous system effects, liver damage, kidney damage, adrenal gland damage, cyanosis, weak and rapid pulse and unconsciousness. Death can occur from respiratory and circulatory failure.

Ingestion:
Causes irritation to the gastrointestinal tract. Symptoms may include nausea, vomiting and diarrhea. Toxic effects parallel those of inhalation. Doses of 0.5 - 1.0 g/kg can be fatal.

Skin Contact:
Causes irritation, rash and blister formation. Prolonged contact can cause skin burns. Can be absorbed through skin with toxic effects.

Eye Contact:
Vapors cause eye irritation. Splashes cause severe irritation, possible corneal burns and eye damage.

Chronic Exposure:
Repeated or prolonged exposure may cause weight loss, low blood pressure, jaundice, reduced urinary output, dermatitis, eye damage and anemia. Dichloroethane is a suspected human carcinogen based on animal data.

Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems, or impaired liver, kidney, cardiovascular, neurological or respiratory function may be more susceptible to the effects of the substance.

---

4. FIRST AIDE MEASURES

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Ingestion:
If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:
Wash skin with soap or mild detergent and water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Call a physician.

Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

---

5. FIRE FIGHTING AND ACCIDENTAL RELEASE MEASURES

Fire:

Flash point: 13C (55F) CC
Autoignition temperature: 413C (775F)
Flammable limits in air % by volume:
lel: 6.2; uel: 15.9
Flammable.

Explosion:

Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Sealed containers may rupture when heated. Contact with strong oxidizers may cause fire. Vapors can flow along surfaces to distant ignition source and flash back. Sensitive to static discharge.

Fire Extinguishing Media:

Dry chemical, foam or carbon dioxide. Water spray may be used to keep fire exposed containers cool, dilute spills to nonflammable mixtures, protect personnel attempting to stop leak and disperse vapors.

Special Information:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece operated in the pressure demand or other positive pressure mode. Combustion by-products include phosgene and hydrogen chloride gases.Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! If a leak or spill has not ignited, use water spray to disperse the vapors, to protect personnel attempting to stop leak, and to flush spills away from exposures. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

---

6. HANDLING AND STORAGE

Protect against physical damage. Store in a cool, dry well-ventilated location, away from any area where the fire hazard may be acute. Outside or detached storage is preferred. Separate from incompatibles. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type tools and equipment, including explosion proof ventilation. Wear special protective equipment (Sec. 8) for maintenance break-in or where exposures may exceed established exposure levels. Wash hands, face, forearms and neck when exiting restricted areas. Shower, dispose of outer clothing, change to clean garments at the end of the day. Avoid cross-contamination of street clothes. Wash hands before

eating and do not eat, drink, or smoke in workplace. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe warnings and precautions listed for the product.

---

8. EXPOSURE CONTROLS/SPECIAL HANDLING

Airborne Exposure Limits:

- OSHA Permissible Exposure Limit (PEL):
50 ppm (TWA), 100 ppm (ceiling)
200 ppm (max)/5 min/3 hour

- ACGIH Threshold Limit Value (TLV):
10 ppm (TWA), A4 - not classifiable as a human carcinogen

- NIOSH IDLH:
50 ppm

Ventilation System:

A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded, wear a supplied air, full-face piece respirator, airlined hood, or full-face piece self-contained breathing apparatus. This substance has poor warning properties.

Skin Protection:

Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact. Polyvinyl alcohol (PVA) and Viton are recommended materials for personal protective equipment.

Eye Protection:

Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

---

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:

Colorless heavy liquid.

Odor:

Chloroform-like odor.

Solubility:

0.81g/100g water @ 20C (68F).

Specific Gravity:
1.24 @ 20C
pH:
No information found.
% Volatiles by volume @ 21C (70F):
100
Boiling Point:
83.4C (181F)
Melting Point:
-35.4C (-31F)
Vapor Density (Air=1):
3.42
Vapor Pressure (mm Hg):
87 @ 25C (77F)
Evaporation Rate (BuAc=1):
No information found.

---

10. STABILITY AND REACTIVITY

Stability:
Stable under ordinary conditions of use and storage. Darkens on exposure to air or light.
Hazardous Decomposition Products:
Emits toxic fumes of phosgene, hydrogen chloride, acetylene, and vinyl chloride when heated to decomposition.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Aluminum or magnesium powder, oxidizing agents, reducing agents, organic peroxides, alkali and alkali earth metals, nitric acid, caustics, nitrogen tetraoxide, ammonia, and dimethylaminopropylamine.
Conditions to Avoid:
Heat, flame, sources of ignition, light and incompatibles.

---

11. TOXICOLOGICAL INFORMATION

Oral rat LD50: 500 mg/kg; inhalation rat LC50: 1000 ppm.7H; skin rabbit LD50: 2800 mg/kg; irritation eye rabbit, Standard Draize, 63 mg severe; skin rabbit, Open Draize, 625 mg mild; investigated as a tumorigen, mutagen, reproductive effector.

--------\Cancer Lists\----------

NTP Carcinogen
Ingredient Known Anticipated IARC

Ethylene Dichloride (107-06-2) No Yes 2B

---

12. ECOLOGICAL INFORMATION

Environmental Fate:
When released into the soil, this material is expected to quickly evaporate. When released into the soil, this material may leach into groundwater. When released to water, this material is expected to quickly evaporate. When released into the water, this material is expected to have a half-life between 1 and 10 days. This material has a log octanol-water partition coefficient of less than 3.0. This material is not expected to significantly bioaccumulate. When released into the air, this material may be moderately degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to have a half-life of greater than 30 days. When released into the air, this material may be removed from the atmosphere to a moderate extent by wet deposition.
Environmental Toxicity:
This material is not expected to be toxic to aquatic life. The LC50/96-hour values for fish are over 100 mg/l. The EC50/48-hour values for daphnia are over 100 mg/l.

---

13. DISPOSAL CONSIDERATIONS

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

---

14. TRANSPORT INFORMATION

Domestic (Land, D.O.T.)

Proper Shipping Name: RQ, ETHYLENE DICHLORIDE
Hazard Class: 3, 6.1
UN/NA: UN1184 Packing Group: II
Information reported for product/size: 52L

International (Water, I.M.O.)

Proper Shipping Name: ETHYLENE DICHLORIDE
Hazard Class: 3, 6.1
UN/NA: UN1184 Packing Group: II
Information reported for product/size: 52L

International (Air, I.C.A.O.)

Proper Shipping Name: ETHYLENE DICHLORIDE
Hazard Class: 3, 6.1
UN/NA: UN1184 Packing Group: II
Information reported for product/size: 52L

---

15. OTHER INFORMATION

NFPA Ratings: Health: **2** Flammability: **3** Reactivity: **0**
Label Hazard Warning:
WARNING! FLAMMABLE LIQUID AND VAPOR. HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN. AFFECTS CENTRAL NERVOUS SYSTEM, LIVER, KIDNEYS, AND CARDIOVASCULAR SYSTEM. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. POSSIBLE CANCER HAZARD. MAY CAUSE CANCER BASED ON ANIMAL DATA. Risk of cancer depends on duration and level of exposure.
Label Precautions:
Wash thoroughly after handling.
Do not breathe vapor.
Keep container closed.
Use only with adequate ventilation.
Do not get in eyes, on skin, or on clothing.
Keep away from heat, sparks and flame.
Label First Aid:
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In all cases call a physician.
Product Use:
Laboratory Reagent.
Revision Information:
MSDS Section(s) changed since last revision of document include: 3, 11.

Disclaimer:

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11.1.2 Diesel Material Safety Data Sheet - MSDS

---

1. GENERAL INFORMATION

DIESEL ENGINE OIL; HEATING OIL; FUEL OIL

---

2. COMPOSITION/INFORMATION ON INGREDIENTS

CHEMICAL NAMES AND SYNONYMS: BASE OIL AND ADDITIVES
GLOBALLY REPORTABLE MSDS INGREDIENTS:
Substance Name Approx. Wt%
---------- ----------
CALCIUM ALKYLENE PHENATE 1-5
SULFIDE CARBONATE
(OVERBASED) (122384-87-6)
CALCIUM LONG-CHAIN ALKARYL 1-5
SULFONATES (LOW OVERBASED)
(156619-82-8)

---

3. HAZARDS IDENTIFICATION

Under normal conditions of use, this product is not considered hazardous according to regulatory guidelines (See section 15).
EMERGENCY OVERVIEW: Clear Dark Amber Liquid. DOT ERG No. : NA
POTENTIAL HEALTH EFFECTS: Under normal conditions of intended use, this product does not pose a risk to health. Excessive exposure may result in eye, skin or respiratory irritation. For further health effects/toxicological data, see Section 11.

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4. FIRST AID MEASURES

EYE CONTACT: Flush thoroughly with water. If irritation occurs, call a physician.
SKIN CONTACT: Wash contact areas with soap and water. Remove and clean oil soaked clothing daily and wash affected area. (See Section 16 - Injection Injury)
INHALATION: Not expected to be a problem. However, if respiratory irritation, dizziness, nausea, or unconsciousness occurs due to excessive vapor or mist exposure, seek immediate medical assistance. If breathing has stopped, assist ventilation with a

mechanical device or mouth-to-mouth resuscitation.
INGESTION: Not expected to be a problem. Seek medical attention if discomfort occurs. Do not induce vomiting.

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5. FIRE-FIGHTING MEASURES

EXTINGUISHING MEDIA: Carbon dioxide, foam, dry chemical and water fog.
SPECIAL FIRE FIGHTING PROCEDURES: Water or foam may cause frothing. Use water to keep fire exposed containers cool. Water spray may be used to flush spills away from exposure. Prevent runoff from fire control or dilution from entering streams, sewers, or drinking water supply.
SPECIAL PROTECTIVE EQUIPMENT: For fires in enclosed areas, fire fighters must use self-contained breathing apparatus.
UNUSUAL FIRE AND EXPLOSION HAZARDS: None.
COMBUSTION PRODUCTS: Fumes, smoke, carbon monoxide, sulfur oxides, aldehydes and other decomposition products, in the case of incomplete combustion.
Flash Point C(F): 204(400) (ASTM D-92).
Flammable Limits (approx.% vol.in air) - LEL: 0.9%, UEL: 7.0%
NFPA HAZARD ID: Health: 0, Flammability: 1, Reactivity: 0

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6. ACCIDENTAL RELEASE MEASURES

NOTIFICATION PROCEDURES: Report spills/releases as required to appropriate authorities. U.S. Coast Guard and EPA regulations require immediate reporting of spills/releases that could reach any waterway including intermittent dry creeks. Report spill/release to Coast Guard National Response Center toll free number (800)424-8802. In case of accident or road spill notify CHEMTREC (800) 424-9300.
PROCEDURES IF MATERIAL IS RELEASED OR SPILLED:
LAND SPILL: Shut off source taking normal safety precautions. Take measures to minimize the effects on ground water. Recover by pumping or contain spilled material with sand or other suitable absorbent and remove mechanically into containers. If necessary, dispose of adsorbed residues as directed in Section 13.
WATER SPILL: Confine the spill immediately with booms. Warn other ships in the vicinity. Notify port and other relevant authorities.Remove from the surface by skimming or with suitable absorbents. If permitted by regulatory authorities the use of suitable dispersants should be considered where recommended in local oil spill procedures.
ENVIRONMENTAL PRECAUTIONS: Prevent material from entering sewers, water sources or low lying areas; advise the relevant authorities if it has, or if it contaminates soil/vegetation.
PERSONAL PRECAUTIONS: See Section 8

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7. HANDLING AND STORAGE

HANDLING: No special precautions are necessary beyond normal good hygiene practices. See Section 8 for additional personal protection advice when handling this product.
STORAGE: Keep containers closed when not in use. Do not store in open or unlabelled containers. Store away from strong oxidizing agents and combustible materials. Do not store near heat, sparks, flame or strong oxidants.
SPECIAL PRECAUTIONS: Prevent small spills and leakages to avoid slip hazard.
EMPTY CONTAINER WARNING: Empty containers retain residue (liquid and/or vapor) and can be dangerous. DO NOT PRESSURIZE, CUT, WELD, BRAZE, SOLDER, DRILL, GRIND OR EXPOSE SUCH CONTAINERS TO HEAT, FLAME, SPARKS, STATIC ELECTRICITY, OR OTHER SOURCES OF IGNITION; THEY MAY EXPLODE AND CAUSE INJURY OR DEATH. Do not attempt to refill or clean container since residue is difficult to remove. Empty drums should be completely drained, properly bunged and promptly returned to a drum reconditioner. All containers should be disposed of in an environmentally safe manner and in accordance with governmental regulations.

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8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS:
When mists/aerosols can occur, the following are recommended: 5 mg/m3 (as oil mist)- ACGIH Threshold Limit Value (TLV), 10 mg/m3 (as oil mist)
- ACGIH Short Term Exposure Limit (STEL), 5 mg/m3 (as oil mist) - OSHA
Permissible Exposure Limit (PEL)
VENTILATION: If mists are generated, use adequate ventilation, local exhaust or enclosures to control below exposure limits.
RESPIRATORY PROTECTION: If mists are generated, and/or when ventilation is not adequate, wear approved respirator.
EYE PROTECTION: If eye contact is likely, safety glasses with side shields or chemical type goggles should be worn.
SKIN PROTECTION: Not normally required. When splashing or liquid contact can occur frequently, wear oil resistant gloves and/or other protective clothing. Good personal hygiene practicesn should always be followed.

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9. PHYSICAL AND CHEMICAL PROPERTIES

Typical physical properties are given below. Consult Product Data Sheet for specific details.
APPEARANCE: Liquid
COLOR: Clear Dark Amber
ODOR: Mild

ODOR THRESHOLD-ppm: NE
pH: NA
BOILING POINT C(F): > 391(735)
MELTING POINT C(F): NA
FLASH POINT C(F): 204(400) (ASTM D-92)
FLAMMABILITY (solids): NE
AUTO FLAMMABILITY C(F): NA
EXPLOSIVE PROPERTIES: NA
OXIDIZING PROPERTIES: NA
VAPOR PRESSURE-mmHg 20 C: NE
VAPOR DENSITY: NE
EVAPORATION RATE: NE
RELATIVE DENSITY, 15/4 C: 0.89
SOLUBILITY IN WATER: Negligible
PARTITION COEFFICIENT: > 3.5
VISCOSITY AT 40 C, cSt: > 100.0
VISCOSITY AT 100 C, cSt: > 10.0
POUR POINT C(F): -12(10)
FREEZING POINT C(F): NE
VOLATILE ORGANIC COMPOUND: NE
DMSO EXTRACT, IP-346 (WT.%): <3, for mineral oil only
FOR FURTHER TECHNICAL INFORMATION, CONTACT YOUR MARKETING REPRESENTATIVE

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10. STABILITY AND REACTIVITY

STABILITY (THERMAL, LIGHT, ETC.): Stable.
CONDITIONS TO AVOID: Extreme heat and high energy sources of ignition.
INCOMPATIBILITY (MATERIALS TO AVOID): Strong oxidizers.
HAZARDOUS DECOMPOSITION PRODUCTS: Product does not decompose at ambient temperatures.
HAZARDOUS POLYMERIZATION: Will not occur.

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11. TOXICOLOGICAL DATA

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--ACUTE TOXICOLOGY---

ORAL TOXICITY (RATS): Practically non-toxic (LD50: greater than 2000 mg/kg). ---Based on testing of similar products and/or the components.
DERMAL TOXICITY (RABBITS): Practically non-toxic (LD50: greater than 2000 mg/kg). ---Based on testing of similar products and/or the components.

INHALATION TOXICITY (RATS): Practically non-toxic (LC50: greater than 5 mg/l). ---Based on testing of similar products and/or the components.
EYE IRRITATION (RABBITS): Practically non-irritating. (Draize score: greater than 6 but 15 or less). ---Based on testing of similar products and/or the components.
SKIN IRRITATION (RABBITS): Practically non-irritating. (Primary Irritation Index: greater than 0.5 but less than 3). ---Based on testing of similar products and/or the components.
OTHER ACUTE TOXICITY DATA: Although an acute inhalation study was not performed with this product, a variety of mineral and synthetic oils, such as those in this product, have been tested. These samples had virtually no effect other than a nonspecific inflammatory response in the lung to the aerosolized mineral oil. The presence of additives in other tested formulations (in approximately the same amounts as in the present formulation) did not alter the observed effects.
---SUBCHRONIC TOXICOLOGY (SUMMARY)---
No significant adverse effects were found in studies using repeated dermal applications of similar formulations to the skin of laboratory animals for 13 weeks at doses significantly higher than those expected during normal industrial exposure. The animals were evaluated extensively for effects of exposure (hematology, serum chemistry, urinalysis, organ weights, microscopic examination of tissues etc.).
---REPRODUCTIVE TOXICOLOGY (SUMMARY)---
No teratogenic effects would be expected from dermal exposure, based on laboratory developmental toxicity studies of major components in this formulation and/or materials of similar composition.
---CHRONIC TOXICOLOGY (SUMMARY)---
Repeated and/or prolonged exposure may cause irritation to the skin, eyes or respiratory tract. Overexposure to oil mist may result in oil droplet deposition and/or granuloma formation. For mineral base oils: Base oils in this product are severely solvent refined and/or severely hydrotreated. Chronic mouse skin painting studies of severely treated oils showed no evidence of carcinogenic effects. These results are confirmed on a continuing basis using various screening methods such as Modified Ames Test, IP-346, and/or other analytical methods. For synthetic base oils: The base oils in this product have been tested in the Ames assay and other tests of mutagenicity with negative results. These base oils are not expected to be carcinogenic with chronic dermal exposures.
---SENSITIZATION (SUMMARY)---
Not expected to be sensitizing based on tests of this product, components, or similar products.
---OTHER TOXICOLOGY DATA---
Used gasoline engine oils have shown evidence of skin carcinogenic activity in laboratory tests when no effort was made to wash the oil off between applications. Used oil from diesel engines did not produce this effect.

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12. ECOLOGICAL INFORMATION

ENVIRONMENTAL FATE AND EFFECTS: This product is expected to be inherently biodegradable. Bioaccumulation is unlikely due to the very low water solubility of this product, therefore bioavailability to aquatic organisms is minimal. Available
ectoxicity data (LL50 >1000 mg/L) indicates that adverse effects to aquatic organisms are not expected from this product. When released into the environment, adsorption to sediment and soil will be the predominant behavior.

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13. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL: Product is suitable for burning in an enclosed, controlled burner for fuel value. Such burning may be limited pursuant to the Resource Conservation and Recovery Act. In addition, the product is suitable for processing by an approved recycling facility or can be disposed of at an appropriate government waste disposal facility. Use of these methods is subject to user compliance with applicable laws and regulations and consideration of product characteristics at time of disposal.
RCRA INFORMATION: The unused product, in our opinion, is not specifically listed by the EPA as a hazardous waste (40 CFR, Part 261D), nor is it formulated to contain materials which are listed hazardous wastes. It does not exhibit the hazardous characteristics of ignitability, corrosivity, or reactivity. The unused product is not formulated with substances covered by the Toxicity Characteristic Leaching Procedure (TCLP). However, used product may be regulated.

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14. TRANSPORT INFORMATION

USA DOT: NOT REGULATED BY USA DOT.
RID/ADR: NOT REGULATED BY RID/ADR.
IMO: NOT REGULATED BY IMO.
IATA: NOT REGULATED BY IATA.
STATIC ACCUMULATOR (50 picosiemens or less): YES

Disclaimer:

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11.1.3 Gasoline Material Safety Data Sheet - MSDS

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1. GENERAL INFORMATION

LEAD-FREE GASOLINE; NO-LEAD GASOLINE - GASOLINE,UNLEADED

Part Number/Trade Name: LEAD-FREE GASOLINE; NO-LEAD GASOLINE

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2. INGREDIENTS/IDENTITY INFORMATION

Proprietary: NO
Ingredient: HYDROCARBONS, AROMATIC
Ingredient Sequence Number: 01
Percent: 15-35
NIOSH (RTECS) Number: 1008732HA
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: NONE RECOMMENDED

Proprietary: NO
Ingredient: SATURATED HYDROCARBONS
Ingredient Sequence Number: 02
Percent: 60-75
NIOSH (RTECS) Number: 1006886SH
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: NONE RECOMMENDED

Proprietary: NO
Ingredient: UNSATURATED HYDROCARBONS
Ingredient Sequence Number: 03
Percent: 1-15
NIOSH (RTECS) Number: 1006887UH
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: NONE RECOMMENDED

Proprietary: NO

Ingredient: DYE AND OTHER ADDITIVES
Ingredient Sequence Number: 04
Percent: 0.02
NIOSH (RTECS) Number: 1003746AD
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: NONE RECOMMENDED

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3. PHYSICAL AND CHEMICAL CHARACTERISTICS

Appearance And Odor: BLUE OR CLEAR, TYPICAL HYDROCARBON ODOR.
Boiling Point: 90.0F,32.2C
Vapor Pressure (MM Hg/70 F): 414 @100C
Vapor Density (Air=1): 3-4
Specific Gravity: 0.71-0.77
Solubility In Water: NEGLIGIBLE.

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4. FIRE AND EXPLOSION HAZARD DATA

Flash Point: -50F,-46C
Flash Point Method: TCC
Lower Explosive Limit: 1.3
Upper Explosive Limit: 6
Extinguishing Media: ANY UL APPROVED CLASS B MEDIA SUCH AS FOAM, CARBON DIOXIDE, DRY CHEMICAL.
Special Fire Fighting Proc: NONE SPECIFIED BY MFG; HOWEVER USE APPROPRIATE PROTECTIVE EQPMT INCLUDING SELF-CONTAINED BREATHING APPARATUS.
Unusual Fire And Expl Hazrds: NONE SPECIFIED BY MFG; HOWEVER MATL IS HEAVIER THAN AIR AND WILL TRAVEL LONG DISTANCES & FLASHBACK. EXPLOSIVE MIXTURE FORMS W/GASOLINE & AIR.

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5. REACTIVITY DATA

Stability: YES
Cond To Avoid (Stability): NONE SPECIFIED BY MFG; HOWEVER AVOID OPEN FLAMES/HEAT/SPARKS/OTHER IGNITION SOURCES.
Materials To Avoid: OXIDIZERS.
Hazardous Decomp Products: NONE SPECIFIED BY MFG.
Hazardous Poly Occur: NO

Conditions To Avoid (Poly): NOT RELEVANT.

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6. HEALTH HAZARD DATA

LD50-LC50 Mixture: UNKNOWN
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: ACUTE:EYE:IRRIT @ HIGH VAP LEVELS OR DIRECT CONTACT W/FLUID. SKIN:IRRIT ON PROLONG CONTACT W/LIQ, DERM RESULTING FROM DEFATTING NATURE OF LIQ. SYSTEMATIC:CNS EFFECTS (NARCOSIS) @ HIGH VAP LEVELS; MUC MEMBRANE IRRIT, PNEUMONIA. INGEST:GASTROINTESTINAL DISTRUBANCES. CHRONIC:PERIPERAL NERVOUS SY EFFECTS, BLOOD ALTERATIONS
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: YES
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: PER MSDS:NONE STATED; HOWEVER CONTAINS GASOLINE WHICH IS CONSIDERED BY IARC TO BE POTENTIAL CARCINOGEN.
Signs/Symptoms Of Overexp: EYE & SKIN IRRITATION. DERMATITIS. NARCOSIS. GI DISTURBANCES:NAUSEA, DIARRHEA, STOMACH PAINS.
Med Cond Aggravated By Exp: NONE SPECIFIED BY MFG.
THOROUGHLY WASH AREA W/SOAP & WATER. INHAL:REMOVE FROM CONTAMINATED AREA. ADMINISTER ARTIFICIAL RESP IF NECESSARY. CALL PHYSICIAN. INGEST:GIVE A VEGETABLE OIL TO RETARD ABSORPTION. DO NOT INDUCE VOMITING. CALL PHYSICIAN. FATAL DOSE ADULT HUMAN APPROX 350G, CHILD APPROX 10-13G.

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: KEEP PUBLIC AWAY. SHUT OFF SOURCE W/O RISK. ADVISE POLICE & NAT RESP CENTER 800-424-8802 IF SUBSTANCE HAS ENTERED A WATER COURSE OR SEWER. CONTAIN LIQ W/EARTH, SAND. RECOVER FREE LIQ BY PPUMPING OR W/SUITABLE ABSORBENT.
Neutralizing Agent: NONE SPECIFIED BY MFG.
Waste Disposal Method: UNDER MANY SPILL SITUATIONS LIQ CAN BE RECOVERED & RECLAIMED. WHERE SOLID ABSORBENTS ARE USED THEY SHOULD BE INCINERATED PER APPLICABLE STATE & LOCAL REGULATIONS.
Precautions-Handling/Storing: USE APPROPRIATE GROUNDING-DISPENSING PROCEDURES. STORE IN RELATIVELY COOL PLACE. DO NOT EXPOSE TO HEAT, OPEN FLAME OR OXIDANTS.
Other Precautions: NONE SPECIFIED BY MFG.

Control Measures

Respiratory Protection: FOR EXPOSURES IN EXCESS OF EXPOSURE LIMITS CHEMICAL CARTRIDGE RESPIRATOR OR AIR SUPPLIED EQUIPMENT.
Ventilation: LOCAL EXHAUST REQUIRED & EXPLOSION PROOF EQUIPMENT.
Protective Gloves: IMPERMEABLE GLOVES.
Eye Protection: NONE SPECIFIED HOWEVER SAF GLASSES/GOGG
Other Protective Equipment: NONE SPEICFIED BY MFG.
Work Hygienic Practices: WASH HANDS AFTER HANDLING & PRIOR TO EAT/DRINK/ SMOKE/USE OF TOILET FACILITIES. FOLLOW GOOD WORK HYGIENE PRACTICES.

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7. TRANSPORTATION DATA

DOT PSN Code: GTN
DOT Proper Shipping Name: GASOLINE
DOT Class: 3
DOT ID Number: UN1203
DOT Pack Group: II
DOT Label: FLAMMABLE LIQUID
IMO PSN Code: HRV
IMO Proper Shipping Name: GASOLINE
IMO Regulations Page Number: 3141
IMO UN Number: 1203
IMO UN Class: 3.1
IMO Subsidiary Risk Label: -
IATA PSN Code: MUC
IATA UN ID Number: 1203
IATA Proper Shipping Name: GASOLINE
IATA UN Class: 3
IATA Label: FLAMMABLE LIQUID
AFI PSN Code: MUC

Label Required: YES
Technical Review Date: 21OCT94
Label Status: F
Common Name: LEAD-FREE GASOLINE; NO-LEAD GASOLINE
Signal Word: DANGER!
Acute Health Hazard-Moderate: X
Contact Hazard-Moderate: X
Fire Hazard-Severe: X
Reactivity Hazard-None: X
Special Hazard Precautions: ACUTE:EYE:IRRIT @ HIGH VAP LEVELS OR DIRECT CONTACT W/FLUID. SKIN:IRRIT ON PROLONG CONTACT W/LIQ, DERM RESULTING FROM DEFATTING NATURE OF LIQ. SYSTEMATIC:CNS EFFECTS (NARCOSIS) @ HIGH VAP LEVELS; MUC MEMBRANE IRRIT, PNEUMONIA. INGEST:GASTROINTESTINAL

DISTRUBANCES. CHRONIC:PERIPERAL NERVOUS SYS EFFECTS, BLOOD ALTERATIONS. 1STAID:EYE:FLUSH FOR @ LEAST 15MINS W/WATER. SKIN:THOROUGHLY WASH AREA W/ SOAP & WATER. INHAL:REMOVE FROM CONTAMINATED AREA. ADMINISTER ARTIFICIAL RESP IF NECESSARY. CALL PHYSICIAN. INGEST:GIVE A VEGETABLE OIL TO RETARD ABSORPTION. DO NOT INDUCE VOMITING. CALL PHYSICIAN. FATAL DOSE ADULT HUMAN APPROX 350G, CHILD APPROX 10-13G.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: BELL FUELS, INC
Label Street: 4116 WEST PATERSON AVE
Label City: CHICAGO
Label State: IL
Label Zip Code: 60646
Label Country: US
Label Emergency Number: 312-286-0200

Disclaimer:

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11.1.4 Lead Material Safety Data Sheet - MSDS

SECTION 1. GENERAL INFORMATION

FREE ELMENTAL LEAD; LEAD SALTS

SECTION 2. COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous Ingredient	Approximate Percent by Weight	C.A.S. Number	Occupational Exposure Limits (OELs)		LD_{50}/LC_{50} Species and Route
Lead	99+%	7439-92-1	OSHA PEL	$0.05mg/m^3$	No Data
			ACGIH TLV	$0.05mg/m^3$	
			NIOSH REL	$<0.10mg/m^3$	

NOTE: OELs for individual jurisdictions may differ from OSHA PELs. Check with local authorities for the applicable OELs in your jurisdiction. OSHA - Occupational Safety and Health Administration; ACGIH - American Conference of Governmental Industrial Hygienists; NIOSH - National Institute for Occupational Safety and Health. OEL – Occupational Exposure Limit, PEL – Permissible Exposure Limit, TLV – Threshold Limit Value, REL – Recommended Exposure Limit.

Trade Names and Synonyms: Lead; Pb; Plumbum; Metallic Lead; Inorganic Lead; ASTM B29; TADANAC Lead, Low-Alpha Lead.

SECTION 3. HAZARDS IDENTIFICATION

Emergency Overview: A bluish-white to silvery-grey heavy, soft metal that does not burn in bulk. Finely-divided lead dust clouds are a moderate fire hazard and moderate explosion hazard, however. When heated in air highly toxic lead oxide fumes can be generated. Inhalation or ingestion of lead may produce both acute and chronic health effects. Possible cancer and reproductive hazard. SCBA and full protective clothing required for fire emergency response personnel.

Potential Health Effects: Inhalation or ingestion of lead dust or fumes may result in headache, nausea, vomiting, abdominal spasms, fatigue, sleep disturbances, weight loss, anemia and leg, arm, and joint pain. Prolonged exposure may also cause central nervous system damage (e.g., fatigue, headaches, tremors, hypertension), gastrointestinal disturbances, anemia, kidney dysfunction and possible reproductive effects. Pregnant women should be protected from excessive exposure to prevent lead crossing the placental barrier and causing infant neurological disorders. Lead is classified as an A3 Carcinogen by the ACGIH and as a 2B Carcinogen by IARC. (see Toxicological Information, Section 11)

Potential Environmental Effects: Lead metal has low bioavailability but its compounds can be hazardous in the environment at low concentrations. They can be particularly toxic in the aquatic environment. Lead bioaccumulates in plants and animals in both the aquatic and terrestrial environments. (see Ecological Information, Section 12)

EU Risk Phrase(s): R61 - May cause harm to unborn child; R62 - Possible risk of impaired fertility; R20/22 - Harmful by inhalation and if swallowed; R33 - Danger of cumulative effects.

SECTION 4. FIRST AID MEASURES

Eye Contact: Flush with warm, running water, including under the eyelids, to remove dust particle(s). If irritation persists seek medical attention.

Skin Contact: *Dust:* Remove contaminated clothing and wash affected area with soap and warm water. Launder contaminated clothing before reuse. Seek medical attention if irritation develops or persists. *Molten Metal:* Flush contact area to solidify and cool but do not attempt to remove encrusted material or clothing. Cover burns and seek medical attention immediately.

Inhalation: Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep affected person warm and at rest. Medical oxygen may be administered, if available, where breathing is difficult. Seek immediate medical attention.

Ingestion: If victim is conscious and can swallow, dilute stomach contents with 2-4 cupfuls of water or milk. Do not induce vomiting. Seek medical attention and bring a copy of this MSDS. Never give anything by mouth to an unconscious person.

SECTION 5. FIRE FIGHTING MEASURES

Fire and Explosion Hazards: Massive metal is not flammable or combustible. Finely-divided lead dust or powder is a moderate fire hazard and moderate explosion hazard when dispersed in the air at high concentrations and exposed to heat, flame, or incandescents. Explosions may also occur upon contact with certain incompatible materials (see Stability and Reactivity, Section 10).

Extinguishing Media: Use any means of extinction appropriate for surrounding fire conditions such as water spray, carbon dioxide, dry chemical, or foam.

Fire Fighting: If possible, move material from fire area and cool material exposed to flame. Highly toxic lead oxide fumes may evolve in fires. Fire fighters must be fully trained and wear full protective clothing including an approved, self-contained breathing apparatus which supplies a positive air pressure within a full face-piece mask.

Flashpoint and Method: Not Applicable.

Upper and Lower Flammable Limit: Not Applicable.

Autoignition Temperature: Not Applicable.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Procedures for Cleanup: Control source of spillage if possible to do so safely. Restrict access to the area until completion of clean-up. Clean up spilled material immediately, observing precautions in Section 8, Personal Protection. Molten metal should be allowed to solidify before cleanup. If solid metal, wear gloves, pick up and return to process. If dust, wear recommended personal protective equipment (see Section 8) and use methods which will minimize dust generation (e.g., vacuum solids). Return uncontaminated spilled material to the process if possible. Place contaminated material in suitable labeled containers for recovery or disposal. Treat or dispose of waste material in accordance with all local, regional, and national requirements.

Personal Precautions: Persons responding to an accidental release should wear protective clothing, gloves and a respirator (see also Section 8). Close-fitting safety goggles may be necessary in some circumstances to prevent eye contact with dust and fume. Where molten metal is involved, wear heat-resistant gloves and suitable clothing for protection from hot-metal splash as well as a respirator to protect against inhalation of lead fume. Workers should wash and change clothing following cleanup of a lead spill to prevent personal contamination with lead dust.

Environmental Precautions: Lead metal has limited bioavailability but its compounds can pose a severe threat to the aquatic and terrestrial environments. Contamination of water and soil should be prevented.

SECTION 7. HANDLING AND STORAGE

Store in a dry, covered area away from incompatible materials, strong acids and food or feedstuffs. Solid metal suspected of containing moisture should be THOROUGHLY DRIED before being added to a molten bath. Otherwise, entrained moisture

could expand explosively and spatter molten metal out of the bath. Always practice good personal hygiene. Refrain from eating, drinking, or smoking in work areas. Thoroughly wash hands before eating, drinking, or smoking in appropriate, designated areas as well as at the end of the workday. No special packaging materials are required.

EU Safety Phrase(s): S53 - Avoid exposure - obtain special instructions before use; S45 – In case of accident, or if you feel unwell, seek medical advice immediately (show label where possible).

SECTION 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Protective Clothing: Gloves and coveralls or other work clothing are recommended to prevent prolonged or repeated direct skin contact when lead is processed. Appropriate eye protection should be worn where fume or dust is generated. Where hot or molten metal is handled, heat resistant gloves, goggles or face shield, and clothing to protect from hot metal splash should be worn. Safety type boots are recommended.

Do not eat, drink or smoke in work areas. Thoroughly wash hands before eating, drinking, or smoking in appropriate, designated areas as well as at the end of the workday. A double locker-shower system with separate clean and dirty sides is usually required for lead handling operations. Remove contaminated clothing promptly and discard or launder before reuse. Inform laundry personnel of contaminants' hazards.

Ventilation: Use adequate local or general ventilation to maintain the concentration of lead fumes in the working environment well below recommended occupational exposure limits. Supply sufficient replacement air to make up for air removed by the exhaust system. Local exhaust is recommended for melting, casting, grinding, burning, and use of powders.

Respirators: Where lead dust or fumes are generated and cannot be controlled to within acceptable levels by engineering means, use appropriate NIOSH-approved respiratory protection equipment (a 42CFR84 Class N, R or P-100 particulate filter cartridge). When exposure levels are unknown, a self-contained breathing apparatus which supplies a positive air pressure within a full face-piece mask should be worn.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance: Malleable, bluish-white or silvery-grey metal	**Odour:** None	**Physical State:** Solid	**pH:** Not Applicable
Vapour Pressure: 1.3 mm Hg at 970°C (negligible @ 20°C)	**Vapour Density:** Not Applicable	**Boiling Point/Range:** 1,740°C	**Freezing/Melting Point/Range:** 328°C
Specific Gravity: 11.34	**Evaporation Rate:** Not Applicable	**Coefficient of Water/Oil Distribution:** Not Applicable	**Odour Threshold:** None
Solubility: Insoluble in water			

SECTION 10. STABILITY AND REACTIVITY

Stability & Reactivity: Massive metal is stable under normal temperatures and pressures. Fresh cut or cast lead surfaces tarnish rapidly due to the formation of an insoluble protective layer of basic lead carbonate.

Incompatibilities: Lead reacts vigorously with strong oxidizers, such as hydrogen peroxide and chlorine trifluoride, and active metals, such as sodium and potassium. Powdered lead metal in contact with disodium acetylide, chlorine trifluoride, sodium carbide or fused ammonium nitrate poses a risk of explosion. Solutions of sodium azide in contact with lead metal can form lead azide, which is a detonating compound. A lead-zirconium alloy (10-70% Zr) will ignite when struck with a hammer.

Hazardous Decomposition Products: High temperature operations such as oxy-acetylene cutting, electric arc welding or overheating a molten bath will generate highly toxic lead oxide fume. Lead oxide is highly soluble in body fluids and the particle size of the metal fumes is largely within the respirable size range, which increases the likelihood of inhalation and deposition of the fume within the body.

SECTION 11. TOXICOLOGICAL INFORMATION

General: Lead accumulates in bone and body organs once it enters the body. Elimination from the body is slow. Initial and periodic medical examinations are advised for persons repeatedly exposed to levels above the exposure limits of lead dust or

fumes. Once lead enters the body, it can affect a variety of organ systems, including the nervous system, kidneys, reproductive system, blood formation, and gastrointestinal system. The primary routes of exposure to lead are inhalation or ingestion of dust and fumes.

Acute:
Skin/Eye: Contact with dust or fume may cause local irritation but would not cause tissue damage.

Inhalation: Exposure to lead dust or fume may cause headache, nausea, vomiting, abdominal spasms, fatigue, sleep disturbances, weight loss, anemia, and pain in legs, arms, and joints. An acute, short-term dose of lead could cause acute encephalopathy with seizures, coma, and death. However, short-term exposure of this magnitude is rare. Kidney damage, as well as anemia, can occur from acute exposure.

Ingestion: Symptoms due to ingestion of lead dust or fume would be similar to those from inhalation. Other health effects such as metallic taste in the mouth and constipation or bloody diarrhea might also be expected to occur.

Chronic:
Prolonged exposure to lead dust and fume may produce many of the symptoms of short-term exposure and may also cause central nervous system damage, gastrointestinal disturbances, anemia, and, rarely, wrist drop. Reduced hemoglobin production has been associated with low lead exposures. Symptoms of central nervous system damage due to moderate lead exposure include fatigue, headaches, tremors and hypertension. Very high lead exposure can result in lead encephalopathy with symptoms of hallucinations, convulsions, and delirium. Kidney dysfunction and possible injury has also been associated with chronic lead poisoning. Chronic over-exposure to lead has been implicated as a causative agency for the impairment of male and female reproductive capacity. Pregnant women should be protected from excessive exposure as lead can cross the placental barrier and unborn children may suffer neurological damage or developmental problems due to excessive lead exposure in pregnant women. Teratogenic and mutagenic effects from exposure to lead have been reported in some studies but not in others. The literature is inconsistent and no firm conclusions can be drawn at this time. Lead and lead compounds are listed as an A3 Carcinogen (Confirmed Animal Carcinogen with Unknown Relevance to Humans) by the ACGIH and as a Group 2B Carcinogen (possibly carcinogenic to humans) by IARC. The NTP, OSHA and the EU do not currently list lead as a human carcinogen.

SECTION 12. ECOLOGICAL INFORMATION

While lead metal is insoluble, its processing or extended exposure in the aquatic and terrestrial environments may lead to the release of lead in bioavailable forms. Lead compounds are not particularly mobile in the aquatic environment but can be toxic to organisms, especially fish, at low concentrations. Water hardness, pH and dissolved organic carbon content are factors which regulate the degree of toxicity. In soil, lead is generally not very mobile or bioavailable as it can become strongly sorbed on soil particles, increasingly so over time, to a degree dependent on soil properties. Lead bioaccumulates in plants and animals in both the terrestrial and aquatic environments.

SECTION 13. DISPOSAL CONSIDERATIONS

If material cannot be returned to process or salvage, dispose of in accordance with applicable regulations.

SECTION 14. TRANSPORT INFORMATION

PROPER SHIPPING NAME .....Not a regulated product in ingot form.
TRANSPORT CANADA AND U.S. DOT CLASSIFICATION .....Not Applicable
TRANSPORT CANADA AND U.S. DOT PIN .....Not Applicable
MARINE POLLUTANT .....No
IMO CLASSIFICATION .....Not Regulated

SECTION 15. REGULATORY INFORMATION

U.S.
Ingredient Listed on TSCA Inventory.....Yes

Hazardous Under Hazard Communication Standard.....Yes

CERCLA Section 103 Hazardous Substances .....Lead RQ: 10 lbs. (4.54 kg.)*
*reporting not required when diameter of the pieces of solid metal released is equal to or exceeds 100 micrometers (0.004 inches).

EPCRA Section 302 Extremely Hazardous Substance.....No

Disclaimer:

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Impact Environmental Consulting, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. IMPACT ENVIRONMENTAL CONSULTING, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, IMPACT ENVIRONMENTAL CONSULTING, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.

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11.1.5 PCB Aroclor 1260 Material Safety Data Sheet - MSDS

I. GENERAL INFORMATION

Part Number/Trade Name	KIT PCB-B-21 AROCLOR 1260 (1NG/UL), 44804
National Stock Number	6810P44803
CAGE Code	54968
Part Number Indicator	F
MSDS Number	179546
HAZ Code	B

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2. PHYSICAL AND CHEMICAL CHARACTERISICS

Hazard Storage Compatibility Code	NK
Appearance/Odor	CLEAR COLORLESS LIQUID
Boiling Point	210F,99C
Melting Point	-177F,-116C
Vapor Pressure	41
Vapor Density	3.9
Specific Gravity	0.69
Decomposition Temperature	N/K
Evaporation Rate	>1 (ETHER=1)
Solubility in Water	NOT APPLICABLE
Percent Volatiles by Volume	1
Chemical pH	N/K
Corrosion Rate	N/K
Container Pressure Code	4
Temperature Code	8
Product State Code	U

---

3. FIRE AND EXPLOSION HAZARD INFORMATION

Flash Point	10
Flash Point Method	UNK
Lower Explosion Limit	1.1%
Upper Explosion Limit	6%
Extinguishing Media	CO*2, FOAM, DRY CHEMICAL
Special Fire Fighting Procedures	USE NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT (FP N)
Unusual Fire/Explosion Hazards	CAN REACT VIGOROUSLY W/REDUCING MATERIALS

---

4. REACTIVITY DATA

Stability	YES
Stability Conditions to Avoid	NOT APPLICABLE
Materials to Avoid	REDUCING AGENTS
Hazardous Decomposition Products	NOT APPLICABLE
Hazardous Polymerization	NO
Polymerization Conditions to Avoid	NOT RELEVANT
LD50 - LD50 Mixture	SEE INGREDIENT 1

---

5. HEALTH HAZARD DATA

Route of Entry: Skin	NO
Route of Entry: Ingestion	NO
Route of Entry: Inhalation	YES
Health Hazards - Acute and Chronic	CONTAINS LOW CONCENTRATION(S) OF MATERIAL(S) KNOWN TO STATE OF CALIFORNIA TO CAUSE CANCER. SUCH CONCENTRATION(S) IS/ARE SUBSTANTIALLY BELOW OSHA-HCS THRESHOLDS WHICH WOULD REQUIRE LISTING HEREIN AS A COMPONENT OF THIS MIXTURE
Carcinogenity: NTP	NO
Carcinogenity: IARC	NO
Carcinogenity: OSHA	NO
Explanation of Carcinogenity	NOT RELEVANT
Symptoms of Overexposure	NONE SPECIFIED BY MANUFACTURER

Medical Cond. Aggrevated by Exposure	NONE SPECIFIED BY MANUFACTURER
Emergency/First Aid Procedures	EYES:FLUSH W/WATER FOR AT LEAST 15 MINUTES. SKIN:FLUSH W/LARGE VOLUMES OF WATER. INHAL:IMMEDIATELY MOVE TO FRESH AIR. GIVE OXYGEN IF BREATHING IS LABORED. IF BREATHING STOPS, GIVE ARTIFICIAL RESPIRATION. INGEST:NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON. NEVER TRY TO MAKE AN UNCONSCIOUS PERSON VOMIT. DO NOT INDUCE VOMITING

---

5. HANDLING AND STORAGE

Steps if Material Released/Spilled	TAKE UP W/ABSORBENT MATERIAL. VENTILATE AREA
Neutralizing Agent	NONE SPECIFIED BY MANUFACTURER
Waste Disposal Method	COMPLY WITH ALL APPLICABLE FEDERAL, STATE OR LOCAL REGULATIONS
Handling and Storage Precautions	RE IN SEALED CNTNR IN COOL, DRY LOCATION. KEEP AWAY FROM HEAT. STORE IN DRY, WELL VENTILATED AREA. KEEP AWAY FROM IGNIT SOURCES. AVOID BRTHG VAPS. AV
Other Precautions	AVOID EYE/SKIN CONT. THIS MATL IS INTENDED FOR R&D USE ONLY & MAY NOT BE USED FOR DRUG, HOUSEHOLD/OTHER PURPOSES. IT SHOULD BE HANDLED ONLY BY QUALIFIED PERSONS TRAINED IN LAB PROCS & GOOD SAFETY PRACTICES
Labeling	FLAMMABLE] KEEP AWAY FROM HEAT. STORE IN DRY, WELL VENTILATED AREA. KEEP AWAY FROM IGNITION SOURCES. AVOID BREATHING VAPORS. AVOID EYE OR SKIN CONTACT. ACUTE/CHRONIC:CONTAINS LOW CONCENTRATIONS OF MATERIAL(S) KNOWN TO STATE OF CALIFORNIA TO CAUSE CANCER. SUCH CONCENTRATION(S) IS/ARE SUBSTANTIALLY BELOW OSHA-HCS THRESHOLDS WHICH WOULD REQUIRE LISTING

---

6. PERSONAL PROTECTION CONSIDERATIONS

Respiratory Protection	WEAR NIOSH/MSHA APPROVED FACE MASK W/ORGANIC VAPOR CANISTER
Ventilation	USE ONLY IN WELL VENTILATED AREA

Protective Gloves	IMPERVIOUS GLOVES (FP N)
Eye Protection	ANSI APPRVD CHEM SAFETY GOGGLES (FP N)
Other Protective Equipment	NOT APPLICABLE
Work Hygenic Practices	NONE SPECIFIED BY MANUFACTURER
Supplemental Health/Safety Data	NONE SPECIFIED BY MANUFACTURER
Disposal Code	O

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7. EXPOSURE INFORMATION

Ingredient #	01
Ingredient Name	POLYCHLORINATED BIPHENYL (AROCLOR 1260); (AROCLOR 1260). LD50:(ORAL,RAT) 1315 MG/KG. %: 0.0001 MG/M3
CAS Number	11096825
NIOSH Number	TQ1362000
Proprietary	NO
Percent	SEE ING
OSHA PEL	0.5 MG/M3 (MFR)
ACGIH TLV	0.5 MG/M3 (MFR)
Recommended Limit	N/K
Ingredient #	02
Ingredient Name	PENTANE, 2,2,4-TRIMETHYL-; (PENTANE, 2,2,4-TRIMETHYLISO-OCTANE) (C*8HL*8)
CAS Number	540841
NIOSH Number	SA3320000
Proprietary	NO
Percent	100
OSHA PEL	N/K (FP N)
ACGIH TLV	N/K (FP N)
Recommended Limit	N/K

Disclaimer:

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11.1.6 Arsenic Material Safety Data Sheet - MSDS

I. GENERAL INFORMATION

Trade Name: Arsenic **Formula**: As
Chemical Family: Metallic element **CAS #**: 7440-38-2

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2. HAZARDOUS INGREDIENTS

Hazardous Components % OSHA/PEL ACGIH/TLV Sec. 313
Arsenic 0-100 10 ug/m^3 0.01 mg/m^3 Yes

---

3. PHYSICAL DATA

Boiling Point: 613 °C (Sublimes) **Melting Point**: 817 °C
Vapor Density (Air=1): N/A **Vapor Pressure**: 1mm @ 372 °C
Solubility in H_2O: Insoluble **% Volatiles**: 0
Appearance and Odor: Steel-grey brittle solid, no odor. **Specific gravity (H_2O=1)**: 5.72gm/cc

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4. FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A **Autoignition Temp**: N/A
Flammability: **Lower**: N/A **Upper**: N/A

Extinguishing Media: Do not use water. Use carbon dioxide, dry chemical extinguishing agents, dry sand, dry ground dolomite.
Special Firefighting Procedures: Use NIOSH/MSHA approved self-contained breathing apparatus and full protective clothing if involved in fire.

Unusual Fire and Explosion Hazard: Slight explosion hazard in the form of a dust when exposed to flame. Moderate fire hazard in the form of dust when exposed to heat or flame or by chemical reaction.

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5. HEALTH HAZARD INFORMATION

Effects of Exposure:

Acute arsenic poisoning (from ingestion) results in marked irritation of the stomach and intestines with nausea, vomiting and diarrhea. In severe cases the vomitus and stools are bloody and the patient goes into collapse and shock with weak, rapid pulse, cold sweats, coma and death. Chronic arsenic poisoning, whether through ingestion or inhalation, may manifest itself in many different ways. There may be disturbances of the digestive system such as loss of appetite, cramps, nausea, constipation or diarrhea. Liver damage may occur, resulting in jaundice. Disturbances of the blood, kidneys and nervous system are not infrequent. Arsenic can cause a variety of skin abnormalities including itching, pigmentation and even cancerous changes. A characteristic of arsenic poisoning is the great variety of symptoms that can be produced. A recognized carcinogen of the skin, lungs, liver. An experimental carcinogen of the mouth, esophagus, larynx, bladder and para nasal sinus. (Sax, Dangerous Properties of Industrial Materials)

Acute Effects:

Inhalation: Causes irritation of mucous membranes and respiratory tract, metallic taste, pharyngitis, bloody nose, perforation of the nasal septum.
Ingestion: May cause vomiting, diarrhea and nausea.
Skin: Causes moderate irritation, skin sensitization.
Eye: Causes moderate irritation.

Chronic Effects:

Inhalation: May cause cancer (skin and lung).
Ingestion: May cause cancer (skin and lung).
Skin: Can cause eczematous dermatitis, pigmentation, hyperkeratosis.
Eye: None known

Other Health Hazards: There is evidence that arsenic may cross the placental barrier. Arsenic is a neurotoxin. Poisoning may affect the heart, GI system, kidneys and liver.

Routes of Entry: Inhalation, ingestion.
Medical Conditions Generally Aggravated by Exposure: No data
Carcinogenicity: **NTP**: Yes **IARC**: Yes **OSHA**: Yes

EMERGENCY AND FIRST AID PROCEDURES:

INHALATION: No specific information available, one should obtain medical attention.
INGESTION: No data available but one should obtain medical attention.
SKIN: Remove contaminated clothing, flood skin with large amounts of water. If irritation persists seek medical attention.
EYE: Immediately flush eyes, including under eyelids, with large amounts of water for at least 15 minutes. Call a physician.

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6. REACTIVITY DATA

Stability: Stable

Conditions to Avoid: Incompatibles, exposure to air.
Incompatibility (Materials to Avoid): Acids, acid fumes, oxidizing agents, halogens, heat, palladium, zinc, platinum, nitrogen trichloride, silver nitrate, acetylenes, chlorosylamine, chromium (VI) oxide, sodium peroxide, dirubidium acetylide.

Hazardous Decomposition Products: At temperatures above the melting point, metal oxide fumes may be evolved. Under reducing conditions (i.e. any strong acid or base plus an active metal) or in the presence of nascent hydrogen, highly toxic arsine gas may be evolved.
Hazardous Polymerization: Will not occur.

---

7. SPILL OR LEAK PROCEDURES

Steps to Be Taken in Case Material Is Released or Spilled: Any method which keeps dust to a minimum is acceptable. Vacuuming is preferred for dust. Use approved respiratory protection if possibility of dust/fume exposure exists. Do not use compressed air for cleaning.

Waste Disposal Method: Dispose of in accordance with State, Federal and Local regulations.

---

8. SPECIAL PROTECTION INFORMATION

Respiratory Protection: Where airborne exposures may exceed OSHA/ACGIH permissible air concentrations, the minimum respiratory protection recommended is a negative pressure air purifying respirator with cartridges that are NIOSH/MSHA approved against dust, fumes and mists having a TWA less than 0.05 mg/m^3.

Ventilation: Glove bag or box preferred.

Protective Gloves: Rubber
Eye/Face Protection: ANSI approved safety goggles with a full face shield.

Other Protective Equipment: Full protective clothing, lab coat and apron, flame and chemical resistant coveralls, is recommended for exposures that exceed permissible air concentrations. All contaminated clothing should be removed before leaving plant premises.

---

9. SPECIAL PRECAUTIONS

Precautions to Be Taken in Handling and Storage: Use of approved respirators is required for applications where adequate ventilation cannot be provided. Activities which generate dust or fume should be avoided. When melted, the temperature should be kept as low as possible. Keep container tightly closed. Store in a cool, dry, well-ventilated area. Wash thoroughly after use.

Work Practices: Avoid inhalation or ingestion. Practice good housekeeping and personal hygiene procedures. No tobacco or food in the work area. Wash thoroughly before eating or smoking. Shower and change clothes at end of work shift. Do not wear contaminated clothing home. Do not blow dust off clothing with compressed air. Maintain eyewash capable of sustained flushing, safety drench shower and hygienic facilities for washing.

Danger: Poison, causes skin and lung cancer.

The above information is believed to be correct, but does not purport to be inclusive and shall be used only as a guide. ESPI shall not be held liable for any damage resulting from handling or from contact with the above product.

11.1.7 Mercury Material Safety Data Sheet – MSDS

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1. GENERAL INFORMATION

Synonyms: Quicksilver; hydrargyrum; Liquid Silver
CAS No.: 7439-97-6
Molecular Weight: 200.59
Chemical Formula: Hg

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2. COMPOSITION/INFORMATION ON INGREDIENTS

Ingredient	CAS No	Percent	Hazardous
Mercury	7439-97-6	90 - 100%	Yes

---

3. HAZARDS IDENTIFICATION

Emergency Overview

DANGER! CORROSIVE. CAUSES BURNS TO SKIN, EYES, AND RESPIRATORY TRACT. MAY BE FATAL IF SWALLOWED OR INHALED. HARMFUL IF ABSORBED THROUGH SKIN. AFFECTS THE KIDNEYS AND CENTRAL NERVOUS SYSTEM. MAY CAUSE ALLERGIC SKIN REACTION.

Health Rating: 4 - Extreme (Poison)
Flammability Rating: 0 - None
Reactivity Rating: 1 - Slight
Contact Rating: 3 - Severe (Life)
Lab Protective Equip: GOGGLES; LAB COAT; PROPER GLOVES
Storage Color Code: Blue (Health)

Potential Health Effects

Inhalation:
Mercury vapor is highly toxic via this route. Causes severe respiratory tract damage. Symptoms

include sore throat, coughing, pain, tightness in chest, breathing difficulties, shortness of breath, headache, muscle weakness, anorexia, gastrointestinal disturbance, ringing in the ear, liver changes, fever, bronchitis and pneumonitis. Can be absorbed through inhalation with symptoms similar to ingestion.

Ingestion:

May cause burning of the mouth and pharynx, abdominal pain, vomiting, corrosive ulceration, bloody diarrhea. May be followed by a rapid and weak pulse, shallow breathing, paleness, exhaustion, tremors and collapse. Delayed death may occur from renal failure. Gastrointenstinal uptake of mercury is less than 5% but its ability to penetrate tissues presents some hazard. Initial symptoms may be thirst, possible abdominal discomfort.

Skin Contact:

Causes irritaton and burns to skin. Symptoms include redness and pain. May cause skin allergy and sensitization. Can be absorbed through the skin with symptoms to parallel ingestion.

Eye Contact:

Causes irritation and burns to eyes. Symptoms include redness, pain, blurred vision; may cause serious and permanent eye damage.

Chronic Exposure:

Chronic exposure through any route can produce central nervous system damage. May cause muscle tremors, personality and behavior changes, memory loss, metallic taste, loosening of the teeth, digestive disorders, skin rashes, brain damage and kidney damage. Can cause skin allergies and accumulate in the body. Repeated skin contact can cause the skin to turn gray in color. A suspected reproductive hazard; may damage the developing fetus and decrease fertility in males and females.

Aggravation of Pre-existing Conditions:

Persons with nervous disorders, or impaired kidney or respiratory function, or a history of allergies or a known sensitization to mercury may be more susceptible to the effects of the substance.

---

4. FIRST AID MEASURES

Inhalation:

Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Ingestion:

Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:

Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention immediately. Wash clothing before reuse. Thoroughly clean shoes before reuse.

Eye Contact:

Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

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5. FIRE FIGHTING MEASURES

Fire:
Not considered to be a fire hazard.
Explosion:
Not considered to be an explosion hazard.
Fire Extinguishing Media:
Use any means suitable for extinguishing surrounding fire. Do not allow water runoff to enter sewers or waterways.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece operated in the pressure demand or other positive pressure mode. Undergoes hazardous reactions in the presence of heat and sparks or ignition. Smoke may contain toxic mercury or mercuric oxide. Smoke may contain toxic mercury or mercuric oxide.

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6. ACCIDENTAL RELEASE MEASURES

Ventilate area of leak or spill. Clean-up personnel require protective clothing and respiratory protection from vapor.

Spills: Pick up and place in a suitable container for reclamation or disposal in a method that does not generate misting. Sprinkle area with sulfur or calcium polysulfide to suppress mercury. Do not flush to sewer. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

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7. HANDLING AND STORAGE

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from any source of heat or ignition. Do not use or store on porous work surfaces (wood, unsealed concrete, etc.). Follow strict hygiene practices. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe warnings and precautions listed for the product.

---

8. EXPOSURE CONTROLS/PERSONAL PROTECTIVE EQUIPMENT

Airborne Exposure Limits:
- OSHA Acceptable Ceiling Concentration:
mercury and mercury compounds: 0.1 mg/m3 (TWA), skin
- ACGIH Threshold Limit Value (TLV):
inorganic and metallic mercury, as Hg: 0.025 mg/m3 (TWA) skin, A4 Not classifiable as a human carcinogen.
- ACGIH Biological Exposure Indices:
total inorganic mercury in urine (preshift): 35 ug/g creatinine;
total inorganic mercury in blood (end of shift): 15 ug/l.

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded and engineering controls are not feasible, a half-face respirator with a mercury vapor or chlorine gas cartridge may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-face piece respirator with a mercury vapor or chlorine gas cartridge may be worn up to 50 times the exposure limit, or the maximum use concentraiton specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-face piece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

---

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:
Silver-white, heavy, mobile, liquid metal.

Odor:
Odorless.
Solubility:
Insoluble in water.
Density:
13.55
pH:
No information found.
% Volatiles by volume @ 21C (70F):
100
Boiling Point:
356.7C (675F)
Melting Point:
-38.87C (-38F)
Vapor Density (Air=1):
7.0
Vapor Pressure (mm Hg):
0.0018 @ 25C (77F)
Evaporation Rate (BuAc=1):
4

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10. STABILITY AND REACTIVITY

Stability:
Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:
At high temperatures, vaporizes to form extremely toxic fumes.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Acetylenes, ammonia, ethylene oxide, chlorine dioxide, azides, metal oxides, methyl silane, lithium, rubidium, oxygen, strong oxidants, metal carbonyls.
Conditions to Avoid:
Heat, flames, ignition sources, metal surfaces and incompatibles.

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11. TOXICOLOGICAL INFORMATION

Toxicological Data:
Investigated as a tumorigen, mutagen, reproductive effector.

Reproductive Toxicity:
All forms of mercury can cross the placenta to the fetus, but most of what is known has been learned from experimental animals. See Chronic Health Hazards.
Carcinogenicity:
EPA / IRIS classification: Group D1 - Not classifiable as a human carcinogen.
--------\Cancer Lists\----------
---NTP Carcinogen---
Ingredient Known Anticipated IARC Category
---------- ----- ----------- -------------
Mercury (7439-97-6) No No 3

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12. ECOLOGICAL INFORMATION

Environmental Fate:
This material has an experimentally-determined bioconcentration factor (BCF) of greater than 100. This material is expected to significantly bioaccumulate.
Environmental Toxicity:
This material is expected to be toxic to aquatic life. The LC50/96-hour values for fish are less than 1 mg/l.

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13. DISPOSAL CONSIDERATIONS

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

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14. TRANSPORTATION INFORMATION

Domestic (Land, D.O.T.)

Proper Shipping Name: RQ, MERCURY
Hazard Class: 8
UN/NA: UN2809
Packing Group: III
Information reported for product/size: 1LB

International (Water, I.M.O.)

Proper Shipping Name: MERCURY
Hazard Class: 8
UN/NA: UN2809
Packing Group: III
Information reported for product/size: 1LB

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15. OTHER INFORMATION

NFPA Ratings: Health: **3** Flammability: **0** Reactivity: **0**
Label Hazard Warning:
DANGER! CORROSIVE. CAUSES BURNS TO SKIN, EYES, AND RESPIRATORY TRACT. MAY BE FATAL IF SWALLOWED OR INHALED. HARMFUL IF ABSORBED THROUGH SKIN. AFFECTS THE KIDNEYS AND CENTRAL NERVOUS SYSTEM. MAY CAUSE ALLERGIC SKIN REACTION.
Label Precautions:
Do not get in eyes, on skin, or on clothing.
Do not breathe vapor.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
Label First Aid:
If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. In all cases get medical attention immediately.
Product Use:
Laboratory Reagent.
Revision Information:
No Changes.

Disclaimer: Follows next page

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Attachment C

Driller Safety Handbook

Former DuPont East Chicago Facility

DRILLER SAFETY HANDBOOK

1.0 PRE-FIELDWORK

It is very difficult to predict all problems that may occur during drilling fieldwork activities. However, if pre-fieldwork preparations are completed thoroughly, the job will likely proceed more safely and smoothly (i.e., with less down time). This section lists some important safety items that should be performed/considered prior to initiation of actual fieldwork. It requires that the Drilling Equipment Inspection form (included as an attachment to this document) is completed for each piece of equipment used on-site. Upon completion of the form, all drill staff should review this list and determine if other pre-fieldwork activities are necessary.

- Determine if the work requires a permit from a regulatory agency. Make sure the permit is available on-site in case it is required.
- Ensure that all items are completed on the Pre-fieldwork Checklist.
- A copy of all maps showing underground equipment, lines, or hazards must be attached or accompany the excavation permit.
- Check with utility one-call service before excavating or drilling.
- Visually inspect each location in the field for underground utilities.
- Drafting maps should be checked for utilities.
- Review a site map with a site representative familiar with layout of underground hazards.
- Determine if surveying is needed to locate underground hazards.
- Obtain work permits and or bonds from public works agency.
- Markers, flags, or painted lines, etc., should be used to identify excavation boundaries and locations, or hazards beyond which excavation must not exceed.
- All dimensions, elevations, and coordinates should be viewed as approximate locations of buried equipment, lines, etc. Elevations may change due to erosion or the addition of fill. Buried cables have been found three to five feet on either side of buried protective boards and markers.
- If buried equipment, lines, etc., exist within 10 feet on either side of the excavation, these should be considered in the excavation area.
- A conscious decision should be made on whether or not to de-energize underground cables within 10 feet (overhead cables within 20 feet) of the excavation prior to excavation.
- If the location of a utility line is unclear, the local utility company should be contacted for clarification of line location.
- Prior to beginning excavation, probing or hand augering to a depth of five feet is recommended. Probing and hand augering should be performed such that the area to be excavated is within the radius of the investigation.
- Excavating around process lines requires extreme caution. If any unusual odors or other signs indicating leakage are observed, the job should be shut down immediately and area supervision notified. Air quality checks must be performed to ensure adequate personnel protection is provided. Whenever possible, process lines should be depressurized before excavating.
- Read and understand the site Health and Safety Plan to ensure that drillers are not

exposed to site-contaminants.
- Locate relevant MSDS forms.
- Locate the map to the nearest emergency room.
- Locate the Exclusion Zone from the HASP.

2.0 MOBILIZATION

The following are safe guidelines related to on- and off-road movement of drilling equipment. Prior to mobilizing or demobilizing drilling equipment, responsible individuals should consider the following:

- Inspect the rig, using the Drilling Equipment Checklist.
- Before moving any equipment, first walk the route of travel with driller, inspecting for depressions, slumps, gullies, ruts, and similar obstacles. The drill site also should be inspected for debris, plant, and animal hazards. It also should be determined if the ground is suitable for heavy equipment travel.
- Make sure bystanders and passengers are clear of equipment.
- After equipment has been moved to a new drilling site, set all brakes and/or locks. When grades are steep, block the wheels.
- Use caution when traveling on steep grades. Conservatively evaluate side-hill capability of equipment movement. Arbitrary addition of drilling tools may raise the center of mass. When possible, travel directly uphill or downhill.
- When moving up a steep grade or slope, anchor a winch line from the vehicle to a suitable
  object at the top of the slope.
- Attempt to cross obstacles such as small logs and small erosion channel or ditches squarely, not at an angle.
- Use the assistance of someone on the ground as a guide when lateral or overhead clearance is restricted, or when setting the drill rig on location.
- Never travel with the mast (derrick) of the drill rig in the raised or partially raised position.
- Do not raise the mast or operate the drill rig if this distance to overhead powerlines is less than 20 feet. In general, distance between the overhead power line and boom should be no less than the height of the boom. Remember to “Look Up and Live.”
- Keep in mind that both hoist lines and overhead powerlines can be moved toward each other by the wind. If strong winds are present, consider having the utility company cover the overhead power lines.
- Prior to drilling, adequate site cleaning and leveling should be performed to accommodate the drilling rig and equipment. This provides a safe, obstacle-free working area. Drilling should not commence when tree limbs, protruding objects, unstable ground, site obstructions, or debris may cause unsafe work conditions and/or limited, awkward work spaces. An area clear of obstructions or debris should be maintained around the drilling or support activities at all times.
- Never leave equipment idling and unattended, especially on any incline or on loose material; the vibration may put the machine in motion.

3.0 EQUIPMENT DECONTAMINATION

Due to the presence of water, heat, pressure, and heavy equipment, decontamination activities can be very dangerous. The following are safety items to be considered during equipment decontamination:

- Obtain flame permit where required for the steam cleaner.
- Follow equipment decontamination procedures outlined in the Health and Safety Plan (HASP) or Project Work Plan.
- Chock wheels of equipment/supply trailer prior to beginning work.
- Use face shield, *Tyvek®*, and gloves, boots, etc., to prevent physical contact with potential contaminants and debris.
- Check hose for possible weakness or potential break points prior to use.
- Do not point wand toward body when in use.
- Use anti-freeze (windshield washer type) in cold weather to prevent water from freezing inside equipment.
- Regarding access/egress, safe footing, lifting hazards, slipping on plastic should be considered as potential hazards, especially inside the decontamination area.
- Beware of burrs and sharp edges when moving augers and drilling equipment.
- Practice good housekeeping.
- Be aware of heat and hot water from steam cleaner.

4.0 SET-UP AND START-UP

Set-up

This information should be reviewed prior to set-up activities at each drilling location:

- If required, a barricade should be set up after defining the exclusion zone.
- When drilling near suspected underground electrical hazards, the rig should be grounded with a ground wire attached to a ground rod.
- All brakes must be set before drilling begins. If the rig is positioned on a steep grade and leveling of ground is impossible or impractical, the wheel of the transport vehicle should be blocked and other means employed to prevent the rig from moving or tipping over (e.g., level jacks on rig).
- Use sufficient blocking under rig jacks to prevent sinking.
- Inspect pulley sheaves for wear and cable/rope positioning.
- Work to be done above three feet on the mast requires the use of a safety harness, or the mast must be lowered.
- Before lifting a relatively heavy object, approach the object by bending at the knees, keeping your back vertical and un-arched while obtaining a firm footing. Grasp the object firmly with both hands and stand slowly and squarely while keeping your back vertical and un-arched. In other words, perform lifting with muscles in your legs, not muscles in your lower back. If the object is in excess of 50 pounds, request assistance.

Start-up
After drill set-up, the following safety items should be observed:

- All personnel should know location and use of kill switch.
  Identify potential pinch points and hazards which could injure fingers and toes.
- All drilling rig personnel and visitors should be instructed to “stand clear” of the drilling rig immediately prior to and during starting of an engine.
- Make sure all gear boxes are in neutral, all hoist levers are disengaged, all hydraulic levers are in the correct non-actuating positions, and the cathead rope is not on the cathead before starting a drilling rig engine.
- Raise the derrick a few inches to check the brakes and always check for overhead power lines.
- Secure and/or lock the mast in upright position if required, according to the drilling manufacturer's recommendations.
- Place the fire extinguisher in an easily accessible location away from the drilling rig.
- Hydraulic lines must be maintained to prevent leakage. Equipment entering the site must be inspected for evidence of leaking and be cleaned prior to initial set-up. If a leak or failure occurs in a hydraulic system, the spill must be cleaned up according to site, local, state, and government regulations.
- Sites should have a written procedure to respond to hydraulic oil spills.

5.0 DRILLING

This section concerns rotating equipment, catheads, wire ropes, and hoists (the part of the drilling rig which may cause serious injuries), and drilling techniques most commonly used during auger and rotary drilling:

- Only personnel necessary to achieve drilling objectives should remain within the exclusion zone. All others should remain outside the exclusion zone.
- Drilling personnel should not wear clothing that may be awkward or loose and get caught in rotating equipment.
- Wear protective gloves when handling augers, cable, rods, or any sharp or splintery materials.
- Proper gloves (see HASP) should always be worn when handling materials which can irritate or contaminate skin.
- Determine noise levels during equipment operation. High noise boundaries must be posted and appropriate personal protection devices must be used.
- When appropriate, noise protection must be worn by employees who are working when drilling equipment is operating.
- Effective communication (hand signals, etc.), especially under high noise conditions, is essential to safety. Clarify use of hand signals.
- Use tools only for the job for which they were intended.
- Do not perform maintenance or refueling while equipment is running.
- Stay clear of cables while lifting equipment or while drilling rig is under heavy strain.
- Do not operate the drilling rig in an electrical (lightening) storm. If drilling is occurring when a storm approaches, stop drilling and lower the mast, if possible. Do not stay near drilling rig if the mast cannot be lowered.
- When removing drilling string from borehole, the rod string should not exceed 1.5 times the height of the mast.
- Do not ride on hook, ropes, or other traveling lines of the rig.
- Do not climb the rig mast while equipment is running. Shut down equipment and use safety harness if climbing mast, is necessary.
- When moving or hoisting stabilizers or drill collars, tag lines should always be used. A helper should not use his hands to hold or control heavy equipment. Instead, he should loop a rope around it and hold onto both ends of the rope.
- The operator of a drilling rig should only operate the rig from the position of the controls. The operator should shut down the drilling engine before leaving the vicinity of the drilling rig.
- All hydraulic lines should be inspected periodically for integrity, and replaced as needed.
- Drilling should always proceed cautiously, especially at depths less than ten feet
- Operation of drilling equipment should be limited to qualified personnel.

Auger Drilling

Auger drilling uses direct power to rotate (screw) flighted augers into the ground. Be aware of the following hazards which may be unique to this type of drilling:

- Only use the manufacturer's recommended method of securing the auger to the drill drive coupling. Do not touch the coupling or the auger with your hands, a wrench, or any other tools during rotation.
- Whenever possible, use tool hoists to handle auger sections.
- Never place hands or fingers under the bottom of an auger section when hoisting the auger over the top of the auger section in the ground, or over other hard surfaces such as the drilling rig platform.
- Never allow feet to get under the auger section that is being hoisted.
- When rotating augers, stay clear of the rotating augers and other rotating components of the drilling rig. Never reach behind or around a rotating auger for any reason whatsoever.
- Never place your hands between the drill rig and an auger, even when attempting to free damaged or bound sampling equipment from the auger.
- Never use your hands or feet to move cuttings away from the auger.
- Augers should be cleaned only when the drill rig is in neutral and the augers have stopped rotating.
- Care should be taken to ensure augers are properly stored and secured when not in use and during transport.

Rotary Drilling

Mud rotary is direct rotary drilling using mud slurry circulation to remove cuttings and keep the borehole wall stabilized. Be aware of the following hazards which may be unique to this type of drilling:

- Lifting heavy equipment (i.e., drill rods, etc.);
- Rotating equipment/parts; and
- Slippery or dangerous work areas caused by messy mud pits or troughs (could fall in); keep area clear.

Air rotary is direct rotary drilling using high pressure air circulation to remove cuttings and keep the bit cool. Be aware of the following hazards which may be unique to this type of drilling:

- Rotating/lifting equipment;
- High pressure air lines;
- Air discharge of cuttings at high velocity; use a cover to control discharge of cuttings;
- Heavy drill rods being lifted;
- Very loud; wear hearing protection;
- Large drill rig and support vehicle (space limitations); and
- Dust generation in dry formations; move upwind and use a cover for dust control

Listed below are general rotary (air and mud) drilling hazards:

- Drill rods should not be braked during lowering into the hole with drill rod chuck jaws.
- Drill rods should not be held or lowered into the hole with pipe wrenches.
- If a string of drill rods is accidentally or inadvertently released into the hole, do not attempt to grab the falling rods with your hands or a wrench.

- In the event of a plugged bit or other circulation blockage, high pressure in the piping and hose between the pump and the obstruction should be relieved or bled down before breaking the first tool joint.
- When drill rods are hoisted from the hole, they should be cleaned for safe handling with a rubber or other suitable rod wiper. Do not use your unprotected hands to clean drilling fluids from drill rods.
- If work must progress over a portable drilling fluids (mud) pit, do not attempt to stand on narrow sides or cross members. The mud pit should be equipped with a rough surface and/or cover panels of adequate strength to hold drilling rig personnel.
- Drill rods should not be lifted and leaned unsecured against the mast. Either provide some method of securing the upper ends of the drill rod sections for safe vertical storage or lay down the rods.

Cathead

Listed below are guidelines regarding cathead operation:

- Only drilling personnel familiar with cathead operation should be allowed to operate equipment. Keep the cathead clean and free of rust and oil and/or grease. The cathead should be cleaned with a wire brush if it becomes rusty.
- The cathead operator must operate the cathead while standing on a level surface
- with good, firm footing conditions, without distraction or disturbance.
- Always use a clean, dry, sound rope. A wet or oily rope may "grab" the cathead and cause drill tools or other items to be rapidly hoisted to the top of the mast. Do not operate the cathead in rain.
- Never wrap the rope from the cathead (or any other rope, wire rope, or cable on the drilling rig) around a hand, wrist, arm, foot, ankle, leg, or any other part of your body.
- Always maintain a minimum of 18 inches (driving spoon length) clearance between the operating hand and the cathead drum when driving samplers, casing, or other tools with the cathead.
- Do not use a rope that is longer than necessary. A rope that is too long can form a ground loop or otherwise become entangled with the operator's legs.
- Do not use more rope wraps than are required to hoist a load.
- Do not leave a cathead unattended with the rope wrapped on the drum.
- Position all other hoist lines to prevent contact with the operating cathead rope.
- When using the cathead and rope for driving or back-driving, make sure that all threaded pipe connections are tight and stay as far as possible from the hammer impact point.
- When stuck tools or similar loads cannot be raised with a hoist, disconnect the hoist line and connect the stuck tools directly to the feed mechanism of the drill. Do not use hydraulic leveling jacks for added pull to the hoist line or the feed mechanism of the drill.
- Should the rope "grab" the cathead or otherwise become tangled in the drum, do not attempt to release the rope. Instead, sound an appropriate alarm for all personnel to rapidly back away and stay clear. The operator should also back away and stay clear. If the rope "grabs" the cathead, and tools are hoisted to the sheaves at the top of the most, the rope often will break, releasing the tools. If the rope does not break, stay clear of the drilling rig until the operator cautiously returns to turn off the drilling rig engine and appropriate action is taken to release the tools. The operator should keep careful watch on the suspended tools and should quickly back away after turning off the engine.

Wire Ropes and Hoists
Listed below are guidelines regarding wire ropes and hoists:

- Replace damaged safety latches on safety hooks before using.
- Always wear the appropriate gloves when handling wire ropes.
- Minimize shock loading on wire rope; apply loads smoothly and steadily.
- Protect wire rope from sharp corners or edges.
- Do not guide wire ropes onto cable drum with your hands.
- Never leave a load suspended in the air when the hoist is unattended.
- Keep your hands away from hoist, wire rope, hoisting hooks, sheaves, and pinch points as slack is being taken up and when the load is being hoisted.
- Never hoist the load over the head**, body, or feet of any person.**

6.0 WELL CONSTRUCTION AND GENERAL HOUSEKEEPING

This section presents safety items around well construction, and general housekeeping. The following safety items should be observed:

- Before lifting a relatively heavy object, approach the object by bending at the knees, keeping your back vertical and un-arched while obtaining a firm footing. Grasp the object firmly with both hands and stand slowly and squarely while keeping your back vertical and un-arched. In other words, perform lifting with muscles in your legs, not muscles in your lower back. If the object is in excess of 50 pounds, request assistance.
- Wastewater and drilling fluids must be properly contained and labeled. Refer to the project Waste Management Plan.
- Suitable storage locations should be provided for all tools, materials, and supplies so that they can be conveniently and safely handled without falling on a member of the drill crew or a visitor, without creating tripping hazards, and without protruding at eye or head level.
- Avoid storing or transporting tools, materials, or supplies within or on the mast (derrick) of the drill rig.
- Pipe, drill rods, bit casings, augers, and similar drilling tools should be stacked in an orderly manner on racks or sills to prevent spreading, rolling, or sliding and should be secured prior to moving equipment.
- Work areas, platforms, walkways, scaffolding, and other accesses should be kept free of materials, obstructions, and substances such as ice, water, mud, excess grease, or oil that could cause a surface to become slick or otherwise hazardous. The use of additional footing safeguards (mats) should be evaluated on a case-by- case basis.
- Keep all controls, control linkages, warning, and operation lights and lenses free of oil, grease, or other substances which would decrease safe handling.
- Do not store gasoline in any portable container other than that specifically designed for the intended purpose.
- Welding gas cylinders should be stored in an upright and secured position.
- Protective caps should be in place when the cylinders are not in use.
- All unattended boreholes must be adequately covered or otherwise protected to prevent personnel, site visitors, or animals from falling into the hole. All open boreholes should be covered, protected, or back filled adequately and according to local and state regulations upon completion of the drilling project.
- Do not tolerate unprofessional conduct ("horse play") on the job site.

7.0 RIGGING DOWN AND DEMOBILIZATION

This section presents safe guidelines when rigging down at a drilling location, or demobilizing for the end of a project. The drill crew may be tired after a long field day, or in a rush to pack up and leave the site. Individuals are often less aware of their surroundings when either fatigued or in haste; which can often lead to an accident. Guidelines are listed below:

- Safety issues are similar to those in Mobilization (Section 2.0) and Set-up (Section 4.0).
- Remind crew to slow down and work safely when rigging down and demobilizing. Many injuries occur at the end of the day. Develop a safety attitude. Allow time to break down equipment.
- Review the day's activities and ensure everything is in order (e.g., field notes).
- Secure site.

DRILLING EQUIPMENT INSPECTION

Equipment identification (Name or Number): _____

Items	CONDITION			Remarks
	Good	Rejected	N/A	
1. Access & Egress*				
2. Backup Alarms*				
3. Body				
4. Brakes*				
5. Clutch*				
6. Control & Levers Labeled*				
7. Cotter Pins/Hardened Pins*				
8. Cover				
9. Data Nameplate				
10. Frame				
11. Fuel & Gas Systems*				
12. Glass*				
13. Guards*				
14. Horn*				
15. Hydraulic System (no leaks)*				
16. Lights				
17. Lugs				
18. Muffler & Exhaust Pipe*				
19. Muffler Guards*				
20. Parking Brakes*				
21. Platform Decking				
22. Rear View Mirror				
23. Rollover Protection*				
24. Seat Belts*				
25. Side Mirrors (both)*				
26. Steering Mechanism*				
27. Tracks, Tires, Wheels*				
28. Turn Signals				
29. Windshield Wipers				

* If any of these are rejected, the equipment shall not be used.

_____ _____

Inspected by Date

Attachment D

Excavation and Trenching Handbook

Former DuPont East Chicago Facility

EXCAVATION AND TRENCHING SAFETY HANDBOOK



1.0 DEFINITIONS

Competent person means someone who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt, corrective measures to eliminate them.

Confined space means a space that is large enough and so configured that an employee can bodily enter and perform work and has limited or restricted means of entry or exit and is not designed for continuous employee occupancy.

Excavation means any man-made cut, cavity, trench, or depression in the earth's surface formed by earth removal.

Hazardous atmosphere means an atmosphere that is explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen-deficient, toxic, or otherwise harmful that may cause death, illness, or injury to persons exposed to it.

Protective system means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Registered professional engineer means a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer who is registered in any state is deemed to be a "registered professional engineer" within the meaning of federal rules when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Shield (trench box) means a structure that is able to withstand the forces imposed on it by a cave-in and thereby protects employees within the structures. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with the OSHA regulations at 29 CFR 1926.652(c)(3) or 29 CFR 1926.652(c)(4). Shields used in trenches are usually referred to as trench boxes or trench shields. Trench boxes or shields protect employees from cave-ins that might occur by providing sheltered space where employees may work. They are not designed to prevent cave-ins. A typical shield consists of two steel plates separated by structural members to form a box open at the top, bottom, and both ends. The box is lowered into the trench so

that the steel plates face the trench's sidewalls. Employees then climb into the protected area defined by the steel plates. As the work progresses, the box is dragged along the bottom of the trench by a chain or cable suspended from a backhoe above the ground.

Shoring system means a structure such as a metal hydraulic mechanical or timber shoring system that supports the sides of an excavation and is designed to prevent cave-ins.

Sloping means a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavations so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environment conditions of exposure, and application of exposure and application of surcharge loads.

Support system means structures such as underpinning, bracing, and shoring that provide support to an adjacent structure or underground installation or to the sides of an excavation or trench.

Surface encumbrance means anything that creates a hazardous surcharge load on the sides of a trench or excavation, such as equipment, building materials, vehicles, soil, and sources of vibration, foundations, streams, water tables, or geological anomalies, that could cause it to cave in and injure or kill those inside.

Trench means a narrow underground excavation that is deeper than it is wide, and no wider than 15 feet (ft) (4.5 meters (m)). In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 ft (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 ft (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

2.0 EXCAVATION AND TRENCHING SAFETY

Hazard Assessment

Excavation and trenching work present serious hazards to all workers involved. Cave-ins pose the greatest risk and are much more likely than other excavation-related accidents to result in worker fatalities. Other potential hazards include falls, falling loads, hazardous atmospheres, and incidents involving mobile equipment.

Before work begins on an excavation or trench, the competent person(s) will evaluate the specific hazardous conditions at the worksite through jobsite studies, observations, test borings for soil type or conditions, and consultations with local officials and utility companies. The following factors will be considered to determine the hazards associated with specific site conditions:

- Traffic
- Proximity and physical conditions of nearby structures
- Soil
- Surface water and groundwater
- Location of the water table
- Overhead and underground utilities
- Weather

Soil Classification

Before any work is begun on an excavation or trench, the soil classification will be determined by the competent person and in accordance with the below characteristics for proper sloping and hazard considerations.

Four Types of Soil

Employees who work on excavations must be trained in the four soil classifications: stable rock, Type A soil, Type B soil and Type C soil. In general, stable rock is not common because we disturb it by excavating, leaving us with the following three soil types to gauge excavations.
Type A: This is the most stable of the soil classifications and implies that you have a slope angle of a 3/4:1 ratio, which means that for every foot of depth, the sides of the excavation will slope back three-quarters of a foot or a 53-degree angle.

Type A: Soils are cohesive with an unconfined compressive strength of 1.5 tons per square foot (tsf) or greater. Examples include clay, silty clay, sandy clay and clay loam. Type A soil may also be "benched," or set at specific angles for employee protection. Benching creates a stair-step condition; the soil comes up 5 feet vertically from the bottom of the excavation, and cuts back 4 feet horizontally at 90-degree angles on the sides. This is repeated to the top of the excavation.

Type B: This soil is less stable than Type A type soil, but is very cohesive and still quite stable. The slope angle for a Type B excavation is a 1:1 ratio or a 45-degree angle. For every foot of depth, the sides of the excavation must slope back 1 foot. Type B soil is cohesive with an unconfined compressive strength greater than 0.5 tsf, but less than 1.5 tsf. Other examples include granular noncohesive soils such as angular gravel, which is similar to crushed rock; silt; silt loam; sandy loam; previously disturbed soils except those that would otherwise be classified

as Type C soil; soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; and dry rock that is not stable. Type B soil may also be benched, coming up 4 feet vertically from the bottom of the excavation and 4 feet horizontally at 90-degree angles on the sides, repeating to the top of the excavation.

Type C: Of all the soil types, this is the least stable and most hazardous, and must be sloped at a 1-1/2:1 ratio or a 34-degree angle. Depending on water saturation or seepage, the angles may need to be greater than 34 degrees for employee safety. Type C soil is cohesive with an unconfined compressive strength of 0.5 tsf or less. Examples include granular soils such as gravel, sand and loamy sand; submerged soil or soil from which water is freely seeping; and submerged rock that is not stable. Benching Type C soil is unacceptable and shall not be done.

Slope Angle Calculations

Determining your slope angle is not complicated; in fact, you don't even need a protractor. This simple equation will tell you the proper opening width: (depth x 2) x type slope ratio + width of original excavation = top width. As an example, let's calculate the slope angle of a simple trench that is 6 feet deep by 2 feet wide, factoring in the type of soil.

- Type A: (6 feet x 2) x .75 + 2 feet = 11 feet wide at the top.
- Type B (6 feet x 2) x 1 + 2 feet = 14 feet wide at the top.
- Type C (6 feet x 2) x 1.5 + 2 feet = 20 feet wide at the top.

Other Manual Tests

Thumb penetration test. When the thumb is pressed firmly into the soil and penetrates no further than the length of the nail, it is probably Type B soil. If the thumb penetrates the full length of the thumb, it is Type C. This is the least accurate of the manual test methods.

Dry strength test. If a sample of dry soil is crumbled freely or with moderate pressure into individual grains, it is considered granular, or Type C. Dry soil that falls into clumps that subsequently break into smaller clumps is probably clay in combination with gravel, sand, or silt (Type B).

Plasticity or wet thread test. A moist sample of the soil is molded into a ball and then rolled into a thin thread approximately 1/8 inch in diameter by 2 inches in length. If the soil sample does not break when held by one end, it may be considered Type B. If the soil sample does break, it is considered Type C.

Soil compression strength test. A pocket penetrometer, shearvane, or torvane may also be used to determine the unconfined compression strength of soils.

Surface Encumbrances
All surface encumbrances that are located so as to create a hazard to employees will be removed or supported, as necessary, to safeguard employees.

Underground Installations
The estimated location of utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, will be determined before opening an excavation.

Utility companies or owners will be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations before the start of actual excavation (811 Dig notification or other State equivalent). When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by state or local law) or cannot establish the exact location of these installations, the excavation work *may not proceed*.

When operations approach the location of underground utilities, excavation will progress with caution until the exact location of the utility is determined. While the excavation is open, underground installations will be protected, supported, or removed as necessary to safeguard employees.

Safety Procedures
General Requirements
If evidence of a situation that could result in possible cave-ins, slides, failure of protective systems, hazardous atmospheres, or other hazardous condition is identified, exposed workers will be removed from the hazard and all work in the excavation or trench stopped until all necessary safety precautions have been implemented.

Competent person. A competent person will oversee work performed at any excavation to ensure compliance with this Plan.

Worker training. Employees who work in or around excavations will be provided training according to their associated work activities. See the ***Training*** subsection of this Plan for specific training requirements.

Protective systems. The excavation or trench must either be sloped or supported as required to comply with OSHA worker protection requirements. See the ***Protective Systems*** subsection of this Plan for more information.

Personal protective equipment (PPE). Employees must use PPE as required by their job task.

Noise protection. Work performed at noise levels that exceed permissible limits must meet the provisions of the **OSHA** 1910.95 - Occupational noise exposure protections.

Safe Access and Exit

Workers will be provided with safe access into and exiting from trenches or excavations that are more than 4 ft deep.

Access. The means of access and the design specifications for such access will be determined by the competent person and in accordance with the following guidelines:

- Ladders used as access to a trench or excavation will extend from the bottom of the excavation to not less than 3 ft (0.9 m) above the surface.
- Ramps used solely for personnel access will be a minimum width of 4 ft (1.2 m) and provided with standard guardrails.
- Ramps used for equipment access will be a minimum width of 12 ft (3.6 m). Curbs not less than 8-in x 8-in (20.3-cm x 20.3-cm) timbers, or equivalent protection, will be provided. Equipment ramps will be designed and constructed in accordance with accepted engineering practice.

Exit route. The means of exit and the design specifications for such exit will be determined by the competent person and in accordance with the following guidelines:

- A stairway, ladder, ramp, personnel hoist, or other safe means of exit will be located in trench excavations that are 4 ft (1.2 m) or more in depth.
- Exit route(s) will be placed within 25 lateral ft of workers.
- When two or more components form a ramp or runway, they must be connected to prevent displacement and be of uniform thickness.
- Cleats or other means of connecting runway components must be attached in a way that would not cause tripping (e.g., to the bottom of the structure).
- Structural ramps used in place of steps must have a nonslip surface.
- Earthen ramps may be used as a means of exit only if a worker can walk them in an upright position and only if they have been evaluated by a competent person.

Perimeter Protection

Protection will be provided to prevent personnel, vehicles, and equipment from falling into excavations.

Fall Protection

All drywells, pits, and shafts will be barricaded or covered. Excavations will be backfilled as soon as possible. Upon completion of exploration and similar operations, test pits, temporary wells, and calyx holes will be backfilled immediately. Walkways or bridges will be provided with standard guardrails where people or equipment are required or permitted to cross over excavations.

Falling Loads

Workers and other personnel must be prevented from passing or standing underneath loads handled by lifting or digging equipment. They must stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped to provide adequate protection for the operator during loading and unloading operations.

Falling Material

Employees will not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at lower levels are adequately protected from the hazard of falling material or equipment.

Employees will be protected by scaling, ice removal, benching, barricading, rock bolting, wire mesh, or other means from loose rock or soil that could create a hazard by falling from the excavation wall. Special attention will be given to slopes that may be adversely affected by weather, moisture content, or vibration.

Placement of excavated material. Excavated material will be placed at least 2 ft (0.6 m) from the edge of an excavation or will be retained by devices that are sufficient to prevent the materials from falling into the excavation. In any case, material will be placed at a distance to prevent excessive loading on the face of the excavation. Materials such as boulders or stumps that may slide or roll into the excavation will be removed or made safe.

Hazardous Atmospheres

Workers will not be permitted to work in or near hazardous atmospheres unless required testing and monitoring, worker precautions, and rescue services are in place. No work is to be

conducted in enclosed areas where hazardous atmospheres or gases could accumulate (e.g., landfills, manure pits, gas distribution lines, or hazardous materials storage locations).

Types of atmospheres. Such atmospheres include those with the following:

- Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent
- A combustible gas concentration greater than 10 percent of the lower flammable limit
- Concentrations of hazardous substances that exceed those specified in the threshold limit values (TLVs) for airborne contaminants established by the American Conference of Governmental Industrial Hygienists (ACGIH)

Atmospheric tests. Air quality tests will be taken before employees enter excavations more than 4 ft in deep when a hazardous atmosphere exists or could be expected to exist. If there is any possibility that the trench or excavation could contain a hazardous atmosphere, the supervisor or other competent person will ensure that:

- Atmospheric testing is conducted before worker entry and continuously during work.
- Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, the atmospheres in the excavation will be tested before employees enter excavations greater than 4 ft (1.2 m) deep.
- Tests will be conducted as often as necessary to ensure the quality and quantity of the atmosphere, including checks for flammable gases and oxygen deficiency.
- A log of all test results will be maintained at the worksite.

Worker precautions. Suitable precautions will be taken as necessary to protect workers in areas where hazardous atmospheres exist or potentially exist. These precautions will include the following:

- Engineering controls such as ventilation
- Respiratory protection in accordance with the HASP
- Full body harnesses and lifelines

Rescue equipment. Where hazardous atmospheres exist or may reasonably be expected to exist, emergency rescue equipment will be on the worksite and readily accessible to rescue personnel. See the ***Emergency Rescue Operations*** subsection of this Plan for more information about emergency procedures.

Daily inspections. Daily inspections for hazardous atmospheres must be conducted by a competent person.

Walkways and Guardrails over Excavations

Walkways will be provided where workers or equipment are allowed to cross over excavations. Guardrails will be provided on walkways used by the general public regardless of the height above the excavation. Guardrails will be provided on walkways used only by on-site personnel if the walkway is 4 ft or more above lower levels. If workers pass below a walkway, guardrails and toeboards will be provided.

Water Accumulation

Control measures. Employees will not work in excavations in which there is accumulated water or in which water is accumulating unless the water hazards posed by accumulation is controlled. Freezing, pumping, draining, and similar control measures will be planned and directed by a registered engineer. Consideration will be given to the existing moisture balances in surrounding soils and the effects on foundations and structures if the soil is disturbed.

Drainage. Diversion ditches, dikes, or other means will be used to prevent surface water entering an excavation and to provide good drainage of the area adjacent to the excavation.

Water control equipment. When continuous operation of groundwater control equipment is necessary, an emergency power source will be provided. Water control equipment and operations will be monitored by a competent person to ensure proper operation.

Mobile Equipment and Motor Vehicle Traffic Precautions

Traffic around the excavation or trench site must be controlled and barricades, signs, and/or flag persons used as needed to control both vehicular and pedestrian traffic.

High visibility PPE. Workers exposed to public vehicular traffic will be provided with and will wear warning vests or other suitable garments marked with or made of reflective or high-visibility material.

Barricades. When vehicles or mobile equipment are used or allowed adjacent to an excavation, substantial stop logs or barricades will be installed. The use of a ground guide is recommended.

Loading/unloading vehicles. Workers will stand away from vehicles being loaded or unloaded to avoid being struck by spillage or falling materials.

Hoisting operations. Excavating or hoisting equipment will not be allowed to raise, lower, or swing loads over or adjacent to personnel in the excavation without substantial overhead protection. Personnel will maintain a safe distance from a hoisting operation until the load has been placed.

Warning system. When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system will be utilized, such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

Stability of Adjacent Structures

Protective systems. If the stability of adjoining buildings or walls is endangered by excavations, shoring, bracing, or underpinning will be provided to ensure the stability of the structure and to protect employees.

Support systems. Sidewalks, pavements, and related structures will not be undermined unless a support system is provided to protect employees and the sidewalk, pavement, or related structure.

Excavation below the level of adjacent structures. Excavations below the level of the base of footing of any foundation or retaining wall will not be permitted unless:

- A support system, such as underpinning, is provided to ensure the stability of the structure and to protect employees involved in the excavation work or in the vicinity thereof; *or*
- The excavation is in stable rock; *o*r
- A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation or determines that the excavation will not pose a hazard to employees.

SITE INSPECTIONS

When personnel will be in or around an excavation, a competent person will inspect the excavation, the adjacent areas, and protective systems daily:

- Before each work shift
- Throughout the work shifts as dictated by the work being done
- After every rainstorm
- After other events that could increase hazards (e.g., snowstorm, windstorm, thaw, earthquake)

- When fissures, tension cracks, sloughing, undercutting, water seepage, bulging at the bottom, or other similar conditions occur
- When there is a change in size, location, or placement of the spoil pile
- Where there is any indication of change in adjacent structures

The competent person will use the attached *Excavation Site Inspection Checklist* or equivalent form when conducting inspections. All completed inspection forms will be maintained at the worksite during construction and stored at *[insert location]* after excavation work is completed.

PROTECTIVE SYSTEMS

General Requirements

Excavations less than 5 ft deep. For excavations less than 5 ft (1.5 m) deep, the competent person will examine the excavation for potential cave-in hazards and determine if a protective system is needed.

Excavations 5 ft deep or deeper. All workers in an excavation or trench 5 ft deep or deeper will be protected from cave-ins by an adequate protective system. Protective systems (such as described below) will have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

Excavations more than 20 ft deep. Protective systems for all excavations more than 20 ft (6.0 m) deep will be designed and approved by a registered professional engineer.

Protective System Selection

The competent person will select the method of protection that is most suitable for the particular excavation site, taking into consideration soil type and surrounding structures. See the ***Soil Classification*** subsection of this Plan for more information.

Types of protective systems. Excavations in which employees could potentially be exposed to cave-ins will be protected by:

1. Sloping or benching the sides of the excavation; *or*
2. Supporting or shoring the sides of the excavation; *or*
3. Placing a shield between the side of the excavation and the work area.

Exempt Excavations

The following excavations do not require protective systems:

- Excavations made entirely in stable rock; *or*

- Excavations are less than 5 ft (1.52 m) deep and examination of the ground by a competent person provides no indication of a potential cave-in.

A fixed means to safely exit exempt excavations will be provided for workers.

Sloping and Benching Systems

The competent person or supervisor will select and construct slopes and configurations of sloping and benching systems from one of four options.

Option 1

Slope the walls of the excavation at an angle so that soil does not roll into the excavation. *The degree of the sloping angle needed depends on the stability of the soil at the site. The maximum allowable slopes for excavations less than 20 ft deep based on soil type and angle to the horizontal are as follows:*

Soil Type	***Height/Depth Ratio***	***Slope Angle***
B	*1:1 or less*	*45*
C	*11/2:1*	*34*

Examples:

In Type B soil, a 10-ft deep trench must be sloped to a 45 degree angle. The total distance across such a trench would be 20 ft plus the width of the trench.

In Type C soil, the 10-ft deep trench would be sloped at a 34 degree angle. The total width of the trench would be 15 ft in both directions, for a total of 30 ft across plus the width of the trench. Sloping will be greater if the areas near the excavation are subject to heavy loads (e.g., soil piles and vehicles).

Excavation in an Unclassified Soil

If the soil is not classified, the excavation must be sloped according to the requirements for Type C soil.

Option 2

Determine maximum slope with site-specific variables. *Determine the maximum slope on the basis of site-specific variables. Consult the Soil Classification section above and reference the Sloping and Benching table above for Option 2.*

Option 3

Use tabulated data to determine the slope. *Use tabulated data, such as tables and charts approved by a registered professional engineer, to design the excavation. These data will be in*

writing and include sufficient explanatory information to enable the user to make a selection, including the criteria for determining the selection and limits of the data. A copy of the information will be kept at the worksite during construction of the protective system.

Option 4

Use a registered professional engineer. *Use a registered professional engineer to design the sloping or benching system based on professional judgment.*

Benching Systems

Benching is not permitted in Type C soil.

Benching may be one of two types:

- Single level or step not exceeding 4 ft high; *or*
- Multiple levels or steps, each not exceeding 4 ft high.

Benching may be used in conjunction with simple sloping. Benches must be below the maximum allowable slope for that soil type. For example, a 10-ft-deep trench in Type B soil must be benched back 10 ft in each direction with the maximum 45 degree angle.

Worker Safeguards

Workers must not work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.

Shoring and Shielding Systems

Option 1

Design the shoring system using the soil classification mentioned above, timber shoring, and aluminum shoring of the OSHA excavation rules or applicable state regulations. Designs for timber shoring in trenches will be determined according to the conditions and requirements site specific excavation rules. Designs for aluminum hydraulic shoring must be according to the manufacturer's tabulated data, but if such data cannot be used, designs must follow the requirements of OSHA regulations. The system must be approved by a registered professional engineer.

Option 2

Design using the system manufacturer's tabulated data. Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data will be in accordance with all specifications, recommendations, and limitations issued or made by the

manufacturer, and the data will be in written form and kept at the jobsite during construction of the protective system. The system must be approved by a registered professional engineer.

Option 3
Design using other tabulated data. Designs of protective systems will be selected from and be in accordance with tabulated data, such as tables and charts approved by a registered professional engineer. These data must be in writing and must include sufficient explanatory information to enable the user to make a selection, including the criteria for determining the selection and limits of the data. A copy of the information must be kept at the worksite during construction of the protective system. Upon completion of the system, the data may be stored away from the jobsite but must be made available to regulatory staff on request.

Option 4
Use a registered professional engineer to design the shoring and shield protective systems. Designs must be in the form of a written plan kept at the jobsite during construction of the protective system.

Shoring
Shoring is used when the location or depth of the trench makes sloping back to the maximum allowable slope impractical. Shoring will be used for unstable soil or depths greater than 5 ft (1.5 m) unless benching, sloping, or other acceptable plan is accepted by the competent person.

Installation and Removal of Shoring or Support Systems
Installation of a shoring or support system will be closely coordinated with the excavation of trenches. All shoring will be installed from the top down and removed from the bottom up.

Installation procedures. Members of shoring or support systems will be securely connected together to prevent sliding, falling, kick-outs, or other predictable failure. Support systems will be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system. Individual members of support systems will not be subjected to loads exceeding those that those members were designed to withstand.

Removal procedures. Before temporary removal of individual members begins, additional precautions will be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system. Removal will begin at, and progress from, the bottom of the excavation. Members will be released slowly so as to note any

indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.

Backfilling procedures. Backfilling will progress together with the removal of support systems from excavations. Excavation of material to a level no greater than 2 ft (0.6 m) below the bottom of the members of a support system will be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.

Shields

A trench shield may be used as long as the protection it provides is equal to or greater than the protection that would be provided by the appropriate shoring system. The competent person or supervisor must follow manufacturer's instructions for premade boxes and shields once a design has been chosen. Shields may be used in conjunction with sloping or benching.

Load requirements. Shield systems will not be subjected to loads exceeding those that the system was designed to withstand.

Installation requirements. Shields will be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

Worker protections. Workers will be protected from the hazard of cave-ins when entering or exiting the areas protected by shields. Workers will not be allowed in shields when shields are being installed, removed, or moved vertically.

Excavations below the depth of the shield. Excavations of earth material to a level not greater than 2 ft (.6 m) below the bottom of a shield will be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

Protective System Materials and Equipment

Maintenance of Materials and Equipment

Materials and equipment used for protective systems will be free from damage or defects that might impair their proper function. Manufactured materials and equipment used for protective systems will be used and maintained in a manner that is consistent with the recommendations of the manufacturer and in a manner that will prevent employee exposure to hazards.

Damaged Materials and Equipment

When material or equipment that is used for protective systems is damaged, a competent person will examine the material or equipment and evaluate its suitability for continued use. If the competent person cannot ensure that the material or equipment is able to support the intended loads or is otherwise suitable for safe use, such material or equipment will be removed from service and will be evaluated and approved by a registered professional engineer before being returned to service.

EMERGENCY RESCUE OPERATIONS

In the event of any emergency situation requiring rescue from an excavation, workers will not attempt to enter an unprotected excavation or trench to perform rescue. Local emergency services will be notified using the standard reporting system. **See Emergency Procedures and Contingencies in the HASP.**

Rescue operations that can be performed safely from outside the excavation, such as hoisting a harnessed victim, will be carried out. Other personnel in the excavation will exit immediately and may provide assistance only when their own safety is ensured.

ACCIDENT INVESTIGATION AND NEAR-MISS REPORTING

Accident Investigation

If an employee sustains a work-related injury, the employee or a co-worker will immediately notify the supervisor of the work-related injury or illness, and the supervisor will ensure that the injured or ill employee receives prompt medical treatment. The employee will complete the employee part of the *Impact Environmental Accident Investigation Report* form. If the date and time of the injury or illness cannot be determined, the date of the last time that the employee worked is entered on the form.

Near-Miss Incident

The investigation procedures for near-miss incidents will follow an abbreviated outline derived from the Accident Investigation procedures. Supervisors will use the *Impact Environmental Near-Miss Incident Report* form or equivalent for gathering information about near misses.

Any person who observes or causes damage to property or equipment will immediately report such damage to a supervisor.

CONTRACTORS

All contractors and contractor employees must have their own excavation and trenching safety policies that are in compliance with federal and any applicable state and local regulations. They must also comply with the requirements of this Plan and any additional requirements stipulated by the plan administrator, competent person, or the *Contractor Health and Safety Agreement*.

ENFORCEMENT OF SAFETY PROCEDURES

All employees, including all levels of management, will be held accountable for obeying the worksite safety and health rules. The following four-step disciplinary policy will be applied to everyone by the appropriate level of supervisor:

- Oral warning
- Written reprimand
- Suspension
- Dismissal

Visitors, including contractors who violate safety and health rules and procedures, will be escorted from the site. Should the disciplined person request a review of the disciplinary action, the supervisor will review the situation and make a recommendation to management, which reserves the right for final decision.

TRAINING

All employees, including contractors, involved in trenching or excavation work must be trained in the requirements of this Plan before any trenching- or excavation-related activities begin.

Supervisor Training

All supervisors of trenching and excavation activities must satisfy OSHA requirements for a competent person. Such supervisors must attend competent person training conducted by a trainer approved by the plan administrator or designee.

Employee Training

Personnel who perform work in trenches or excavations must comply with the requirements of this Plan and receive appropriate training that will include:

- HAZWOPER 40-hour
- OSHA 10-hour Construction
- Safe work practices during work in excavations

- The use of personal protective equipment (PPE) that will typically be required during work in excavations
- Procedures to be followed if a hazardous atmosphere exists or could reasonably be expected to develop during work in an excavation
- Emergency and nonentry rescue methods and procedures for calling rescue services

Refresher Training

Refresher training will be performed whenever worksite inspections conducted by the supervisor or the plan administrator or designee indicate that an employee or contractor does not have the necessary knowledge or skills to safely work in or around excavations.

Training Records

Training records will be maintained by the plan administrator or designee.

RECORDKEEPING

The competent person or supervisor will ensure that the following records and documents are kept for each excavation or trench project in a place accessible for inspection by authorized personnel and regulatory agency staff:

- The credentials of the competent person(s)
- Soil classification methodology and results of tests
- Methodology and background information used to determine which protective systems are required and the type of systems used
- Records of the employee training program, including dates of training and attendee lists
- Safety program enforcement activities
- Worksite inspection reports or logs
- The aspects of the protective systems that have been designed or approved by a registered professional engineer, including the name of such individual or, if a firm, the firm's name, the name of the engineer of record that approved the work for the firm, and the registration number
- Where applicable, evidence that the registered professional engineer of record is in fact working within a discipline applicable to the excavation work
- Accident investigation and near-miss incident reports
- Copies of related safety and health plans
- Injury and illness records

Attachment E

Project Start Briefing Form

Former DuPont East Chicago Facility

DATE	EMPLOYEE NAME	SAFETY OFFICER/SUPERVISOR	ACKNOLEDGEMENT THAT YOU HAVE READ AND UNDERSTSAND THE HASP SUPPLEMENT – TARGET SAFETY TOPIC FOR CONSTRUCTION PERSONNEL

Attachment F

Respirator Medical Examination Questionnaire

Former DuPont East Chicago Facility

Attachment 4
Appendix C to 1910.134:OSHA Respirator Medical Evaluation Questionnaire (Mandatory)

To the employer: Answers to questions in Section 1, and to question 9 in Section 2 of Part A, do not require a medical examination.

To the employee:
Can you read (circle one): Yes No
Your employer must allow you to answer this questionnaire during normal working hours, or at a time and place
that is convenient to you. To maintain your confidentiality, your employer or supervisor must not look at or review your answers, and your employer must tell you how to deliver or send this questionnaire to the health
care professional who will review it.
Part A. Section 1. (Mandatory) The following information must be provided by every employee who has been
selected to use any type of respirator (please print).
1. Today's date:_____
2. Your name:_____
3. Your age (to nearest year):_____
4. Sex (circle one): Male Female
5. Your height: _____ ft. _____ in.
6. Your weight: _____ lbs.
7. Your job title:_____
8. A phone number where you can be reached by the health care professional who reviews this questionnaire
(include the Area Code): _____
9. The best time to phone you at this number: _____
10. Has your employer told you how to contact the health care professional who will review this questionnaire
(circle one): . . . . . Yes No
11. Check the type of respirator you will use (you can check more than one category):
a. _____ N, R, or P disposable respirator (filter-mask, non-cartridge type only).
b. _____ Other type (for example, half- or full-facepiece type, powered-air purifying, supplied-air, self-contained
breathing apparatus).
12. Have you worn a respirator (circle one): . . . . . Yes No
If "yes," what
type(s):_____
_____
_____

Part A. Section 2. (Mandatory) Questions 1 through 9 below must be answered by every employee who has been
selected to use any type of respirator (please circle "yes" or "no").

1. Do you currently smoke tobacco, or have you smoked tobacco in the last month: . . . . . Yes No

2. Have you ever had any of the following conditions?

a. Seizures (fits): . . . . . Yes No
b. Diabetes (sugar disease): . . . . . Yes No
c. Allergic reactions that interfere with your breathing: . . . . . Yes No
d. Claustrophobia (fear of closed-in places): . . . . . Yes No
e. Trouble smelling odors (except when you had a cold): . . . . . Yes No

3. Have you ever had any of the following pulmonary or lung problems?

a. Asbestosis: . . . . . Yes No
b. Asthma: . . . . . Yes No
c. Chronic bronchitis: . . . . . Yes No
d. Emphysema: . . . . . Yes No
e. Pneumonia: . . . . . Yes No
f. Tuberculosis: . . . . . Yes No
g. Silicosis: . . . . . Yes No
h. Pneumothorax (collapsed lung): . . . . . Yes No
i. Lung cancer: . . . . . Yes No
j. Broken ribs: . . . . . Yes No
k. Any chest injuries or surgeries: . . . . . Yes No
l. Any other lung problem that you've been told about: . . . . . Yes No

4. Do you currently have any of the following symptoms of pulmonary or lung illness?

a. Shortness of breath: . . . . . Yes No
b. Shortness of breath when walking fast on level ground or walking up a slight hill or incline: Yes No
c. Shortness of breath when walking with other people at an ordinary pace on level ground: . . Yes No
d. Have to stop for breath when walking at your own pace on level ground: . . . . . Yes No
e. Shortness of breath when washing or dressing yourself: . . . . . Yes No
f. Shortness of breath that interferes with your job: . . . . . Yes No
g. Coughing that produces phlegm (thick sputum): . . . . . Yes No
h. Coughing that wakes you early in the morning: . . . . . Yes No
i. Coughing that occurs mostly when you are lying down: . . . . . Yes No
j. Coughing up blood in the last month: . . . . . Yes No
k. Wheezing: . . . . . Yes No
l. Wheezing that interferes with your job: . . . . . Yes No
m. Chest pain when you breathe deeply: . . . . . Yes No
n. Any other symptoms that you think may be related to lung problems: . . . . . Yes No

5. Have you ever had any of the following cardiovascular or heart problems?

a. Heart attack: . . . . . Yes No
b. Stroke: . . . . . Yes No
c. Angina: . . . . . Yes No
d. Heart failure: . . . . . Yes No
e. Swelling in your legs or feet (not caused by walking): . . . . . Yes No
f. Heart arrhythmia (heart beating irregularly): . . . . . Yes No
g. High blood pressure: . . . . . Yes No
h. Any other heart problem that you've been told about: . . . . . Yes No

6. Have you ever had any of the following cardiovascular or heart symptoms?
a. Frequent pain or tightness in your chest: . . . . . Yes No
b. Pain or tightness in your chest during physical activity: . . . . . Yes No
c. Pain or tightness in your chest that interferes with your job: . . . . . Yes No
d. In the past two years, have you noticed your heart skipping or missing a beat: . . . . . Yes No
e. Heartburn or indigestion that is not related to eating: . . . . . Yes No
f. Any other symptoms that you think may be related to heart or circulation problems: . . . . . Yes No
7. Do you currently take medication for any of the following problems?
a. Breathing or lung problems: . . . . . Yes No
b. Heart trouble: . . . . . Yes No
c. Blood pressure: . . . . . Yes No
d. Seizures (fits): . . . . . Yes No
8. Has your wearing a respirator caused any of the following problems? (If you've never used a respirator, check the following space __ and go to question 9:)
a. Eye irritation: . . . . . Yes No
b. Skin allergies or rashes: . . . . . Yes No
c. Anxiety that occurs only when you use the respirator: . . . . . Yes No
d. Unusual weakness or fatigue: . . . . . Yes No
e. Any other problem that interferes with your use of a respirator: . . . . . Yes No
9. Would you like to talk to the health care professional who will review this questionnaire about your answers
to this questionnaire: . . . . . Yes No
Questions 10 to 15 below must be answered by every employee who has been selected to use either a full-facepiece respirator or a self-contained breathing apparatus (SCBA). For employees who have been
selected to use other types of respirators, answering these questions is voluntary.
10. Have you ever lost vision in either eye (temporarily or permanently): . . . . . Yes No
11. Do you currently have any of the following vision problems?
a. Wear contact lenses: . . . . . Yes No
b. Wear glasses: . . . . . Yes No
c. Color blind: . . . . . Yes No
d. Any other eye or vision problem: . . . . . Yes No
12. Have you ever had an injury to your ears, including a broken ear drum: . . . . . Yes No
13. Do you currently have any of the following hearing problems?
a. Difficulty hearing: . . . . . Yes No
b. Wear a hearing aid: . . . . . Yes No
c. Any other hearing or ear problem: . . . . . Yes No
14. Have you ever had a back injury: . . . . . Yes No
15. Do you currently have any of the following musculoskeletal problems?
a. Weakness in any of your arms, hands, legs, or feet: . . . . . Yes No
b. Back pain: . . . . . Yes No
c. Difficulty fully moving your arms and legs: . . . . . Yes No
d. Pain or stiffness when you lean forward or backward at the waist: . . . . . Yes No
e. Difficulty fully moving your head up or down: . . . . . Yes No
f. Difficulty fully moving your head side to side: . . . . . Yes No
g. Difficulty bending at your knees: . . . . . Yes No
h. Difficulty squatting to the ground: . . . . . Yes No

i. Difficulty climbing a flight of stairs or a ladder carrying more than 25 lbs: . . . . . Yes No
j. Any other muscle or skeletal problem that interferes with using a respirator: . . . . . Yes No

Part B Any of the following questions, and other questions not listed, may be added to the questionnaire at the discretion of the health care professional who will review the questionnaire.

1. In your present job, are you working at high altitudes (over 5,000 feet) or in a place that has lower than normal amounts of oxygen: . . . . . Yes No

If "yes," do you have feelings of dizziness, shortness of breath, pounding in your chest, or other symptoms when you're working under these conditions: . . . . . Yes No

2. At work or at home, have you ever been exposed to hazardous solvents, hazardous airborne chemicals (e.g., gases, fumes, or dust), or have you come into skin contact with hazardous chemicals: . . . . . Yes No

If "yes," name the chemicals if you know them:_____
_____
_____

3. Have you ever worked with any of the materials, or under any of the conditions, listed below:

a. Asbestos: . . . . . Yes No
b. Silica (e.g., in sandblasting): . . . . . Yes No
c. Tungsten/cobalt (e.g., grinding or welding this material): . . . . . Yes No
d. Beryllium: . . . . . Yes No
e. Aluminum: . . . . . Yes No
f. Coal (for example, mining): . . . . . Yes No
g. Iron: . . . . . Yes No
h. Tin: . . . . . Yes No
i. Dusty environments: . . . . . Yes No
j. Any other hazardous exposures: . . . . . Yes No

If "yes," describe these exposures:_____
_____
___
_____
___

4. List any second jobs or side businesses you have:_____
_____
____

5. List your previous occupations:_____
_____
_____

6. List your current and previous hobbies:_____
_____
_____

7. Have you been in the military services? . . . . . Yes No

If "yes," were you exposed to biological or chemical agents (either in training or combat): . . . . . Yes No

8. Have you ever worked on a HAZMAT team? . . . . . Yes No

9. Other than medications for breathing and lung problems, heart trouble, blood pressure, and seizures mentioned earlier in this questionnaire, are you taking any other medications for any reason (including over-the-counter medications): . . . . . Yes No
If "yes," name the medications if you know them:_____
10. Will you be using any of the following items with your respirator(s)?
a. HEPA Filters: . . . . . Yes No
b. Canisters (for example, gas masks): . . . . . Yes No
c. Cartridges: . . . . . Yes No
11. How often are you expected to use the respirator(s) (circle "yes" or "no" for all answers that apply to you)?:
a. Escape only (no rescue): . . . . . Yes No
b. Emergency rescue only: . . . . . Yes No
c. Less than 5 hours per week: . . . . . Yes No
d. Less than 2 hours per day: . . . . . Yes No
e. 2 to 4 hours per day: . . . . . Yes No
f. Over 4 hours per day: . . . . . Yes No
12. During the period you are using the respirator(s), is your work effort:
a. Light (less than 200 kcal per hour): . . . . . Yes No
If "yes," how long does this period last during the average shift:_____hrs._____mins.
Examples of a light work effort are sitting while writing, typing, drafting, or performing light assembly work; or
standing while operating a drill press (1-3 lbs.) or controlling machines.
b. Moderate (200 to 350 kcal per hour): . . . . . Yes No
If "yes," how long does this period last during the average shift:_____hrs._____mins.
Examples of moderate work effort are sitting while nailing or filing; driving a truck or bus in urban traffic; standing while drilling, nailing, performing assembly work, or transferring a moderate load (about 35 lbs.) at
trunk level; walking on a level surface about 2 mph or down a 5-degree grade about 3 mph; or pushing a wheelbarrow with a heavy load (about 100 lbs.) on a level surface.
c. Heavy (above 350 kcal per hour): . . . . . Yes No
If "yes," how long does this period last during the average shift:_____hrs._____mins.
Examples of heavy work are lifting a heavy load (about 50 lbs.) from the floor to your waist or shoulder; working
on a loading dock; shoveling; standing while bricklaying or chipping castings; walking up an 8-degree grade
about 2 mph; climbing stairs with a heavy load (about 50 lbs.).
13. Will you be wearing protective clothing and or equipment (other than the respirator) when you're using your
respirator: . . . . . Yes No
If "yes," describe this protective clothing and or equipment:_____
_____
____
14. Will you be working under hot conditions (temperature exceeding 77 deg. F): . . . . . Yes No
15. Will you be working under humid conditions: . . . . . Yes No

16. Describe the work you'll be doing while you're using your respirator(s):
_____
_____
_____
_____
17. Describe any special or hazardous conditions you might encounter when you're using your respirator(s) (for
example, confined spaces, life-threatening gases):
_____
_____
_____
_____
18. Provide the following information, if you know it, for each toxic substance that you'll be exposed to when
you're using your respirator(s):
Name of the first toxic substance:_____
Estimated maximum exposure level per shift:_____
Duration of exposure per shift_____
Name of the second toxic substance:_____
Estimated maximum exposure level per shift:_____
Duration of exposure per shift:_____
Name of the third toxic substance:_____
Estimated maximum exposure level per shift:_____
Duration of exposure per shift:_____
The name of any other toxic substances that you'll be exposed to while using your respirator:
_____
_____
_____
19. Describe any special responsibilities you'll have while using your respirator(s) that may affect the safety and
well-being of others (for example, rescue, security):
_____
_____
_____
_____

Apéndice C: Cuestionario de Evaluación Médico obligado por la OSHA (La agencia de seguridad y salud ocupacional) Parte 29 CFR 1910.134 Mandatorio para Proteccion del Sistema Respiratorio

Marque con un circulo para indicar sus respuestas a cada pregunta.
Para el empleado: Puede usted leer (circule uno): Sí o No
Su patrón debe dejarlo responder estas preguntas durante horas de trabajo o en un tiempo y lugar que sea conveniente para usted. Para mantener este cuestionario confidencial, su patrón o supervisor no debe ver o revisar sus respuestas. Su patrón debe informarle a quien dar o enviar este cuestionario para ser revisado por un
profesional de sanidad con licencia autorizado por el estado.

Parte A. Sección 1. (Mandatorio). La siguiente información debe de ser proveida por cada empleado que ha
sido seleccionado para usar cualquier tipo de respirador (escriba claro por favor).

1. Fecha :_____
2. Nombre:_____
3. Edad:_____
4. Su sexo (circule uno) Masculino o Femenino
5. Altura: _____pies _____pulgadas
6. Peso: _____libras
7. Su ocupación, título o tipo de trabajo: _____
8. Número de teléfono al donde pueda ser llamado por un profesional de sanidad con licencia que revisara este cuestionario (incluya el área):_____
9. Indique la hora mas conveniente para llamarle a este numero:_____
10. ¿Le ha informado su patrón como comunicarse con el profesional de sanidad con licencia que va a revisar
este cuestionario (circule una respuesta)? . . . . . Sí o No
11. Anote el tipo de equipo protector respíratorio que va utilizar (puede anotar mas de una categoría)
a._____ Respirador disponible de clase N, R, o P (por ejemplo: respirador de filtro mécanico, respirador sin
cartucho)
b._____ Otros tipos (respirador con cartucho químico, máscara con cartucho químico, máscara con manguera con soplador (PAPR),máscara con manguera sin soplador (SAR), aparato respiratorio autónomos (SCBA)).
12. ¿Ha usado algun tipo de respirador ? . . . . . Sí o No

Si ha usado equipo protector respíratorio, que tipo(s) ha utilizado:
_____
_____

Parte A. Seccion 2. (Mandatorio): Preguntas del 1 al 9 deben ser contestadas por cada empleado que fue seleccionado a usar cualquier tipo de respirador. Marque con un circulo para indicar sus repuestas.

1. ¿Corrientemente fuma tabaco, o ha fumado tabaco durante el ultimo mes? . . . . . Sí o No
2. ¿Ha tenido algunas de las siguientes condiciones medicas?
a. Convulsiones : . . . . . Sí o No
b. Diabetes (azucar en la sangre): . . . . . Sí o No
c. Reacciones alergicas que no lo deja respirar: . . . . . Sí o No
d. Claustrofobia (miedo de estar en espacios cerrados): . . . . . Sí o No
e. Dificultad oliendo excepto cuando ha cogido un resfriado: . . . . . Sí o No
3. ¿Ha tenido algunas de los siguientes problemas pulmonares?
a. Asbestosis: . . . . . Sí o No
b. Asma: . . . . . Sí o No
c. Bronquitis cronica: . . . . . Sí o No
d. Emfisema: . . . . . Sí o No
e. Pulmonía: . . . . . Sí o No
f. Tuberculosis: . . . . . Sí o No
g. Silicosis: . . . . . Sí o No
h. Neumotorax (pulmon colapsado): . . . . . Sí o No
i. Cáncer en los pulmones: . . . . . Sí o No
j. Costillas quebradas: . . . . . Sí o No
k. Injuria o cirujía en el pecho: . . . . . Sí o No
l. Algun otro problema de los pulmones que le ha dicho su medico: . . . . . Sí o No
4. ¿Corrientemente tiene alguno de los siguientes síntomas o enfermedades en sus pulmones?
a. Respiración dificultosa . . . . . Sí o No
b. Respiración dificultosa cuando camina rapido sobre terreno plano o subiendo una colina: Sí o No
c. Respiración dificultosa cuando camina normalmente con otras personas sobre terreno plano: Sí o No
d. Cuando camina normalmente en terreno plano se encuentra corto de resuello? . . . . . Sí o No
e. Respiración dificultosa cuando se esta bañando o vistiendo: . . . . . Sí o No
f. Respiración dificultosa que lo impede trabajar: . . . . . Sí o No
g. Tos con flema: . . . . . Sí o No
h. Tos que lo despierta temprano en la mañana: . . . . . Sí o No
i. Tos que occure cuando esta acostado: . . . . . Sí o No
j. Ha tosido sangre en el ultimo mes: . . . . . Sí o No
k. Silbar o respirar con mucha dificultad: . . . . . Sí o No
l. Silbar que lo impede trabajar: . . . . . Sí o No
m. Dolor del pecho cuando respira profundamente: . . . . . Sí o No
n. Otros símtomas que crea usted estar relacionados a los pulmones: . . . . . Sí o No
5. ¿Ha tenido algunos de los siguientes problemas con el corazón?
a. Ataque cardiaco: . . . . . Sí o No
b. Ataque cerebrovascular: . . . . . Sí o No
c. Dolor en el pecho: . . . . . Sí o No
d. Falla de corazón: . . . . . Sí o No
e. Hinchazón en las piernas o pies (que no sea por caminar): . . . . . Sí o No
f. Latidos irregulares del corazón: . . . . . Sí o No
g. Alta presión: . . . . . Sí o No
h. Algun otro problema cardio-vascular o cardiaco: . . . . . Sí o No
6. ¿Ha tenido algunos de los siguientes síntomas causados por su corazón?
a. Dolor de pecho frecuente o pecho apretado: . . . . . Sí o No
b. Dolor o pecho apretado durante actividad fisica: . . . . . Sí o No

c. Dolor o pecho apretado que no lo deja trabajar normalmente: . . . . . Sí o No
d. En los ultimos dos años ha notado que su corazón late irregularmente: . . . . . Sí o No
e. Dolor en el pecho o indigestion que no es relacionado a la comida: . . . . . Sí o No
f. Algunos otros síntomas que usted piensa ser causado por problemas de su corazón o de su circulation.
. . . . . Sí o No
7. ¿Esta tomando medicina por algunso de los siguientes problemas?
a. Respiración dificultosa: . . . . . Sí o No
b. Problemas del corazón: . . . . . Sí o No
c. Alta presión : . . . . . Sí o No
d. Convulsiones: . . . . . Sí o No
8. ¿Le ha causado alguno de los siguientes problemas usando el respirador? (si no ha usado un respirador, deje
esta pregunta en blanco__ y continue con pregunta 9).
a. Irritación de los ojos: . . . . . Sí o No
b. Alergias del cutis o sarpullido: . . . . . Sí o No
c. Ansiedad que ocurre solamente cuando usa el respirado: . . . . . Sí o No
d. Debilidad, falta de vigor o fatiga desacostumbrada: . . . . . Sí o No
e. Algun otro problema que le impida utilizar su respirador: . . . . . Sí o No
9. ¿Le gustaria hablar con el profesional de sanidad con licencia autorizado por el estado que revisara este cuestionario sobre sus respuestas? . . . . . Sí o No

Las preguntas del 10 al 15 deben ser contestadas por los empleados seleccionados para usar una máscara
con cartucho químico o aparato respiratorio autónomo (SCBA). Los empleados que usan otro tipo de respirador no tienen que contestar estas preguntas.

10. ¿Ha perdido la vista en cualquiera de sus ojos (temporalmente o permanente): . . . . . Sí o No
11. ¿Corrientemente tiene algunos de los siguientes problemas con su vista?
a. Usa lentes de contacto: . . . . . Sí o No
b. Usa lentes: . . . . . Sí o No
c. Daltoniano (dificultad distinguiendo colores): . . . . . Sí o No
d. Tiene algún problema con sus ojos o su vista: . . . . . Sí o No
12. ¿Ha tenido daño en sus oidos incluyendo rotura del tímpano: . . . . . Sí o No
13. ¿Corrientemente tiene uno de las siguientes problemas para oir?
a. Dificultad oyendo: . . . . . Sí o No
b. Usa un aparato para oir: . . . . . Sí o No
c. Tiene algun otro problema con sus oidos o dificultad escuchando: . . . . . Sí o No
14. ¿Se ha dañado o lastimado su espalda? . . . . . Sí o No
15. ¿Tiene uno de los siguientes problemas de su aparato muscular or eskeleto?
a. Debilidad en sus brazos, manos, piernas o pies : . . . . . Sí o No
b. Dolor de espalda: . . . . . Sí o No
c. Dificultad para mover sus brazos y piernas completamente: . . . . . Sí o No
d. Dolor o engarrotamiento cuando se inclina para adelante o para atras: . . . . . Sí o No
e. Dificultad para mover su cabeza para arriba o para abajo completamente: . . . . . Sí o No
f. Dificultad para mover su cabeza de lado a lado: . . . . . Sí o No
g. Dificultad para agacharse doblando sus rodillas: . . . . . Sí o No
h. Dificultad para agacharse hasta tocar el piso: . . . . . Sí o No
i. Dificultad subiendo escaleras cargando mas de 25 libras: . . . . . Sí o No
j. Alguno problema muscular o con sus huesos que le evite usar un respirador: . . . . . Sí o No

Parte B - Las siguientes preguntas pueden ser agregadas al cuestionario a discrecion del profesional de
sanidad con licencia autorizado por el estado.

1. ¿Esta trabajando en las alturas arriba de 5,000 pies o en sitios que tienen menos oxígeno de lo normal? . . . . . Sí o No

Si la respuesta es "Sí", se ha sentido mareado, o ha tenido dificultad respirando, palpitaciones, o cualquier otro síntoma que usted no tiene cuando no esta trabajando bajo estas condiciones: . . . . . Sí o No

2. ¿En el trabajo o en su casa, ha estado expuesto a solventes o contaminantes peligrosos en el aire (por ejemplo, humos, neblina o polvos) o ha tenido contacto del cutis con químicas peligrosas? . . . . . Sí o No

Escriba las químicas y productos con las que ha estado expuesto, si sabe cuales son:_____

3. ¿Ha trabajado con los siguientes materiales o las condiciones anotadas abajo?:

a. Asbestos: . . . . . Sí o No
b. Sílice (Limpiar mediante un chorro de arena): . . . . . Sí o No
c. Tungsteno/Cobalto (pulverizar o soldadura): . . . . . Sí o No
d. Berilio: . . . . . Sí o No
e. Aluminio: . . . . . Sí o No
f. Carbón de piedra (minando): . . . . . Sí o No
g. Hierro: . . . . . Sí o No
h. Estaño: . . . . . Sí o No
i. Ambiente polvoriento: . . . . . Sí o No
j. Otra exposicion peligrosa: . . . . . Sí o No

Describa las exposiciones peligrosas:

_____
_____

4. ¿Tiene usted otro trabajo o un negocio aparte de este?

_____
_____
_____

5. Apunte su previos trabajos:

_____

6. Apunte sus pasatiempos:

_____
_____
_____

7. ¿Tiene servicio militar? . . . . . Sí o No

Si la respuesta es "Sí", ha estado expuesto a agentes químicos o biologicos durante entrenamiento o combate: . . . . . Sí o No

8. ¿Alguna vez ha trabajado en un equipo de HAZMAT (equipo respondedor a incidentes de materiales peligosos con emergencia)? . . . . . Sí o No

9. ¿Esta tomando alguna medicina que no haya mencionado en este cuestionario (incluyendo remedios caseros o
medicinas que compra sin receta)? . . . . . Sí o No
Si la respuesta es “Sí”, cuales son_____
10. ¿Va a usar algunas de las siguientes partes con su respirador?
a. filtros HEPA (filtro de alta eficiencia que remueve partículas tóxicas en la atmósfera): . . . . Sí o No
b. Canastillo (por ejemplo, máscara para gas): . . . . . Sí o No
c. Cartuchos: . . . . . Sí o No
11. ¿Cuántas veces espera usar un respirador?
a. Para salir de peligro solamente (no rescates): . . . . . Sí o No
b. Recates de emergencia solamente: . . . . . Sí o No
c. Menos de 5 horas *por semana*: . . . . . Sí o No
d. Menos de 2 horas *por día*: . . . . . Sí o No
e. 2 a 4 horas *por día*: . . . . . Sí o No
f. Mas de 4 horas *por día*: . . . . . Sí o No
12. ¿Durante el tiempo de usar el respirador, su trabajo es...?
a. **Ligero** (menos de 200 kcal por hora): . . . . . Sí o No
Si la respuesta es “sí”, cuanto tiempo dura la obra _____horas _____minutos
Ejemplos de trabajos ligeros: estar sentado escribiendo, escribiendo a máquina, diseñando, trabajando la línea de
montaje, o estar parado gobernando un taladro o máquinas:
b. **Moderado** (200-350 kcal por hora): . . . . . Sí o No
Si la respuesta es “sí”cuanto tiempo dura en promedio por jornada _____horas_____minutos
Ejemplos de trabajos moderados : sentado clavando o archivando; manejando un camión o autobús en trafico
pesado; estar de pie taladrando, clavando, trabajando la línea de montaje, o transferiendo una carga (de 35 libras)
a la altura de la cintura; caminando sobre tierra plana a 2 millas por hora o bajando a 3 millas por hora; empujando una carretilla con una carga pesada (de 100 libras) sobre terreno plano.
c. **Pesado** (mas de 350 kcal por hora): . . . . . Sí o No
Si la respuesta es “sí”cuanto tiempo dura en promedio por jornada _____horas_____minutos
Ejemplos de trabajos pesados: levantando cargas pesadas (mas de 50 libras) desde el piso hasta la altura de la
cintura o los hombros; trabajando cargando o descargando; transpalear; estar de pie trabajando de albañil o demenuzando moldes; subiendo a 2 millas por hora; subiendo la escalera con una carga pesada (mas de 50 libras).
13. ¿Va a estar usando ropa o equipo protectivo cuando use el respirador? . . . . . Sí o No
Si la respuesta es “sí” describa que va a estar
usando_____
_____
_____
14. ¿Va a estar trabajando en condiciones calurosas (temperatura mas de 77 grados F)? . . . . . Sí o No
15. ¿Va a estar trabajando en condiciones humedas? . . . . . Sí o No

16. Describa el tipo de trabajo que va a estar usted haciendo cuando use el respirador.

_____

_____

17. Describa cualquier situacion especial o peligrosa que pueda encontrar cuando este usando el respirador (por
ejemplo, espacios encerrados, gases que lo puedan matar, etc.)

_____

18. Provea la siguiente informacion si la sabe, por cada sustancia tóxica que usted va a estar expuesto cuando
este usando el respirador(s):

Nombre de la primera sustancia tóxica_____

Maximo nivel de exposición por jornada de trabajo_____

Tiempo de exposición por jornada_____

Nombre de la segunda sustancia tóxica_____

Maximo nivel de exposición por jornada de trabajo_____

Tiempo de exposición por jornada_____

Nombre de la tercera sustancia tóxica_____

Máximo nivel de exposición por jornada de trabajo_____

Tiempo de exposición por jornada_____

El nombre de cualquier sustancia tóxica que usted va a estar expuesto cuando este usted usando el
respirador_____

_____

19. Describa alguna responsabilidad especial que usted va a tener cuando usted este usado el respirador(s) que
pueda afectar la seguridad o la vida de otros (por ejemplo, rescate, seguridad).

_____

Attachment G

Dust Control and Suppression Handbook

Former DuPont East Chicago Facility

DUST PERVENTION AND CONTROL SAFETY HANDBOOK



1.0 DEFINITIONS

Additional best management practice shall mean using **<u>at least one</u>** additional measure if the required best management practices are ineffective at preventing off-property transport of particulate matter.

Additional requirements shall mean when applicable, any measure that is required, e.g., a dust control plan when project sites are over 5 acres in size.

Best management practice (BMPs) shall mean any action or process that is used to prevent or mitigate the emission of fugitive dust into the air.

Bulk materials transport shall mean the carrying, moving, or conveying of loose materials including, but not limited to, earth, rock, silt, sediment, sand, gravel, soil, fill, aggregate, dirt, mud, construction or demolition debris, and other organic or inorganic material containing particulate matter onto a public road or right-of-way in an unenclosed trailer, truck bed, bin, or other container.

Code shall mean project specific City or State safety or construction-based ordinance, as amended from time to time.

Cover shall mean the installation of a temporary cover material on top of disturbed soil surfaces or stockpiles, such as netting, mulch, wood chips, gravel or other materials capable of preventing wind erosion.

Dust control measure shall mean any action or process that is used to prevent or mitigate the emission of fugitive dust into the air, including but not limited to the best management practices identified in this Manual.

Dust generating activity or source shall mean a process, operation, action, or land use that creates emissions of fugitive dust or causes off-property or off-vehicle transport. Dust generating activity or source shall include a paved parking lot containing an area of more than one half (1/2) acre.

Earthmoving shall mean any process that involves land clearing, disturbing soil surfaces, or moving, loading, or handling of earth, dirt, soil, sand, aggregate, or similar materials.

Local wind speed shall mean the current or forecasted wind speed for Site specific area as measured at the nearest surface weather observation station or as measured onsite with a portable weather station or hand-held anemometer.

Off-property transport shall mean the visible emission of fugitive dust beyond the property line of the property on which the emission originates or the project boundary when the emission originates in the public right-of-way or on public property.

Off-vehicle transport shall mean the visible emission of fugitive dust from a vehicle that is transporting dust generating materials on a public road or right-of-way.

On-tool local exhaust ventilation shall mean a vacuum dust collection system attached to a construction tool that includes a dust collector (hood or shroud), tubing, vacuum, and a high efficiency particulate air (HEPA) filter.

On-tool wet dust suppression shall mean the operation of nozzles or sprayers attached to a construction tool that continuously apply water or other liquid to the grinding or cutting area by a pressurized container or other water source.

Operator or owner shall mean any person who has control over a dust generating source either by operating, supervising, controlling, or maintaining ownership of the activity or source including, but not limited to, a contractor, lessee, or other responsible party of an activity, operation, or land use that is a dust generating activity or source.

Particulate matter shall mean any material that is emitted into the air as finely divided solid or liquid particles, other than uncombined water, and includes dust, smoke, soot, fumes, aerosols and mists.

Required best management practices shall mean specific measures that are required to be implemented if a dust generating activity is occurring.

Sensitive area *shall mean a specific area that* warrants special protection from adverse impacts due to the deposition of fugitive dust, such as natural areas (excluding buffer zones), sources of water supply, wetlands, critical wildlife habitat, or wild and scenic river corridors.

Soil retention shall mean the stabilization of disturbed surface areas that will remain exposed and inactive for 30 days or more or while vegetation is being established using mulch, compost, soil mats, or other methods.

Stockpile or Pile shall mean any accumulation of bulk materials that contain particulate matter being stored for future use or disposal. This includes backfill materials and storage piles for soil, sand, dirt, mulch, aggregate, straw, chaff, or other materials that produce dust.

Storm drainage facility shall mean those improvements designed, constructed or used to convey or control stormwater runoff and to remove pollutants from stormwater runoff after precipitation.

Surface roughening shall mean to modify the soil surface to resist wind action and reduce dust emissions from wind erosion by creating grooves, depressions, ridges or furrows perpendicular to the predominant wind direction using tilling, ripping, discing, or other method.

Track-out shall mean the carrying of mud, dirt, soil, or debris on vehicle wheels, sides, or undercarriages from a private, commercial, or industrial site onto a public road or right-of- way.

Vegetation shall mean the planting or seeding of appropriate grasses, plants, bushes, or trees to hold soil or to create a wind break. All seeded areas must be mulched, and the mulch should be adequately crimped and or tackified. If hydro-seeding is conducted, mulching must be conducted as a separate, second operation. All planted areas must be mulched within twenty- four (24) hours after planting.

Wet suppression shall mean the application of water by spraying, sprinkling, or misting to maintain optimal moisture content or to form a crust in dust generating materials and applied at a rate that prevents runoff from entering any public right-of-way, storm drainage facility or watercourse.

Wind barrier shall mean an obstruction at least five feet high erected to assist in preventing the blowing of fugitive dust, comprised of a solid board fence, chain link and fabric fence, vertical wooden slats, hay bales, earth berm, bushes, trees, or other materials installed perpendicular to the predominant wind direction or upwind of an adjacent residential, commercial, industrial, or sensitive area that would be negatively impacted by fugitive dust.

2.0 PURPOSE

The purpose of this Handbook is to identify the steps that will be taken to reduce the potential for particulate emissions during remediation activities. The handbook includes activity-specific dust control criteria and dust suppression procedures. Best management practices (BMPs) will be implemented throughout the project. BMPs include wetting active remediation areas, minimizing or ceasing activities during periods of high wind, sweeping or wetting paved areas, wetting unpaved areas, application of dust suppressant materials and covering stockpiles.

This plan provides specific information about the generation and control of dust emissions during the excavation of soil material, stockpiling of these materials and other activities associated with the remediation. This plan is to be used in conjunction with the site Remedial Work Plan (or

equivalent), Site-Specific Health and Safety Plan (HASP), and the Air Monitoring Plan (or equivalent) developed for this project. The following section details potential dust sources and dust control methods.

Impact Environmental will implement a dust control training program for all Site personnel. This training program will review the potential sources of dust, individual responsibilities, and actions for controlling dust as described in this handbook. The training will emphasize the importance of dust control to the overall success of the remedial activities and familiarize Site personnel with the air monitoring requirements and appropriate dust control procedures that must be adhered to in accordance with this plan to minimize dust generation.

3.0 POTENTIAL DUST GENERATION ACTIVITIES AND CONTROLS

Remediation activities will have the potential to generate emissions in the form of fugitive dust. Dust control methods will vary based on the activities occurring at the Site. Mai activities to be conducted during remediation which have the potential to generate dust emissions, and the respective dust control measures, are described in the summary table below:

ACTIVITY	DUST CONTROL
Truck traffic	Wet down unpaved haul roads. Keep paved roads clean or wet down if damaged and cracked and cannot be kept clean.
Soil excavation, loading activities	Wind barrier. Water spray/mist, adjust excavation activities, suspend work under unfavorable conditions (sustained wind speed greater than 20 miles per hour).
Stockpiling	Wind barrier. Water spray/mist. Use of airborne dust wet suppression system as required. Cover stockpiles with tarps during sustained wind greater than 20 miles per hour and at the end of each day. Inactive Hazardous piles will remained covered.
Soil Loading, Hauling, and Backfill Replacement	Use of airborne dust wet suppression system and water spray mist as required.

This Handbook describes established best management practices for controlling dust emissions that are practical and used in common practice to prevent or mitigate impacts to air quality from dust generating activities at remediation sites. The objective of the dust control measures included are to to reduce dust emissions from human activities and to prevent those emissions from impacting site workers or surrounding communities. This approach is based on following principles:

Prevent – avoid creating dust emissions through good project planning and modifying or replacing dust generating activities.

Minimize – reduce dust emissions with methods that capture, collect, or contain emissions.

Mitigate – when preventing fugitive dust or minimizing the impacts are not feasible, This Handbook provides specific measures to mitigate dust.

More specifically, this plan establishes the following procedures for each dust generating activity outlined below:

1. ***Required Best Management Practices*** – this includes the specific measures that are required to be implemented if the dust generating activity is occurring. For example, high wind restrictions (temporarily halting work when wind speeds exceed 30 mph) are required best management practices for earthmoving, demolition/ renovation associated activities.

2. ***Additional Best Management Practices*** – this includes additional measures if the required best management practices are ineffective at preventing off-property transport of particulate matter or protection of site workers. **At least one** of the additional best management practices outlined must be implemented on the site.

Earthmoving Activities

Dust emissions from earthmoving activities depend on the type and extent of activity being conducted, the amount of exposed surface area, wind conditions, and soil type and moisture content, including:

- Site preparation (clearing, grubbing, scraping)
- Road construction
- Grading and overlot grading
- Excavating, trenching, backfilling and compacting
- Loading and unloading dirt, soil, gravel, or other earth materials
- Dumping of dirt, soil, gravel, or other earth materials into trucks, piles, or receptacles
- Screening of dirt, soil, gravel, or other earth materials

Best Management Practices to Control Dust

Required Best Management Practices*:* Any person, owner, or operator who conducts earthmoving that is a dust generating activity or source shall implement the following best management practices to prevent off-property transport of fugitive dust emissions:

(i) **Minimize disturbed area:** plan the project or activity so that the minimum amount of disturbed soil or surface area is exposed to wind or vehicle traffic at any one time.

(ii) **Reduce vehicle speeds:** establish a maximum speed limit or install traffic calming devices to reduce speeds to a rate to mitigate off-property transport of dust entrained by vehicles.

(iii) **Minimize drop height:** Drivers and operators shall unload truck beds and loader or excavator buckets slowly, and minimize drop height of materials to the lowest height possible, including screening operations.

(iv) **High winds restriction:** temporarily halt work activities during high wind events greater than
30 mph if operations would result in off-property transport.

(v) **Restrict access:** restrict access to the work area to only authorized vehicles and personnel.

Additional Best Management Practices: In the event the above are ineffective to prevent off- property transport, the person, owner, or operator shall use **<u>at least one</u>** of the following best management practices:

(i) **Wet suppression:** apply water to disturbed soil surfaces, backfill materials, screenings, and other dust generating operations as necessary and appropriate considering current weather conditions, and prevent water used for dust control from entering any public right-of-way, stormwater drainage facility, or watercourse.

(ii) **Wind barrier**: construct a fence or other type of wind barrier to prevent wind erosion of top soils.

(iii) **Vegetation:** plant vegetation appropriate for retaining soils or creating a windbreak.

(iv) **Surface roughening:** stabilize an active construction area during periods of inactivity or when vegetation cannot be immediately established.

(v) **Cover:** install cover materials during periods of inactivity and properly anchor the cover.

(vi) **Soil retention:** stabilize disturbed or exposed soil surface areas that will be inactive for more than 30 days or while vegetation is being established.

Construction and Demolition

Dust generated from construction and demolition activities may contain significant levels of silica, lead, asbestos, and particulate matter. Inhalation of silica and asbestos is known to cause lung cancer, and exposure to even small quantities of lead dust can result in harm to children and the unborn.

In addition to complying with the dust control measures below, any person engaged in construction or demolition tasks must comply with applicable state and federal regulations for asbestos and lead containing materials and notification and inspection requirements under the State codes and rules.

Best Management Practices to Control Dust

Required Best Management Practices*:* Any person, owner, or operator who conducts construction or demolition tasks that is a dust generating activity or source shall implement the following best management practices to prevent off-property transport of fugitive dust emissions:

(i) **Possible asbestos and lead containing materials:** demolition and renovation activities that may involve asbestos or lead containing materials must be conducted in accordance with *2012 International Building Code* (IBC)*,* as adopted by the Code Sec. 5-26 and amended by Code Sec. 5-27 (59) (amending IBC §3602.1.1) and all other state and local regulations;

(ii) **Restrict access:** restrict access to the demolition area to only authorized vehicles and personnel;

(iii) **High winds restriction:** temporarily halt work activities during high wind events greater than 30 mph if operations would result in off-property transport; and

(iv) **Minimize drop height:** Drivers and operators shall unload truck beds and loader or excavator buckets slowly, and minimize drop height of materials to the lowest height possible, including screening operations.

Additional Best Management Practices: In the event the above are ineffective to prevent off- property transport, the person, owner, or operator shall use **at least one** of the following best management practices:

(i) **Wet suppression:** apply water to demolished materials or pre-wet materials to be demolished as necessary. Prevent water used for dust control from entering any public right-of-way, storm drainage facility, or watercourse.

(ii) **Wind barrier**: construct a fence or other type of wind barrier to prevent onsite dust generating materials from blowing offsite.

Stockpiles

Stockpiles are used for both temporary and long-term storage of soil, fill, dirt, sand, aggregate, woodchips, mulch, asphalt and other industrial feedstock, construction and landscaping materials. Fugitive dust can be emitted from stockpiles while working the active face of the pile or when wind blows across the pile. The quantity of emissions depends on pile height and exposure to wind, moisture content and particle size of the pile material, surface roughness of the pile, and frequency of pile disturbance.

Best Management Practices to Control Dust

Required Best Management Practices: Any owner or operator of a stockpile that is a dust generating activity or source shall implement the following best management practices to prevent off property transport of fugitive dust emissions:

(i) **Minimize drop height:** Drivers and operators shall unload truck beds and loader or excavator buckets slowly, and minimize drop height of materials to the lowest height possible, including screening operations.

Additional Best Management Practices: In the event the above are ineffective to prevent off-property transport, the person, owner, or operator shall use **at least one** of the following best management practices:

(i) **Wet suppression:** Apply water to the active face when working the pile or to the entire pile during periods of inactivity. Prevent water used for dust control from entering any public right- of-way, storm drainage facility, or watercourse.

(ii) **Cover:** install cover materials during periods of inactivity and anchor the cover.

(iii) **Surface roughening:** stabilize a stockpile during periods of inactivity or when vegetation cannot be immediately established.

(iv) **Stockpile location:** locate stockpile at a distance equal to ten times the pile height from property boundaries that abut residential areas.

(v) **Vegetation:** seed and mulch any stockpile that will remain inactive for 30 days or more.

(vi) **Enclosure:** construct a three-sided structure equal to or greater than the height of the pile to shelter the pile from the predominant winds.

Street Sweeping

Street sweeping is an effective method for removing dirt and debris from streets or roadways and preventing it from entering storm drains or becoming airborne. Regenerative air sweepers and mechanical sweepers with water spray can also be effective at removing particulate matter from hard surfaces.

Best Management Practices to Control Dust

Required Best Management Practices: Any owner or operator that conducts sweeping operations or
services on paved or concrete roads, parking lots, rights-of-way, pedestrian ways, plazas or other solid surfaces, and whose operations are a dust generating activity or source shall implement the following best management practices to prevent off-property transport of fugitive dust emissions:

(i) **Uncontrolled sweeping prohibited:** the use of rotary brushes, power brooms, or other mechanical sweeping for the removal of dust, dirt, mud, or other debris from a paved public road, right-of-way, or parking lot without the use of water, vacuum system with filtration, or other equivalent dust control method is prohibited. Mechanical or manual sweeping that occurs between lifts of asphalt paving operations or due to preparation for pavement markings are excluded from this prohibition, due to engineering requirements associated with these operations.

Additional Best Management Practices: In the event the above are ineffective to prevent off-property transport, the person, owner, or operator shall use **at least one** of the following best management practices:

(i) **Wet suppression:** use a light spray of water or wetting agent applied directly to work area or use equipment with water spray system while operating sweeper or power broom. Prevent water used for dust control from entering any storm drainage facility or watercourse.

(ii) **Vacuum system:** use sweeper or power broom equipped with a vacuum collection and filtration system.

(iii) **Other method:** use any other method to control dust emissions that has a demonstrated particulate matter control efficiency of 80 percent or more.

Track-out / Carry-out

Mud, dirt, and other debris can be carried from a site on the wheels or undercarriage of equipment and vehicles onto public roads. When this material dries, it can become airborne by wind activity or when other vehicles travel on it. This is a health concern and can cause visibility issues and safety hazards.

Best Management Practices to Control Dust

***Required Best Management Practices*:** Any owner or operator of any operation that has the potential to result in track-out of mud, dirt, dust, or debris on public roads and rights-of-way and whose operation is a dust generating activity or source shall implement the following best management practices to prevent off-property transport of fugitive dust emissions:

(i) **Contracts and standards:** comply with track-out prevention requirements and construction best management practices as set forth in the Code, City regulations or policies, as specified in applicable contract documents.

(ii) **Remove deposition:** promptly remove any deposition that occurs on public roads or rights- of-way as a result of the owner's or operator's operations. Avoid over-watering and prevent runoff into any storm drainage facility or watercourse.

***Additional Best Management Practices*:** In the event the above are ineffective to prevent off- property transport, the person, owner, or operator shall use **at least one** of the following best management practices:

(i) **Install rails, pipes, grate**, or similar track-out control device.

(ii) **Install a gravel bed track-out apron** that extends at least 50 feet from the intersection with a public road or right-of-way.

(iii) **Install gravel bed track-out apron** with steel cattle guard or concert wash rack.

(iv) **Washing Station:** Install and utilize on-site vehicle and equipment washing station.

(v) **Install a paved surface** that extends at least 100 feet from the intersection with a road or right-of-way.

(vi) **Manually remove** mud, dirt, and debris from equipment and vehicle wheels, tires and undercarriage.

Bulk Materials Transport

Haul trucks are used to move bulk materials, such as soil, fill, rock, demolition debris, or mulch to and from project sites, material suppliers, storage yards and disposal facilities. Dust emissions from haul trucks, if uncontrolled, can be a safety hazard by impairing visibility or by depositing debris/contaminates on roads, pedestrians, bicyclists, or other vehicles.

Best Management Practices to Control Dust

Required Best Management Practices: Any owner or operator of a dust generating activity or source for which vehicles used to transport bulk materials to and from a site within the City on a public or private road or on a public right-of-way shall prevent off-vehicle transport of fugitive dust emissions. To prevent off-vehicle transport of fugitive dust to and from the site, the owner or operator shall implement the following measures:

(i) **Cover Loads:** Loads shall be completely covered, or all material enclosed in a manner that prevents the material from blowing, dropping, sifting, leaking, or otherwise escaping from the vehicle. This includes the covering of hot asphalt and asphalt patching material with a tarp or other impermeable material.

(ii) **Minimize drop height:** Drivers and operators shall load and unload truck beds and loader or excavator buckets slowly, and minimize drop height of materials to the lowest height possible, including screening operations.

***Additional Best Management Practices*:** In the event the above are ineffective to prevent off- vehicle transport, the person, owner, or operator shall use **at least one** of the following best management practices:

(i) **Wet suppression:** apply water to bulk materials loaded for transport as necessary to prevent fugitive dust emissions and deposition of materials on roadways. Prevent water used for dust control from entering any public right-of-way, storm drainage facility, or watercourse.

(ii) **Other technology:** use other equivalent technology that effectively eliminates off-vehicle transport, such as limiting the load size to provide at least three inches of freeboard to prevent spillage.

Unpaved Roads and Haul Roads

Road dust from unpaved roads is caused by particles lifted by and dropped from rolling wheels traveling on the road surface and from wind blowing across the road surface. Road dust can aggravate heart and lung conditions as well as cause safety issues such as decreased driver visibility and other safety hazards.

Best Management Practices to Control Dust

Required Best Management Practices: Any owner or operator of an unpaved road located on a construction site greater than five acres on private property or an unpaved road used as a public right- of-way shall implement the following best management practices to prevent off-property transport of fugitive dust emissions:

(i) **Reduce vehicle speeds:** establish a maximum speed limit or install traffic calming devices to reduce speeds to a rate that prevents off-property transport of dust entrained by vehicles.

(ii) **Restrict access:** restrict travel on unpaved roads by limiting access to only authorized vehicle use.

Additional Best Management Practices: In the event the above are ineffective to prevent off- property transport, the person, owner, or operator shall use **at least one** of the following best management practices:

(i) **Wet suppression:** apply water to unpaved road surface as necessary and appropriate considering current weather conditions, and prevent water used for dust control from entering any public right-of-way, storm drainage facility, or watercourse.

(ii) **Surface improvements:** install gravel or similar materials with sufficient depth to reduce dust or pave high traffic areas.

(iii) **Access road location:** locate site access roads away from residential or other populated areas.

Parking Areas/ Staging Areas

This section applies to unpaved areas where vehicles, material or other equipment are parked or stored on a routine.

Best Management Practices to Control Dust- Unpaved Parking Lots

Required Best Management Practices: Any owners or operator of an unpaved parking/ staging area greater than one acre shall use **at least one** of the following best management practices to prevent off- property transport of fugitive dust emissions

(i) **Surface improvements:** install gravel or similar materials with sufficient depth to reduce dust or pave high traffic areas.

(ii) **Vegetation:** plant vegetation appropriate for retaining soils or creating a wind break.

(iii) **Wet suppression:** apply water as necessary and appropriate considering current weather conditions to prevent off-property transport of fugitive dust emissions. Prevent water used for dust control from entering any public right-of-way, storm drainage facility, or watercourse.

(iv) **Wind barrier:** construct a fence or other type of wind barrier.

(v) **Reduce vehicle speeds:** establish a maximum speed limit or install traffic calming devices to reduce speeds to a rate that prevents off-property transport of dust entrained by vehicles.

(vi) **Restrict access:** restrict travel in parking lots to only those vehicles with essential duties and limit access to hours of operation or specific events.

Open Areas and Vacant Lots

Open areas are typically not a significant source of wind-blown dust emissions if the coverage of vegetation is sufficient or soil crusts are intact. However, if soils in open areas are disturbed by

vehicle traffic, off-highway vehicle use, bicycling or grazing, or if they have become overpopulated by prairie dogs, dust emissions can become a problem.

Best Management Practices to Control Dust

Required Best Management Practices: Any owner or operator of an open area greater than one-half acre shall use **at least one** of the following best management practices to stabilize disturbed or exposed soil surface areas that are intended to or remain exposed for 30 days or more and to prevent off- property transport of fugitive dust emissions:

(i) **Vegetation:** plant vegetation appropriate for retaining soils or creating a wind break.

(ii) **Cover:** install cover materials over exposed areas during periods of inactivity and properly anchor the cover.

(iii) **Surface roughening:** stabilize an exposed area during periods of inactivity or when vegetation cannot be immediately established.

(iv) **Soil retention:** stabilize disturbed or exposed soil surface areas that will be inactive for more than 30 days or while vegetation is being established, using mulch, compost, soil mats, or other methods.

(v) **Wet suppression:** apply water to disturbed soil surfaces as necessary and appropriate considering current weather to prevent off-property transport of fugitive dust emissions. Prevent water used for dust control from entering any public right-of-way, storm drainage facility, or watercourse.

(vi) **Wind barrier:** construct a fence or other type of wind barrier to prevent wind erosion of top soils.

4.0 MONITORING ACTIVITIES

Impact Environmental will provide air monitoring for this project and be responsible for the collection, evaluation, presentation, and data management of the real-time air monitoring results. The scope of this will be contingent on the site-specific HASP/QAPP or Remedial Work Plan (or equivalent). Other responsibilities include maintenance of sampling equipment and implementation of on-site recommendations for response actions.

The plan for a full scale air monitoring program is detailed in the HASP/ QAPP and generally consists of the following:

- Mobilization and air monitoring equipment preparation for the Site will be initiated prior to the start of removal activities. The perimeter air monitoring stations will monitor ambient air continuously while removal activities are being conducted. Small stockpiles will only be temporarily formed when pulling soil within the reach of the excavator while loading a truck; therefore, continuous 24/7 air monitoring will not be necessary.

- Two (2) perimeter air monitoring stations will be deployed along the site boundary downwind of remedial activities to monitor fugitive emissions from the Site into nearby communities.

- One (1) upwind air monitoring station will collect upwind data either on a set daily frequency or continuously to evaluate background particulate levels.

- One (1) air monitoring station will be directly downwind of ongoing remedial activities to monitor exposure risks and emission levels to onsite workers.

- Some project Sites may warrant a dedicated weather station to be deployed and operated to continuously monitor meteorological conditions during the remedial activities.

Contact List/ Communications Pathway

In the event that Action Levels have been exceeded or removal activities have caused an emission issue, utilize contact lists within the HASP and follow communication pathways outline within the QAPP to inform the necessary personnel of the incident.

Reporting Requirements

Monitoring and reporting requirements are outline in the Site specific HASP.

Attachment H

Employee Accident Report

Former DuPont East Chicago Facility

Employee Accident Report

EMPLOYEE

Name_____SS#_____Emp ID#_____

Home Address_____
Street city zip code phone

Sex: M F Birth Date_____ Age:_____ Employment Status: Full time _____Part time _____%_____

Job Title _____Time in Present Position _____ Yrs _____Months

Department _____Work Address_____
building/room # phone

Supervisor_____
name building/room # phone

Accident Date_____ Time _____am/pm Location_____

What were you doing and using (tools, chemicals, equipment, etc.) when the accident occurred? Describe what happened.

_____

_____

_____

Was this part of your normal job duty? _____ Yes _____No

Parts of body affected or injured_____

Witnesses:_____/_____

name phone name phone

Report prepared by (if different from the injured employee)_____
name phone

I understand that it is my right to apply for Workers' Compensation benefits and that I have two years from the date of this accident to do so. For more information regarding workers' compensation, call the New York State Department of Labor. I also authorize release of medical information regarding this accident to the Prime Contractors claim administrators.

EMPLOYEE SIGNATURE:_____DATE:_____

SUPERVISOR/CHARGE PERSON

This accident was reported to me on _____at_____ Cost Center/Dept # _____
(date) (time)

IS FURTHER INVESTIGATION REQUIRED? ___Yes ___No _____
Supervisor/Charge Person Signature Date

HEALTH CARE PROVIDER

Treated by:_____
print name signature

Address_____
name of facility street city state zip code phone

Hospitalized overnight as inpatient? _____yes _____no (if emergency room only mark no)

Diagnosis/Assessment_____

Parts of body affected_____

Reaggravation of previous work injury? _____ yes _____no Date of initial injury_____

Attachment I

OSHA 300 Forms

Former DuPont East Chicago Facility

OSHA's Form 300 (Rev. 01/2004)

Log of Work-Related Injuries and Illnesses

Attention: This form contains information relating to employee health and must be used in a manner that protects the confidentiality of employees to the extent possible while the information is being used for occupational safety and health purposes.

Year 20__ __

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

You must record information about every work-related death and about every work-related injury or illness that involves loss of consciousness, restricted work activity or job transfer, days away from work, or medical treatment beyond first aid. You must also record significant work-related injuries and illnesses that are diagnosed by a physician or licensed health care professional. You must also record work-related injuries and illnesses that meet any of the specific recording criteria listed in 29 CFR Part 1904.8 through 1904.12. Feel free to use two lines for a single case if you need to. You must complete an Injury and Illness Incident Report (OSHA Form 301) or equivalent form for each injury or illness recorded on this form. If you're not sure whether a case is recordable, call your local OSHA office for help.

Establishment name _____

City _____ State _____

Identify the person			Describe the case			Classify the case				Enter the number of days the injured or ill worker was:		Check the "Injury" column or choose one type of illness:					
						CHECK ONLY ONE box for each case based on the most serious outcome for that case:											
								Remained at Work				(M)					
(A) Case no.	(B) Employee's name	(C) Job title (*e.g., Welder*)	(D) Date of injury or onset of illness	(E) Where the event occurred (*e.g., Loading dock north end*)	(F) Describe injury or illness, parts of body affected, and object/substance that directly injured or made person ill (*e.g., Second degree burns on right forearm from acetylene torch*)	Death (G)	Days away from work (H)	Job transfer or restriction (I)	Other record-able cases (J)	Away from work (K)	On job transfer or restriction (L)	Injury (1)	Skin disorder (2)	Respiratory condition (3)	Poisoning (4)	Hearing loss (5)	All other illnesses (6)
____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
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____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
____	_____	_____	___/___ month/day	_____	_____	☐	☐	☐	☐	____ days	____ days	☐	☐	☐	☐	☐	☐
			Page totals ➤			___	___	___	___	___	___	___	___	___	___	___	___

Be sure to transfer these totals to the Summary page (Form 300A) before you post it.

Public reporting burden for this collection of information is estimated to average 14 minutes per response, including time to review the instructions, search and gather the data needed, and complete and review the collection of information. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any other aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistical Analysis, Room N-3644, 200 Constitution Avenue, NW, Washington, DC 20210. Do not send the completed forms to this office.

Injury (1) | Skin disorder (2) | Respiratory condition (3) | Poisoning (4) | Hearing loss (5) | All other illnesses (6)

OSHA's Form 300A (Rev. 01/2004)

Summary of Work-Related Injuries and Illnesses

Year 20__ __

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

All establishments covered by Part 1904 must complete this Summary page, even if no work-related injuries or illnesses occurred during the year. Remember to review the Log to verify that the entries are complete and accurate before completing this summary.

Using the Log, count the individual entries you made for each category. Then write the totals below, making sure you've added the entries from every page of the Log. If you had no cases, write "0."

Employees, former employees, and their representatives have the right to review the OSHA Form 300 in its entirety. They also have limited access to the OSHA Form 301 or its equivalent. See 29 CFR Part 1904.35, in OSHA's recordkeeping rule, for further details on the access provisions for these forms.

Number of Cases

Total number of deaths	Total number of cases with days away from work	Total number of cases with job transfer or restriction	Total number of other recordable cases
_____	_____	_____	_____
(G)	(H)	(I)	(J)

Number of Days

Total number of days away from work	Total number of days of job transfer or restriction
_____	_____
(K)	(L)

Injury and Illness Types

Total number of . . .

	(M)		
(1) Injuries	_____	(4) Poisonings	_____
		(5) Hearing loss	_____
(2) Skin disorders	_____	(6) All other illnesses	_____
(3) Respiratory conditions	_____		

Post this Summary page from February 1 to April 30 of the year following the year covered by the form.

Public reporting burden for this collection of information is estimated to average 58 minutes per response, including time to review the instructions, search and gather the data needed, and complete and review the collection of information. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any other aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistical Analysis, Room N-3644, 200 Constitution Avenue, NW, Washington, DC 20210. Do not send the completed forms to this office.

Establishment information

Your establishment name _____

Street _____

City _____ State _____ ZIP _____

Industry description (*e.g., Manufacture of motor truck trailers*)

_____

Standard Industrial Classification (SIC), if known (*e.g., 3715*)

___ ___ ___ ___

OR

North American Industrial Classification (NAICS), if known (e.g., 336212)

___ ___ ___ ___ ___ ___

Employment information *(If you don't have these figures, see the Worksheet on the back of this page to estimate.)*

Annual average number of employees _____

Total hours worked by all employees last year _____

Sign here

Knowingly falsifying this document may result in a fine.

I certify that I have examined this document and that to the best of my knowledge the entries are true, accurate, and complete.

_____ _____
Company executive Title

( ) - / /
Phone Date

Optional

Worksheet to Help You Fill Out the Summary

At the end of the year, OSHA requires you to enter the average number of employees and the total hours worked by your employees on the summary. If you don't have these figures, you can use the information on this page to estimate the numbers you will need to enter on the Summary page at the end of the year.

How to figure the average number of employees who worked for your establishment during the year:

❶ ***Add*** the total number of employees your establishment paid in all pay periods during the year. Include all employees: full-time, part-time, temporary, seasonal, salaried, and hourly.

The number of employees paid in all pay periods = ❶ _____

❷ ***Count*** the number of pay periods your establishment had during the year. Be sure to include any pay periods when you had no employees.

The number of pay periods during the year = ❷ _____

❸ ***Divide*** the number of employees by the number of pay periods.

❶ / ❷ _____ = ❸ _____

❹ ***Round the answer*** to the next highest whole number. Write the rounded number in the blank marked *Annual average number of employees*.

The number rounded = ❹ _____

For example, Acme Construction figured its average employment this way:

For pay period...	Acme paid this number of employees...
1	10
2	0
3	15
4	30
5	40
▼	▼
24	20
25	15
26	+10
	830

Number of employees paid = 830 ❶

Number of pay periods = 26 ❷

830 / 26 = 31.92 ❸

31.92 rounds to 32 ❹

32 is the annual average number of employees

How to figure the total hours worked by all employees:

Include hours worked by salaried, hourly, part-time and seasonal workers, as well as hours worked by other workers subject to day to day supervision by your establishment (e.g., temporary help services workers).

Do not include vacation, sick leave, holidays, or any other non-work time, even if employees were paid for it. If your establishment keeps records of only the hours paid or if you have employees who are not paid by the hour, please estimate the hours that the employees actually worked.

If this number isn't available, you can use this optional worksheet to estimate it.

Optional Worksheet

_____ ***Find*** the number of full-time employees in your establishment for the year.

X _____ ***Multiply*** by the number of work hours for a full-time employee in a year.

_____ This is the number of full-time hours worked.

\+ _____ ***Add*** the number of any overtime hours as well as the hours worked by other employees (part-time, temporary, seasonal)

_____ ***Round*** the answer to the next highest whole number. Write the rounded number in the blank marked *Total hours worked by all employees last year.*

U.S. Department of Labor
Occupational Safety and Health Administration

OSHA's Form 301
Injury and Illness Incident Report

Attention: This form contains information relating to employee health and must be used in a manner that protects the confidentiality of employees to the extent possible while the information is being used for occupational safety and health purposes.

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

This *Injury and Illness Incident Report* is one of the first forms you must fill out when a recordable work-related injury or illness has occurred. Together with the *Log of Work-Related Injuries and Illnesses* and the accompanying *Summary,* these forms help the employer and OSHA develop a picture of the extent and severity of work-related incidents.

Within 7 calendar days after you receive information that a recordable work-related injury or illness has occurred, you must fill out this form or an equivalent. Some state workers' compensation, insurance, or other reports may be acceptable substitutes. To be considered an equivalent form, any substitute must contain all the information asked for on this form.

According to Public Law 91-596 and 29 CFR 1904, OSHA's recordkeeping rule, you must keep this form on file for 5 years following the year to which it pertains.

If you need additional copies of this form, you may photocopy and use as many as you need.

Completed by _____

Title _____

Phone (_____)_____--_____ **Date** ____/ ____/ ____

Information about the employee

1) **Full name** _____

2) **Street** _____

City _____ **State** _____ **ZIP** _____

3) **Date of birth** _____ / _____ / _____

4) **Date hired** _____ / _____ / _____

5) ❒ **Male**
❒ **Female**

Information about the physician or other health care professional

6) **Name of physician or other health care professional** _____

_____

7) **If treatment was given away from the worksite, where was it given?**

Facility _____

Street _____

City _____ **State** _____ **ZIP** _____

8) **Was employee treated in an emergency room?**
❒ **Yes**
❒ **No**

9) **Was employee hospitalized overnight as an in-patient?**
❒ **Yes**
❒ **No**

Information about the case

10) **Case number from the *Log*** _____ *(Transfer the case number from the Log after you record the case.)*

11) **Date of injury or illness** _____ / _____ / _____

12) **Time employee began work** _____ **AM / PM**

13) **Time of event** _____ **AM / PM** ☐ **Check if time cannot be determined**

14) ***What was the employee doing just before the incident occurred?*** **Describe the activity, as well as the tools, equipment, or material the employee was using. Be specific.** ***Examples:*** **"climbing a ladder while carrying roofing materials"; "spraying chlorine from hand sprayer"; "daily computer key-entry."**

15) ***What happened?*** **Tell us how the injury occurred.** ***Examples:*** **"When ladder slipped on wet floor, worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; "Worker developed soreness in wrist over time."**

16) ***What was the injury or illness?*** **Tell us the part of the body that was affected and how it was affected; be more specific than "hurt," "pain," or sore."** ***Examples:*** **"strained back"; "chemical burn, hand"; "carpal tunnel syndrome."**

17) ***What object or substance directly harmed the employee?*** ***Examples:*** **"concrete floor"; "chlorine"; "radial arm saw."** ***If this question does not apply to the incident, leave it blank.***

18) ***If the employee died, when did death occur?*** **Date of death** _____ / _____ / _____

Public reporting burden for this collection of information is estimated to average 22 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Persons are not required to respond to the collection of information unless it displays a current valid OMB control number. If you have any comments about this estimate or any other aspects of this data collection, including suggestions for reducing this burden, contact: US Department of Labor, OSHA Office of Statistical Analysis, Room N-3644, 200 Constitution Avenue, NW, Washington, DC 20210. Do not send the completed forms to this office.

If You Need Help...

If you need help deciding whether a case is recordable, or if you have questions about the information in this package, feel free to contact us. We'll gladly answer any questions you have.

- **Visit us online at www.osha.gov**
- **Call your OSHA Regional office and ask for the recordkeeping coordinator**

  or

- **Call your State Plan office**

U.S. Department of Labor
Occupational Safety and Health Administration

Federal Jurisdiction

Region 1 - 617 / 565-9860
Connecticut; Massachusetts; Maine; New Hampshire; Rhode Island

Region 2 - 212 / 337-2378
New York; New Jersey

Region 3 - 215 / 861-4900
DC; Delaware; Pennsylvania; West Virginia

Region 4 - 404 / 562-2300
Alabama; Florida; Georgia; Mississippi

Region 5 - 312 / 353-2220
Illinois; Ohio; Wisconsin

Region 6 - 214 / 767-4731
Arkansas; Louisiana; Oklahoma; Texas

Region 7 - 816 / 426-5861
Kansas; Missouri; Nebraska

Region 8 - 303 / 844-1600
Colorado; Montana; North Dakota; South Dakota

Region 9 - 415 / 975-4310

Region 10 - 206 / 553-5930
Idaho

State Plan States

Alaska - 907 / 269-4957

Arizona - 602 / 542-5795

California - 415 / 703-5100

*Connecticut - 860 / 566-4380

Hawaii - 808 / 586-9100

Indiana - 317 / 232-2688

Iowa - 515 / 281-3661

Kentucky - 502 / 564-3070

Maryland - 410 / 527-4465

Michigan - 517 / 322-1848

Minnesota - 651 / 284-5050

Nevada - 702 / 486-9020

*New Jersey - 609 / 984-1389

New Mexico - 505 / 827-4230

*New York - 518 / 457-2574

North Carolina - 919 / 807-2875

Oregon - 503 / 378-3272

Puerto Rico - 787 / 754-2172

South Carolina - 803 / 734-9669

Tennessee - 615 / 741-2793

Utah - 801 / 530-6901

Vermont - 802 / 828-2765

Virginia - 804 / 786-6613

Virgin Islands - 340 / 772-1315

Washington - 360 / 902-5554

Wyoming - 307 / 777-7786

*Public Sector only

Attachment J

Near Miss/ Incident Report Form

Former DuPont East Chicago Facility

Incident Report Form

This form should be used to report any of the following; injury/illness to students or visitors; environmental accidents (an accident in which a harmful substance is released into the environment); fires; spills / incidents; non-vehicular accidents; or any unsafe conditions/ acts observed on Site.

SECTION 1 - REQUIRED INFORMATION *(Individual reporting the incident)*

First Name **Last Name** **Email**

Address (Home or Work)

Phone **Date Reported** (MM/DD/YYYY)

Status: ☐ Student ☐ Faculty ☐ Staff ☐ Visitor ☐ Contractor

SECTION 2 - INCIDENT INFORMATION

Date of the Incident (MM/DD/YYYY) **Time** (HH:MM) AM PM **Campus Location**

Type: ☐ Injury/Illness ☐ Unsafe Condition ☐ Environmental Spill ☐ Fire ☐ Laboratory Spill/Incident ☐ Non-Vehicular Accident ☐ Other:

Description and cause of the incident (Indicate conditions such as weather, construction, cleaning, etc. with your explanation. Visitors should include their purpose for being on campus)

Name of Parties Involved and/or Witnesses:

SECTION 3: INJURY OR ILLNESS

Type: ☐ None ☐ Physical Injury ☐ Occupational Illness ☐ Potential Harmful Exposure

Injured Persons and Description of Injuries:

Treatment: ☐ None ☐ 1st Aid ☐ Emergency Medical Services ☐ Personal Physician
☐ Student Health Services ☐ Hospital (Outpatient) ☐ Hospital (Admitted)

SECTION 4: PROPERTY DAMAGE/LOSS (NON-VEHICULAR)

Damaged or Lost Items:

☐ None ☐ Personal Property ☐ University Property

Description of Damages or Items Lost (include approximate value if the items are insured)

Report Completed by: ☐ Same as Above **or**

Name **Phone** **Email**

Date Reported (MM/DD/YYYY)

Attachment B

Commuyλΐüè ⊥Lw Monitoring Plan (CAMP)

Former DuPont East Chicago Facility

Community Air Monitoring Plan

Former DuPont East Chicago Facility, Indiana

EPA ID: IND 005174354

August 8, 2019

Prepared for:

East Chicago Gateway Partners, LLC
5135 Kennedy Avenue
East Chicago, Indiana 46312

Prepared by:

Impact Environmental Indiana, LLC
170 Keyland Court
Bohemia, New York 11716

IE Project #11300

Introduction

The potential for generation of dust emissions during activities associated with the CMI scope of work must be adequately addressed to prevent exposure to off-site communities. The Community Air Monitoring Plan (CAMP) focuses on perimeter air monitoring to protect and inform the surrounding community. The rationale of the program is to test air quality along the Facility perimeter as per prevailing wind data provided by the onsite weather station. This is to provide protection of fugitive dust or contaminants to the adjacent natural areas and residential neighborhoods. Testing will include real-time and time-weighted instruments and techniques. These results will be used to mitigate potential impacts of activities to the surrounding community.

Monitoring Parameters

Particulates (Dust)/Aerosols

Suspended particulate is particulate matter 10 micrometers (0.01mm) or less in diameter that is a mixture of solid particles and liquid droplets. Total suspended particulate will be directly measured and reported as a mass per volume of air – micrograms per cubic meter (ug/m^3). The instrument that will be used for these measurements will be a TSI model 8530, Dust Track II. The instrument uses light-scattering laser photometry and can detect dust, smoke fumes and mists. The dust metering can detect concentrations from 0.01 mg/m3 up to 400 mg/m3 in real-time. The instrument can be monitored remotely using telemetry unit.

Organic Vapors

Organic vapors include volatile, non-methane, and semi-volatile organic hydrocarbon compounds. These compounds are potentially emitted from vehicle use, fossil-fuel combustion equipment use (saws, hydraulic earth moving, sizing and sorting equipment, etc.) or from soil contaminants. Organic vapors will be directly measured and reported on a part per million basis (ppm). The instrument that will be used for these measurements is the Rae Systems model 3000, MiniRae. The instrument uses photo-ionization detection and can detect total non-methane volatile organic compounds at concentrations from 0.0 to 15,000 parts per million. The instrument can be monitored remotely using telemetry unit.

Inorganics

Lead, arsenic, cadmium, zinc and crystalline silica are contaminants of concern that are present in soil that can be put into air from activities associated with remediation efforts (source removal, vehicle traffic, concrete breaking, grubbing, etc.). These contaminants are also potentially contained in soil and masonry media that will be used to construct the permeable earthen barrier cover. The results of inorganics testing will be indirectly measured and reported as a mass per volume of air – micrograms per cubic meter (ug/m^3). The instrument used for this will be a GilAir Plus. The instrument has a variable flow rate that ranges between 20cc/min to 5,000 cc/min. It is fitted with a technology that can perform both high-flow constant pressure and constant flow and low-flow constant pressure and constant flow.

Meteorological Data

Meteorological conditions will be monitored continuously via a weather station positioned at a location that is central to the Facility. The station will monitor temperature, barometric pressure and wind speed. The instrumentation can be monitored remotely using a telemetry unit. The data can be used in concert with emission data collected under the air monitoring program.

Monitoring Procedures

Based on wind patterns observed by the onsite meteorological station, prevailing wind will be established. During the performance of remedial and investigative field activities, airborne fugitive particulate emissions will be measured at one upwind monitoring station and at two downwind monitoring stations positioned along the property line. The measurements will be made using a portable particulate monitoring device (DustTrak II Aerosol Monitor 8530). The monitoring device can detect airborne particulate (PM-10) at concentrations ranging from 1 to 1000 micrograms per cubic meter (ug/m3). Detected concentrations are logged within the instrument memory and can be retrieved using Microsoft Windows-based software provided by the manufacturer. Retrieved data can be imported into standard PC-based spreadsheet and database software for analysis and report presentation.

At a minimum, where the particulate monitoring device is used, the following information will be logged.

- Instrument type and detection range

- Control settings
- Reading locations
- Atmospheric conditions
- Calibration Records – To be performed a minimum of once per day.

Testing and Monitoring Frequency

Direct, real-time, analysis of particulate and organic vapors will be performed 24-hours a day from within three (one upwind and two downwind) portable enclosed units along the Facility perimeter. The units will be hardwired to electric service and/or will have a 40-hour battery. Results will be compiled via telemetry directly to a web-based portal. The telemetry unit is a Netronix Thiamis unit. Data will be compiled onto a database that can be used to generate measurements that can be used on a real-time basis to adjust remedial activities and, where necessary, rapidly deploy emission control measures to safeguard off-site receptors. Adjustments can include equipment optimization, activity rate reductions and/or shut-down of equipment or operations. Additionally, the direct measurement data may be used to prompt testing for speciated inorganics.

Routine testing for metals will occur for one 8-hour day once per week at the Facility perimeter or when prompted by an event. This will involve collection of samples from a 480L sample (using the variable speed pump) over a filter cassette. The cassette is removed and analyzed to determine inorganic metals concentrations. The filters will be analyzed for As, Pb, PM-10 and Crystalline Silica at an offsite laboratory. The findings will be reviewed, and filter sample results will be shared via electronic submission and CPP outlets. Testing for crystalline silica will involve using a variable speed pump and aluminum cyclone in conformance with ISO 7708.1195. The pumps will be calibrated, and leak tested and then run at a rate of 2.5 liters per minute for 480 minutes (8 hours), resulting in a 1200 L sample. Analysis for crystalline silica will be collected on a cartridge filter and performed by a commercial testing laboratory using x-ray diffraction. All sample collection will include field blanks and will be handled under an active chain-of-custody procedure.

Monitoring Equipment Calibration

All instruments used will be calibrated at the beginning and end of each work shift, in accordance with the manufacturer's recommendations. If the owner's manual is not available, the personnel operating the equipment will contact the applicable office representative, rental agency or manufacturer for technical

guidance for proper calibration. Calibration procedures can be referenced within the QAPP. In General, calibration of the VOC and PM10 instrumentation will occur in accordance with each of the equipment manufacturer's calibration and quality assurance requirements. The VOC and PM10 monitors will be calibrated at least daily, and calibrations will be recorded in the field activity logbook.

Action Levels

An action level is a measurement at which work must cease or due to detected particulates potentially migrating off-site. The action levels are based on concentrations within the breathing zone.

Particulates

If during handling of the soil/ fill the total downwind PM-10 particulate level is 0.5 milligrams per cubic meter (mg/m3) for 15 minutes or 0.2 mg/m3 greater than background (upwind perimeter) for the 1-hour period or if airborne dust is observed leaving the work area, then the investigative and remedial activities must immediately stop, and the dust suppression techniques listed in the attached Dust Control and Prevention Handbook will be employed. A detected exceedance of action levels will cause an immediate shutdown of all Facility remediation activities until the emissions of particulate can be mitigated.

Organic Vapors

Detection of odors is subjective; the Field Team Leader will be charged with the responsibility of making a determination if measures are required to abate odors. Since the contaminant concentrations in the soil/fill are generally below the odor threshold, the odor sources during the Facility will be the operation of diesel engines associated with hydraulic equipment.

If the ambient air concentration of total VOCs exceeds 5 parts per million (ppm) above the background (upwind location) for the 15-minute average, intrusive field activities will be temporarily halted while monitoring continues. If the total VOC concentration readily decreases (through observation of instantaneous readings) below 5 ppm above background, then intrusive field activities can resume with continuous monitoring.

If the ambient air concentrations of total VOCs persist at levels in excess of 5 ppm above background but less than 25 ppm above background, intrusive field activities will be halted, the source of the elevated VOC concentrations identified, corrective actions to reduce or abate the emissions undertaken, and air

monitoring will be continued. Once these actions have been implemented, intrusive field activities can resume provided the following two conditions are met:

- The 15-minute average VOC concentrations remain below 5 ppm above background.

- The VOC level 200 feet downwind of the sample location, or half the distance to the nearest potential receptor or residential/commercial structure (whichever is less but in no case less than 20 feet), is below 5 ppm over background for the 15- minute average.

- If the ambient air concentrations of total VOCs are above 25 ppm above background, the intrusive field activities must cease, and emissions control measures must be implemented.

Periodic monitoring for VOCs is required during non-intrusive activities such as collection of soil samples, or equipment decontamination. If these activities are undertaken at the Facility, ambient direct-reading (instantaneous) VOC data will be periodically collected at the location of the non-intrusive activity and recorded in the field activity logbooks.

Inorganics

For inorganics laboratory analysis results, if the following thresholds are exceeded, field activities will be modified to reduce dust generation and an evaluation will be conducted to determine the source activity.

TARGET ANALYTE	PERIMITER THRESHOLD
Lead	10 ug/m3
Arsenic	1 ug/m3
Cadmium	2 ug/m3
Zinc	500 ug/m3
Crystalline Silica	10 ug/m3

Reporting

All data measurements collected during the performance of the community air monitoring program will be compiled for electronic submission, included in the Quarterly Progress Reports and made available to the community via CPP outlets.



IMPACT ENVIRONMENTAL
170 KEYLAND COURT
BOHEMIA, NEW YORK 11716
TEL (631) 269-8800
FAX (631) 269-1599

Scale:
0 155 310 620 Feet

Prepared By: LR | Reviewed By: KK

N
W E
S

Map Reference:

Legend

- Real Time Air Monitoring Station with Telemetry
- Weather Station
- Property Boundary

Figure :1 Community Air Monitoring Plan Map

Attachment C

Quality Assurance Project Plan

Former DuPont East Chicago Facility

Quality Assurance Project Plan

Former DuPont East Chicago Facility, Indiana

EPA ID: IND 005174354

! dzƎdzăű y, 2019

REVISION NUMBER: 0п

Prepared for:

East Chicago Gateway Partners, LLC
5135 Kennedy Avenue
East Chicago, Indiana 46312

Prepared by:

Impact Environmental Indiana, LLC
170 Keyland Court
Bohemia, New York 11716

IE Project #11300

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ATTACHMENTS

Attachment A: Project Team Qualifications
Attachment B: Field Standard Operating Procedures
Attachment C: Laboratory Standard Operating Procedures

ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
%D	Percent Difference
%R	Percent Recovery
°C	degrees Celsius
°F	degrees Fahrenheit
AOC	Administrative Order on Consent
APM	Associate Project Manager
ASTM	American Society for Testing and Materials
CAG	Community Advisory Group
CCB	Continuing Calibration Blank
CCC	Criterion Continuous Concentration
CCV	Continuing Calibration Verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMC	Criterion Maximum Concentration
COC	Contaminants of Concern
C-O-C	Chain-of-Custody
CQA	Construction Quality Assurance
cy	cubic yards
DI	Deionized
DL	Detection Limit
DO	Dissolved Oxygen
DOT	U.S. Department of Transportation
DQI	Data Quality Indicator
DQO	Data Quality Objective
ECGP	East Chicago Gateway Partners
EDD	Electronic Data Deliverable
ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
ERP	Emergency Response Plan
FCR	Field Change Requests
FS	Feasibility Study
FSP	Field Sampling Plan
GBSD	Geophysical, Bathymetric, Shoreline, and Debris Survey

Acronym / Abbreviation	Definition
GC	Gas Chromatograph
GFF	Glass Fiber Filter
GIS	Geographic Information System
GPS	Global Positioning System
H&S	Health and Safety
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HMW	High Molecular Weight
HPLC	High Performance Liquid Chromatography
ICAL	Initial Calibration
ICB	Initial Calibration Blank
ICIAP	Institutional Controls Implementation and Assurance Plan
ICP-AES	Inductively Coupled Plasma – Atomic Emission Spectrometry
ICS	Interference Check Solution
ICV	Initial Calibration Verification
ID	Identification
IDQTF	Intergovernmental Data Quality Task Force
IMU	Inertial Measurement Unit
IDEM	Indiana Department of Environmental Management
LCS	Laboratory Control Sample
LIMS	Laboratory Information Management System
LMW	Low Molecular Weight
LOD	Limit of Detection
LOQ	Limit of Quantitation
MB	Method Blank
MDL	Method Detection Limit
mg	milligram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliter
MLLW	mean lower low water
MLW	mean low water
MPC	Measurement Performance Criterion
MS	Mass Spectrometer
MS	Matrix Spike
mS/cm	milliSiemens per centimeter

Acronym / Abbreviation	Definition
MSD	Matrix Spike Duplicate
mV	millivolts
NA	Not Applicable
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephlometric Turbidity Units
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic Aromatic Hydrocarbon
PAL	Project Action Level
PARCCS	Precision, Accuracy, Representativeness, Comparability, Completeness, Sensitivity
PID	Photoionization Detector
PM	Project Manager
PMP	Project Management Plan
POC	Particulate organic carbon
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PT	Proficiency Testing
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QCP	Quality Control Plan
RA	Remedial Action
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDWP	Remedial Design Work Plan
RF	Response Factor
RPD	Relative Percent Difference
RRT	Relative Retention Time
RSD	Relative Standard Deviation
RT	Retention Time
SBE	Single-beam Echosounder
SD	Standard Deviation
SOP	Standard Operating Procedure
SOW	Scope of Work

Acronym / Abbreviation	Definition
TBD	To Be Determined
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UFP	Uniform Federal Policy
UFP-QAPP	Uniform Federal Policy-Quality Assurance Project Plan
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
USDOT	US Department of Transportation
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
VOC	Volatile Organic Compound

UFP-QAPP Overview

This Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP) has been prepared pursuant to the requirements set forth in the RCRA § 3008(h) Administrative Order on Consent (Docket No. RCRA-05-2019-003) executed by E.I. du Pont Nemours and Company (DuPont), Chemours Company FC, LLC (Chemours) and East Chicago Gateway Partners, LLC (ECGP) on November 16, 2018 with the United States Environmental Protection Agency, Region 5 of the Former DuPont East Chicago Facility (herein referred to as the Site), located in the City of East Chicago, Lake County, Indiana.

This Optimized UFP-QAPP serves as a "project-specific quality plan" for this project and encompasses elements of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP). The plan integrates technical and quality aspects to ensure scientifically sound data is collected and evaluated to meet the project and data quality objectives for the Project. It is the basis for the quality assurance (QA) and quality control (QC) elements of the entire Project, including multiple proposed pre-design supplemental investigation events, implementation of remedial actions, and the evaluation of remedial performance of as outlined in the Corrective Measures Implementation Work Plan (CMI WP) and subsidiary plans. This UFP-QAPP serves as a "tool box" for various activities, by compiling and addressing QA and QC requirements for multiple work elements and types of sampling/monitoring programs. During the duration of the Project, as the scopes of the various field elements are refined, applicable addenda to this UFP-QAPP will be issued as necessary and appropriate.

The UFP-QAPP has been developed in accordance with the following documents:

- Uniform Federal Policy for Quality Assurance Project Plans - Optimized UFP-QAPP Worksheets (Intergovernmental Data Quality Task Force [IDQTF], March 2012);
- Uniform Federal Policy (UFP) for Quality Assurance Project Plans (QAPPs) Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs, Part 1: UFP-QAPP Manual, Part 2A: UFP-QAPP Workbook and Part 2B, Quality Assurance/Quality Control Compendium: Minimum Quality Assurance/Quality Control (QA/QC) Activities (IDQTF, March 2005);
- EPA Requirements for QA Project Plans, QA/R-5 (EPA/240/B-01/003, U.S. Environmental Protection Agency, March 2001, Reissue Notice May 2006);
- Guidance for Quality Assurance Project Plans, QA/G-5 (EPA/240/R-02/009, U.S. Environmental Protection Agency, December 2002);

The following Attachments are included at the end of this document:

Attachment A: Project Team Qualifications

Attachment B: Field Standard Operating Procedures

Attachment C: Laboratory Standard Operating Procedures

Quality Assurance Project Plan Crosswalk

Optimized UFP-QAPP Worksheets		QA/R-5 Elements	
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		A4	Project/Task Organization
#4, #7 & #8	Personnel Qualifications and Sign-off Sheet	A8	Special Training/Certification
#6	Communication Pathways	A4	Project/Task Organization
#9	Project Planning Session Summary	A5 A6	Problem Definition/Background Project/Task Description
#10	Conceptual Site Model	A5 A6	Problem Definition/Background Project/Task Description
#11	Project/Data Quality Objectives	A7	Quality Objectives and Criteria
#12	Measurement Performance Criteria	B5	Quality Control
#13	Secondary Data Uses and Limitations	B9	Non-direct Measurements
#14 & #16	Project Tasks & Schedule	B1	Sampling Process Design (Experimental Design)
#15	Project Action Limits and Laboratory-Specific Detection / Quantitation Limits	A7 B5	Quality Objectives and Criteria Analytical Methods
#17	Sampling Design and Rationale	B1	Sampling Process Design (Experimental Design)
#18	Sampling Locations and Methods	B2	Sampling Methods
		B4	Analytical Methods
#19 & #30	Sample Containers, Preservation, and Hold Times	B2 B3	Sampling Methods Sample Handling and Custody
#20	Field QC	B5	Quality Control
#21	Field Standard Operating Procedures (SOPs)	B2 B8	Sampling Methods Inspection/Acceptance of Supplies and Consumables
#22	Field Equipment Calibration, Maintenance, Testing, and Inspection	B6 B7	Instrument/Equipment Testing, Inspection, and Maintenance Instrument/Equipment Calibration and Frequency
#23	Analytical SOPs	B4	Analytical Methods
#24	Analytical Instrument Calibration	B5	Quality Control
#25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection	B5	Quality Control
#26 & #27	Sample Handling, Custody, and Disposal	B3	Sample Handling and Custody

#28	Analytical Quality Control and Corrective Action	B5	Quality Control
#29	Project Documents and Records	A9 B10	Documents and Records Data Management
#31, #32 & #33	Assessments and Corrective Action	C1	Assessments and Response Actions
		C2	Reports to Management
#34	Data Verification and Validation Inputs	D1	Data Review, Verification, and Validation
#35	Data Verification Procedures	D2	Verification and Validation Methods
#36	Data Validation Procedures	D2	Verification and Validation Methods
#37	Data Usability Assessment	D3	Reconciliation with User Requirements

Worksheet #1 & 2: Title and Approval Page

Site/Project Name: Former DuPont East Chicago Facility

Site Location: 5215 Kennedy Avenue, East Chicago, IN

Contract Number: Not applicable (NA)

Contract Title: NA

Document Title: Uniform Federal Policy - Quality Assurance Project Plan (UFP - QAPP) for the Former DuPont East Chicago Facility

Preparer's Name and Organizational Affiliation: Michael Bluight, PG – Impact Environmental

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Preparation Date (Day/Month/Year): August 8, 2019 - Revision 04

Signatories:

Project Manager, Lead Organization – Supervising Contractor, Impact Environmental
Mr. Kevin Kleaka

8-8-19
Signature / Date

QA/QC Lead, Lead Organization – Supervising Contractor, Impact Environmental
Mr. Michael Bluight, PG

8-8-19
Signature / Date

Data Quality Reviewer, Project Manager – TestAmerica Laboratories, Chicago IL
Mr. Richard Wright

Richard Wright Digitally signed by Richard Wright DN: cn=Richard Wright, o, ou, email=richard.wright@tetratech.com, c=US Date: 2019.08.08 14:28:31 -05'00'
8-8-19
Signature / Date

Project Administrator, Lead Organization – Settling Party, East Chicago Gateway Partners (ECGP)/ Administrative Order on Consent Project Manager
Mr. Richard Parrish, PG

8-8-19
Signature / Date

Project Coordinator, Federal Regulatory Agency – U.S. Environmental Protection Agency Region 5
Ms. Jennifer Dodds

Signature / Date

Quality Reviewer, Federal Regulatory Agency – U.S. Environmental Protection Agency Region 5
Mr. Zachary Sasnow

Signature / Date

Lead Organization: East Chicago Gateway Partners LLC (ECGP) - Settling Party
Impact Environmental Indiana LLC. (Impact Environmental) - Supervising Contractor

Federal Regulatory Agency: U.S. Environmental Protection Agency (EPA) Region 5

***Other Agencies and Entities*:** Indiana Department of Environmental Management (IDEM)
Eurofins TestAmerica Laboratories, Chicago IL- Supervising Laboratory
Eurofins TestAmerica Laboratories, Sacramento, CA
Eurofins Frontier Global Sciences Laboratories, Bothell, WA

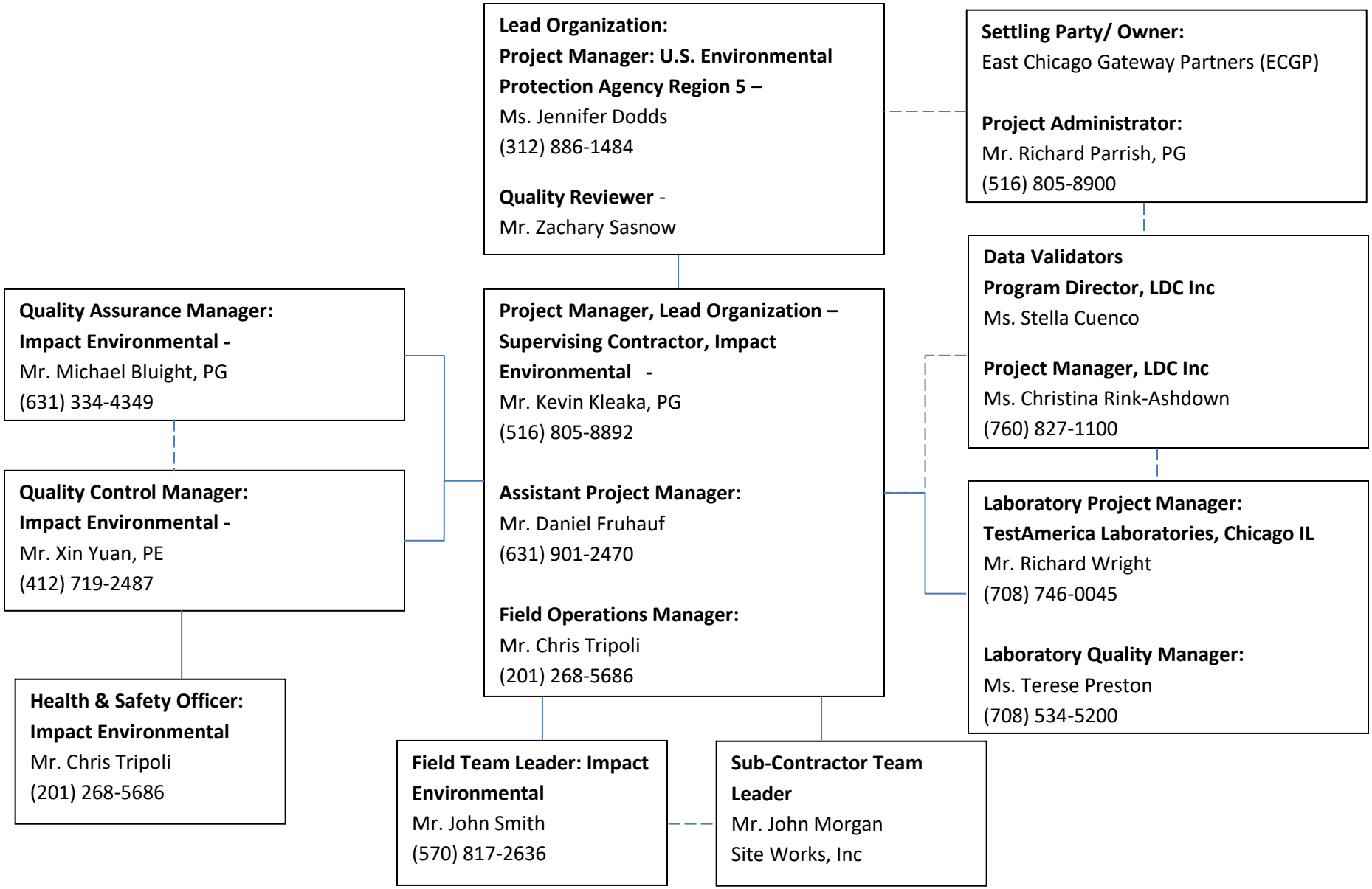
Plans and reports from previous investigations relevant to this project (listed chronologically):

RCRA Process Milestone	Owner/Party	Purpose	Year
RCRA 3008 (h) Administrative Order on Consent	USEPA/ DuPont	Enforcement Order based on discovery of a release	1997
Current Conditions Report	DuPont/ CH2M2 Hill	Identify and define site impacts	1997
Phase I RCRA Facility Investigation (RFI)	DuPont/ DuPont Corporate Remediation Group (DCRG)	Identify and define site impacts	2002
Installation of PRB Wall - Interim Remedial Measure (IRM)	DuPont/ DCRG	IRM to mitigate migration of contaminated groundwater off-site	2002
Current Human Exposure Under Control - Environmental Indicator (EI)	DuPont/ DCRG/ USEPA	Human exposure designated as “under control” by USEPA	2004
Phase II RFI	DuPont/ DCRG	Identify and define site impacts	2005
Migration of Contaminated Groundwater Under Control - EI	DuPont/ DCRG/ USEPA	Migration of contaminated groundwater designated as under control	2005
Human Health Risk Assessment (HHRA)	DuPont/	Identify human health risks	2011

	Pioneer Technologies Corporation	associated with exposure to site impacts	
Baseline Ecological Risk Assessment (BERA)	DuPont/ Parsons	Identify ecological risks associated with exposure to site impacts	2012
Buffer Zone IRM Excavations	DuPont/ Parsons/ Summit	Excavate, treat and dispose on-site contaminated soils within the Buffer Zone Area	2013 - 2016
Corrective Measures Study	DuPont / Parsons	Evaluate and propose final remedial actions	2015
Final Decision Response to Comments	USEPA/ Chemours/ ECGP	USEPA selected final remedies	2018
RCRA 3008 (h) Administrative Order on Consent for Corrective Measures	USEPA/ ECGP/ Chemours/ Dupont	USEPA Enforcement Order to complete selected remedies	2018

Worksheet #3 & 5: Project Organization and QAPP Distribution

Project Organization



Distribution List

QAPP Recipients	Title	Organization	Telephone Number	E-mail Address
Jennifer Dodds	Project Manager	EPA, Region 5	Office: (312) 886-1484	dodds.jennifer@epa.gov
Zachary Sasnow	Quality Reviewer	EPA, Region 5	Office: (312) 886 – 0258	sasnow.zachary@epa.gov
Richard Parish	Project Administrator	ECGP	Office: (631) 805-8900	rich@impactenvironmental.com
Kevin Kleaka	Project Manager	Impact Environmental	Office: (631) 269-8800 x129	kkleaka@impactenvironmental.com
Daniel Fruhauf	Assistant Project Manager	Impact Environmental	Office: (631) 269-8800 x141	dfruhauf@impactenvironmental.com
Chris Tripoli	Field Operations Manager	Impact Environmental	Office: (201) 268-5686	ctripoli@impactenvironmental.com
Michael Bluight	Quality Assurance Manager	Impact Environmental	Office: (516) 269-8800 x118	mbluight@impactenvironmental.com
Xin Yuan	Quality Control Manager	Impact Environmental	Office: (516) 269-8800 x111	xyuan@impactenvironmental.com
Richard Wright	Laboratory Project Manager	TestAmerica Laboratories, Inc	Office: (708) 746-0045	Richard.Wright@testamericainc.com
Terese Preston	Laboratory Quality Manager	TestAmerica Laboratories, Inc	Office: (708) 534-5200	Terese.Preston@testamericainc.com
Christina Rink-Ashdown	Data Validator	LDC	Office: 760-827-1100	Crink-ashdown@lab-data.com

Worksheets #4, #7, & #8: Personnel Responsibilities, Qualifications and Sign-off Sheet

ECGP (Settling Party)

*Statement of Qualifications for Project Staff and Contractors are presented in Appendix A.

Name	Project Role / Responsibilities	Education/ Experience	Specialized Training/ Certifications	Signature/Date
Richard Parrish, PG	Project Administrator; Provides oversight of all aspects of the work to be conducted for the Project as required by the Settlement Agreement (RCRA Order on Consent for the Implementation of Corrective Measures	*Education:* BA Earth & Space Science Concentration in Environmental Geology Waste Management Certificate Program, Waste Management Institute, (CED) Candidate. SUNY at Stony Brook *Experience:* 34+ years	Certified Professional Geologist US EPA 40hr Hazardous Materials Response for First Responders Training US EPA 24hr Sampling for Hazardous Material Training NYS Law Enforcement Seminar Certified Environmental Inspector LIA Young Entrepreneur of the Year 1992 Hofstra University School of Business Achievement Award 1992 National Groundwater Association, Groundwater Contaminant Modeling (CED)	

Impact Environmental (Supervising Contractor)

Name	Project Role / Responsibilities	Education/ Experience	Specialized Training/ Certifications	Signature/Date
Kevin Kleaka, PG	Project Manager (PM); Manages the overall Project performance and quality of the Project deliverables in accordance with the contract and regulatory requirements; serves as primary line of communication with ECGP; procures resources required to effectively complete the required work; and handles changes in the scope of work, schedule, and/or costs requiring Impact Environmental action	*Education:* BS, Environmental Science, Applied Environmental Science Program SUNY at Plattsburg *Experience:* 24+ years	Licensed Profession Geologist (NYS# 000735) Gold Certified Brownfield Professional 2012 Advanced Tools for In-Situ Remediation Workshop ASTM Technical & Professional Training for Assessment of Vapor Intrusion into Structures of Property & New York State Department of Health, Vapor Intrusion Training New York Precision Equipment Global	

	with ECGP.		Survey Positioning Training MTBE & TBA Comprehensive Site Assessment and Successful Groundwater Remediation Environmental Data Resources, Due Diligence Workshop Advanced Technologies for Accelerated Natural Attenuation Eophysical Survey Systems, Theory and Practice of Applying Subsurface Interface Radar in Engineering and Geophysical Investigation. 40-Hour Occupational Safety & Health Administration	
Daniel Fruhauf	Assistant Project Manager; Assists the PM with duties above; serves as secondary line of communication with ECGP; and serves as the primary point of contact with Impact Environmental Health and Safety (H&S) Officer, QA/QC Leads, and Field Team Leads.	*Education:* BA, Environmental Science, Ecosystems and Human Impact Program SUNY at Stony Brook *Experience:* 7+ years	HAZWOPER 40hr + 8hr Refreshers OSHA 10hr Construction Safety OSHA 30hr Construction Safety Transportation Worker Identification Card (TWIC) NYC Office of Environmental Remediation (OER) Trained MTA/Amtrak Track Safety MTA/NYC Transit Track Safety LIRR Safety Blue Card NYSDEC SWPPP Certified Inspector Certified NYSDOL Asbestos Inspector	
Michael Bluight, PG	Quality Assurance Manager; Oversees the administration of the quality program for the Project, ensuring work is performed in accordance with approved plans/addenda; reviews/ approves quality-related deliverables; coordinates internal review/approval of Project deliverables; establishes/ maintains document control system; and conducts periodic	*Education:* BS, Geology SUNY at Stony Brook MS (In Progress) Hydrogeology SUNY at Stony Brook *Experience:* 19+ years	OSHA 40-hour HAZWOPER Training OSHA 10-hour Construction Safety CPR & First Aide Training Undergraduate Excellence in Teaching – SUNY @ Stony Brook Professional Geologist NYS#000872	

	inspections/audits to verify compliance.			
Xin Yuan, PE	Quality Control Manager; Oversees the administration of the quality program for the Project, ensuring environmental compliance/ permitting in accordance with approved work plans/addendums; reviews/ approves quality of materials-imported/exported; review and evaluated data for decision level application; document control system; and conducts periodic inspections/audits to verify compliance.	*Education:* MS, Civil Engineering UMass, Amhurst BS, Environmental Engineering Tsinghua University, Beijing, China *Experience:* 9+ years	US EPA 40hr Hazardous Materials Response for First Responders Training Professional Engineer in MA, PA, NJ, IN & NY	
Chris Tripoli	Remedial Construction Coordinator; Coordinates planning and execution of field activities, including training, equipment maintenance, and record keeping; ensures all field staff have 40-hour Occupational Safety and Health Administration (OSHA) hazardous waste and emergency response (HAZWOPER) training under 29 Code of Federal Regulations (CFR) 1910.120 with current 8-hour refresher; oversees field implementation and enforcement of the QAPP and other Project plans; and provides daily updates on Project progress.	*Education:* N/A *Experience:* 31+ years	US Navy Propulsions Engineer Training 40-Hour Occupational Safety & Health Administration CPR/Basic Life Support, Standard Level First Aid Course National Safety Council Member Diesel Mechanic Training	

John Smith	Field Team Leader; Coordinates planning and execution of field activities, including training, equipment maintenance, and record keeping; ensures all field staff have 40-hour Occupational Safety and Health Administration (OSHA) hazardous waste and emergency response (HAZWOPER) training under 29 Code of Federal Regulations (CFR) 1910.120 with current 8-hour refresher; oversees field implementation and enforcement of the QAPP and other Project plans; and provides daily updates on Project progress	*Education:* BS, Earth & Environmental Science. Wilkes University *Experience:* 5+ years	OSHA 40hr HAZWOPER	

TestAmerica Laboratories, Inc – Chicago IL (Analytical Subcontractor Laboratory)

Name	Project Role / Responsibilities	Education/ Experience	Specialized Training/ Certifications	Signature/Date
Richard Wright	Laboratory Project Manager; Oversees receipt of samples, analysis of requested fractions, and generation of data results.	*Education:* M.S. and B.S in Environmental Science. Governors State University Experience: 33 years in environmental analysis, method development/validation, and experimental design	Participated in over thirty professional training seminars, conferences and expositions pertaining to project management and field monitoring, analytical chemistry, supervision, health and safety and proposal administration.	
Terese Preston	Laboratory Quality Assurance Manager; Serves as the focal point for QA/QC in the laboratory. Ensuring communication and monitoring standards of performance to ensure that systems are in place to produce the level of quality as defined in this document.	*Education:* B.A in Biology. Jamestown College Experience: 35 years in the environmental industry with a primary focus on QA practices and procedures, management, communications and analytical chemistry.	Quality Assurance of Chemical Measurements – ACS short course Flameless AA Spectroscopy Training Course – Thermo-Jarrell Ash Corporation Managing Hazardous Wastes – APWA Management by Responsibility Seminar Northern Illinois Water Analysts Member Ethics Training	

*Statement of Qualifications for Project Staff and Contractors are presented in **Appendix A**.

Laboratory Data Consultants, Inc – Carlsbad, CA (Analytical Subcontractor Laboratory)

Name	Project Role / Responsibilities	Education/ Experience	Specialized Training/ Certifications	Signature/Date
Stella Cuenco	Program Manager; Oversees receipt of samples, analysis of requested fractions, and generation of data results.	*Education:* B.S in Chemistry. University of the Philippines. *Experience:* Over 27 years of environmental laboratory and data validation experience under DoD and EPA guidelines.	N/A	
Christina Rink-Ashdown	Project Manager; Monitor schedules, compliance of validation to the Required Guidelines and perform routine surveillance activities.	*Education:* B.S Biology. University of California, San Diego *Experience:* 11 years in the environmental industry with a primary focus on data validation in trace metals, radiochemistry and wet chemistry areas for major Federal and commercial projects.	Radiometric Data Validation Specialist	

*Statement of Qualifications for Project Staff and Contractors are presented in **Appendix A**.

Worksheet #6: Communication Pathways

Communication Driver	Responsible Organization	Name	Contact Information	Procedure (timing, pathway, documentation, etc.)
Contact with Regulatory Agencies/Stakeholders	ECGP	Richard Parrish, PG	W: 631-269-8800 x101 C: 516-805-8900 rich@impactenvironmental.com	All formal communication with regulatory agencies (EPA, IDEM) and/or stakeholders will be performed by the ECGP Project Administrator, unless delegated directly to Impact Environmental, or other entity.
Contact with ECGP	Impact Environmental	Kevin Kleaka Daniel Fruhauf	C: 516-805-8892 kkleaka@impactenvironmental.com C: 631-901-2470 dfruhauf@impactenvironmental.com	All formal communication with ECGP will be directed through the PM/APM. Applicable personnel will be copied on technical discussions. Communication will be conducted via email to obtain written/formal approval of documents/issues and via phone and/or email to discuss project status, technical items, issues, etc.
Management of project tasks	Impact Environmental	Kevin Kleaka Daniel Fruhauf Chris Tripoli John Smith	C: 516-805-8892 kkleaka@impactenvironmental.com C: 631-901-2470 dfruhauf@impactenvironmental.com C: 201-268-5686 ctripoli@impactenvironmental.com C: 570-817-2636 jsmith@impactenvironmental.com	Provide oversight concerning project activities (field and office) and communicate with project team including subcontractors (verbal, email and/or phone).

Updates to QAPP (prior to field work and/or during project execution)	Impact Environmental	Michael Bluight Xin Yuan	C: 631-334-4349 mbluight@impactenvironmental.com C: 412-719-2487 xyuan@impactenvironmental.com	The Impact Field Lead and/or QA/QC Lead will immediately contact (via phone and/or email) the PM/APM regarding issues that may result in deviations from the approved plan. The PM/APM will then contact ECGP (following the "Reporting of Field Issues" and "Contact with Impact" drivers), who will subsequently contact EPA (following the "Reporting of Field Issues" and "Contact with Regulatory Agencies/Stakeholder" drivers) for notification purposes. This initial notification will be performed within 24 hours. The Impact Field Lead and/or QA/QC Leads will initiate documented changes to the QAPP (e.g., procedure changes, additional sample locations, modified analytical suites) as Addenda, Amendments or Field Change Requests (FCRs). The Impact Field Lead and/or QA/QC Leads will then forward information to the PM/APM, who will follow the "Contact with ECGP" driver. ECGP will then follow the "Contact with Regulatory Agencies/Stakeholder" driver. Copies will be forwarded to all parties listed in Worksheet #3 (deadline timeframe to be agreed upon during initial notification). Changes must be approved by

				ECGP and EPA prior to implementation.
Updates to Project Field Plans (e.g., CMI WP; Community Participation Plan, SWPPP, Health and Safety Plan [HASP], and other subsidiary plans.)	Impact Environmental	Kevin Kleaka Daniel Fruhauf Michael Bluight Xin Yuan	C: 516-805-8892 kkleaka@impactenvironmental.com C: 631-901-2470 dfruhauf@impactenvironmental.com C: 631-334-4349 mbluight@impactenvironmental.com C: 412-719-2487 xyuan@impactenvironmental.com	Impact Field Lead will immediately contact (via phone and/or email) the PM/APM regarding issues that may result in deviations from an approved plan. The PM/APM will then contact ECGP (following the "Reporting of Field Issues" and "Contact with GSH" drivers), who will subsequently contact EPA (following the "Reporting of Field Issues" and "Contact with Regulatory Agencies/Stakeholder" drivers) for notification purposes. This initial notification will be performed within 24 hours. Impact Personnel will initiate documented changes to the plan as Addenda, Amendments or FCRs. The Impact QA/QC Leads will then forward information to the PM/APM, who will follow the "Contact with ECGP" driver. ECGP will then follow the "Contact with Regulatory Agencies/ Stakeholder" driver. Copies will be forwarded to applicable parties (deadline timeframe to be agreed upon during initial notification). Changes must be approved by

				ECGP and EPA prior to implementation.
Field activity status; reporting of field issues	Impact Environmental	Chris Tripoli John Smith	C: 201-268-5686 ctripoli@impactenvironmental.com C: 570-817-2636 jsmith@impactenvironmental.com	At least daily communication (phone or email) during field work activities by Impact Field Leads with PM/APM to provide routine updates. The Impact Field Leads will oversee field personnel who are responsible for ensuring the protocols specified in the QAPP are carried out during field activities. The PM/APM will communicate frequently (daily to weekly depending on nature/complexity of field work) with ECGP; see the "Contact with ECGP" driver. ECGP will communicate frequently (daily to weekly depending on nature/complexity of field work) with EPA; see the "Contact with Regulatory Agencies/ Stakeholder" driver.
Real time modifications, notifications, and approval	Impact Environmental	Chris Tripoli John Smith	C: 201-268-5686 ctripoli@impactenvironmental.com C: 570-817-2636 jsmith@impactenvironmental.com	Impact Field Leads to communicate with PM/APM, who will subsequently communicate with ECGP and EPA following "Field Activity Status/ Reporting of Field Issues" driver. Notify ECGP for verbal approval and original approval authority signatures (as applicable) or email acknowledgement within two

				working days. In accordance with the CMI Work Plan, the EPA Project Manager may authorize field modifications to activities, provided that modifications are consistent with the SOW and Clean-up Objectives. EPA approval must be documented in writing within five days of the field modification. Notify other active and relevant parties in Worksheet #3 within five working days by electronic mail.
Reporting of laboratory data quality issues	*QAPP Approved - Analytical Laboratory Subcontractors* TestAmerica, Inc Chicago IL	Richard Wright – Project Manager Terese Preston Quality Assurance Manager	W: (708) 746-0045 Richard.Wright@testamericainc.com W: (708) 534-5200 Terese.Preston@testamericainc.com	All quality issues with sample receipt, method analysis and data reporting conveyed (phone and/or email) to Impact PM/APM (who will subsequently discuss with Impact QA/QC Leads and/or Sub-Contractor Lead as per "Reporting of Data Activities Status" driver) within one business day of discovery. Any laboratory data quality issues need to be reported to the EPA within five business days. As discussed above in the "Updates to QAPP" driver, any deviations from the approved QAPP will require documentation and subsequent approval by the EPA.
Reporting of data activities status (i.e., data analysis, management, and verification/validation)	Data Validator Contractor - (Team Contractor)	Stella Cuenco Christina Rink-Ashdown	W: **760-827-1100** - W: **760-827-1100** Crink-ashdown@lab-data.com	At least weekly communication (phone and/or email) during data- related activities Impact QA/QC Leads and/or Impact PM/APM to provide routine updates.

Reporting of issues during data activities	Data Validator Contractor - (Team Contractor)	Stella Cuenco Christina Rink-Ashdown	W: **760-827-1100** - W: **760-827-1100** Crink-ashdown@lab-data.com	Reporting to ECGP and Impact Environmental of any data analysis, management or verification/validation issues within one business day of discovery. Reporting to ECGP and Impact Environmental of any laboratory quality issues (see "Reporting of Laboratory Data Quality Issues" driver) within one business day of notification by laboratory to Data Management Contractor. ECGP will subsequently contact EPA (following the "Contact with Regulatory Agencies/Stakeholder" drivers) for notification purposes. Data Management Contractor will prepare documentation of issue (deviations, corrective actions, etc. following "Initiation of Corrective Action" driver/ Worksheets #31 and #32). Data Management Contractor will then forward information to ECGP and Impact Environmental. ECGP will then follow the "Contact with Regulatory Agencies/ Stakeholder" driver as applicable. Copies will be forwarded to applicable parties. Changes must be approved by EPA prior to implementation.

Stop Work	All Personnel	All Personnel	NA	Personnel will immediately notify the on-site task-specific Field Leads and Site Safety Officer once a "Stop Work" variation is noted and the need for corrective action is identified. Subsequently, the Impact Field Leads (for field-related issues), the H&S Lead (for safety-related issues), and/or the QA/QC Leads (for quality-related issues) – as well as the PM/APM – will be notified. The PM/APM will then follow the "Contact with ECGP" driver as soon as possible after work stoppage. ECGP will then follow the "Contact with Regulatory/Agencies/Stakeholder " driver to notify EPA of the Stop Work issue within 24 hours.
Initiation of corrective actions	Various (see Worksheets #31 and #32)	Various (see Worksheets #31 and #32)	Various (see Worksheets #31 and #32)	Various (see Worksheets #31 and #32)

Worksheet #9: Project Planning Session Summary

Date of Planning Session: November 28, 2018

Location: Impact Environmental Office (Bohemia, NY)

Purpose/Outcome: Reviewed initial scope of corrective measures implementation, deliverables, timelines and other logistical components. Delegated action items, identified critical pathways, developed initial project progression and anticipated field schedule. Discussed with ECGP development and construction during corrective measures implementation period and implications thereof.

Participants:

Name	Organization	Title/Role	Contact Information	
Richard Parrish	ECGP	Project Administrator	(631) 805-8900	rich@impactenvironmental.com
Kevin Kleaka	Impact Environmental	Project Manager	(516) 805-8892	kkleaka@impactenvironmental.com
Michael Bluight	Impact Environmental	Quality Assurance Manager	(631) 334-4349	mbluight@impactenvironmental.com
Daniel Fruhauf	Impact Environmental	Assistant Project Manager	(631) 901-2470	dfruhauf@impactenvironmental.com

Date of Planning Session: December 12, 2018

Location: Impact Environmental Office (Bohemia, NY)

Purpose/Outcome: Delegated writing tasks and responsibilities pursuant to the CMI Workplan and related ancillary documents. Discussed items needed by previous owner/consultants and staff responsible to pursue information/documents Discussed various technical CMI items to be developed including remedial methods, soil data objectives and data gaps for design of groundwater remedy. It was decided that Geotechnical and hydrogeological investigations will be needed to design and implement an effective groundwater treatment system at the Site, considering redevelopment goals. This would adjust the CMI workplan to a "Phased Approach" implementing soil remedies and supplemental geotechnical/groundwater evaluation prior to the design and construction of a building or groundwater treatment systems.

Participants:

Name	Organization	Title/Role	Contact Information	
Richard Parrish	ECGP	Project Administrator	(631) 805-8900	rich@impactenvironmental.com
Kevin Kleaka	Impact Environmental	Project Manager	(516) 805-8892	kkleaka@impactenvironmental.com
Michael Bluight	Impact Environmental	Quality Assurance Manager	(631) 334-4349	mbluight@impactenvironmental.com
Daniel Fruhauf	Impact Environmental	Assistant Project Manager	(631) 901-2470	dfruhauf@impactenvironmental.com
John Smith	Impact Environmental	Field Team Leader	(570) 817-2636	jsmith@impactenvironmental.com

Date of Planning Session: December 17, 2018

Location: EPA Region 5 Office (Chicago, IL)

Purpose: EPA Region 5 Kick-Off Meeting, Former DuPont East Chicago Facility. Presented elements of the CMI Workplan and overall progression of project tasks and schedules. An outline of the initial documents, project staff and the preliminary schedule was a handed out for review and discussion. Discussed various community participation activities, challenges and expectations. Discussed how a "phased approach" to implementation will effect the project schedule and supported rational. Discussed the potential for hydraulic control measures along the northern portion of the Site and implications on the groundwater remedy. Discussed submittal timelines and deliverable deadlines. Discussed the conceptual site model and submission of the CSM Update Report.

Participants:

Name	Organization	Title/Role	Contact Information	
Jennifer Dodds	EPA Region 5	EPA Project Manager	(312) 886-1484	dodds.jennifer@epa.gov
Richard Parrish	ECGP	Project Administrator	(631) 805-8900	rich@impactenvironmental.com
Kevin Kleaka	Impact Environmental	Project Manager	(516) 805-8892	kkleaka@impactenvironmental.com
Michael Bluight	Impact Environmental	Quality Assurance Manager	(631) 334-4349	mbluight@impactenvironmental.com
Daniel Fruhauf	Impact Environmental	Assistant Project Manager	(631) 901-2470	dfruhauf@impactenvironmental.com
Sathya Yalvigi	Chemours Company (Associate Settling Party)	Corporate Remediation Group - Project Director	(302) 773-4291	sathya.v.yalvigi@chemours.com

Date of Planning Session: January 23, 2017

Location: Impact Environmental Office (Bohemia, NY)

Purpose: Discussed ancillary documents and items needing attention to the CMI Workplan, this included the QAPP, the Community Participation Plan, Stormwater Pollution Prevention Plan etc. Discussed equipment and staff needs to implement the CMI workplan SOW. Discussed data objectives and process flow chart for excavation, treatment, disposal of site soil/fill, Importation of cap material and other remedial processes. Discussed clearing and grubbing operations, health and safety considerations, contractor bidding tasks and permitting items.

Participants:

Name	Organization	Title/Role	Contact Information	
Richard Parrish	ECGP	Project Administrator	(631) 805-8900	rich@impactenvironmental.com
Kevin Kleaka	Impact Environmental	Project Manager	(516) 805-8892	kkleaka@impactenvironmental.com
Michael Bluight	Impact Environmental	Quality Assurance Manager	(631) 334-4349	mbluight@impactenvironmental.com
Daniel Fruhauf	Impact Environmental	Assistant Project Manager	(631) 901-2470	dfruhauf@impactenvironmental.com

Worksheets #10: Conceptual Site Model

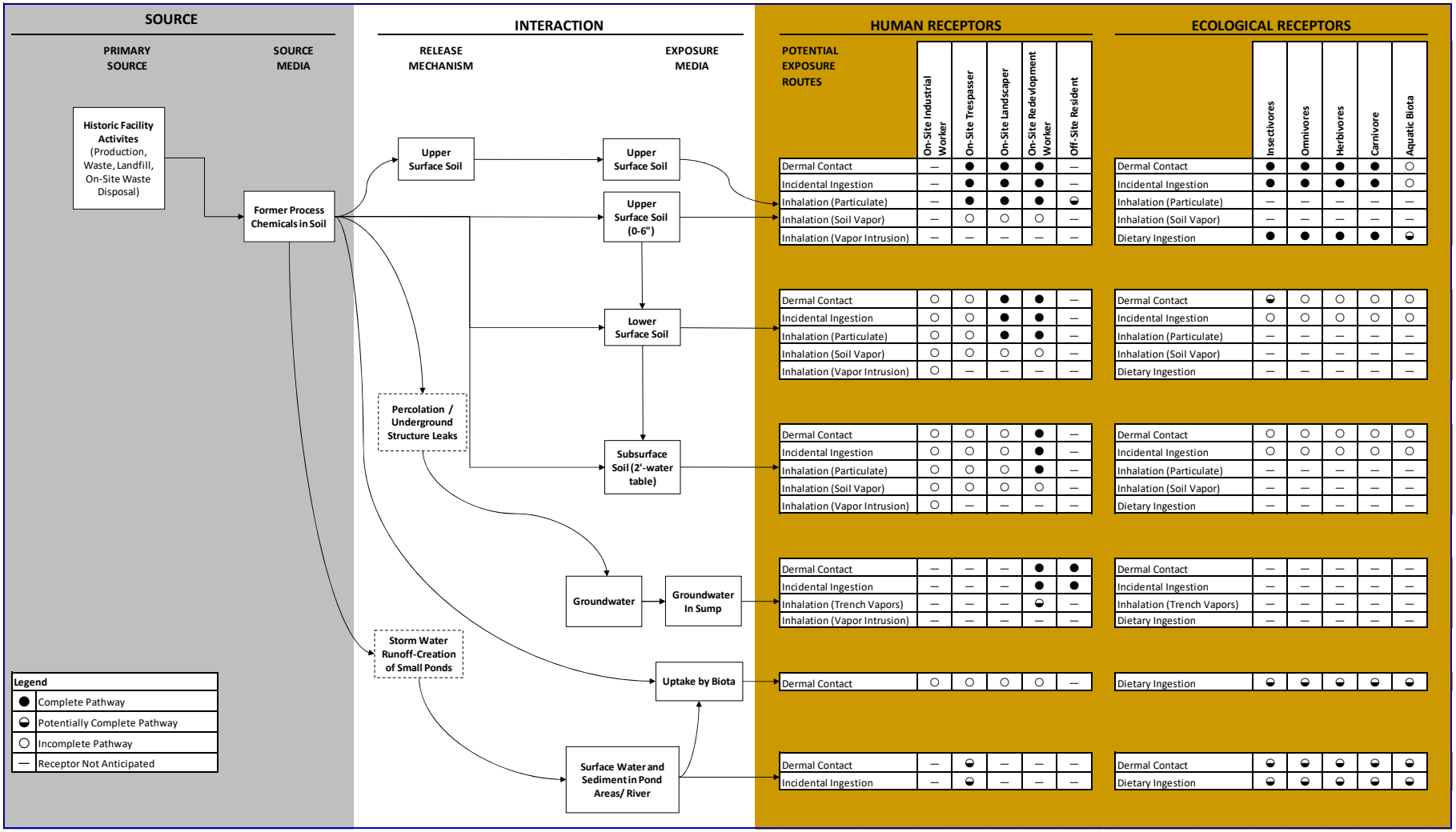
Conceptual Site Model: As of February 4, 2019

A conceptual Site Model (CSM) Update Report was submitted to the USEPA on February 4, 2019 and discusses the following:

- Background information, i.e., site history (unless this information is presented in an Executive Summary)
- Sources of known or suspected hazardous waste;
- Known or suspected contaminants or classes of contaminants;
- Primary release mechanism;
- Secondary contaminant migration;
- Fate and transport considerations;
- Potential receptors and exposure pathways;
- Land use considerations;
- Key physical aspects of the site (e.g., site geology, hydrology, topography, climate); and
- Current interpretation of nature and extent of contamination to the extent that it will influence project-specific decision-making.

On the following page is presented the CSM Diagrams specific to the Redevelopment Area, the Leased area, the Open Area, the Buffer Zone Area and the Natural Area.

CSM Diagram of the Redevelopment and Leased Area



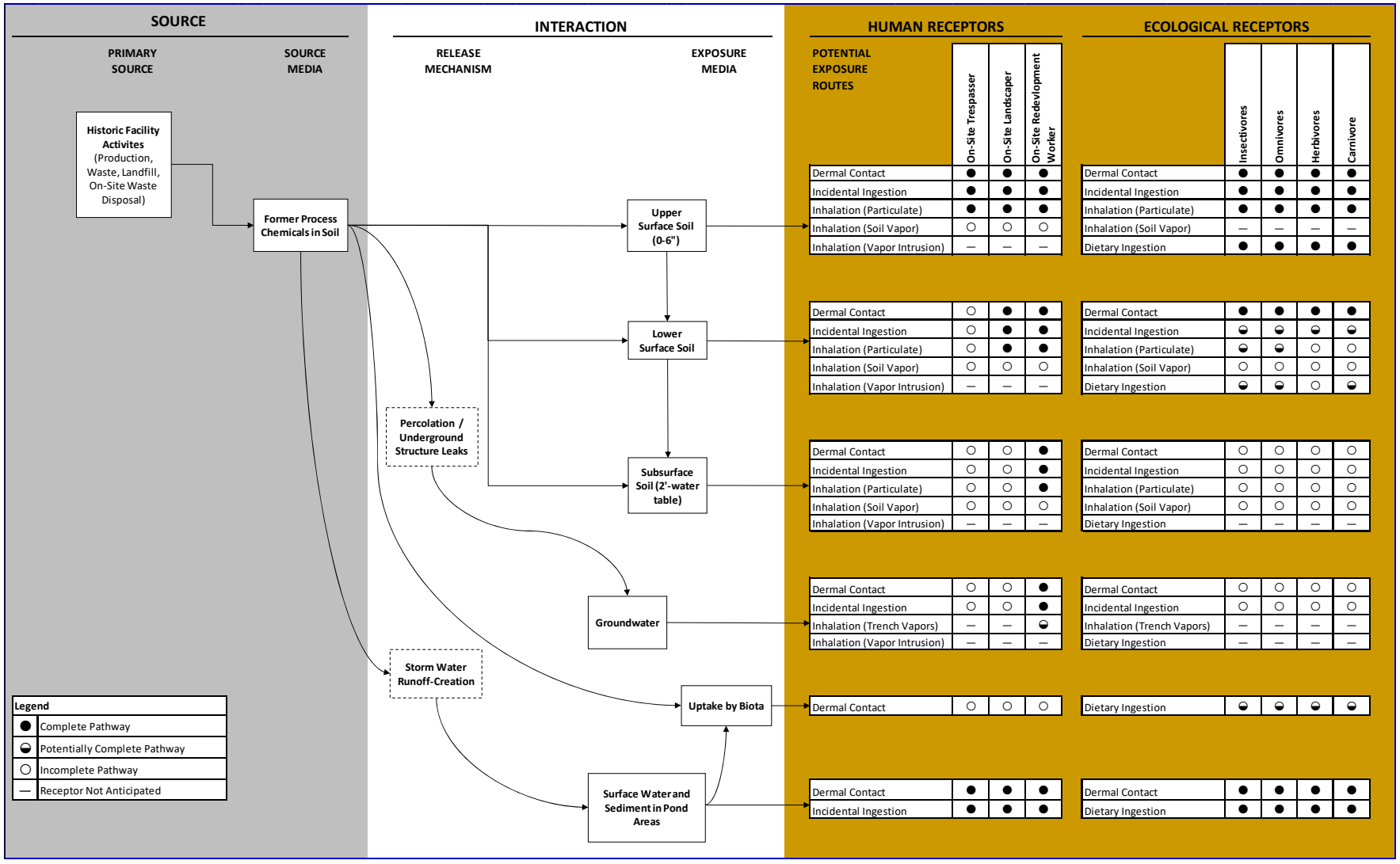
HUMAN RECEPTORS

POTENTIAL EXPOSURE ROUTES	On-Site Industrial Worker	On-Site Trespasser	On-Site Landscaper	On-Site Redevlopment Worker	Off-Site Resident
Dermal Contact	—	●	●	●	—
Incidental Ingestion	—	●	●	●	—
Inhalation (Particulate)	—	●	●	●	◒
Inhalation (Soil Vapor)	—	○	○	○	—
Inhalation (Vapor Intrusion)	—	—	—	—	—
Dermal Contact	○	○	●	●	—
Incidental Ingestion	○	○	●	●	—
Inhalation (Particulate)	○	○	●	●	—
Inhalation (Soil Vapor)	○	○	○	○	—
Inhalation (Vapor Intrusion)	○	—	—	—	—
Dermal Contact	○	○	○	●	—
Incidental Ingestion	○	○	○	●	—
Inhalation (Particulate)	○	○	○	●	—
Inhalation (Soil Vapor)	○	○	○	○	—
Inhalation (Vapor Intrusion)	○	—	—	—	—
Dermal Contact	—	—	—	●	●
Incidental Ingestion	—	—	—	●	●
Inhalation (Trench Vapors)	—	—	—	◒	—
Inhalation (Vapor Intrusion)	—	—	—	—	—
Dermal Contact	○	○	○	○	—
Dermal Contact	—	◒	—	—	—
Incidental Ingestion	—	◒	—	—	—

ECOLOGICAL RECEPTORS

	Insectivores	Omnivores	Herbivores	Carnivore	Aquatic Biota
Dermal Contact	●	●	●	●	○
Incidental Ingestion	●	●	●	●	○
Inhalation (Particulate)	—	—	—	—	—
Inhalation (Soil Vapor)	—	—	—	—	—
Dietary Ingestion	●	●	●	●	◒
Dermal Contact	◒	○	○	○	○
Incidental Ingestion	○	○	○	○	○
Inhalation (Particulate)	—	—	—	—	—
Inhalation (Soil Vapor)	—	—	—	—	—
Dietary Ingestion	—	—	—	—	—
Dermal Contact	○	○	○	○	○
Incidental Ingestion	○	○	○	○	○
Inhalation (Particulate)	—	—	—	—	—
Inhalation (Soil Vapor)	—	—	—	—	—
Dietary Ingestion	—	—	—	—	—
Dermal Contact	—	—	—	—	—
Incidental Ingestion	—	—	—	—	—
Inhalation (Trench Vapors)	—	—	—	—	—
Dietary Ingestion	—	—	—	—	—
Dietary Ingestion	◒	◒	◒	◒	◒
Dermal Contact	◒	◒	◒	◒	◒
Dietary Ingestion	◒	◒	◒	◒	◒

CSM Diagram of the Open Area



POTENTIAL EXPOSURE ROUTES	On-Site Trespasser	On-Site Landscaper	On-Site Redevlopment Worker
Dermal Contact	●	●	●
Incidental Ingestion	●	●	●
Inhalation (Particulate)	●	●	●
Inhalation (Soil Vapor)	○	○	○
Inhalation (Vapor Intrusion)	—	—	—

	Insectivores	Omnivores	Herbivores	Carnivore
Dermal Contact	●	●	●	●
Incidental Ingestion	●	●	●	●
Inhalation (Particulate)	●	●	●	●
Inhalation (Soil Vapor)	—	—	—	—
Dietary Ingestion	●	●	●	●

Dermal Contact	○	●	●
Incidental Ingestion	○	●	●
Inhalation (Particulate)	○	●	●
Inhalation (Soil Vapor)	○	○	○
Inhalation (Vapor Intrusion)	—	—	—

Dermal Contact	●	●	●	●
Incidental Ingestion	◒	◒	◒	◒
Inhalation (Particulate)	◒	◒	○	○
Inhalation (Soil Vapor)	○	○	○	○
Dietary Ingestion	◒	◒	○	◒

Dermal Contact	○	○	●
Incidental Ingestion	○	○	●
Inhalation (Particulate)	○	○	●
Inhalation (Soil Vapor)	○	○	○
Inhalation (Vapor Intrusion)	—	—	—

Dermal Contact	○	○	○	○
Incidental Ingestion	○	○	○	○
Inhalation (Particulate)	○	○	○	○
Inhalation (Soil Vapor)	○	○	○	○
Dietary Ingestion	—	—	—	—

Dermal Contact	○	○	●
Incidental Ingestion	○	○	●
Inhalation (Trench Vapors)	—	—	◒
Inhalation (Vapor Intrusion)	—	—	—

Dermal Contact	○	○	○	○
Incidental Ingestion	○	○	○	○
Inhalation (Trench Vapors)	—	—	—	—
Dietary Ingestion	—	—	—	—

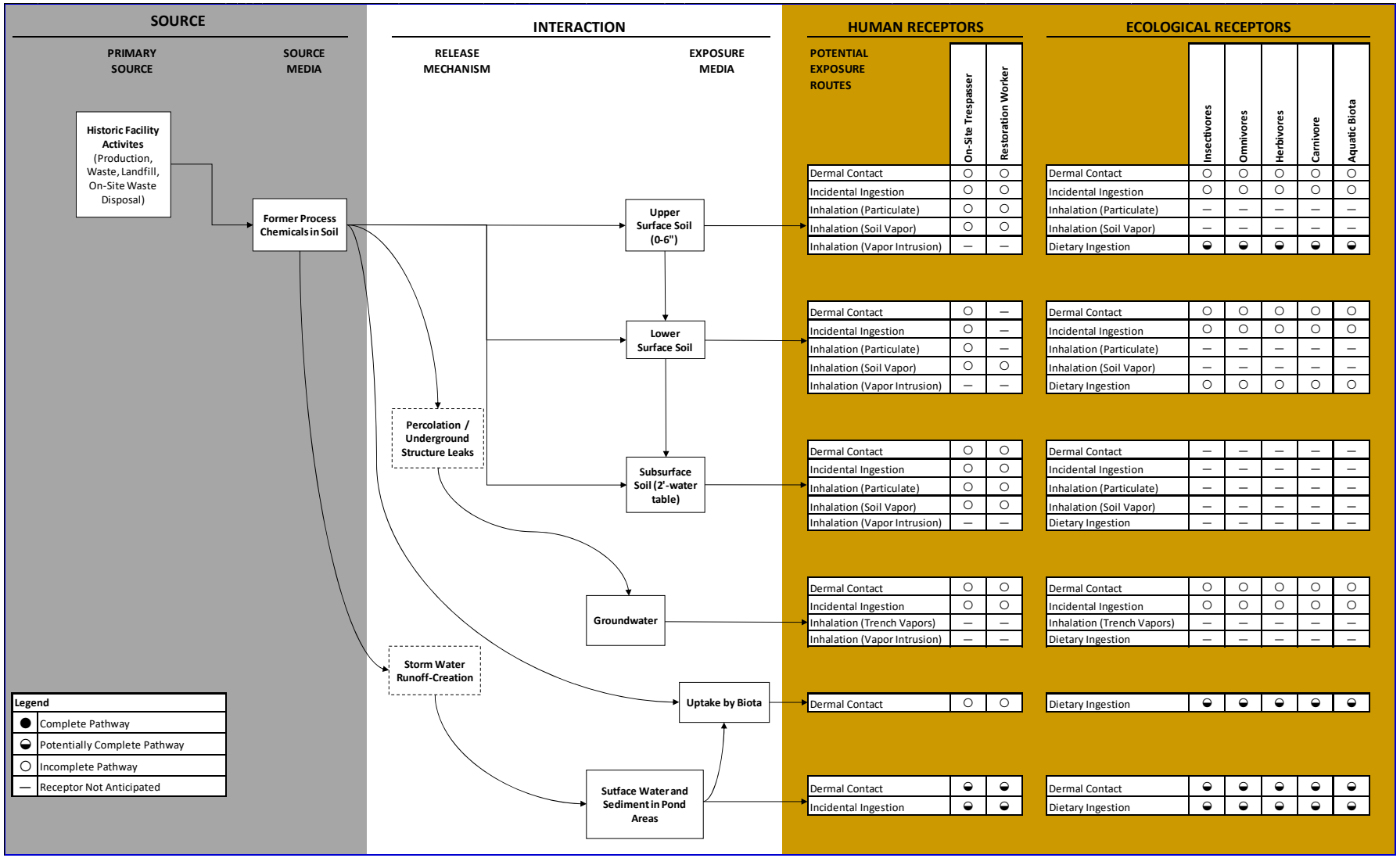
Dermal Contact	○	○	○

Dietary Ingestion	◒	◒	◒	◒

Dermal Contact	●	●	●
Incidental Ingestion	●	●	●

Dermal Contact	●	●	●	●
Dietary Ingestion	●	●	●	●

CSM Diagram of the Buffer and Natural Area



Worksheet #11: Project/Data Quality Objectives

Project Objectives – Remedial Design

Based on remaining unacceptable risks to human health and ecological receptors discussed in Worksheet 10. The following Project Quality Objectives have been established:

- Eliminate dermal contact exposure risk inorganic metal constituents found in surficial soils within the Redevelopment, Leased Areas and Open Area.
- Discontinue arsenic loading into groundwater from highly contaminated Source Areas located within the Redevelopment Area.
- Reduce dissolved arsenic concentrations within groundwater plumes found in Pool A (Northerly flowing) and Pool B (Southwesterly flowing).

The primary objective of the Corrective Measure Implementation is to address the PQOs mentioned above and design an expedited, cost-effective remedy that is consistent with the USEPA Final Decision Response to Comment document and RCRA 3008(h) Administrative Order on Consent for Corrective Measures Implementation Order. The following selected remedies have been established for the Former DuPont East Chicago Facility:

- Control direct contact with contaminated soil by maintaining existing pavement, foundation barriers, and the installation and maintence of a permeable soil cover.
- Excavate, treat and dispose off-site of soil greater than 1,000 mg/kg arsenic from source areas to remove and stabilize significant portions of the arsenic at the facility.
- Excavate and dispose off-site lead contaminated soil in the Leased Area in addition to maintaining existing barriers of concrete or asphalt to mitigate direct human contact and achieve a residual cancer risk of 1x10-5 and lead exposure factor less than 1.0.
- Treat in-situ soil below the water table within source area excavations where saturated soil concentrations warrant treatment to further reduce arsenic source to groundwater.
- Create enhanced microbial enhanced sulfate reduction injection treatment zones along the plume flow paths and bio-barrier located near the river to intercept arsenic along the plumes and reduce or eliminate additional arsenic migration beyond the northern and southern compliance points.

These EPA selected remedies adequately mitigate human and ecological exposure risks associated with the PQOs and unacceptable exposures identified in the previous risk assessments.

The following table below discusses project data inputs along with the Data Quality Objectives (DQOs) Planning Process:

Worksheet #11: Data Quality Objectives (DQOs) Table

Data Set Inputs	Who is Using the Data?	What will the Data be Used For?	Where, When and How Is the data Being Collected	Who will Collect and Generate the Data?	How will the Data be Reported?	How "Good" Does the Data Need to be?
Geotechnical Investigation Data	Impact, ECGP, USEPA and IDEM	Remedial design options, ground improvement for redevelopment	Redevelopment Area, Open Area – 2019 – Collected via Geotechnical Investigation see CMI Work Plan	Impact and Geotechnical Sub-contractor	See Worksheet #29	Standard QA/QC
Landfill Beneficial Reuse Study Data		Cap construction material options, Reuse options and Landfill Closure	Open Area – 2019 – Collected via Geotechnical Investigation see CMI Work Plan	Impact and Geotechnical Contractor		Standard QA/QC
Hydrogeological Data		Groundwater Treatment Optimization and Hydraulic Control/Redevelopment Design	Redevelopment Area, Open Area – 2019-2020 – Collected via Data Logger/ Pneumatic Slug Testing Study see CMI Work Plan	Impact		Standard QA/QC
Baseline Groundwater Monitoring Data		See Worksheet #17				Project-Specific See Worksheet #20 and #34
Source Area Hazardous Material Treatment Data		To verify Source Area material is below Hazardous TCLP limits and may be disposed off-site	Redevelopment Area – 2019- Collected via Source Area waste characterization sampling	Impact		Standard QA/QC
In-Situ Stabilization Application Data		To verify application of ISS treatment product is within treatment design specifications, Determining the completeness of mixing reagents	Redevelopment Area – 2019- Collected via ongoing maintence logging and grid/ dosage volume documentation	Impact		Documentation of collected application data will be submitted to USEPA
Source Removal and ISS Treatment Groundwater Performance Data		See Worksheet #17				Project Specific See Worksheet #20 and #34
Donor Source Cap Material Data		Waste classification analysis to demonstrate that the soil and masonry media accepted from a Donor Source is safe to use for the barrier cover and meets the specifications of the CMI Work Plan	Redevelopment Area, Leased Area, and Open Area – 2019 – 2022 – Collected via submission or collection and review prior to Site acceptance of material and use	Donor Source Submission, Environmental Consultant Sub-contractors, Impact		Standard QA/QC
LVA Manufacturing Data		Verification that soil and masonry media processing is producing a product that meets the design specifications	Redevelopment Area, Leased Area, and Open Area – 2019 – 2022 – Collected via stockpile sampling of LVA Product	Impact		Standard QA/QC
Permeable Earthen Cap Data		To measure and assess completeness of Cap Construction and Coverage and constructability of redevelopment	Redevelopment Area, Leased Area, and Open Area – 2019 – 2022 – Collected via volumetric measurements of cap cells (total volume, thickness, Area) and compaction metrics (Nuclear Density, elevations)	Impact		Standard QA/QC

Worksheet Table #12: Measurement Performance Criteria

Worksheet Table #12a: Measurement Performance Criteria – Total Metals (Aqueous)

Matrix	Aqueous (Groundwater)
Analytical Group	Total (As, Cd, Fe, Pb, Zn & Ca)
Concentration Level	Low/Medium
USEPA Reference	ISM02.4
Laboratory SOP(s)	TestAmerica SOPs UP-QA-QAM(Rev.09) and UP-ME-6010B

Sampling Program	Analytical Method(s)	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Measurement Performance Activity	QC Sample Assesses Error for S, A or both (S&A)
Baseline Groundwater Monitoring Event Post-Remedial Groundwater Monitoring Events	SW-846 6010B 3010A	Bias/Precision	All analytes within 10% of expected value	Second-Source Calibration Verification (ICV)	A
		Bias/Precision	All analytes within 10% of expected value	Continuing Calibration Verification (CCV)	A
		Precision	RPD ≤30% (if both samples > LOQ)	Field Duplicate	S&A
		Precision	± 25% of known concentration	Matrix Spike Duplicate	A
		Accuracy	No target analyte concentrations ≥ ½ QL	Field Blank (FB)	S&A
		Accuracy/Bias	+/- RL (< LOQ for each analyte)	Method Blank (MB)	S&A
		Accuracy/Bias	± 20% of known concentration	LCS	A

		Accuracy/Bias	<LOQ for each analyte	Field Equipment Rinsate Blank	S&A
		Accuracy/Bias	±25% of known concentration	Matrix Spike	A
		Accuracy/Bias	5x dilution must agree within 10% of the original determination	Dilution Test (SD)	A
		Accuracy/Bias	Recovery within 25% of expected results	Post-Digestion Spike (PDS)	A
		Sensitivity	LOQ < ½ PAL (80-120% if possible)	QL Verification Sample	A
		Representativeness	Implementation of approved plans and procedures	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S
		Comparability	Use of standard procedures and methods as outlined in approved plans/modifications	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	A
		Completeness	95% (per field event activity)	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S&A

Worksheet Table #12b: Measurement Performance Criteria – Speciated Metals (Aqueous)

Matrix	Aqueous (Groundwater)
Analytical Group	Speciated Metals (As: As III and As V)
Concentration Level	Low/Medium
USEPA Reference	ISM02.4
Laboratory SOP(s)	TestAmerica SOPs UP-QA-QAM(Rev.09) and DV-MT-0026

Sampling Program	Analytical Method(s)	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Measurement Performance Activity	QC Sample Assesses Error for S, A or both (S&A)
Baseline Groundwater Monitoring Event Post-Remedial Groundwater Monitoring Events	HPLC-ICPMS Coupled Speciated Analyses	Bias/Precision	All analytes within 10% of expected value	Second-Source Calibration Verification (ICV)	A
		Bias/Precision	All analytes within 10% of expected value	Continuing Calibration Verification (CCV)	A
		Precision	RPD ≤30% (if both samples > LOQ)	Field Duplicate	S&A
		Precision	± 25% of known concentration	Matrix Spike Duplicate	A
		Accuracy	No target analyte concentrations ≥ ½ QL	Field Blank (FB)	S&A
		Accuracy/Bias	+/- RL (< LOQ for each analyte)	Method Blank (MB)	S&A
		Accuracy/Bias	± 20% of known concentration	LCS	A
		Accuracy/Bias	<LOQ for each analyte	Field Equipment Rinsate Blank	S&A

		Accuracy/Bias	± 25% of known concentration	Matrix Spike	A
		Accuracy/Bias	5x dilution must agree within 10% of the original determination	Dilution Test (SD)	A
		Accuracy/Bias	Recovery within 25% of expected results	Post-Digestion Spike (PDS)	A
		Sensitivity	LOQ < ½ PAL (50-150% if possible)	QL Verification Sample	A
		Representativeness	Implementation of approved plans and procedures	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S
		Comparability	Use of standard procedures and methods as outlined in approved plans/modifications	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	A
		Completeness	95% (per field event activity)	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S&A

Worksheet #12c: Measurement Performance Criteria – Anions (Aqueous)

Matrix	Aqueous (Groundwater)
Analytical Group	Anions (Chloride, Nitrate as N, Nitrite as N, Sulfate)
Concentration Level	Low/Medium
USEPA Reference	ISM02.4
Laboratory SOP(s)	TestAmerica SOPs UP-QA-QAM(Rev.09) and UP-WC-300.0

Sampling Program	Analytical Method(s)	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Measurement Performance Activity	QC Sample Assesses Error for S, A or both (S&A)
Baseline Groundwater Monitoring Event Post-Remedial Groundwater Monitoring Events	SM-846 9056A	Bias/Precision	All analytes within 10% of expected value	Second-Source Calibration Verification (ICV)	A
		Bias/Precision	All analytes within 10% of expected value	Continuing Calibration Verification (CCV)	A
		Precision	RPD ≤15% (if both samples > LOQ)	Field/Lab Duplicate	S&A
		Precision	± 20% of known concentration	Matrix Spike Duplicate	A
		Accuracy	No target analyte concentrations ≥ ½ QL	Field Blank (FB)	S&A
		Accuracy/Bias	+/- RL (< LOQ for each analyte)	Method Blank (MB)	S&A
		Accuracy/Bias	± 10% of known concentration	LCS	A
		Accuracy/Bias	<LOQ for each analyte	Field Equipment Rinsate Blank	S&A

		Accuracy/Bias	±20% of known concentration	Matrix Spike	A
		Sensitivity	LOQ < ½ PAL (80-120% if possible)	QL Verification Sample	A
		Representativeness	Implementation of approved plans and procedures	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S
		Comparability	Use of standard procedures and methods as outlined in approved plans/modifications	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	A
		Completeness	95% (per field event activity)	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S&A

Worksheet Table #12d: Measurement Performance Criteria - Phosphorus (Aqueous)

Matrix	Aqueous (Groundwater)
Analytical Group	Phosphorus (Total)
Concentration Level	Low/Medium
USEPA Reference	ISM02.4
Laboratory SOP(s)	TestAmerica SOPs UP-QA-QAM(Rev.09) and UP-WC-Phosphorus

Sampling Program	Analytical Method(s)	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Measurement Performance Activity	QC Sample Assesses Error for S, A or both (S&A)
Baseline Groundwater Monitoring Event Post-Remedial Groundwater Monitoring Events	SM4500P	Bias/Precision	All analytes within 10% of expected value	Second-Source Calibration Verification (ICV)	A
		Bias/Precision	All analytes within 10% of expected value	Continuing Calibration Verification (CCV)	A
		Precision	RPD ≤30% (if both samples > LOQ)	Field Duplicate	S&A
		Precision	± 25% of known concentration ≤ 20% RPD	Matrix Spike Duplicate	A
		Accuracy	No target analyte concentrations ≥ ½ QL	Field Blank (FB)	S&A
		Accuracy/Bias	+/- RL (< LOQ for each analyte)	Method Blank (MB)	S&A
		Accuracy/Bias	± 20% of known concentration	LCS	A
		Accuracy/Bias	<LOQ for each analyte	Field Equipment Rinsate Blank	S&A

		Accuracy/Bias	±25% of known concentration	Matrix Spike	A
		Sensitivity	LOQ < ½ PAL (80-120% if possible)	QL Verification Sample	A
		Representativeness	Implementation of approved plans and procedures	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S
		Comparability	Use of standard procedures and methods as outlined in approved plans/modifications	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	A
		Completeness	95% (per field event activity)	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S&A

Worksheet #12e: Measurement Performance Criteria – Sulfide (Aqueous)

Matrix	Aqueous (Groundwater)
Analytical Group	Sulfide
Concentration Level	Low/Medium
USEPA Reference	ISM02.4
Laboratory SOP(s)	TestAmerica SOPs UP-QA-QAM(Rev.09) and UP-WC-Sulfide

Sampling Program	Analytical Method(s)	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Measurement Performance Activity	QC Sample Assesses Error for S, A or both (S&A)
Baseline Groundwater Monitoring Event Post-Remedial Groundwater Monitoring Events	SM-846 SM4500-2SF 9034	Bias/Precision	All analytes within 10% of expected value	Second-Source Calibration Verification (ICV)	A
		Bias/Precision	All analytes within 10% of expected value	Continuing Calibration Verification (CCV)	A
		Precision	RPD ≤30% (if both samples > LOQ)	Field Duplicate	S&A
		Precision	± 25% of known concentration ≤ 20% RPD	Matrix Spike Duplicate	A
		Accuracy	No target analyte concentrations ≥ ½ QL	Field Blank (FB)	S&A
		Accuracy/Bias	No analyte detected > report limit	Method Blank (MB)	S&A
		Accuracy/Bias	± 20% of known concentration	LCS	A
		Accuracy/Bias	<LOQ for each analyte	Field Equipment Rinsate Blank	S&A

		Accuracy/Bias	±25% of known concentration	Matrix Spike	A
		Representativeness	Implementation of approved plans and procedures	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S
		Comparability	Use of standard procedures and methods as outlined in approved plans/modifications	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	A
		Completeness	95% (per field event activity)	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S&A

Worksheet Table#12f: Measurement Performance Criteria - Total Organic Carbon (Aqueous)

Matrix	Aqueous (Groundwater)
Analytical Group	Total Organic Carbon
Concentration Level	Low/Medium
USEPA Reference	ISM02.4
Laboratory SOP(s)	TestAmerica SOPs UP-QA-QAM(Rev.09) and UP-WC-TOC

Sampling Program	Analytical Method(s)	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Measurement Performance Activity	QC Sample Assesses Error for S, A or both (S&A)
Baseline Groundwater Monitoring Event Post-Remedial Groundwater Monitoring Events	SW846 9060A	Bias/Precision	All analytes within 10% of expected value	Second-Source Calibration Verification (ICV)	A
		Bias/Precision	All analytes within 10% of expected value	Continuing Calibration Verification (CCV)	A
		Precision	RPD ≤30% (if both samples > LOQ)	Field Duplicate	S&A
		Precision	± 25% of known concentration ≤ 20% RPD	Matrix Spike Duplicate	A
		Accuracy	No target analyte concentrations ≥ ½ QL	Field Blank (FB)	S&A
		Accuracy/Bias	+/- RL (< LOQ for each analyte)	Method Blank (MB)	S&A
		Accuracy/Bias	± 20% of known concentration	LCS	A
		Accuracy/Bias	<LOQ for each analyte	Field Equipment Rinsate Blank	S&A

		Accuracy/Bias	±25% of known concentration	Matrix Spike	A
		Sensitivity	LOQ < ½ PAL (80-120% if possible)	QL Verification Sample	A
		Representativeness	Implementation of approved plans and procedures	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S
		Comparability	Use of standard procedures and methods as outlined in approved plans/modifications	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	A
		Completeness	95% (per field event activity)	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S&A

Worksheet Table #12g: Measurement Performance Criteria – Alkalinity/Bicarbonate (Aqueous)

Matrix	Aqueous (Groundwater)
Analytical Group	Alkalinity/Bicarbonate Alkalinity
Concentration Level	Low/Medium
USEPA Reference	ISM02.4
Laboratory SOP(s)	TestAmerica SOPs UP-QA-QAM(Rev.09) and UP-WC-Alkalinity

Sampling Program	Analytical Method(s)	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Measurement Performance Activity	QC Sample Assesses Error for S, A or both (S&A)
Baseline Groundwater Monitoring Event Post-Remedial Groundwater Monitoring Events	SM 2320B	Bias/Precision	All analytes within 10% of expected value	Second-Source Calibration Verification (ICV)	A
		Bias/Precision	All analytes within 10% of expected value	Continuing Calibration Verification (CCV)	A
		Precision	RPD ≤30% (if both samples > LOQ)	Field Duplicate	S&A
		Accuracy	No target analyte concentrations ≥ ½ QL	Field Blank (FB)	S&A
		Accuracy/Bias	No analyte detected > report limit	Method Blank (MB)	S&A
		Accuracy/Bias	± 20% of known concentration	LCS	A
		Accuracy/Bias	<LOQ for each analyte	Field Equipment Rinsate Blank	S&A
		Representativeness	Implementation of approved plans and procedures	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S

		Comparability	Use of standard procedures and methods as outlined in approved plans/modifications	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	A
		Completeness	95% (per field event activity)	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S&A

Worksheet Table #12h: Measurement Performance Criteria – PFOA/PFOS (Aqueous)

Matrix	Aqueous (Groundwater)
Analytical Group	PFOA/PFOS
Concentration Level	Low/Medium
USEPA Reference	ISM02.4
Laboratory SOP(s)	TestAmerica SOPs UP-QA-QAM(Rev.09) and WS-LC-0025

Sampling Program	Analytical Method(s)	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Measurement Performance Activity	QC Sample Assesses Error for S, A or both (S&A)
Baseline Groundwater Monitoring Event Post-Remedial Groundwater Monitoring Events	EPA 537 (Modified)	Bias/Precision	All analytes within 10% of expected value	Second-Source Calibration Verification (ICV)	A
		Bias/Precision	All analytes within 10% of expected value	Continuing Calibration Verification (CCV)	A
		Precision	RPD ≤30% (if both samples > LOQ)	Field Duplicate	S&A
		Precision	± 30% of known concentration	Matrix Spike Duplicate	A
		Accuracy	No target analyte concentrations ≥ ½ QL	Field Blank (FB)	S&A
		Accuracy/Bias	No target analytes ≥ RL	Method Blank (MB)	S&A
		Accuracy/Bias	± 30% of known concentration	LCS	A
		Accuracy/Bias	<LOQ for each analyte	Field Equipment Rinsate Blank	S&A

		Accuracy/Bias	±30% of known concentration	Matrix Spike	A
		Representativeness	Implementation of approved plans and procedures	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S
		Comparability	Use of standard procedures and methods as outlined in approved plans/modifications	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	A
		Completeness	95% (per field event activity)	Data Evaluation as part of Data Verification (WS#35) and Data Usability (WS#37) procedures	S&A

Worksheet #13: Secondary Data Uses and Limitations

The Site has been extensively studied though various investigations from 1990 to present. These investigations were predominantly performed by CH2M Hill, DuPont Corporate Remediation Group, URS Corporation, and Parsons. The EPA has provided regulatory oversight on all environmental investigations studies and reports conducted, providing feedback, correction and requiring clarification when necessary. All data collected, findings and conclusions have been evaluated and approved by the EPA and therefore contain no known limitations. Data, findings and conclusions contained within the below documents and/or investigations have been utilized in whole or in part to the development of the current CMI Scope of Work.

Investigation Type	Year Issued	Name of Report	Company Conducting Investigation	Regulatory Agency	Sample Types
Historical/ WMUs	February 1990	Groundwater Assessment Phase I	CH2M Hill, Inc	EPA	Groundwater
Historical/ WMUs	August 1991	Groundwater Assessment Phase II	CH2M Hill, Inc	EPA	Groundwater
Historical/ Baseline/ SWMU/ AOC	October 1997	Current Conditions Report (CCR)	CH2M Hill, Inc	EPA	Soil and Groundwater
Evaluate and Prioritize SWMUs and AOCs	October 2002	Phase I RCRA Facility Investigation (RFI) Report	DuPont Corporate Remediation Group	EPA	Soil and Groundwater
Evaluate and Prioritize SWMUs and AOCs	January 2004	Phase II RFI Report	DuPont Corporate Remediation Group	EPA	Soil and Groundwater
Evaluation of Remedial Actions	October 2006	Corrective Measures Study (CMS)	DuPont Corporate Remediation Group	EPA	-
IRM Performance Monitoring	September 2009	PRB Groundwater Sampling Data Report	URS Corporation	EPA	Groundwater
Ecological Evaluation	July 2011	Screening Level Ecological Risk Assessment (SLERA)	Parsons	EPA	Soil and Groundwater
Human Health Evaluation	September 2011	Human Health Risk Assessment (HHRA)	Pioneer Technologies Corporation	EPA	Soil and Groundwater
Ecological Evaluation	February 2012	Baseline Ecological Risk Assessment	Parsons	EPA	Soil and Groundwater

Investigation Type	Year Issued	Name of Report	Company Conducting Investigation	Regulatory Agency	Sample Types
Evaluation of Remedial Technology	September 2013	Technical Memorandum - Remedial Technology Screening Evaluation	Parsons	EPA	-
Site-wide Groundwater Trend and Association Study	March 2014	Groundwater Evaluation Report	Parsons	EPA	Groundwater
Study ISCF Method for Groundwater Treatment	July 2014	Bench Scale Study Report	CH2M Hill and Parsons	EPA	Lab Study
Landfill Profiling/ Evaluation	November 2014	Landfill Evaluation	Parsons	EPA	Soil
Proposed Remedial Actions for Cleanup	March 2015	Corrective Measures Study (CMS)	Parsons	EPA	Soil/ Groundwater
Pilot Testing/ Performance Evaluation of ISCF	August 2015	Technical Memorandum- Pilot Test Injection Activities and Initial Results	Parsons	EPA	Groundwater
Leased Area Proposed Remedial Actions for Cleanup	October 2016	Addendum to the Corrective Measures Study for the Grace Parcel	Parsons	EPA	Soil
Completion of IRM Buffer zone Work	December 2016	Interim Remedial Measures Completion Report	Parsons	EPA	Soil/ Waste Characterization
Pilot Test and Performance Evaluation Study	January 2018	Final Comprehensive Pilot Test Study Report	Parsons	EPA	Groundwater
Waste Characterization and Soil Profiling of Source Areas	May 2018	Technical Memorandum – CMS Excavation Area Soil Profiling	Parsons	EPA	Soil

Worksheets #14 & #16: Project Tasks and Schedule

The Corrective Measure Implementation (CMI) process has been divided into definable features of work and the tasks required to complete each definable feature of work that has been identified. The schedule for these activities are dynamic, and due to the sequential nature of many of the supporting activities, with data generated by supplemental investigation activities informing and guiding subsequent investigation/ remedial activities, the deliverable schedule is presented relative to predecessor activities, with specific EPA-specified deadlines also provided in **Bold font** where applicable. Given the nature of project coordination and planning, field task are subject to change based on external and internal factors, if a delay occurs reasons will be substantiated to the EPA. Tasks that are being managed by the EPA (e.g., review and revision periods, etc.) are not identified in this worksheet however will influence task timelines. In addition, the following table does not include frequent, periodic meetings between EPA and ECGP/Impact Environmental that will be convened to discuss the status of ongoing investigation and design efforts, upcoming activities, and deliverable status in order to facilitate completion of the CMI SOW. Copies of the current schedules for site-wide activities are provided at the end of this worksheet. Deliverable due dates correspond to the order of the associated deliverables.

To monitor and control Project progress, a working Project schedule (Smartsheet Inc. Project Management Tools) will be maintained that will include activities to support Project execution and compliance with completing the required SOW. This "Working Project Schedule" will be updated for actual starts and finishes (e.g., review/comment of deliverables). The updated Smartsheet Project schedule will be provided to the EPA with the Quarterly Progress Reports, or as requested.

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Preparation of an Updated Conceptual Site Model (CSM)	Impact Environmental / ECGP	November 2018	January 2019	CSM	*Draft to EPA:* **Submitted January 15, 2019** *Final to EPA:* **Accepted February 4, 2019**
Preparation of Corrective Measure Implementation Work Plan (CMI WP)	Impact Environmental / ECGP	November 2018	July 2019	Corrective Measure Implementation Work Plan	*Draft to EPA:* **≤90 days after EPA issuance of Administrative Order (submitted on February 14, 2019)** *Final to EPA:* **≤60 days after receipt of EPA comments**
Preparation of The Site-Specific Health and Safety Plan (HASP)	Impact Environmental / ECGP	November 2018	July 2019	HASP (Appendix to CMI WP)	*Draft to EPA:* **Submitted March 29, 2019** *Final to EPA:* **≤30 days after receipt of EPA comments**

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Preparation of Uniform Federal Policy - Quality Assurance Project Plan (UFP-QAPP)	Impact Environmental / ECGP	November 2018	July 2019	UFP - QAPP (Appendix to the CMI WP)	*Draft to EPA:* **April 15, 2019** *Final to EPA:* **≤30 days after receipt of EPA comments**
Preparation of Community Participation Plan (CPP)	Impact Environmental / ECGP	November 2018	July 2019	CPP (Appendix to CMI WP)	*Draft to EPA:* **April 15, 2019** *Final to EPA:* **≤30 days after receipt of EPA comments**
Site Mobilization/ Clearing and Grubbing (Mobilization Improvements)	Impact Environmental / ECGP	July 2019	Continuous	Email Correspondence / Quarterly Progress Reporting	*Draft to EPA:* **Nov 15, 2019** *Final to EPA:* **≤30 days after receipt of EPA comments**
Well Viability Survey	Impact Environmental / ECGP	July 2019	July 2019	Email Correspondence / Quarterly Progress Reporting	*Draft to EPA:* **July 31, 2019** *Final to EPA:* **≤30 days after receipt of EPA comments**

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Subsurface Structures and Disturbed Fill Survey	Impact Environmental / ECGP	July 2019	September 2019	Technical Memorandum / 2019 Q3 Progress Report	*Draft to EPA:* **June 31, 2019** **November 15, 2019** *Final to EPA:* **≤30 days after receipt of EPA comments**
Utility Markout Source Areas Geophysical Survey/ Source Area Boundary Survey	Impact Environmental / ECGP	August 2019	September 2019	Technical Memorandum / 2019 Q3 Progress Report/ Corrective Measures Implementation Report	*Draft to EPA:* **July 31, 2019** **November 15, 2019** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Geotechnical Investigation	Impact Environmental / ECGP	August 2019	September 2019	Technical Memorandum / 2019 Q3 Progress Report/	*Draft to EPA:* **July 31, 2019** **November 15, 2019** *Final to EPA:* **≤30 days after receipt of EPA comments**
Groundwater Well Installation/ Abandonments and Development	Impact Environmental / ECGP	August 2019	September 2019	Technical Memorandum / 2019 Q3 Progress Report/ Corrective Measures Implementation Report	*Draft to EPA:* **July 31, 2019** **November 15, 2019** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Groundwater Monitoring Well Network TOC Survey	Impact Environmental / ECGP	September 2019	September 2019	Technical Memorandum / 2019 Q3 Progress Report/ Corrective Measures Implementation Report	*Draft to EPA:* **August 31, 2019** **November 15, 2019** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Baseline Groundwater Monitoring Sampling Event	Impact Environmental / ECGP	September 2019	October 2019	Technical Memorandum / 2019 Q3 Progress Report/ Corrective Measures Implementation Report	*Draft to EPA:* **August 31, 2019** **November 15, 2019** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Preliminary Groundwater Treatment Event	Impact Environmental / ECGP	August 2019	November 2019	Technical Memorandum / 2019 Q4 Progress Report/ Corrective Measures Implementation Report	*Draft to EPA:* **August 31, 2019** **January 15, 2020** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Former Site Infrastructure Demolition and Underground Utility Removal	Impact Environmental / ECGP	October 2019	June 2020	Technical Memorandum / 2019 Q4, 2020 Q1, Q2, and Q3 Progress Reports	*Draft to EPA:* **July 31, 2019** **Quarterly Deliverables** *Final to EPA:* **≤30 days after receipt of EPA comments**

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Source Area Excavation/ ISS Application/ Source Area Material Treatment and Off-Site Disposal	Impact Environmental / ECGP	September 2019	August 2020	Technical Memorandum / 2019 Q3/Q4 Progress Reports/ Corrective Measures Implementation Report	*Draft to EPA:* **July 31, 2019** **November 15, 2019/ January 15, 2020** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Material Importation/ Excavation Backfill/ LVA Manufacturing/ Cap Construction	Impact Environmental / ECGP	September 2019	TBD	Technical Memorandum / 2019 Q3/Q4 Progress Reports/ Corrective Measures Implementation Report	*Draft to EPA:* **August 31, 2019** **Quarterly Deliverables** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Gary Road Entrance Improvement	Impact Environmental / ECGP	October 2019	December 2019	Email Correspondence	*Draft to EPA:* **Upon City Approvals/ Initiation of Work and Work Completion** *Final to EPA:* N/A
Landfill Beneficial Use Determination (BUD) Study	Impact Environmental / ECGP	June 2020	July 2020	Technical Memorandum / 2020 Q2 Progress Report/ Corrective Measures Implementation Report	*Draft to EPA:* **May 31, 2020** **July 15, 2020** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Source Excavation/ ISS Application/ Preliminary Groundwater Treatment Groundwater Performance Monitoring Events (Multiple Events)	Impact Environmental / ECGP	April 2020	April 2021	Technical Memorandum/ 2020 Q1/Q2/Q3/Q4 Progress Reports/ Technical Memorandum Report of Findings / Remedial Construction Phase II Report/ Corrective Measures Implementation Report	*Draft to EPA:* **February 28, 2020** **Quarterly Deliverables** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Groundwater Pneumatic Slug Testing (PST) Event	Impact Environmental / ECGP	April 2020	May 2020	Technical Memorandum / 2020 Q2 Progress Report/ Corrective Measures Implementation Report	*Draft to EPA:* **March 31, 2020** **July 15, 2020** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Preparation of the CMI Work Plan: Remedial Construction Phase II Report	Impact Environmental / ECGP	September 2020	March 2021	CMI WP: Remedial Construction Phase II	*Draft to EPA:* **March 31, 2021** *Final to EPA:* **≤30 days after receipt of EPA comments**

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Groundwater Treatment System Installation	Impact Environmental / ECGP	April 2021	August 2021	Technical Memorandum / 2021 Q2/Q3 Progress Reports/ Corrective Measures Implementation Report	*Draft to EPA:* **August 31, 2021** **November 15, 2021/ January 15, 2022** **Quarterly Deliverables** *Final to EPA:* **≤30 days after receipt of EPA comments**
Groundwater Treatment Injection Events (4 Events)	Impact Environmental / ECGP	August 2021	November 2021	Technical Memorandum / 2021 Q4 Progress Reports/ Technical Memorandum of Result/ Corrective Measures Implementation Report	*Draft to EPA:* **July 31, 2021** **Quarterly Deliverables** *Final to EPA:* **≤30 days after receipt of EPA comments**
Groundwater Treatment Performance Monitoring (4 Events)	Impact Environmental / ECGP	April 2022	November 2022	Technical Memorandum/ 2022 TBD Progress Reports/ Technical Memorandum/ Corrective Measures Implementation Report	*Draft to EPA:* **March 31, 2022** **Quarterly Deliverables** *Final to EPA:* **≤30 days after receipt of EPA comments**
Southern Biowall Barrier Construction	Impact Environmental / ECGP	April 2022	November 2022	Technical Memorandum/ 2022 Progress Reports/ Corrective Measures Implementation Report	*Draft to EPA:* **March 31, 2022** **Quarterly Deliverables** *Final to EPA:* **≤30 days after receipt of EPA comments**

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Landfill Modification for Redevelopment	Impact Environmental / ECGP	April 2020	August 2021	Technical Memorandum/ 2020 2021 Quarterly Progress Reports/ Technical Memorandum/ Corrective Measures Implementation Report	*Draft to EPA:* **March 31, 2020 Quarterly Deliverables** *Final to EPA:* **≤30 days after receipt of EPA comments**
Ground Improvement / Foundation Construction/ Hydraulic Control Features Installation	Impact Environmental / ECGP	April 2022	November 2021	Email Correspondence/ 2022 Progress Reports/ Corrective Measures Implementation Report	*Draft to EPA:* **March 31, 2022 Quarterly Deliverables** *Final to EPA:* **≤30 days after receipt of EPA comments**
Hydrogeologic Study Groundwater Treatment Contingency Design	Impact Environmental / ECGP	TBD	TBD	Hydraulic Control and Groundwater Treatment Contingency Design Report	*Draft to EPA:* **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Hydraulic Control/ Groundwater Treatment Contingency Implementation	Impact Environmental / ECGP	TBD	TBD	Technical Memorandum/ Quarterly Progress Reports/ Technical Memorandum/ Corrective Measures Implementation Report	*Draft to EPA:* **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Update to Conceptual Site Model	Impact Environmental / ECGP	TBD	TBD	Updated CSM Report/ Corrective Measures Implementation Report	*Draft to EPA:* **TBD** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Closure of Onsite Landfill	Impact Environmental / ECGP	TBD	TBD	On-site Solid Waste Landfill Closure Report / Corrective Measures Implementation Report	*Draft to EPA:* **TBD** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**
Corrective Measure Implementation Completion	Impact Environmental / ECGP	TBD	TBD	Corrective Measures Implementation Report	*Draft to EPA:* **TBD (upon completion of all field activities, data management/ validation/usability and performance monitoring activities)** *Final to EPA:* **≤30 days after receipt of EPA comments**
Long-Term Monitoring and Maintence Plan (LTMMP)	Impact Environmental / ECGP	TBD	TBD	LTMMP /Corrective Measures Implementation Report	*Draft to EPA:* **TBD** **TBD** *Final to EPA:* **≤30 days after receipt of EPA comments**

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Associated Deliverable(s)	Deliverable Due Date
Data Management	TestAmerica, Chicago/ Impact	In conjunction with Sample Collection/ Sample Analyses Activities	TBD (throughout Project)	As requested - data tables, statistics, figure inputs (such as data boxes)	As agreed during request
Data Validation	LDC	Upon receipt of a Sample Data Package Report/EDD	60 days after receipt of the last Sample Data Package Report/EDD for Field/ Sampling Activities	Data Validation Reports	60 days after receipt of last Sample Data Package Report/EDD per week/event
Data Usability Assessment	Impact Environmental / ECGP	Upon completion of each activity, event, study, etc. (including data analyses and validation) and/or prior to use of data in Decision Making and Reporting	TBD	Usability Assessment (stand-alone deliverable or section with Associated Deliverable/ Technical Memorandum)	60 days after completion of each activity, event, study, etc. (including data analyses and validation) and/or prior to use of data Associated Deliverable/Technical Memorandum)

Worksheet #15: Project Action Limits and Laboratory-Specific Limits – #15 Introduction and Remediation Goals

The Worksheet #15 tables provide the Project Action Limits (PALs), laboratory-specific reporting and QC limits for the matrices and analytes to be tested during the Project. Information has been consolidated for the laboratories that may be utilized during CMI Scope of Work.

The following Cleanup Goals were established in the Final Decision Response to Comments document by the EPA for the Site:

- Minimize direct contact exposure to contaminated surficial fill.
- Achieve 1x10E^{-5} residual risk from direct contact with soil/fill, and a non-cancer HI<1 across entire Redevelopment Area.
- Remediate identified soil/fill-to-groundwater Source Areas where arsenic concentrations in soil/fill are greater than 1000 mg/kg (part per million).
- Arsenic in groundwater at the northern compliance points was established at the Maximum Contaminant Level (MCL) of 10 µg/L for the USEPA Drinking Water Standard.
- Arsenic in groundwater at the southern compliance points was established at the Indiana Surface Water Quality Standard of 148 µg/L.

As presented in Table 3.4 in the CMS, the following Site-Specific Groundwater Cleanup Goals have been established:

Groundwater Cleanup Goals		
Constituents	**Northern Site Boundary**	**Southern Site Boundary**
Arsenic	10 µg/L	148 µg/L
Cadmium	5 µg/L	3.82 µg/L
Lead	15 µg/L	6.49 µg/L

Cleanup goals established for groundwater were based on MCLs designated by USEPA National Drinking Water Standards along the northern compliance points and IDEM Surface Water Quality Standards along the southern compliance points. Based on these above Cleanup Goals the following Project Action Limits (PALs) have been established for remedial actions and monitoring at the Site:

Site-Specific Project Action Limits (PALs)			
PAL	**Matrix**	**CMI Component**	**PAL Reference #**
USEPA National Drinking Water Standards	Aqueous (Pool A (flowing northerly	Groundwater Northern Compliance Point	1
IDEM Surface Water Quality Standards	Aqueous (Pool B (flowing southerly)	Groundwater Southern Compliance Point	2
EPA Unregulated Contaminant Monitoring Rule (UCMR 3) Values	Site-wide	EPA Request	3

Worksheet #15: Project Action Limits and Laboratory-Specific Limits Table - #15a Metals

Matrix: Solid / Aqueous

Analytical Method: EPA 6010B - 3010A

Analyte	PAL Reference 1 (µg /L)	PAL Reference 2 (µg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (µg/L) [2]	Primary Laboratory LOD (µg/L) [2]	Primary Laboratory LOQ (µg/L) [2]
Arsenic	10	148	≤ ½PAL if possible; at least ≤ PAL	3.65	5.00	10.0
Cadmium	5	3.82	≤ ½PAL if possible; at least ≤ PAL	0.433	1.00	2.00
Iron	-	*	≤ ½PAL if possible; at least ≤ PAL	81.9	100	200
Lead	15	6.49	≤ ½PAL if possible; at least ≤ PAL	2.70	3.00	5.00
Zinc	-	*	≤ ½PAL if possible; at least ≤ PAL	5.00	10.0	20.0
Calcium	-	*	≤ ½PAL if possible; at least ≤ PAL	53.3	100	200

Matrix: Aqueous

Analytical Method: EPA 6010B - 3010A Field Filtered

Analyte	PAL Reference 1 (mg/L)	PAL Reference 2 (µg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (µg/L) [2]	Primary Laboratory LOD (µg/L) [2]	Primary Laboratory LOQ (µg/L) [2]
Arsenic	10	148	≤ ½PAL if possible; at least ≤ PAL	3.65	5.00	10.0
Cadmium	5	3.82	≤ ½PAL if possible; at least ≤ PAL	0.433	1.00	2.00
Iron	-	*	≤ ½PAL if possible; at least ≤ PAL	81.9	100	200
Lead	15	6.49	≤ ½PAL if possible; at least ≤ PAL	2.70	3.00	5.00
Zinc	-	*	≤ ½PAL if possible; at least ≤ PAL	5.00	10.0	20.0
Calcium	-	*	≤ ½PAL if possible; at least ≤ PAL	53.3	100	200

1 The project quantitation limit goal will be a LOD at or below the PAL, preferably one-half the PAL to account for the potential for dilution and matrix interferences.

2 Primary laboratory will be TestAmerica, Chicago; no secondary laboratory selected at this time (refer to Worksheets #19 &#30).

* As calculated from pH and Hardness from IAC 327 Article 2 Surface Water Quality Standards for Lake Erie and Lake Michigan Drainage Basins

Worksheet #15: Project Action Limits and Laboratory-Specific Limits Table - #15b

Matrix: Aqueous

Analytical Method: EPA 4500 PE

Analyte	PAL Reference 1 (mg/L)	PAL Reference 2 (mg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (mg/L) [2]	Primary Laboratory LOD (mg/L) [2]	Primary Laboratory LOQ (mg/L) [2]
Phosphorus	-	-	LOQ	0.0239	0.0250	0.0500

Matrix: Aqueous

Analytical Method: EPA 4500 PE Field Filtered

Analyte	PAL Reference 1 (mg/L)	PAL Reference 2 (mg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (mg/L) [2]	Primary Laboratory LOD (mg/L) [2]	Primary Laboratory LOQ (mg/L) [2]
Phosphorus	-	-	LOQ	0.0239	0.0250	0.0500

1 The project quantitation limit goal will be set at the analyte LOQ – this analyte is for information purposes only and not a cleanup objective.

2 Primary laboratory will be TestAmerica, Chicago; no secondary laboratory selected at this time (refer to Worksheets #19 &#30).

Worksheet #15: Project Action Limits and Laboratory-Specific Limits Table - #15c Anions, Ion Chromatography

Matrix: Aqueous

Analytical Method: EPA 9056A

Analyte	PAL Reference 1 (mg/L)	PAL Reference 2 (mg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (mg/L) [2]	Primary Laboratory LOD (mg/L) [2]	Primary Laboratory LOQ (mg/L) [2]
Chloride	-	-	LOQ	0.170	0.170	0.200
Nitrate as N	10	-	≤ ½PAL if possible; at least ≤ PAL	0.0680	0.100	0.200
Nitrite as N	1	-	≤ ½PAL if possible; at least ≤ PAL	0.0500	0.100	0.200
Sulfate	-	-	LOQ	0.0950	0.100	0.200

Worksheet #15: Project Action Limits and Laboratory-Specific Limits Table - #15d Sulfide, Acid soluble and Insoluble

Matrix: Aqueous

Analytical Method: EPA 9034 Calc

Analyte	PAL Reference 1 (mg/L)	PAL Reference 2 (mg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (mg/L) [2]	Primary Laboratory LOD (mg/L) [2]	Primary Laboratory LOQ (mg/L) [2]
Sulfide	-	-	LOQ	0.231	0.500	1.00

Worksheet #15: Project Action Limits and Laboratory-Specific Limits Table - #15e Organic Carbon, Total (TOC)

Matrix: Aqueous

Analytical Method: EPA 9060A

Analyte	PAL Reference 1 (mg/L)	PAL Reference 2 (mg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (mg/L) [2]	Primary Laboratory LOD (mg/L) [2]	Primary Laboratory LOQ (mg/L) [2]
TOC Result 1	-	-	LOQ	0.470	0.500	1.00
TOC Result 2	-	-	LOQ	0.470	0.500	1.00
Total Organic Carbon - Duplicates	-	-	LOQ	0.470	0.500	1.00

1 The project quantitation limit goal will be set at the analyte LOQ – the analyte is for information purposes only and is not a cleanup objective.

2 Primary laboratory will be TestAmerica, Chicago; no secondary laboratory selected at this time (refer to Worksheets #19 &#30).

Worksheet #15: Project Action Limits and Laboratory-Specific Limits Table - #15f Alkalinity

Matrix: Aqueous

Analytical Method: EPA 2320B

Analyte	PAL Reference 1 (mg/L)	PAL Reference 2 (mg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (mg/L) [2]	Primary Laboratory LOD (mg/L) [2]	Primary Laboratory LOQ (mg/L) [2]
Alkalinity	-	-	LOQ	3.74	5.00	5.00
Bicarbonate Alkalinity	-	-	LOQ	3.74	5.00	5.00

Worksheet #15: Project Action Limits and Laboratory-Specific Limits Table - #15g Arsenic Speciation

Matrix: Aqueous

Analytical Method: HPLC-ICPMS Coupled As Speciation EPA Method 1632

Analyte	PAL Reference 1 (µg/L)	PAL Reference 2 (µg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (µg/L) [2]	Primary Laboratory LOQ (µg/L) [2]
As (III)	-	-	LOQ	0.003	0.01
As (V)	-	-	LOQ	0.754	2.00

Worksheet #15: Project Action Limits and Laboratory-Specific Limits Table - #15h PFOA & PFOS

Matrix: Aqueous

Analytical Method: EPA 537

Analyte	PAL Reference 1 (µg/L)	PAL Reference 2 (µg/L)	PAL Reference 3 (µg/L)	Project Quantitation Limit Goal [1]	Primary Laboratory MDL (µg/L) [2]	Primary Laboratory LOQ (µg/L) [2]
PFOS	-	-	0.04	≤ ½PAL if possible; at least ≤ PAL	0.00085	0.0002
PFOA	-	-	0.02	≤ ½PAL if possible; at least ≤ PAL	0.00054	0.0002

1 The project quantitation limit goal will be set at the analyte LOQ – the analyte is for information purposes only and is not a cleanup objective.

2 Primary laboratory will be TestAmerica, Chicago; no secondary laboratory selected at this time (refer to Worksheets #19 &#30).

Worksheet #17: Sampling Design and Rationale

The overall approach of the Corrective Measures Implementation (CMI) Work Plan is to complete the required tasks for the design, construction and operation of the corrective measures concurrently with the process necessary for redevelopment of the Site. For proper implementation of corrective measures and redevelopment to occur with long-term sustainable effects, supplemental studies, surveys and investigations will be required. Furthermore, once remedial actions have taken place sampling events and monitoring will be required for performance monitoring and achievement of meeting cleanup goals.

In general, studies will rely upon previously collected data to model or conclude new information, surveys will rely upon non-intrusive field activities and investigations will rely upon intrusive field activities. These information gathering mechanisms will provide means for remedial design optimization and redevelopment constructability planning. This approach will result in a phased remedial design focused on compliance objectives during early stages of engineering, planning and site preparation work; and followed by long-term remedial objectives during and after construction of the future buildings slated for redevelopment. For the purposes of the CMI Work Scope the following sampling design have been developed and discussed in the CMI Workplan.

Baseline Groundwater Sampling

Prior to performing the Source Area soil excavation and stabilization work, a baseline groundwater monitoring event will be performed. This work can be performed in concert with the geotechnical investigation. The purpose of the groundwater monitoring event shall be for the following objectives:

Evaluate the efficacy of the 2015 remedial pilot test injection events and measure any changes in geochemistry.

- Evaluate groundwater conditions associated with the Source Areas, to determine whether sulfide mineral (iron/arsenic) precipitation conditions exists, iron oxide complexes/sulfate mineral dissolution conditions exist (arsenic liberation) and determination of potential arsenic dissolution based on future remedial actions.
- Apply the field measurements/laboratory analyses towards updated fate and transport model preparation.
- Confirm the amendment dosage associated with Source Area In-Situ soil Stabilization/Solidification.
- Utilize the field measurements, laboratory analyses and modeling output for optimizing the groundwater remediation work plan.

The following preparatory tasks will be performed to confirm reliable groundwater data essential for proper evaluation prior to the baseline groundwater monitoring event.

Groundwater Sampling

Upon completion of well installation, survey, and development/reconditioning work, and prior to the start of the Source Area unsaturated fill/ saturated fill ISS work, a sitewide baseline groundwater monitoring event will be performed. A total of 67 pre-existing and proposed monitoring wells will be sampled for this monitoring event as presented in tabular form on **Table 7** and locations indicated on **Figure 8B:** Proposed Groundwater Monitoring Well Network within the CMI Work Plan. University of Waterloo wells, piezometers, injection wells and any other diagnostic groundwater well will be excluded from this baseline monitoring event. The following wells will be utilized for the baseline monitoring event:

- Monitoring Wells: MW-10S (proposed, MW-10D (proposed), MW-11S (proposed), MW-11D (proposed), MW-15S (proposed), MW-15D (proposed), MW-19S (proposed), MW-19D (proposed), MW-21S (proposed), MW-21D (proposed) MW-22S (proposed), MW-22D (proposed), MW-23S (proposed), MW-23D, MW-24S (proposed), MW-24D, MW-25S (proposed), MW-25D, MW-30S, MW-30D, MW-34S, MW-34D, MW-35, MW-35D, MW-41S, MW-41D, MW-42S (proposed), MW-42I (proposed), MW-42D (proposed), MW-43S (proposed), MW-43D, MW-46S, MW-46D, MW-47S, MW-47D, MW-52S, MW-52D, MW-53S, MW-53D, MW-54S, MW-54D, MW-55S, MW-55D, MW-57S (proposed), MW-57I (proposed), MW-57D (proposed), MW-58S (proposed), MW-58I (proposed), MW-58D (proposed), MW-59S (proposed), MW-59D (proposed), MW-60S (proposed), MW-60D (proposed), MW-61S (proposed), MW-62D (proposed), MW-63S (proposed), MW-63D

(proposed), MW-64S (proposed), MW-64D (proposed) MW-65S (proposed), MW-65D (proposed), MW-66S (proposed), MW-66D (proposed), MW-67S (proposed), MW-67D (proposed), MW-68S (proposed), MW-68D (proposed), MW-69S (proposed), MW-69D (proposed), MW-70S (proposed), MW-70D (proposed), MW-71S (proposed) and MW-71D (proposed).

- Permeable Reactive Barrier Wells: PRB-10S (proposed), PRB-10D, PRB-13S, PRB-13D, PRB-14S, PRB-14D, PRB-15S, PRB-15D, PRB-16S (proposed), PRB-16D, PRB-17S (proposed), PRB-17D, PRB-18S, PRB-18D, PRB-19S, and PRB-19D.

Water Level loggers will be temporarily removed from wells identified in the groundwater monitoring network, prior to the start of the sample collection work. Sample collection will be performed utilizing USEPA Low Flow/Volume Protocols and Procedures. A solinst or equivalent water level meter will be installed in the well prior to the start of the low-flow purge, to measure physical and geochemical parameters (ORP, pH, Specific Conductivity) will be measured and recorded for groundwater low-flow stability confirmation and utilization for potential iron and sulfate complex mineralization/sorption and/or dissolution conditions within the water table aquifer. Collected groundwater samples will be containerized within laboratory prepared and preserved.

Groundwater Sampling Procedures

The USEPA Low-Flow/Volume groundwater purging, and sample collection is a method that reduces well drawdown mixing and formation stress, isolates stagnant water above the well screen, and reduces sample turbidity which improves sample accuracy. Groundwater samples collected by this methodology represents naturally mobile metal constituents in groundwater and not stagnant water within the well casing or mobilized colloids or other impurities generated by high-volume purging. The actual purge volume is based on stabilization of physical and chemical parameters during said low-flow purging. The procedures to perform low flow groundwater sampling will be implemented in accordance with SOP-15 indicated on Worksheet 21 and included as Attachment A.

Water Level loggers will be temporarily removed from wells identified in the monitoring well network, prior to the start of the sample collection work, and replaced once the sample collection work is completed. Sample collection will be performed utilizing USEPA Low Flow/Volume Protocols and Procedures. The low flow sampling assembly will consist of a high performance, stainless steel, variable flow rate submersible pump (QED Model Power Pro ESP or equivalent) with LDPE discharge tubing. The tubing outlet will be connected to a plastic flow control valve/flow splitter, with a dedicated outlet directing flow for sample collection and a separate outlet directing reduced purge flow to a water quality multimeter positioned with a flow-thru cell. The pump and tubing will be installed within the well, at or proximal to the middle of the reported well screen interval, a minimum of 2 hours prior to initiating the low-flow minimal volume purge, aquifer stabilization and sample collection work. The purpose of this step is to minimize aquifer disturbance and in-situ well water mixing, pursuant to Federal and State low-flow sample collection protocols and procedures. A Solnist or equivalent water level meter will be installed concurrent with the submersible pump and tubing installation, to measure the extent of water table drawdown due to the resultant low-flow purge.

Prior to connecting the pump effluent tubing to the parameter meter assembly, the pump will be engaged, and flow rate controlled via an at-grade flow controller. After the flow rate is established, the effluent tubing will be connected to the water quality meter/ flow-thru cell assembly and low-volume purging will proceed. Stabilization measurements will be measured and recorded every 5 minutes of pump operation to determine whether parameter stabilization is achieved (water quality readings should be measured within the specified criteria over 3 consecutive readings 5 minutes apart). The following USEPA water quality stabilization indicator parameter criteria (ASTM Standard D6771-02) will be utilized:

Parameter	**Stabilization Criteria**
pH	Difference of ± 0.2
Specific Electric Conductance	Difference of ± 3%

Temperature	Difference of 0.5 degrees Celsius
Turbidity	± 10% (when turbidity is greater than 10 NTUs)
Oxidation-Reduction Potential (ORP)	± 20 millivolts (mV)
Dissolved Oxygen (DO)	10% or ± 0.2 mg/l (whichever is greater)

Calibration standards for the equipment utilized and the sampling procedures for this work are presented in Worksheet 22.

Groundwater Sampling and Analysis

After aquifer stability is achieved (pursuant to the defined USEPA low-flow sample collection protocols and procedures), groundwater sample collection will proceed. With the pump continuing to operate, the plastic flow control valve/flow splitter will be rotated, directing flow towards the dedicated sample collection outlet, and sample collection will commence. Total metal and additional inorganic parameters will be collected first, followed by the collection of dissolved metal samples. Prior to the collection of dissolved metals samples, a 0.45-micron filter will be installed at the sample collection outlet. Collected groundwater samples will be containerized within laboratory prepared and preserved bottles and glassware, immediately placed within an iced cooler and transported to a certified ELAP accredited environmental laboratory under standard chain of custody protocols and procedure for analyses. The following laboratory analyses will be performed on the resultant groundwater samples:

- Total Arsenic, Lead, Iron, Cadmium, Zinc, Phosphorus and Calcium by USEPA Test Method 6010B.
- Perfluoro octonoic acid (PFOA) and Perfluoro octane sulfuric acid (PFOS) by USEPA Test Method 537.
- Speciated Arsenic (As III/As V) by USEPA Test Method 1632.
- Sulfate by USEPA Test Methods 375.3 (or 9056).
- Sulfide by USEPA Test Method 376.1.
- Total Organic Carbon by USEPA Test Method 415.1 (or 9060).
- Alkalinity by USEPA Test Method 310.2.
- Bicarbonate by USEPA Test Method SM 2320 B.
- Chloride by USEPA Test Method 300.0.
- Nitrate by USEPA Test Method 353.1 (or 9056).
- Nitrite by USEPA Test Method 354.1

These analyses and the recorded physical and geochemical parameters (ORP, pH, DO, Specific Conductivity) will be utilized to determine:

- Monitor the progress of the 2016 Pilot Test ISCR injection work.
- Establish baseline metal contaminant concentrations in groundwater prior to the Source Area excavation/ISS work.
- Evaluate potential iron and sulfate complex mineralization/sorption and/or dissolution conditions within the water table aquifer.
- Utilize the field measurements and laboratory analyses for modified (“sliding) Stiff geochemical evaluation, contaminant Fate and Transport model preparation and Stormwater input model calculations.

The sampling and analysis for this activity will comply with USEPA protocols and procedures to demonstrate laboratory reporting duplicity, analysis accuracy and precision as detailed in Worksheet 20.

Source Area Excavation, ISS and Preliminary Groundwater Treatment Performance Monitoring

The performance groundwater monitoring events will be performed identical to the protocols and procedures as the baseline groundwater monitoring event to the extent practical. The following performance monitoring events are proposed, based on the type of remedial work performed and remedial event completion:

- Post Source Area Removal/ISS (Northern Area): Four monitoring events, conducted one-month, two months, four months and six months after the completion of the work.

- Post Source Area Removal/ISS (Northern Area): Four monitoring events, conducted one-month, two months, four months and six months after the completion of the work.

- Post Preliminary Groundwater Treatment: Three monitoring events, conducted four-months, eight-months and 12-months after the completion of the work.

If the monthly groundwater monitoring schedule overlaps seasonal cold weather periods where ambient temperatures are below 32 degrees Fahrenheit, then monthly events scheduled will be rolled back and continued once ambient temperatures are above that threshold. Please note that due to the compressed timeframe to conduct the abovementioned remedial events, the resultant performance monitoring events are staggered and not concurrent with each remedial event.

The purpose of the monitoring events is to monitor and evaluate the efficacy of the Source Area removal work and ISS work, concurrent with the remedial progress related to the preliminary groundwater injection work. The findings of the groundwater quality review will be utilized to validate and optimize the next phase of the work for long-term groundwater treatment design. Applicability of historic groundwater remediation approaches proposed to the USEPA will be assessed based on the data review. Potential revised groundwater treatments methods may be proposed to the USEPA as a result of the data evaluation. Specific examination tasks will include, but not limited to the following tasks:

Scrutinize potential changes in geochemistry and contaminant concentrations in groundwater downgradient from the former Source Areas.

- Evaluate geochemistry/contaminant changes in groundwater for stability and/or rebound.

- Continue to monitor the progress of the 2015 groundwater treatment Pilot Test work, with concurrent examination of potential enhancement and/or diminishment of pilot test efficacy related to the ISS remedy.

- Determination of source-area related groundwater contaminant plume cessation based upon potential stabilization of contaminated saturated soil related to the ISS remedy, with concurrent evaluation of potential contaminant plume rebound over time.

The performance groundwater monitoring events will be performed in the same manner and procedures as the pre-treatment baseline groundwater monitoring, to the extent practical. It is expected that groundwater samples will be collected from the following pre-existing monitoring wells and new monitoring wells installed as part of the Source Area fill/soil excavation and ISS work and redevelopment preparation work:

- Monitoring Wells: MW-15, MW-19, MW-19S (proposed), MW-21, MW-21S (proposed), MW-22, MW-22S (proposed), MW-23, MW-23S (proposed), MW-24, MW-24S (proposed), MW-25, MW-25S (proposed), MW-30, MW-30D, MW-34S, MW-34D, MW-35, MW-35D, MW-41S, MW-41D, MW-43, MW-43S (proposed), MW-

46S, MW-46D, MW-47S, MW-47D, MW-52S, MW-52D, MW-53S, MW-53D, MW-54S, MW-54D, MW-55S, MW-55D, MW-57S (proposed), MW-57D (proposed), MW-58S (proposed), MW-58D (proposed), MW-59S (proposed), MW-59D (proposed), MW-60S (proposed), MW-60D (proposed), MW-61S (proposed), MW-62D (proposed), MW-63S (proposed), MW-63D (proposed), MW-64S (proposed), and MW-64D (proposed).

- Permeable Reactive Barrier Wells: PRB-10, PRB-10S (proposed), PRB-13, PRB-13S, PRB-14, PRB-14S, PRB-15, PRB-15S, PRB-16, PRB-16S (proposed), PRB-17, PRB-17S (proposed), PRB-18S, PRB-18D, PRB-19S, and PRB-19D.

USEPA low-flow groundwater purging, aquifer stabilization and sample collection protocols and procedures, equivalent to the protocols and procedures utilized during the baseline groundwater monitoring event will be employed. Groundwater samples will be collected, recorded, prepared and transported under chain of custody procedure to the environmental laboratory in an identical manner as carried out during the baseline groundwater monitoring event. Physical and geochemical parameters (ORP, pH, DO, Specific Conductivity) will be measured from each well in the monitoring network and recorded. The following laboratory analyses will be performed on the resultant groundwater samples:

- Total Arsenic, Lead, Iron, Cadmium, Zinc, Phosphorus and Calcium by USEPA Test Method 6010B.
- Speciated Arsenic (As III/As V) by USEPA Test Method 1632.
- Sulfate by USEPA Test Methods 375.3 (or 9056).
- Sulfide by USEPA Test Method 376.1.
- Total Organic Carbon by USEPA Test Method 415.1 (or 9060).
- Alkalinity by USEPA Test Method 310.2.
- Bicarbonate by USEPA Test Method SM 2320 B.
- Chloride by USEPA Test Method 300.0.
- Nitrate by USEPA Test Method 353.1 (or 9056).
- Nitrite by USEPA Test Method 354.1
- PFOA and PFOS by USEPA Test Method 537 (If warranted as per results of Baseline event)

The sampling and analysis for this activity will comply with USEPA protocols and procedures to demonstrate laboratory reporting duplicity, analysis accuracy and precision as detailed in Worksheet 20.

Post-Treatment Sampling and Waste Characterization

Post-treatment sampling and analysis will be performed from each pile to confirm that it has been rendered nonhazardous and that it meets the disposal facilities acceptance criteria. Post-treatment sampling will be conducted using test pits and consist of a randomized single grab sampling procedure from various locations across and within each pile. A total of 10 grab samples will be collected from each 1,000 tons of material. A single composite sample will be generated from the 10-point grab samples collected by homogenizing mixing the sample in a stainless-steel decontaminated bowl and breaking that sample into 2 sampling jars bearing the identical sampling information. One grab sample will be randomly selected from the 10 grab sample aliquots for sampling utilizing an EnCore© vial, Terra Core™ vial, or equivalent.

This collection method is consistent with the USEPA recognized stratified random sampling approach for collection of a representative sample of waste piles. All post-treatment samples collected will be containerized and sent to an Indiana accredited Laboratory as per sample procedures, chain-of-custody protocols as outlined SOP-19, SOP-23 and SOP-24 as presented in Worksheet 21. Initial post-treatment sample analysis that will be performed on 1 of the 2

composite sample containers will consist of the preparation of a leachate sample using USEPA SW-846 Method SW1311.

This collection method is consistent with the USEPA recognized stratified random sampling approach for collection of a representative sample of waste piles. All post-treatment samples collected will be containerized and sent to an Indiana accredited Laboratory as per sample procedures, chain-of-custody protocols and health and safety considerations outlined in the QAPP. Initial post-treatment sample analysis that will be performed on 1 of the 2 composite sample containers will consist of the preparation of a leachate sample using USEPA SW-846 Method SW1311.

Analysis will be performed on the leachate sample for the COC (lead, arsenic or cadmium). If the testing of the leachate sample indicates that the sample is no longer classified as hazardous waste for toxicity (demonstrating that the stabilization was effective), the following steps will be initiated. These steps are predicated upon the need to have the successfully stabilized nonhazardous material tested and qualified for off-site disposal.

1. The remaining leachate sample will be analyzed for waste characterization purposes for the following method target analytes:

    - TCLP Metals (the remaining 5 of the 8 RCRA)

2. A second sample volume will be prepared from the composite sample material secured utilizing 4oz Amber Jar with septa will be tested for Total Volatiles.

3. A third sample volume will be prepared from the composite sample material utilizing 8oz clear Jar with septa will be tested for Total Semi-volatiles, PCBs, Total Cyanides and Sulfides.

Worksheet #18: Sampling Locations and Methods

Sampling Program & Matrix [1]	Sampling Location	Number of Samples	Sample Collection Depth	Rationale	Analytical Group[2]	Sampling SOP Reference
Baseline Groundwater Sampling	Utilized pre-existing and proposed onsite monitoring well locations	127 Samples in total • 97 Primary Samples • 30 QA/QC Samples	Well screens (approximately center of well screens as per USEPA low-flow sample collection procedure) depth varies; well screen depths and extents presented in CMI WP	Evaluate the efficacy of the 2015 remedial pilot test injection events and measure any changes in geochemistry. Evaluate groundwater conditions associated with the Source Areas, to determine whether sulfide mineral (iron/arsenic) precipitation conditions exists, iron oxide complexes/sulfate mineral dissolution conditions exist (arsenic liberation) and determination of potential arsenic dissolution based on future remedial actions. Confirm the amendment dosage associated with Source Area In-Situ soil Stabilization/Solidification. Utilize the field measurements, laboratory analyses and modeling output for optimizing the groundwater remediation work plan. Evaluate groundwater samples collected from the proposed and existing remedial supply wells, for chemical of concern (COC) concentrations and chemical/physical properties. Screen the monitoring network for non-COC, emerging contaminants.	• Total Arsenic, Iron, Cadmium, Lead, Zinc, and Calcium by USEPA Test Method 6010B. • Phosphorus by USEPA Tests Method SM 4500. • PFOA and PFOS by USEPA Tests Method 537. • Speciated Arsenic (As III/As V) by USEPA Test Method 1632. •Sulfate by USEPA Test Methods 375.3 (or 9056). • Sulfide by USEPA Test Method 376.1. • Total Organic Carbon by USEPA Test Method 415.1 (or 9060). • Alkalinity by USEPA Test Method 310.2. • Bicarbonate by USEPA Test Method SM 2320 B. • Chloride by USEPA Test Method 300.0. • Nitrate by USEPA Test Method 353.1 (or 9056). • Nitrite by USEPA Test Method 354.1.	SOP-10 SOP-15

Sampling Program & Matrix [1]	Sampling Location	Number of Samples	Sample Collection Depth	Rationale	Analytical Group[2]	Sampling SOP Reference
Remedial Performance Monitoring Groundwater Sampling	Utilized pre-existing and proposed onsite monitoring well locations	127 Samples in total • 97 Primary Samples • 30 QA/QC Samples	Well screens (approximately center of well screens as per USEPA low-flow sample collection procedure) depth varies; well screen depths and extents presented in CMI WP	Evaluate geochemistry/contaminant changes in groundwater for stability and/or rebound. Continue to monitor the progress of the 2015 groundwater treatment Pilot Test work, with concurrent examination of potential enhancement and/or diminishment of pilot test efficacy related to the ISS remedy. Determination of source-area related groundwater contaminant plume cessation based upon potential stabilization of contaminated saturated soil related to the ISS remedy, with concurrent evaluation of potential contaminant plume rebound over time.	• Total Arsenic, Iron, Cadmium, Lead, Zinc, and Calcium by USEPA Test Method 6010B. Phosphorus by USEPA Tests Method SM 4500. • PFOA and PFOS by USEPA Tests Method 537 (If warranted). • Speciated Arsenic (As III/As V) by USEPA Test Method 1632. •Sulfate by USEPA Test Methods 375.3 (or 9056). • Sulfide by USEPA Test Method 376.1. • Total Organic Carbon by USEPA Test Method 415.1 (or 9060). • Alkalinity by USEPA Test Method 310.2. • Bicarbonate by USEPA Test Method SM 2320 B. • Chloride by USEPA Test Method 300.0. • Nitrate by USEPA Test Method 353.1 (or 9056). • Nitrite by USEPA Test Method 354.1.	SOP-10 SOP-15

1 Details on the sampling and analysis program are outlined in the CMI Work Plan.

2 Analyte lists are presented on Worksheet #15

Worksheets #19 & 30: Sample Containers, Preservation, and Hold Times – Soil Matrix

TestAmerica Laboratories, Chicago
2417 Bond Street
University Park, IL 60484

Required Accreditations/Certifications: NELAP/Illinois
Sample Delivery Method: Provided by the Laboratory

Analyte/ Analyte Group	Matrix	Method/SOP [4]	Containers [1, 5] (number, size, and type)	Preservation [5]	Holding Time [3] (preparation/ analysis)	Data Package Turnaround
TCLP As, Cd & Pb (ICP)	Solid	EPA 6010B (See Worksheet #23 for laboratory-specific SOP designation)	4 -oz glass jar with Teflon lid	Cool to ≤ 6°C	Up to 180 days from extraction to analysis.	3 business days
TCLP RCRA Metals minus As, Cd, Pb	Solid	EPA 6010B (See Worksheet #23 for laboratory-specific SOP designation)	4 -oz glass jar with Teflon lid	Cool to ≤ 6°C	Up to 180 days from extraction to analysis.	10 business days
TCLP VOCs	Solid	EPA 8260B/1311 (See Worksheet #23 for laboratory-specific SOP designation)	Wide- mouth glass containers with Teflon-lined caps.	4 ± 2°C	Up to 14 days from extraction to analysis (if stored in darkness by lab at 4 ± 2°C	10 business days

Analyte/ Analyte Group	Matrix	Method/SOP	Containers [1, 5] (number, size, and type)	Preservation [5]	Holding Time [3] (preparation/ analysis)	Data Package Turnaround
TCLP SVOCs	Solid	EPA 8270D/1311 (See Worksheet #23 for laboratory-specific SOP designation)	8 oz glass	4 ± 2°C. Sealed zero headspace containers	14 days.	10 business days
TCLP Herbicides	Solid	EPA 8151/1311 (See Worksheet #23 for laboratory-specific SOP designation)	8 oz glass	4 ± 2°C	Up to 7 days from extraction to analysis (if stored in darkness by lab at 4 ± 2°C.	10 business days
TCLP Pesticides	Solid	EPA 8081/1311 (See Worksheet #23 for laboratory-specific SOP designation)	8 oz glass	4 ± 2°C	Up to 7 days from extraction to analysis (if stored in darkness by lab at 4 ± 2°C.	10 business days
TCLP Mercury	Solid	EPA 7074A/1311 (See Worksheet #23 for laboratory-specific SOP designation)	8 oz glass	4 ± 2°C	Up to 28 days from extraction to analysis (if stored in darkness by lab at 4 ± 2°C	10 business days

Analyte/ Analyte Group	Matrix	Method/SOP [4]	Containers [1, 5] (number, size, and type)	Preservation [5]	Holding Time [3] (preparation/ analysis)	Data Package Turnaround
Flashpoint	Solid	EPA D92 (See Worksheet #23 for laboratory-specific SOP designation)	A clear glass 8 oz wide jar (unpreserved)	None specified	None specified	10 business days
pH	Solid	EPA 9045D (See Worksheet #23 for laboratory-specific SOP designation)	4 -oz glass jar with Teflon lid	4°C	Sample must be analyzed on site immediately (within 15 minutes) after collection	10 business days
Sulfide	Solid	EPA 9031 (See Worksheet #23 for laboratory-specific SOP designation)	4 -oz glass jar with Teflon lid	4°C	Up to 7 days.	10 business days
Cyanide	Solid	EPA 9014 (See Worksheet #23 for laboratory-specific SOP designation)	4 -oz glass jar with Teflon lid	4°C	14 days from collection (if stored in darkness by lab at 4°C	10 business days

Worksheets #19 & 30: Sample Containers, Preservation, and Hold Times – Aqueous

TestAmerica Laboratories, Chicago
2417 Bond Street
University Park, IL 60484

Required Accreditations/Certifications: NELAP/Illinois
Sample Delivery Method: Provided by the Laboratory

Analyte/ Analyte Group	Matrix	Method/SOP [4]	Containers [1, 5] (number, size, and type)	Preservation [5]	Holding Time [3] (preparation/ analysis)	Data Package Turnaround
Total Metals - As,Ca, Cd, Fe, Pb, Zn	Aqueous	EPA 6010B (See Worksheet #23 for laboratory-specific SOP designation)	250-mL HDPE	HNO_3	180 days	10 business days
PFCs	Aqueous	EPA 537 (Modified) WS-LC-0025 (See Worksheet #23 for laboratory-specific SOP designation)	2 - 250 ml HPDE	Cool to 4 ± 2 C	14 days	30 business days
Total Phosphorus	Aqueous	EPA SM4500 PE (See Worksheet #23 for laboratory-specific SOP designation)	250-mL glass	H_2SO_4 and 4°C	28 days	10 business days
Chloride	Aqueous	EPA 9056A See Worksheet #23 for laboratory-specific SOP designation)	125-mL HDPE	4°C	28 days	10 business days

Analyte/ Analyte Group	Matrix	Method/SOP [4]	Containers [1, 5] (number, size, and type)	Preservation [5]	Holding Time [3] (preparation/ analysis)	Data Package Turnaround
Nitrate	Aqueous	EPA 9056 See Worksheet #23 for laboratory-specific SOP designation)	125-mL HDPE	4°C	48 hours	10 business days
Nitrite	Aqueous	EPA SM4500NO_2 See Worksheet #23 for laboratory-specific SOP designation)	125-mL HDPE	4°C	48 hours	10 business days
Sulfate	Aqueous	EPA 9060A See Worksheet #23 for laboratory-specific SOP designation)	125-mL HDPE	4°C	28 days	10 business days
Total Organic Carbon	Aqueous	EPA 9060A See Worksheet #23 for laboratory-specific SOP designation)	250-mL glass	H_2SO_4 and 4°C	28 days	10 business days
Alkalinity/ Bicarbonate Alkalinity	Aqueous	SM 2320B	250-mL HDPE	4°C	14 days	10 business days

Analyte/ Analyte Group	Matrix	Method/SOP [4]	Containers [1, 5] (number, size, and type)	Preservation [5]	Holding Time [3] (preparation/ analysis)	Data Package Turnaround
As (III) / As (V) Arsenic Speciation	Aqueous	EPA 1632 Mod. SOP2987	250 mL - HDPE, Teflon, PETG	Hydrochloric Acid to pH < 2, stored at 0-6°C from preservation to analysis	Immediate/ 28 Days from collection	10 business days

1 Sample bottleware will be in accordance with the EPA's "Specification and Guidance for Obtaining Contaminant-Free Sample Containers" (EPA 540/R-93/051; December 1992). Glass containers (if utilized) will be provided by the laboratory. The storage of bottleware at the Project location will be kept to a minimum; however, as the Project is under the direction of EPA Region 2, the New Jersey requirement to limit bottleware to 4 days on-site is not applicable.

2 If glass bottleware is utilized AND the sample will be frozen, the container should be filled no more than two-thirds (2/3) full to allow expansion during the freezing process.

3 Holding time is calculated from the date/time of sample collection to the date/time of sample preparation or sample analysis (depending on parameter). For sediment core sampling, the holding time will be calculated from the date/time of core opening, logging, and sub-sampling. If a sediment core sub-sample is preserved (i.e., frozen), sample preparation/analysis holding times will begin upon thawing of material.

4 Laboratory-specific SOPs in relation to the provided methods and associated extraction/cleanup procedures are provided in Worksheet #23.

5 Alternative bottle sizes and preservatives may be utilized as deemed appropriate by the laboratory and field staff and Lab.

Worksheet #20: Field QC Summary

Field QC samples to be collected over the duration of the project will include:

Field Environmental Duplicate Samples

Duplicate environmental samples will be analyzed to evaluate the reproducibility and representativeness of the sampling procedures. Duplicate samples will be collected at a rate of five percent of the total samples for each specific matrix for each type of chemical analysis (i.e., one duplicate for up to every 10 samples). The duplicate samples will be collected as additional volume from the same location/sampling interval and at the same time as the primary environmental sample; however, the duplicated samples will be "coded" in such a manner that the laboratory will not be able to determine of which original field sample they are duplicated (i.e., "blind" duplicates). An explanation of the duplicate "coding" must be written in the field logbook. Preservation and analysis of duplicate samples will be identical to those for the associated environmental samples. Precision of field data will be evaluated based on the calculation of RPD, with acceptance criteria outlined in Worksheet #12. Field environmental duplicates will not be collected for samples associated with waste characterization analyzes or general soil chemistry/geotechnical parameter testing.

Matrix Spikes

Matrix spike/matrix spike duplicate (MS/MSD) samples (also known as spike/duplicate samples or laboratory fortified samples) will be used to assess precision and accuracy of the analytical methods. In this procedure, additional aliquots of an actual field sample are collected at a specific location, and then "spiked" in the laboratory by the addition of known amounts of an analyte or analytes. These samples are then analyzed identically to the field samples. A comparison of the resulting concentration to the original sample concentration, and among two "spike" sample concentrations, provides information on the ability of the analytical procedure to generate a correct result from the sample.

Additional volume for MS/MSD samples will be collected in the field at a rate of five percent, and will be analyzed on a per batch basis, with up to 10 samples constituting a batch. The validity of MS/MSD %R and RPD values will be determined using the acceptance criteria stated in Worksheet #12.

Field Equipment Rinsate Blanks

A field blank will be collected to evaluate the potential for residual chemical contamination of environmental samples from inadequate decontamination of field equipment. Field blanks will be collected by pouring laboratory-supplied deionized (DI) water over and/or through non-dedicated, decontaminated equipment, and collecting the rinsate. Field blanks will be collected at a frequency of one per decontamination event, not to exceed one per day, per type of sampling equipment and event, for chemical parameters (e.g., field blanks are not necessary for geotechnical or water quality parameters). Analysis of field blanks will be performed using the same methodology as the associated environmental samples, and the blanks will be preserved as indicated in the applicable methods. Sufficient equipment will be available and field activities scheduled, as possible, to minimize the number of field blanks required. The validity of Quantitative Limits (QL) and Reporting Limit/LOQ values will be determined using the acceptance criteria stated in Worksheet #12.

Trip Blanks

A trip blank serves to detect possible cross-contamination of samples resulting from handling, storage and shipment procedures for volatile parameters (e.g., GRO). Trip blanks consist of volatile organic analysis (VOA) vials filled with DI water prior to initiation of daily field activities and preserved accordingly, which accompany the day's aqueous environmental samples (for volatile parameters) through collection and shipment to the laboratory. In addition, trip blanks are stored by the laboratory under the same conditions as the environmental samples. A trip blank must accompany each cooler containing aqueous samples for volatile parameter analysis and will be analyzed identically to the associated environmental samples. All aqueous samples will be consolidated in one cooler for daily shipment, as possible, to minimize the number of trip blanks required for the field program. At this time, no aqueous samples for volatile parameters are planned for the Project, and no trip blanks will be required for the PDI field program.

Cooler Temperature Blanks

A cooler temperature blank will be included in each cooler of samples shipped from the Project to verify that the cooler temperature has been maintained at the required temperature (e.g., 4 ± 2°C; see Worksheet #19 for preservation requirements per analyte). A vial will be filled with either potable or DI water, unpreserved, and labeled with "Cooler Temperature Indicator" and the date. The laboratory will record the temperature of the blank water on the chain of custody form immediately upon cooler arrival.

Performance Evaluation (PE) Samples

PE samples (also known as proficiency test [PT] samples) are samples provided to the laboratory for the direct purpose of demonstrating that the laboratory, and even to a specific individual analyst, can successfully analyze a sample within acceptable limits. The PE sample can be obtained from a provider or prepared by a chemist separate from the analyst. The true value of the PE sample must remain unknown by the analyst. Successful analysis of PE samples in the laboratory's fields of testing is a requirement for the laboratory to maintain certification.

Worksheet #20: Field QC Summary

Sampling Program	Matrix	Analytical Group	Primary Samples	Field Duplicates *	Matrix Spike/Matrix Spike Duplicate	Field Equipment Rinsate Blanks	Trip Blanks*	Cooler Temperature Blanks*	Split Samples***	PE Samples*	Total Number
Baseline Assessment Groundwater Sampling Event											
Groundwater Sample Collection	Aqueous (Water)	Total Arsenic, Iron, Lead, Cadmium, Zinc, Phosphorus and Calcium	97	One per every 10 project samples NA	Frequency one set (two samples per set) per twenty (10) groundwater samples collected: three MS/MSD sets (10 samples) estimated)	Frequency of one (1) equipment blank sample per sample collection day: ten (10) samples estimated	NA	One per cooler NA	USEPA may request and collect split sampling for QA purposes; sufficient mass of matrix material shall be collected as appropriate for EPA split sampling requirements NA	Only if determined to be necessary****	127
		PFOA and PFOS									
		Speciated Arsenic (As III/As V)									
		Sulfate									
		Sulfide									
		Total Organic Carbon									
		Chloride									
		Nitrate									
		Nitrite									
		Alkalinity			NA						
		Bicarbonate			NA						
		Conductivity, temperature, ORP, DO, pH, optical turbidity,	97 (concurrent with low-flow sample collection)	NA	NA	NA	NA	NA	NA	NA	97

Sampling Program	Matrix	Analytical Group	Primary Samples	Field Duplicates *	Matrix Spike/Matrix Spike Duplicate	Field Equipment Rinsate Blanks	Trip Blanks*	Cooler Temperature Blanks*	Split Samples***	PE Samples*	Total Number
Post-Remedial Groundwater Sampling Event/s (Below is per event total of 4 events)											
Groundwater Sample Collection	Aqueous (Water)	Total Arsenic, Iron, Lead, Cadmium, Zinc, Phosphorus and Calcium	97 (may be reduced based on Baseline sample data/ EPA Approval)	One per every 10 project samples NA	Frequency one set (two samples per set) per twenty (10) groundwater samples collected: three MS/MSD sets (10 samples) estimated)	Frequency of one (1) equipment blank sample per sample collection day: ten (10) samples estimated	NA	One per cooler NA	USEPA may request and collect split sampling for QA purposes; sufficient mass of matrix material shall be collected as appropriate for EPA split sampling requirements NA	Only if determined to be necessary****	127
		PFOA and PFOS									
		Speciated Arsenic (As III/As V)									
		Sulfate									
		Sulfide									
		Total Organic Carbon									
		Chloride									
		Nitrate									
		Nitrite									
		Alkalinity			NA						
		Bicarbonate			NA						
		Conductivity, temperature, ORP, DO, pH, optical turbidity,	97 (concurrent with low-flow sample collection)	NA	NA	NA	NA	NA	NA	NA	97

Notes:

* = See definition of QC samples on subsequent pages of this worksheet

** = Split samples will be collected to determine the degree of comparability between laboratories as deemed necessary when multiple subcontractors are used for a sample matrix/fraction over the course of the Project. EPA's oversight team will be collecting a certain number of split samples for QA/enforcement purposes based on EPA's Oversight QAPP.

*** = In addition to the annual reference/PE samples that are required for a laboratory to maintain certification, Project-specific PE samples may be used to monitor laboratory performance. These Project-specific PE samples (procured from an approved vendor) will be submitted to a laboratory if it appears that there is a recurring issue of insufficient quality based on verification and/or validation review of the data. This determination will be made by the IEC Project Team, in concert with EPA Region 5. If Project-specific PE samples are submitted to a laboratory, the laboratory will be required to provide acceptable results prior to receiving more samples.

Worksheet #21: Field SOPs

SOP No.	SOP Title	Originating Organization of SOP	Equipment	Modified for Project Work? (Y/N)	Associated Work Element(s)
01	Field Documentation	Impact Environmental	N/A	N	Daily entries for all field activities, Field log Notebook and Photographic Logging
02	Field Procedures Change Management	Impact Environmental	N/A	Y	Protocols and Communication for Modifications to Field Procedures based on existing conditions
03	Site Reconnaissance, Preparation and Restoration	Impact Environmental	N/A	Y	Documenting Field Conditions for pre-activity purposes
04	Utility Clearance for Intrusive	Impact Environmental	Magnetic Utility Finder/ Metal detector/ Other	Y	Former and Live Utility Awareness Public Utility Markouts – 811 Onsite Utility Markouts Prior to Intrusive Activities

SOP No. [1]	SOP Title	Originating Organization of SOP	Equipment Type	Modified for Project Work? (Y/N)	Associated Work Element(s)
05	Geophysical Survey	Impact Environmental	Ground-penetrating radar (GPR); measurement tape	Y	Evaluation of potential below grade structures and utilities Marking potential structures prior to intrusive work
06	Geographic Land Surveying	Impact Environmental	GPS Surveying Equipment GIS	Y	Geospatially marking all sample locations and field measurements Data Input for field measurements and reporting
07	Global Positioning Satellite System (GPS) Surveying	Impact Environmental	GPS Handheld system Rover Trimble / GeoXT	Y	GPS Data Acquisition and Management Application of GPS to field tracking and project decisions
08	LVA Manufacturing and Use	Impact Environmental	Scalper and Crusher, Heavy Equipment	Y	LVA Construction, Manufacturing and Specification LVA Onsite Usage and Application
09	Well Decommissioning and Abandonment	Impact Environmental	Hand tools/ Grout pump	Y	Decommissioning and removing onsite monitoring wells

SOP No. [1]	SOP Title	Originating Organization of SOP	Equipment Type	Modified for Project Work? (Y/N)	Associated Work Element(s)
10	Monitoring Well/Piezometer Installation	Impact Environmental	Hand tools/ Geoprobe and tooling/	Y	Groundwater Well Installation Procedures and Specifications Well Protection and Completion
11	Monitoring Well Development	Impact Environmental	Peristaltic pump, tubing, IDW Container	Y	Monitoring Well Development Purging Procedures IDW Considerations
12	Groundwater Level Measurement	Impact Environmental	Water level meter/ Interface probe	Y	Water level gauging and usage
13	Field Water Quality Measurements and Calibration	Impact Environmental	Horiba U-50	Y	Calibration and Procedures for Horiba for field water quality data reading and recording
14	Continuous Water Level Monitoring	Impact Environmental	Vented Pressure Transducer and Handheld Data Logger	Y	Water Column gauging for continuous reading and trend analysis
15	Groundwater Sampling Procedures	Impact Environmental	Low-flow/ Peristaltic pump, tubing, IDW Container	Y	Water Column Sampling Procedures IDW Considerations

SOP No. [1]	SOP Title	Originating Organization of SOP	Equipment Type	Modified for Project Work? (Y/N)	Associated Work Element(s)
16	ISCF – Injection Procedures	Impact Environmental	Remediation System Trailer, Polyethylene Tanks, Heat Wraps, Inline mixer/ pumps, Well-head assembly	Y	Preliminary Groundwater Treatment
17	Hollow Stem Auger and Direct Push Drilling Methods	Impact Environmental	Geoprobe - HSA drill rig, rotary drill rig	Y	Borehole Installation Procedures IDW Considerations
18	Boring Log Completion, Soil Classification, and Logging	Impact Environmental	N/A	N	Protocols and Standardized Method on Recording Field Activity, Soil Conditions and Geologic Parameters
19	Surface and Subsurface Soil Sampling	Impact Environmental	Geoprobe, Hand tools/ Other	Y	Soil Borehole Column Sampling Protocols IDW Considerations
20	Pneumatic Slug Test (PST) Procedures/Protocols	Impact Environmental	Geoprobe/ Other	Y	Installation and Procedures of PST
21	Investigative/ Remedial Derived Waste (containerized) storage/containment	Impact Environmental	N/A	Y	Guidelines and protocols for IDW and RDW Management

SOP No. [1]	SOP Title	Originating Organization of SOP	Equipment Type	Modified for Project Work? (Y/N)	Associated Work Element(s)
22	Equipment Decontamination Procedures	Impact Environmental	N/A	Y	Equipment decontamination and containerization of wastes
23	Sample Identification and Nomenclature	Impact Environmental	N/A	Y	Sample Identification Rational and Scheme
24	Sample Handling and Custody	Impact Environmental	N/A	Y	Sample Handling responsibilities, protocols and guidelines
25	In-Situ Stabilization Procedures	Impact Environmental	Backhoe, Excavator, Grout Pump, Feeder	Y	In-situ stabilization of saturated soil/fill within source areas
26	Ex-Situ Source Area Material Treatment	Impact Environmental	Backhoe, Excavator	Y	Procedures and guidelines for Ex-situ Soil Treatment;

SOP No. [1]	SOP Title	Originating Organization of SOP	Equipment Type	Modified for Project Work? (Y/N)	Associated Work Element(s)
27	Soil Transport and Off-site Disposal	Impact Environmental	Hand Auger, Payloader and Triaxle	Y	Procedures, Protocols and Guidelines for Waste Characterization Sampling, Facility Approval, Transport and Disposal of Source Area Material

1 Field SOPs are presented in **Appendix B**

Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection

Field Equipment	Activity	Frequency	Acceptance Criteria		Corrective Action	Responsible Person	Field Activity Reference	Associated SOP Reference [1]
Water Quality Meter [Horiba or equivalent]	Calibration/ Check [standard solutions]	Prior to day's activities; end of day's activities; anytime anomaly suspected	DO	± 0.1 mg/L	Clean probe; replace battery; replace membrane; replace probe; recalibrate	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	CMI WP - *Water Column Sampling*	UFP-QAPPP SOP-13 Operation Manuel
			ORP	± 1 mV				
			pH	+/- 0.01 SU				
			Salinity	± 1 ppth				
			Specific Conductivity	± 0.01 mS/cm				
			Temperature*	± 0.1 °C				
			TDS	± 0.1 mg/L				
			Turbidity	± 0.1 NTU				
	Maintenance [check/replace battery]	Prior to day's activities; anytime anomaly suspected	Same as above for Calibration		Replace battery; replace probe; recalibrate			
	Inspection [visual]	Prior to day's activities	No defects noted		Replace probe; recalibrate			
PID	Calibration [standard gases]	Prior to day's activities; end of day's activities; anytime anomaly suspected	± 5 ppm		Clean probe; replace battery; replace probe; recalibrate	Impact Environmental Field Team Leader (daily) Impact Environmental HSO (weekly)	HASP - *Air Monitoring*	UFP-QAPPP SOP-16 Operation Manuel
	Maintenance [check/replace battery]	Prior to day's activities; anytime anomaly suspected	Same as above for Calibration		Replace battery; replace probe; recalibrate			
	Inspection [visual]	Prior to day's activities	No defects noted		Replace probe; recalibrate			
GPS (Trimble Geo 7x Handheld GPS Unit)	Calibration [check against known designated benchmarks points]	Prior to day's activities; end of day's activities; anytime anomaly suspected	GPS – real-time positional accuracies at the rover on the order of ±0.1 foot both horizontally and vertically		Replace battery; replace instrument; recalibrate	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	CMI WP - *GPS Data Acquisition for field Measurements, Source Area Boundary and Project Tracking*	UFP-QAPPP SOP-07 Operation Manuel
	Maintenance [check/replace battery]	Prior to day's activities; anytime anomaly suspected	Same as above for Calibration		Replace battery; replace instrument; recalibrate			
	Inspection [visual]	Prior to day's activities	No defects noted		Replace instrument; recalibrate			

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	Field Activity Reference	Associated SOP Reference [1]
Water Level Indicator	Calibration [check against known calibrated measurement]	Anytime anomaly suspected or damage noted	± 0.01 foot	Replace	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	CMI WP - *Water Column Gauging*, *Sampling*	UFP-QAPPP SOP-12 Operation Manuel
	Inspection [visual]	Prior to day's activities	No defects noted	Replace			
Peristaltic, bladder, bilge or equivalent pump	Inspection [visual]	Prior to day's activities	No defects noted	Replace	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	CMI WP - *Water Column Sampling*	UFP-QAPPP SOP-13 Operation Manuel
	Testing [check operation of motor]	Prior to day's activities	No defects noted	Replace			
Hand tools; auger	Inspection [visual]	Prior to day's activities	No defects noted	Replace	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	CMI WP- *Ex-situ stockpile sampling/ waste characterization sampling*	UFP-QAPPP SOP-19 Operation Manuel
40Hz Magnetic Locator	Calibration [check against known calibrated measurement]	Prior to day's activities	± 1 foot	Replace	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	CMI WP- *Below-grade Anomalies, Utility Clearance and Confirmation, Soft Digging Uses*	UFP-QAPPP SOP-04 Operation Manuel
	Inspection [visual]	Prior to day's activities	No defects noted	Replace			
In-Situ, Inc. Rugged TROLL 100	Software Calibration	Monthly or Anytime anomaly suspected, Sensor indicator alert	±0.05% full scale (FS) ±0.1% FS	Replace	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	CMI WP- *Hydrogeological Study, Continuous depth to water gauge data*	UFP-QAPPP SOP-14 Operation Manuel
	Inspection [visual]	Prior to day's activities	No defects noted	Replace			
HSA, Direct Push Drill Rig	Inspection [visual]	Prior to day's activities	No defects noted	Replace	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	CMI WP- *Geotechnical, Hydrogeologic Study, in-situ soil sampling, Monitoring Well Installation*	UFP-QAPPP SOP-17 Operation Manuel
	Testing [check operation of motor]	Prior to day's activities	No defects noted	Replace			
	Maintenance	Monthly Schedule	Operational Specs (as per Manuel)	Replace worn parts, repairs, fluid changes			

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	Field Element Reference	Associated SOP Reference [1]
Sensidyne Gilian GilAir Plus Air Sampling Pump	Field Calibration	Upon Calibration Sensor Alert	≤ 5% of flow rate	Replace	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	HASP – *Personal Breathing Zone monitoring for particulates, metals and other worker hazards*	UFP-QAPPP SOP-16 Operation Manuel
	Inspection [visual]	Prior to day's activities	No defects noted	Replace			
DustTrak II Aerosol Monitor 8530	Field Calibration (Standard/ Particle Size)	Weekly	PM10 accuracy ± 95 %	Replace	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	HASP – *Air monitoring for particulates in work zone and downwind locations*	UFP-QAPPP SOP-16 Operation Manuel
	Zero Calibration	Prior to day's activities	Baseline Zero	Replace			
	Inspection [visual]	Prior to day's activities	No defects noted	Replace			
Ground - Penetrating Radar (GSSI UtilityScan Pro)	Calibration	Factory calibrated	Factory calibrated (Verified)	Replace	Impact Environmental Field Team Leader (daily) Impact Environmental Operations Manager (weekly)	HASP – *Air monitoring for particulates in work zone and downwind locations*	UFP-QAPPP SOP-16 Operation Manuel
	Testing [check operation/ connections]	Daily	± 3 feet in resulting imagery	Replace			
	Inspection [visual]	Prior to day's activities	No defects noted	Replace			

1 SOPs are contained in **Appendix B** and Operation Manuals presented as Attachments.

Worksheet #23: Analytical SOPs

Laboratory: **TestAmerica Laboratories, Chicago IL**

SOP#, Date, and Title [1]	Definitive or Screening Data	Matrix/ Analytical Group	SOP Option or Equipment Type	Modified for Project? Y/N
SOP2987 - Arsenic Speciation by Hydride-Generation Cryo-Trapping GC-AAS	Definitive	Aqueous (Water)/Speciation of Arsenate and Arsenite.	HG-CT-GC-AAS	N
UP-GE-8081, 8/6/2018, Gas Chromatography-Semi Volatiles Pesticides by SW-846 Method 8081A and 8081 B	Definitive	Soil (Sediment)/ Gas Chromatography of chlorinated pesticides.	GC	N
UP-GE-8151A, 8/6/2018, Gas Chromatography-Semi Volatiles Herbicides by SW-846 Method 8151A	Definitive	Aqueous (water), and Soil (Sediment)/ Gas Chromatography of Chlorinated Phenoxy Acid Herbicides.	GC	N
UP-MB-8270D, 09/28/2018, Gas Chromatography/Mass Spectrometry- Semi Volatiles SW-846 Method 8270D	Definitive	Aqueous (water) and Soil (Sediment)/ Gas Chromatography/Mass Spectrometry of Semi Volatile base/neutral and acid (BNA) compounds.	GC/MS	N
UP-ME-6010B, 8/6/2018, Metals Analysis Trace Inductively Coupled	Definitive	Soil (Sediment)/ Trace Inductively Coupled Argon Plasma Emission Spectrometry for Metal concentrations.	ICAP	N
UP-ME-7471, 10/26/2018, Metals Analysis: Mercury by SW-846 7471A/7471B- (Modified)-Determination of Mercury in Stones	Definitive	Soil (Sediment)/ Mercury Soil Digestion Procedure-SW-846 Method 7471A/7471B	Cold Vapor AA	N
UP-SP-007, 8/6/2018, Sample Preparation Herbicides from a Waste Water Matrix or TCLP	Definitive	Aqueous (water)/ Extraction and clean up	TCLP	N

Extracts Using SW-846 8151A		procedures of chlorinated acid herbicides.		
UP-SP-1311, 9/28/18, Sample Preparation Toxicity Characteristic Leaching Procedure (TCLP)	Definitive	Soil (Sediment)/ Toxicity Characteristic Leaching Procedure for organic and inorganic contaminants.	ZHE	N
UP-SP-3000, 8/31/18, Sample Preservation Metals Digestion by SW-846 3000 Series	Definitive	Aqueous (water), and Soil (Sediment)/ Preparation for Metals Analysis by Trace Inductively Couples Argon Plasma and Inductively Coupled Argon Plasma/Mass Spectrometry	ICP and ICP-MS	N
UP-SP-3510, 12/8/2017, Sample Preparation Semivolatile and Nonvolatile Organic Compounds from a WasteWater or Leachate Matrix using Separatory Funnel Extraction.	Definitive	Aqueous (water)/ Extraction methods for semivolatile and nonvolatile organic compounds.	Separation Funnel	N
UP-WC-300.0, 10/5/2017, Wet Chemistry Inorganic Ions by Ion Chromatography	Definitive	Aqueous (water), and Soil (Sediment)/ Determining inorganic anions by Ion Chromatography.	Ion Chromatograph	N
UP-WC-1010, 2/28/19, Wet Chemistry Flash Point	Definitive	Aqueous (water)/ Determining Flash Point using closed cup and open cup techniques.	Herzog Model HFP 339, Automated Closed- Cup Flash Point Tester and Cleveland Open Cup Flash Point Tester	N
UP-WC-ALKALINITY,1/31/18, Alkalinity	Definitive	Aqueous (water), and Soil (Sediment)/ Determine the alkalinity using ManTech PC Titrate.	ManTech PC Titrate	N
UP-WC-CN, 12/1/2017, Wet Chemistry: Cyanide (Total /Weak Acid)	Definitive	Aqueous (water), and Soil (Sediment)/ Using Colorimetry to analyze Cyanide.	Spectrophotometer	N

UP-WC-Ph, 02/4/2019, Wet Chemistry pH	Definitive	Aqueous (water), and Soil (Sediment)/ The pH is determined using the appropriate SW-846 method.	pH meter with electrode	N
UP-WC-PHOSPHORUS, 2/4/2019, Wet Chemistry Phosphorus and Ortho-Phosphorus	Definitive	Aqueous (water), and Soil (Sediment)/ Phosphorus is determined using Colorimetry	Any Spectrophotometer	N
UP-WC-SULFIDE, 10/26/18, Wet Chemistry Total Acid Soluble and Reactive Sulfide	Definitive	Aqueous (water), and Soil (Sediment)/ Method 9030B (distillation) and 9034 (titration) for acid extractable analysis.	Titration and Distillation using flasks, pipettes and burets	N
UP-WC-TOC, 10/25/2017, Total Organic Carbon/Total Inorganic (Dissolved) Carbon	Definitive	Aqueous (water)/ TOC and TIC/DIC using UV persulfate oxidation and non-dispersive IR detection	Tekmar-Dohrmann Phoenix 8000 TOC Analyzer with XYZ Autosampler and TOCTalk version 3.2 software on the PC.	N
Method Summary Document - Per- and Polyfluorinated Substances (PFAS) in Water, Soils, Sediments and Tissue [Method 537 Modified]	Summary (SOP Proprietary)	Aqueous (water), and Soil (Sediment)/ Method 537 liquid chromatography / tandem mass spectrometry (LC/MS/MS)	LC/MS/MS	N

1 Laboratory SOPs are included in **Appendix C** – Laboratory SOPs

Worksheet #24: Analytical Instrument Calibration

Instrument /Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
GC SW8081A SW8081B SW8082 SW8082A SW8151A	Minimum five-point initial calibration for all target analytes[2]	Initial calibration prior to sample analysis. Perform instrument re-calibration once per year minimum.	Linear regression correlation coefficient $r^2 \geq 0.99$, $r \geq 0.995$. RSD of CF ≤ 20%	Correct problem then repeat initial calibration	UP-GE-8151A (Herbicides)
	Initial calibration verification (ICV) must be from a 2nd source	Once immediately following initial calibration	All target analytes within 15% of expected value Within 20% for 8081B/8082A	Correct problem then repeat initial calibration	
	Continuing calibration verification (CCV)	Non-IS Methods: Before sample analysis, every 12 hours, and at the end of the analysis sequence. IS Methods: Before sample analysis, every 12 hours or per specified Project QAPP/ Program frequency.	All analytes within 15% of expected value and within the RT Window. Average of all analytes 15%. Within 20% for 8081B/8082A	Repeat CCV once, if it again fails criteria, identify and correct problem, repeat initial CCV (re-calibrate if necessary) and re-analyze all samples since last successful CCV.	
	Breakdown check (Endrin and DDT)[1]	Before sample analysis	Degradation ≤15% for either Endrin or DDT.	Inlet/column maintenance; repeat breakdown check and re-analyze all samples since last successful breakdown check.	
	Method blank	One per analytical prep batch, not to exceed 20 samples in a batch.	No analytes detected RL values between the RL and MDL will be evaluated and flagged with a 'J'	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank	
	LCS for all analytes	One per prep batch, not to exceed 20 samples in a batch.	Statistical Control Limits	Re-prep and analyze the LCS and all samples in the affected analytical batch	
	Surrogate(s)	Every sample, spike, standard, and method blank	Statistical Control Limits	Check system, re-inject, re-extract	

	MS/MSD	One per batch per matrix, if insufficient sample for MS/MSD, then a LCS/LCSD will be analyzed.	Statistical Control Limits	None (LCS is used to determine if data is acceptable).	
GC SW8081A SW8081B SW8082 SW8082A SW8151A	Second-column confirmation	100% for all positive results	Same as for initial or primary column analysis	Same as for initial or primary column analysis. If the relative % difference of results between the 2 columns is greater than 40%, a comment should be placed in LIMS.	
	Retention time window calculated for each analyte (see section 9 for how to calculate RTWs).	System set-up, with each new column or major instrument maintenance. Update the mid-RTW at the start of the run or daily. (as needed)	Each analyte of the LCS, MS/MSD and CCV must be within the calculated RTW.	Correct the problem and re-process or re-analyze samples. If questions, see the supervisor or technical director.	
	MDL verification	Minimum – yearly	Detectible	Re-evaluate MDL standard used and MDL	
	Internal Standards	Every sample/standard and blank	Retention time ±30 seconds from retention time of the mid-point std. in the CCV/ICAL (sample/standard). EICP area within -50% to +100% of ICAL mid-point std for the CCV and samples.	Refer to corrective action section of method SOP.	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
LC/MS/MS EPA Method 537	Minimum five-point initial calibration for target analytes, lowest concentration standard at or near the reporting limit	Initial calibration prior to sample analysis	RSD ≤ limits in 24-1	Evaluate standards, chromatography, and mass spectrometer response. If problem found with above, correct as appropriate, then repeat initial calibration.	Lab Manager / Analyst	WS-LC-0025
	Initial calibration blank	Once per initial calibration, following initial calibration and prior to ICV.	Results less than the reporting limit.	Identify the source of the contamination, complete appropriate cleaning, and repeat calibation.	Lab Manager / Analyst	WS-LC-0025
	Second-source calibration verification	Once per initial calibration, following initial calibration.	Percent difference ≤ limits in 24-1	Evaluate data. If problem (e.g., concentrated standard, plugged transfer line) found, correct, then repeat second source verification. If it still fails, then repeat initial calibration.	Lab Manager / Analyst	WS-LC-0025
	Daily calibration verification	Before sample analysis, after every 10 samples, and at the end of the sequence.	Percent difference ≤ limits in 24-1	Evaluate standard, chromatography, and mass spectrometer response. If problem found with above, correct as appropriate, then repeat CCV. If still fails, repeat initial calibration.	Lab Manager / Analyst	WS-LC-0025

Instrument/Method	QC Check	Frequency	Acceptance Criteria[2]	Corrective Action[3]	SOP Reference
GC/MS Gas Chromatography SW8260B SW8270C SW8270D	Check of mass spectral ion intensities[1], i.e., Tune	Prior to initial calibration or Continuing calibration verification, every 12 hours	Refer to criteria listed in the method SOP for Tune criteria, including DDT, Benzidine and Pentachlorophenol requirements for 8270.	Retune the instrument and verify (instrument maintenance may be needed).	UP-MB-8270D (SVOC's)
SW8260B	Minimum five-point initial calibration for all target analytes	Initial calibration prior to sample analysis. Perform instrument re-calibration as necessary and after major instrument maintenance.	SPCCs average RF $\geq$ 0.30 or 0.1 depending on the compound and %RSD for RFs for CCCs $\leq$ 30% and all other target analytes	Correct problem then repeat initial calibration	
SW8270C			SPCCs average RF $\geq$ 0.050 and %RSD for RFs for CCCs $\leq$ 30%	Correct problem then repeat initial calibration	
			option (if %RSD is > 15%)– linear regression $r^2 \geq 0.990$, $r \geq 0.995$.	Refer to individual SOP for corrective action procedure.	
SW8270D			All analytes < 20% RSD, up to 10% of analytes can be > 20% RSD Most analytes must meet minimum RF's (see Table 4 in 8270D SOP)	Correct problem then repeat initial calibration	
SW8260B SW8270C SW8270D	Initial calibration verification (ICV) must be from a 2nd source.	Immediately following five-point (minimum) initial calibration and before samples are analyzed.	All analytes within 30% of expected value	Correct problem then repeat ICV, if criteria fails it may be necessary to repeat initial calibration or report outlier with PM/QA approval and qualification (NCM required).	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[2]	Corrective Action[3]	SOP Reference
	Relative Retention time window	Each sample	Relative retention time (RRT) of the analyte within 0.06 RRT units of the RRT of the internal standard	Correct problem then reprocess or re-analyze all samples analyzed since the last retention time check	
GC/MS Gas Chromatography SW8260B	Continuing calibration verification (CCV)	Daily, before sample analysis and every 12 hours of analysis time	SPCCs average RF $\geq$ 0.30 or 0.1 depending on the compound; and	Correct problem then repeat CCV, if criteria is met, repeat associated samples. If criteria is not met, it may be necessary to repeat initial calibration and re-analyze all samples since last successful CCV.	UP-MB-8270D (SVOC's)
SW8270C			SPCCs average RF $\geq$ 0.050; and		
SW8260B SW8270C			CCCs: $\leq$20% difference (when using RFs) or drift (when using least squares regression).		
SW8270D			All analytes < 20% RSD, up to 10% of analytes can be > 20% RSD Most analytes must meet minimum RF's (see Table 4 in 8270D SOP)		
SW8260B SW8270C SW8270D	Method blank	One per analytical prep batch	No analytes detected $\geq$ RL values between the RL and MDL will be evaluated and flagged with a 'J' ; (Common lab contaminants cited in SOP < 3x RL)	Correct problem then re-prep[5] and analyze method blank and all samples processed with the contaminated blank. Common lab contaminants < 3x RL will be narrated.	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[2]	Corrective Action[3]	SOP Reference
SW8260B SW8270C	Internal Standards	Every sample/standard and blank	Retention time ±30 seconds from retention time of the mid-point std. in the CCV/ICAL (sample/standard). EICP area within -50% to +100% of ICAL mid-point std for the CCV and samples.	Refer to corrective action section of method SOP.	
GC/MS Gas Chromatography SW8270D			Retention time ±30 seconds from retention time of the mid-point std. in the CCV/ICAL (sample/standard). EICP area within -50% to +100% of ICAL mid-point standard Area based on CCV	Refer to corrective action section of method SOP.	UP-MB-8270D (SVOC's)
SW8260B SW8270C SW8270D	LCS for all target analytes	Volatiles: one per tune per 12-hour sequence. Semivolatiles: One per prep batch, not to exceed the 20 samples in a batch.	Statistical Control Limits	Refer to corrective action section of method SOP.	
	MS/MSD	One set per batch of 20 samples per matrix, if insufficient sample for MS/MSD, then a LCS/LCSD will be analyzed.	Statistical Control Limits	None (the LCS is used to evaluate and determine if the batch is acceptable).	
	Surrogate(s)	Every sample, spike, standard, and blank	Statistical Control Limits	Refer to corrective action section of method SOP.	
SW8260B	pH check	All 8260 water samples All low level 5035 soils are prepped in sodium sulfate (refer to the method SOP for exceptions).	pH ≤2.	If the pH is > 2, then comment the data, in the PIPE database, and LIMS.	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[2]	Corrective Action[3]	SOP Reference
SW8260B	Residual chlorine check (samples suspected of coming from a chlorinated waste stream)	Each sample from a suspected chlorinated waste stream.	Residual chlorine should be negative.	If the residual chlorine is positive, then comment in LIMS via an NCM.	
	MDL verification	Minimum – yearly	Detectible	Re-evaluate MDL standard used and MDL;	
ICAP SW6010B SW6010C SW6010D	Initial calibration (one to three standards for each element- and a blank)	Daily initial calibration prior to sample analysis.	>/= 0.995 (6010B/6010D) >/= 0.998 (6010C)	Re-calibrate	UP-ME-6010B (Metals Analysis Trace Inductively Coupled)
	Curve high-standards read-back S1 / S2 6010B/6010C	Daily after curve	+/- 5% of known concentration	Re-calibrate, re-run samples for affected elements	
	Linear Range Check Standard 6010D	Daily	+/- 10% of known concentration	If LRC fails, sample concentrations can not exceed the high standard of the curve.	
	Second-source calibration verification (ICV)	Daily after initial calibration	All analytes within 10% of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.	
	Second-source calibration verification – Low Level (ICVL) 6010C / 6010D	Daily after mid-range ICV (Conc. = RL Level)	All analytes +/-30% (6010C) +/- 20% (6010D) of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.	
	Initial Calibration blank (ICB)	After ICV	+/- RL (6010B / 6010C) +/- ½ RL (6010D)	Correct problem then re-analyze for affected elements; may report results >10X contamination level or non-detects if biased high	
	CRI (2X RL)	At the beginning of an analytical run	50-150%	NA	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[2]	Corrective Action[3]	SOP Reference
	MRL (at RL)	At the beginning of an analytical run	70-130% (Project Specific)	Per QAPP	
	Interference check solution (ICSA) 6010B/6010C/6010D	At the beginning of an analytical run	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- RL	Correct problem; re-analyze ICSA; re-analyze all affected samples; may report non-detects if biased high.	
	Interference check solution (ICSB) 6010B / 6010C	At the beginning of an analytical run	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- RL	Correct problem; re-analyze ICSB; re-analyze all affected samples; may report non-detects if biased high.	
	Method Blank	One per prep batch of </= 20 samples	+/- RL < /2 RL per QAPP	Correct problem, re-prep and re-analyze the method blank and all samples for affected elements; may report results >10X contamination level or non-detects if biased high.	

Instrument /Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
ICAP 6010B 6010C 6010D	Post digestion spike addition (PDS)	When dilution test fails for some programs	Recovery within 25% of expected results	None	UP-ME-6010B (Metals Analysis Trace Inductively Coupled)
	Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analytical sequence	All analytes within 10% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.	
	Second-source calibration verification – Low Level (CCVL) 6010C only	After mid-range CCV (Conc. = RL Level)	All analytes within 30% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.	
	Continuing Calibration blank (CCB)	After each CCV	+/- RL	Correct problem and re-analyze affected elements of bracketed samples; may report results >10X contamination level or non-detects if biased high	
	Internal Standard	All samples and QC	50 – 150%	Re-analyze sample at a dilution	
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL	

Instrument /Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
ICP/MS SW6020A SW6020B	Initial calibration (one to three standards for each element- and a blank)	Daily initial calibration prior to sample analysis.	r >/= 0.998 (6020A) r >/= 0.995 (6020B)	Re-calibrate	DV-MT-0026, 2/1/2019, HPLC-ICPMS Coupled Speciation Analysis
	Curve high-standards read-back S1 6020A / 6020B	Daily after curve	+/- 5% of known concentration	Re-calibrate, re-run samples for affected elements	
	Linear Range Check Standard 6020B		+/- 10% of know concentration	If LRC fails, sample concentrations cannot exceed the high standard of the curve.	
	Second-source calibration verification (ICV)	Daily after initial calibration	All analytes within 10% of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.	
	Second-source calibration verification – Low Level (ICVL) 6020A / 6020B	Daily after mid-range ICV/ICB (Conc. = RL Level)	All analytes within 30% of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.	
	Initial Calibration blank (ICB)	After ICV	+/- RL (6020A) +/- ½ RL(6020B)	Correct problem then re-analyze for affected elements; may report results >10X contamination level or non-detects if biased high	
	CRI (2X RL)	At the beginning of an analytical run	50-150%	NA	

	MRL (at RL)	At the beginning of an analytical run	70 – 130% (Project Specific)	Per QAPP	
	Interference check solution (ICSA) 6020A / 6020B	At the beginning of an analytical run and every 12 hours	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- RL	Correct problem; re-analyze ICSA; re-analyze all affected samples; may report non-detects if biased high.	
	Interference check solution (ICSB) 6020A	At the beginning of an analytical run and every 12 hours	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- RL	Correct problem; re-analyze ICSB; re-analyze all affected samples; may report non-detects if biased high.	
	Method Blank	One per prep batch of </= 20 samples	+/- RL < ½ RL per QAPP	Correct problem, re-prep and re-analyze the method blank and all samples for affected elements; may report results >10X contamination level or non-detects if biased high	
	LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	Correct problem, then re-prep and analyze the LCS and all samples for affected elements; may report non-detects if biased high.	
	Method duplicate	One per prep batch per matrix upon request	</= 20 RPD	Repeat	
	MS/MSD	One per prep batch per matrix	+/- 25% of known concentration	None	
	Dilution test (SD)	Each new sample matrix	5x dilution must agree within 10% (6020A); 20% (6020B) of the original determination	Perform post digestion spike addition upon request	

Instrument/ Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
6020A cont.	Post digestion spike addition (PDS)	When dilution test fails for some programs	Recovery within 25% of expected results	None	DV-MT-0026, 2/1/2019, HPLC-ICPMS Coupled Speciation Analysis
	Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analytical sequence	All analytes within 10% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.	
	Second-source calibration verification – Low Level (CCVL) 6020A	After mid-range CCV/CCB (Conc. = RL Level)	All analytes within 30% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.	
	Continuing Calibration blank (CCB)	After each CCV	+/- RL	Correct problem and re-analyze affected elements of bracketed samples; may report results >10X contamination level or non-detects if biased high	
	Internal Standard	All samples and QC	30 – 150%	Re-analyze sample at a dilution	
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL	

Instrument/ Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
Cold Vapor AA SW7470A SW7471B	Calibration curve – minimum 5 standards and blank	Quarterly, monthly, or daily – see individual SOP	r ≥ 0.995	Recalibrate	SOP SW-846 7471A/7471B (Mercury)
	Initial Calibration Verification – mid-level, second-source required (ICV)	Immediately following initial calibration and daily at the beginning of each analytical sequence.	±10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.	
	Initial Calibration Blank (ICB)	After ICV	+/- RL	Correct problem then proceed; may report results >10X contamination level or non-detects if biased high	
	Method blank	One per batch of 20 or fewer samples	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank. may report results >10X contamination level or non-detects if biased high	
	CRA (at RL level)	One per batch of 20 or fewer samples	No established limits	None	
	LCS	One per batch of 20 or fewer samples	+/- 20% of known concentration	Correct problem, re-prep and repeat LCS, MB and all samples in the batch; may report non-detects if the LCS is biased high.	
	Matrix duplicate	One per matrix per batch of 20 or fewer samples as requested	</= 20 RPD	Repeat once	

	MS/MSD	One pair per matrix per batch of 20 or fewer samples	+/- 25% of known concentration	None	
	Continuing calibration verification (CCV)	Beginning, every 10 samples, and at end of sequence	±20% of known concentration	Correct problem then repeat CCV, CCB and all samples since last successful CCB; may report non-detects if biased high.	
	Continuing Calibration Blank (CCB)	After every CCV	+/- RL	Correct problem then repeat CCV,CCB and all samples since last successful CCB; may report results >10X contamination level or non-detects if biased high	
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL	

Instrument	Calibration Procedure/Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	SOP Number
HG-CT-GC-AAS	Initial calibration is a 6 point calibration curve from 0.01-0.5 µg/L	Each new run	Curve RSD < 20% or correlation coefficient ≥0.995, Passing ICV	Recalibrate, perform instrument maintenance if calibration cannot conform to criteria, recalibrate	'SOP2987
	ICV	After each calibration	±20% of true value for TIAs, ±30% of true value for As3+	Reanalyze the ICV. If criteria still not met, recalibrate and reanalyze. Samples cannot be reported until ICV criteria have been met.	
	ICB	Immediately after the ICV	< RL	Associated samples must be reanalyzed. Samples cannot be reported until ICB criterion is met.	
	LOD	Annually	Result of a spike 2-3x the current MDL > method blank mean + 3s	Reprep and reanalyze LOD. If second failure, redo MDL study	
	CCV	Every 10 samples	±20% of true value for TIAs, ±30% of true value for As3+	Reanalyze in duplicate, both reanalyses must meet criteria. Reanalyze samples associated with failing CCV	
	CCB	Immediately after the CCV and at a frequency of every 10 samples	< RL	Associated samples must be reanalyzed. Samples cannot be reported until CCB criterion is met.	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
Spectrophotometer SW9010B SW9010C SW9014 SM4500CNE	Initial calibration (6 standards (9014); 7 standards (4500CNE) and a calibration blank)	Initial daily calibration prior to sample analysis.	$r \geq 0.995$ y-intercept < abs. value of RL	Correct problem then repeat initial calibration	UP-WC-CN (Cyanide)
	Distilled standards 9010B / 9010C (one high and one low)	Once per calibration – Only when curve is not distilled	+/- 10% of known concentration (high) +/- 25% of known concentration (low)	Correct problem then repeat distilled standards and related samples	
SOP 9010B or Method 9010C	Second-source calibration verification (ICV)	Immediately following initial daily calibration	+/- 10% of known concentration	Correct problem. Repeat, then repeat initial calibration if necessary	
	Initial Calibration Blank (ICB)	Following ICV	+/- RL	Correct problem. Repeat, then repeat initial calibration, ICV and ICB if necessary; may report non-detects if CCV is biased high	
	Method blank	One per prep batch of 20 or fewer samples	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank; may report non-detects and results >10X the contamination level.	
	LCS	One per prep batch of 20 or fewer samples	+/- 15% of known concentration +/- 10% for Drinking Waters	Re-prep, re-analyze affected samples; may report non-detects if biased high	

	Matrix duplicate (optional if MS/MSD performed)	One per matrix per prep batch of 20 or fewer samples upon request	</= 20 RPD </= 10 RPD for Drinking Waters	None	
	MS/MSD	One per matrix per prep batch	+/- 25% of known concentration +/- 15% for Drinking Waters	None unless both spike recoveries very low, then PDS	
	Post Digestion Spike (PDS)	When both MS and MSD recoveries are very low	+/- 15% of known concentration	None	
	Continuing calibration verification (CCV)	After every 10 readings and at the end of the analysis sequence	+/- 10% of known concentration	Correct problem then re-read the CCV, CCB and all samples since last successful CCV/CCB; may report non-detects if CCV is biased high	
	Continuing Calibration Blank (CCB)	After every CCV	+/- RL	Correct problem then re-read the CCV, CCB and all samples since last successful CCV/CCB; may report non-detects and results >10X the contamination level.	
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
Man Tech SM2320B Alkalinity forms	LCS	One per batch of 20 or fewer samples	± 20% of known concentration ± 15% SM2320B	Correct problem and repeat LCS, MB and all samples in the batch; May report non-detects if the LCS is biased high.	UP-WC-ALKALINITY
	Method blank	One per batch of 20 or fewer samples	No analyte detected > report limit	Correct problem and repeat MB, LCS and all samples in the batch; May report non-detects and samples >10X the contamination level	
Titration and Distillation using Flask, pipettes. SM4500 S2F Sulfide	Duplicate (optional if MS/MSD performed; Not performed for Sulfide)	One per batch of 20 or fewer samples	±20%	None	UP-WC-SULFIDE
	MS/MSD (Not performed for SM2320B; SM4500Cl_F)	Available for some titrimetric tests at one pair per batch of 20 or fewer samples.	+/- 25% of known concentration	None	
	Standardization	Per specific SOP	NA	NA	
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
Tekmar-Dohrmann Phoenix 8000 TOC Analyzer with XYZ Autosampler and TOCTalk version 3.2 software on the PC SM5310C 9060A:	Calibration curve – minimum 5 standards and blank	Quarterly or daily – see individual SOP	r ≥ 0.995 y-intercept < abs. value of RL	Recalibrate	UP-WC-TOC
	Initial Calibration Verification – mid-level, second-source required (ICV)	Immediately following initial calibration and daily at the beginning of each analytical sequence.	±10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.	
	Initial Calibration Blank (ICB)	After ICV	+/- RL	Correct problem then proceed; may report results >10X contamination level or non-detects if biased high	
	Method blank	One per batch of 20 or fewer samples One per 10 samples for 9066; 420.4	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank. may report results >10X contamination level or non-detects if biased high	
	LCS	One per batch of 20 or fewer samples One per 10 samples for 9066; 420.4	+/- 20% of known concentration +/- 10% for * methods +/- 15% for Chloride methods	Correct problem, re-prep and repeat LCS, MB and all samples in the batch; may report non-detects if the LCS is biased high.	
	Matrix duplicate (optional if MS/MSD performed)	One per matrix per batch of 20 or fewer samples as requested	</= 20 RPD </+ 10 RPD for * methods </= 30 RPD for soils	Repeat once	

	MS/MSD	One pair per matrix per batch of 20 or fewer samples One per 10 samples for 353.2; 9060A; SM5310C; 9251	+/- 25% of known concentration +/- 10% for * methods	None	
	Continuing calibration verification (CCV)	Beginning, every 10 samples, and at end of sequence	±10% of known concentration	Correct problem then repeat CCV, CCB and all samples since last successful CCB; may report non-detects if biased high.	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
Spectrophotometer SM4500P Phosphorus	Continuing Calibration Blank (CCB)	After every CCV	+/- RL	Correct problem then repeat CCV,CCB and all samples since last successful CCB; may report results >10X contamination level or non-detects if biased high	UP-WC-PHOSPHORUS
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
pH meter with an electrode SW9040B/C, SW9045C/D: pH.	Calibration Curve – minimum of 5 standards and blank	Initial Calibration before each batch (where applicable)	R ≥ 0.995.	Recalibrate	UP-WC-pH
	Initial Calibration Verification (second source) (ICV)	Immediately after initial calibration and daily at beginning of analytical sequence (where applicable)	±10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.	
	Initial Calibration Blank	With ICV (where applicable)	+/- RL	Correct problem then proceed; may report results >10X contamination level or non-detects if biased high	
	Method blank	One per batch of 20 or fewer samples (where applicable)	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank; may report results >10X contamination level or non-detects if biased high.	
	LCS	One per batch of 20 or fewer samples (where applicable)	±20% of known concentration	Correct problem, re-prep and repeat LCS, MB and all samples in the batch; may report non-detects if the LCS is biased high.	

	MS/MSD	Each batch (where applicable)	± 20%	None	
	Duplicate	When spike not available	±20%	None	
	Continuing Calibration verification (CCV)	Beginning, every 10 samples, and end of batch (where applicable)	±10% of known concentration	Correct problem then repeat CCV, CCB and all samples since last successful CCB; may report non-detects if biased high.	
	Continuing Calibration blank	With each CCV (where applicable)	+/- RL	Correct problem then repeat CCV,CCB and all samples since last successful CCB; may report results >10X contamination level or non-detects if biased high	
	Calibration checks	Alternate pH buffers every 10 readings. Read-back DO calibration bottle. Conductivity standards must bracket samples in each range.	pH buffers +/- 0.2 SU DO bottle +/- 0.5 mg/L Cond. stds. After samples, <10% drift	Re-calibrate and re-read samples since last in-control check.	
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL	

Instrument/Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]	SOP Reference
Herzog Model HFP 339, Automated Closed- Cup Flash Point Tester and Cleveland Open Cup Flash Point Tester	STD - n-Decane (Flashpoint)	One per batch of 20 or fewer samples – applicable for flash point only	Statistical limits	Re-analyze	UP-WC-1010 (Wet Chemistry Flash Point)
SW1010A D-92: Flash Point.	Duplicate	One for each batch of 20 or fewer samples Note: (Duplicates are not performed for Flashpoint or Paint Filter when samples are non-detect)	Report results	None	

Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Mercury Analyzer	Check tubing for wear Fill rinse tank with 10% HCl Fill reductant bottle with 10% Stannous Chloride			Daily Daily Daily	Appropriate performance	Perform additional maintenance prior to instrument calibration or calibration verification	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	SW-846 7471B; SW-846 7470A (Mercury, TCLP Mercury)
ICP	Check pump tubing Check fluid level in waste container Check torch Check sample spray chamber for debris Check nebulizer Check entrance slit for debris Check/Refill recirculator			Daily Daily Daily Monthly Monthly Yearly by Service Rep. Monthly	Appropriate performance	Perform Additional Maintenance Prior to Instrument Calibration or Calibration verification	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	DV-MT-0026, 2/1/2019, HPLC-ICPMS Coupled Speciation Analysis
ICP MS	Check pump tubing Change pump tubing Check torch Check / clean nebulizer Clean cones Check air filters Check multiplier voltages & do cross calibration Check/Change vacuum pump oil Check chiller water level/Refill			Daily As required Weekly As required As required As required Weekly Monthly Monthly	Appropriate performance	Perform Additional Maintenance Prior to Instrument Calibration or Calibration verification	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	DV-MT-0026, 2/1/2019, HPLC-ICPMS Coupled Speciation Analysis

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
UV-Vis Spectrophotometer	Clean ambient flow cell Precision check/alignment of flow cell Wavelength verification check			As required As required Annually	Appropriate performance	Perform Additional Maintenance Prior to Instrument Calibration or Calibration verification	Analyst/Certified Instrument Technician (TestAmerica Laboratory	UP-WC-CN (Cyanide) SW-846 9014 (Cyanide) UP-WC-PHOSPHORUS UP-WC-Sulfide
Auto Analyzers	Clean sampler Check all tubing Clean inside of colorimeter Clean pump well and pump rollers Clean wash fluid receptacle Clean optics and cells			As required As required As required As required As required As required	Appropriate performance	Perform Additional Maintenance Prior to Instrument Calibration or Calibration verification	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-WC-TOC
LC/MS/MS	Replace columns as needed, check eluent reservoirs Check all tubing Sensitivity check Instrument performance and sensitivity			Daily or as needed	CCV pass criteria	Recalibrate	TestAmerica Chemist Instrument Technician (TestAmerica Laboratory)	WS-LC-0025

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
HP / Agilient GC/MS	Pump oil-level check Pump oil changing Analyzer bake-out Analyzer cleaning Resolution adjustment Change multiplier Change filaments			Monthly Annually As required As required As required As required As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-MB-8270D (SVOC's)
Gas Chromatograph	Compare standard response to previous day or since last initial calibration Check temp. of detector, inlet, column oven Septum replacement Check system for gas leaks (with SNOOP-MS VOA) Check for loose/frayed wires and insulation Bake injector/column Change/remove sections of guard column Replace connectors/liners Change/replace column(s)			Daily Daily As required W/cylinder change as required As Required As Required As Required As Required As Required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-MB-8270D (SVOC's)
Electron Capture Detector (ECD)	Detector wipe test (Ni-63) Detector cleaning			Semi-annually As required	Appropriate Performance	Perform Additional Maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-GE-8151A(Herbicides)
Flame Ionization Detector (FID)	Detector cleaning			As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-MB-8270D (SVOC's)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Autosamplers GC/MS & GC Volatiles	Check lines Change filters Replace Needles Check Gaskets Re-calibrate Replace Sensors			As required As required As required As required As required As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-MB-8270D (SVOC's)
Autosamplers GC/MS Semivolatiles	Replace Syringe			As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-MB-8270D (SVOC's)
Concentrators GC/MS & GC Volatiles	Change Trap Replace Lines			As required As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-MB-8270D (SVOC's)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Balances	Class 1 traceable weight check Clean pan and check if level Field service			Daily, when used Daily At least Annually	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-WC-pH UP-WC-Sulfide UP-SP-3510 UP-SP-3000 UP-WC-Phosphorus UP-ME-7471 UP-WC-1010 UP-SP-007 DV-MT-0026 UP-SP-1311
Conductivity Meter	KCl calibration Conductivity cell cleaning			Daily, applicable standards As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-WC-300.0
Turbidimeter	Check light bulb			Daily, when used	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	-

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Deionized/Distilled Water	Conductivity Point Sources Daily conductivity check Check deionizer light Monitor for VOA's System cleaning Replace cartridge & large mixed bed resins			Water Quality SOP *UP-QA-035* Daily Daily As required As required As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	DV-MT-0026 UP-WC-CN UP-WC-Phosphorus UP-WC-TOC UP-WC-Sulfide UP-WC-pH UP-SP-3510 UP-ME-7471 UP-SP-007 UP-WC-300.0 UP-SP-1311
Drying Ovens	Temperature monitoring Temperature adjustments			Daily As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-SP-3510 UP-MB-8270D UP-MV-8260B UP-SP-007 UP-GE-8081 UP-SP-1311
Refrigerators/ Freezers	Temperature monitoring Temperature adjustment Defrosting/cleaning			Continuous As required As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-WC-300.0 UP-WC-TOC UP-SP-3510 UP-MV-8260B UP-SP-007

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
pH/Specific Ion Meter	Calibration/check slope Clean electrode			Daily As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-WC-pH UP-SP-3510 UP-MV-8260B UP-SP-007 UP-SP-1311
Water baths	Temperature monitoring Water replaced			Daily As needed	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	UP-SP-3510 UP-ME-7471 UP-SP-007 UP-SP-1311
BOD Incubator	Temperature monitoring Coil and incubator cleaning			Continuous As required	Appropriate performance	Perform additional maintenance	Analyst/Certified Instrument Technician (TestAmerica Laboratory)	-
Buck Scientific 200 A AAS	As needed replacement of components Calibration checks Visual inspection of components			As needed maintenance/ calibration checks every 10 injections	80-120% for TIAs 70-130% for As3+	Recalibration	EFGS Analyst	SOP2987

Worksheets #26 & 27: Sample Handling, Custody, and Disposal

Sampling Organization: Impact Environmental (overall); Impact Environmental (field sampling); TestAmerica Laboratories, Chicago IL (sample/data control/ management)

Custody Requirements: The procedures for sample collection, packaging, handling, and tracking are outlined in SOP for the field activities.

Analytical Laboratories: Eurofins TestAmerica Laboratories, Chicago IL- Supervising Laboratory

Eurofins TestAmerica Laboratories, Sacramento, CA

Eurofins Frontier Global Sciences Laboratories, Bothell, WA

Method of Sample Delivery (shipper/carrier): Provided by the Supervising Labratory.

Number of Days from Reporting until Sample Disposal: Samples will be retained at least until EPA has reviewed and accepted the associated validated results. Soil and liquid sample extracts will be held just above freezing (less than or equal to 6 degrees Celsius) for a minimum of 30 days from collection for potential future analysis. Approval for disposal of excess sample mass will be obtained by ECGP from EPA and other potentially responsible parties.

Activity	Organization and Title or Position of Person Responsible for the Activity	Reference
Sample Collection, Packaging, and Handling		
Sample Collection	Field Team / Impact Environmental	See Worksheet #21
Sample Packaging	Field Team / Impact Environmental	See Worksheet #21
Coordination of Shipment	ECGP/ TestAmerica Laboratories, Chicago IL	Discussed in text following this table
Type of Shipment/Carrier	Provided by the laboratory	NA
Sample Receipt and Analysis		
Sample Receipt	Eurofins TestAmerica Laboratories, Chicago IL - Supervising Laboratory Eurofins TestAmerica Laboratories, Sacramento, CA Eurofins Frontier Global Sciences Laboratories, Bothell, WA	See Worksheets #15 and #23

Activity	Organization and Title or Position of Person Responsible for the Activity	Reference
Sample Custody and Storage	Eurofins TestAmerica Laboratories, Chicago IL - Supervising Laboratory Eurofins TestAmerica Laboratories, Sacramento, CA Eurofins Frontier Global Sciences Laboratories, Bothell, WA	See Worksheets #15 and #23
Sample Preparation	Eurofins TestAmerica Laboratories, Chicago IL - Supervising Laboratory Eurofins TestAmerica Laboratories, Sacramento, CA Eurofins Frontier Global Sciences Laboratories, Bothell, WA	See Worksheets #15 and #23
Sample Determinative Analysis	Eurofins TestAmerica Laboratories, Chicago IL - Supervising Laboratory Eurofins TestAmerica Laboratories, Sacramento, CA Eurofins Frontier Global Sciences Laboratories, Bothell, WA	See Worksheets #15 and #23
Sample Archiving		
Sample storage	Eurofins TestAmerica Laboratories, Chicago IL - Supervising Laboratory Eurofins TestAmerica Laboratories, Sacramento, CA Eurofins Frontier Global Sciences Laboratories, Bothell, WA	See Worksheets #15 and #23; Laboratory QA Manual
Sample extract/digestate storage	Eurofins TestAmerica Laboratories, Chicago IL - Supervising Laboratory Eurofins TestAmerica Laboratories, Sacramento, CA Eurofins Frontier Global Sciences Laboratories, Bothell, WA	See Worksheets #15 and #23; Laboratory QA Manual

Activity	Organization and Title or Position of Person Responsible for the Activity	Reference
Sample Disposal		
Sample disposal	Eurofins TestAmerica Laboratories, Chicago IL - Supervising Laboratory Eurofins TestAmerica Laboratories, Sacramento, CA Eurofins Frontier Global Sciences Laboratories, Bothell, WA	See Worksheets #15 and #23; Laboratory QA Manual

Data Submittal/Availability (EDD)

Upon receipt of laboratory deliverables (report/EDD) and field information (such as sample ID and location) by Impact Environmental Field Team, the data will be processed into the FileShare/ Impact Server database/ EDD portal. The Project team will be able to access results in the database via electronic data **EQuIS Data Processor (EDP)** will be set to update daily at a minimum.

The status of the data as to review (i.e., non-validated or validated; refer to Worksheets #34, #35, and #36) is tracked in the database and noted in EDP. Preliminary data may be utilized during evaluation of the need for additional sampling and/or analyses. Analysis conducted and reported from sister laboratories will be integrated into EDD by the Supervising Laboratory. Only validated data will be used during reporting, final decision making, and preparation of the design. Both Impact and TestAmerica will maintain the EDD - all electronic data and database records will be maintained for the entirety of the Record Retention Period as per the Administrative Order on Consent.

Upon submission of a field event-related report, the associated data (which have been validated and updated with qualifiers) will be provided in the EPA Region 5 standardized EDD format from EarthSoft https://www.epa.gov/superfund/region-5-superfund-electronic-data-submission.

Worksheet #28: Analytical Laboratory Quality Control and Corrective Action - #28a – Metals

Matrix Aqueous

Analytical Group Metals

Analytical Method/SOP Reference SW-846 6010B / SOP UP-ME-6010B

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
Initial calibration (one to three standards for each element and a blank)	Daily initial calibration prior to sample analysis	r >/= 0.995	Correct problem then repeat initial calibration;	Lab Analyst	
Curve high-standards readback	Daily after curve	+/- 5% of known concentration	Re-calibrate, re-run samples for affected elements	Lab Analyst	
Second-source calibration verification (ICV)	Daily after initial calibration	+/- 10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.	Lab Analyst	
Initial Calibration Blank (ICB)	After ICV	+/- RL (LOQ)	Correct problem then re-analyze for affected elements; may report results > 10x contamination level or non-detects if biased high	Lab Analyst	
Interference check solution (ICSA)	After the ICAL and prior to sample analysis	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- 2x RL	Correct problem; re-analyze ICSA; re-analyze all affected samples; may report non-detects if biased high.	Lab Analyst	
Interference check solution (ICSAB)	After the ICAL and prior to sample analysis	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- 2x RL	Correct problem; re-analyze ICSB; re-analyze all affected samples; may report non-detects if biased high.	Lab Analyst	
MB	One per prep batch of </= 20 samples	+/- RL (LOQ)	Correct problem; if required, re-prep and re-analyze MB and all associated samples for affected elements; may report results >10x the contamination level or non-detects if biased high. If re-analysis cannot be performed, apply "B" qualification to affected analyte(s) in all samples in associated preparation batch.	Lab Analyst	< RL (LOQ) for each analyte

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	80-120%R
Sample Duplicate or LCSD	One per prep batch per client request	RPD ≤ 20%	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	RPD ≤ 30%
MS	1 per preparatory batch (≤ 20 samples)	75-125%R	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	75-125%R
MSD	1 per preparatory batch (≤ 20 samples)	RPD ≤ 20%	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	RPD ≤ 20%
Dilution Test	Upon failure of MS/MSD; one per preparatory batch	Five-fold dilution must agree within ± 10% of the original measurement	Apply "*" flag to affected analyte(s) in the parent sample flag if acceptance criteria are not met.	Lab Analyst	±10% of original
Post-Digestion Spike	Upon failure of MS/MSD; one per preparatory batch	80-120%R	Apply "*" flag to affected analyte(s) in the parent sample flag if acceptance criteria are not met.	Lab Analyst	80-120 %R
Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analysis sequence	+/- 10% of known concentration	Correct problem then repeat the CCV/CCB and all samples since the last successful CCV/CCB for the affected elements; may report non-detects if CCV is biased high.	Lab Analyst	90-110%R
Continuing Calibration Blank (CCB)	After every CCV	+/- RL (LOQ)	Correct problem then re-read the CCV/CCB and all samples since the last successful CCV/CCB for the affected elements; may report results > 10x the contamination level.	Lab Analyst	< RL (LOQ)

Worksheet #28: Analytical Laboratory Quality Control and Corrective Action - #28b Phosphorus

Matrix Aqueous

Analytical Group Wet Chemistry

Analytical Method/SOP Reference SM 4500_P_E / UP-WC-4500PE

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
Initial calibration (six standards and a blank)	Daily initial calibration prior to sample analysis	r >/= 0.995	Correct problem then repeat initial calibration;	Lab Analyst	
Second-source calibration verification (ICV)	Daily after initial calibration	+/- 10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.	Lab Analyst	90-110%R
Initial Calibration Blank (ICB)	After ICV	+/- RL (LOQ)	Correct problem then re-analyze; may report results > 10x contamination level or non-detects if biased high	Lab Analyst	< RL (LOQ)
MB	One per prep batch of </= 20 samples	+/- RL (LOQ)	Correct problem; if required, re-prep and re-analyze MB and all associated samples; may report results >10 x the contamination level or non-detects if biased high. If re-analysis cannot be performed, apply "B" qualification in all samples in associated preparation batch.	Lab Analyst	< RL (LOQ)
LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	80-120%R
Sample Duplicate or LCSD	One per prep batch per client request	RPD ≤ 20%	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	RPD ≤ 20%
MS	1 per preparatory batch (≤ 20 samples)	75-125%R	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	75-125%R

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
MSD	1 per preparatory batch (≤ 20 samples)	RPD ≤ 20%	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	RPD ≤ 20%
Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analysis sequence	+/- 10% of known concentration	Correct problem then repeat the CCV/CCB and all samples since the last successful CCV/CCB; may report non-detects if CCV is biased high.	Lab Analyst	90-110%R
Continuing Calibration Blank (CCB)	After every CCV	+/- RL (LOQ)	Correct problem then re-read the CCV/CCB and all samples since the last successful CCV/CCB; may report results > 10x the contamination level.	Lab Analyst	< RL (LOQ)

Worksheet #28: Analytical Laboratory Quality Control and Corrective Action - #28a – Metals

Matrix Aqueous

Analytical Group Metals

Analytical Method/SOP Reference SW-846 6010B / SOP UP-ME-6010B

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
Initial calibration (one to three standards for each element and a blank)	Daily initial calibration prior to sample analysis	r >/= 0.995	Correct problem then repeat initial calibration;	Lab Analyst	
Curve high-standards readback	Daily after curve	+/- 5% of known concentration	Re-calibrate, re-run samples for affected elements	Lab Analyst	
Second-source calibration verification (ICV)	Daily after initial calibration	+/- 10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.	Lab Analyst	
Initial Calibration Blank (ICB)	After ICV	+/- RL (LOQ)	Correct problem then re-analyze for affected elements; may report results > 10x contamination level or non-detects if biased high	Lab Analyst	
Interference check solution (ICSA)	After the ICAL and prior to sample analysis	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- 2x RL	Correct problem; re-analyze ICSA; re-analyze all affected samples; may report non-detects if biased high.	Lab Analyst	
Interference check solution (ICSAB)	After the ICAL and prior to sample analysis	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- 2x RL	Correct problem; re-analyze ICSB; re-analyze all affected samples; may report non-detects if biased high.	Lab Analyst	
MB	One per prep batch of </= 20 samples	+/- RL (LOQ)	Correct problem; if required, re-prep and re-analyze MB and all associated samples for affected elements; may report results >10x the contamination level or non-detects if biased high. If re-analysis cannot be performed, apply "B" qualification to affected analyte(s) in all samples in associated preparation batch.	Lab Analyst	< RL (LOQ) for each analyte

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	80-120%R
Sample Duplicate or LCSD	One per prep batch per client request	RPD ≤ 20%	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	RPD ≤ 30%
MS	1 per preparatory batch (≤ 20 samples)	75-125%R	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	75-125%R
MSD	1 per preparatory batch (≤ 20 samples)	RPD ≤ 20%	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	RPD ≤ 20%
Dilution Test	Upon failure of MS/MSD; one per preparatory batch	Five-fold dilution must agree within ± 10% of the original measurement	Apply "*" flag to affected analyte(s) in the parent sample flag if acceptance criteria are not met.	Lab Analyst	±10% of original
Post-Digestion Spike	Upon failure of MS/MSD; one per preparatory batch	80-120%R	Apply "*" flag to affected analyte(s) in the parent sample flag if acceptance criteria are not met.	Lab Analyst	80-120 %R
Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analysis sequence	+/- 10% of known concentration	Correct problem then repeat the CCV/CCB and all samples since the last successful CCV/CCB for the affected elements; may report non-detects if CCV is biased high.	Lab Analyst	90-110%R
Continuing Calibration Blank (CCB)	After every CCV	+/- RL (LOQ)	Correct problem then re-read the CCV/CCB and all samples since the last successful CCV/CCB for the affected elements; may report results > 10x the contamination level.	Lab Analyst	< RL (LOQ)

Matrix Aqueous

Analytical Group As Speciation

Analytical Method/SOP Reference EPA 1632 Mod / SOP2987

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
Method Blank	1 per 10 samples	< RL	Reanalyze blank to confirm result. If result confirm, redigest samples	Lab Analyst	Results within acceptance limits
MS/MSD	1 pair per prep batch up to 20 samples	TIAs: 50-150% recovery, <35% RPD As3+: 30-170% recovery, <35% RPD	Re-analyze result and examine other QC results. For RPD failures, qualify data or analyze additonal aliquot..	Lab Analyst	Results within acceptance limits
LCS/LCSD	1 pair per prep batch up to 20 samples	TIAs: 50-150% recovery, <35% RPD As3+: 30-170% recovery, <35% RPD	Re-analyze result for confirmation. If the result confirms recalibrate.	Lab Analyst	Results within acceptance limits
Duplicate	MS/MSD fulfills requirement.	<35% RPD	Qualify data where appripriate. If qualification is not possible an additional aliquot is analyzed.	Lab Analyst	Results within acceptance limits

Worksheet #28: Analytical Laboratory Quality Control and Corrective Action - #28b Phosphorus

Matrix Aqueous

Analytical Group Wet Chemistry

Analytical Method/SOP Reference SM 4500_P_E / UP-WC-4500PE

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
Initial calibration (six standards and a blank)	Daily initial calibration prior to sample analysis	r >/= 0.995	Correct problem then repeat initial calibration;	Lab Analyst	
Second-source calibration verification (ICV)	Daily after initial calibration	+/- 10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.	Lab Analyst	90-110%R
Initial Calibration Blank (ICB)	After ICV	+/- RL (LOQ)	Correct problem then re-analyze; may report results > 10x contamination level or non-detects if biased high	Lab Analyst	< RL (LOQ)
MB	One per prep batch of </= 20 samples	+/- RL (LOQ)	Correct problem; if required, re-prep and re-analyze MB and all associated samples; may report results >10 x the contamination level or non-detects if biased high. If re-analysis cannot be performed, apply "B" qualification in all samples in associated preparation batch.	Lab Analyst	< RL (LOQ)
LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	80-120%R
Sample Duplicate or LCSD	One per prep batch per client request	RPD ≤ 20%	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	RPD ≤ 20%
MS	1 per preparatory batch (≤ 20 samples)	75-125%R	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	75-125%R

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
MSD	1 per preparatory batch (≤ 20 samples)	RPD ≤ 20%	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	RPD ≤ 20%
Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analysis sequence	+/- 10% of known concentration	Correct problem then repeat the CCV/CCB and all samples since the last successful CCV/CCB; may report non-detects if CCV is biased high.	Lab Analyst	90-110%R
Continuing Calibration Blank (CCB)	After every CCV	+/- RL (LOQ)	Correct problem then re-read the CCV/CCB and all samples since the last successful CCV/CCB; may report results > 10x the contamination level.	Lab Analyst	< RL (LOQ)

Worksheet #28: Analytical Laboratory Quality Control and Corrective Action - #28c PFCs

Matrix Aqueous

Analytical Group PFCs

Analytical Method/SOP Reference EPA Method 537/ WS-LC-0025

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
Method Blank	One per preparation batch	No target analytes ≥ RL	Evaluate blank, reanalyze if carryover suspected. Evaluate impact on samples. If necessary, re-extract and reanalyze method blank and all samples processed with the contaminated blank.	Lab Manager / Analyst	No target analytes ≥ RL
Isotope Dilution Analyte (IDA): added prior to extraction	Every sample, spiked sample, standard, and method blank	25 – 150 IDA	Reanalyze once. Assess matrix, dilute if needed. Evaluate impact on data.	Lab Manager / Analyst	< RL (LOQ)
LCS	One LCS per preparation batch	64 – 124%R 67 – 127%R	Reanalyze LCS once. If acceptable, report. Otherwise, evaluate samples and impact. If samples non-detect and bias is high, report. If bias is low, re-extract and reanalyze the LCS and all samples in the associated prep batch for failed analytes, if sufficient sample material is available.	Lab Manager / Analyst	30 RPD
MS/MSD (assumes adequate volume)	One MS/MSD pair per preparation batch	Limits in 28-1	Evaluate the data, and re-prepare/reanalyze the native sample and MS/MSD pair if laboratory error is indicated.	Lab Manager / Analyst	< RL (LOQ)

Worksheet #28: Analytical Quality Control and Corrective Action – #28d IC Anions

Matrix Aqueous

Analytical Group Wet Chemistry

Analytical Method/SOP Reference SW-846 9056A / UP-WC-300.0

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
Initial calibration (six standards and a blank)	Monthly initial calibration prior to sample analysis	r >/= 0.995	Correct problem then repeat initial calibration;	Lab Analyst	
Second-source calibration verification (ICV)	Daily after initial calibration	+/- 10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.	Lab Analyst	90-110%R
Initial Calibration Blank (ICB)	After ICV	+/- RL (LOQ)	Correct problem then re-analyze; may report results > 10x contamination level or non-detects if biased high	Lab Analyst	< RL (LOQ)
MB	One per prep batch of </= 20 samples	+/- RL (LOQ)	Correct problem; if required, re-prep and re-analyze MB and all associated samples; may report results >10 x the contamination level or non-detects if biased high. If re-analysis cannot be performed, apply "B" qualification in all samples in associated preparation batch.	Lab Analyst	< RL (LOQ)
LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	80-120%R
Sample Duplicate or LCSD	One per prep batch per client request	RPD ≤ 20%	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	RPD ≤ 20%
MS	1 per preparatory batch (≤ 20 samples)	75-125%R	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	75-125%R

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
MSD	1 per preparatory batch (≤ 20 samples)	RPD ≤ 20%	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	RPD ≤ 20%
Continuing Calibration Verification (CCV)	Prior to sample analysis and after every 10 readings and at the end of the analysis sequence	+/- 10% of known concentration	Correct problem then repeat the CCV/CCB and all samples since the last successful CCV/CCB; may report non-detects if CCV is biased high.	Lab Analyst	90-110%R
Continuing Calibration Blank (CCB)	After every CCV	+/- RL (LOQ)	Correct problem then re-read the CCV/CCB and all samples since the last successful CCV/CCB; may report results > 10x the contamination level.	Lab Analyst	< RL (LOQ)

Worksheet #28: Analytical Laboratory Quality Control and Corrective Action - #28e Sulfide

Matrix Aqueous

Analytical Group Wet Chemistry

Analytical Method/SOP Reference SW-846 9034/ UP-WC-Sulfide

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
MB	One per prep batch of </= 20 samples	+/- RL (LOQ)	Correct problem; if required, re-prep and re-analyze MB and all associated samples; may report results >10 x the contamination level or non-detects if biased high. If re-analysis cannot be performed, apply "B" qualification in all samples in associated preparation batch.	Lab Analyst	< RL (LOQ)
LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	80-120%R
Sample Duplicate or LCSD	One per prep batch per client request	RPD ≤ 20%	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	RPD ≤ 20%
MS	1 per preparatory batch (≤ 20 samples)	75-125%R	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	75-125%R
MSD	1 per preparatory batch (≤ 20 samples)	RPD ≤ 20%	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	RPD ≤ 20%

Worksheet #28: Analytical Laboratory Quality Control and Corrective Action - #28f - TOC

Matrix Aqueous

Analytical Group Wet Chemistry

Analytical Method/SOP Reference SW-846 9060A / UP-WC-TOC

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
Initial calibration (six standards and a blank)	Daily initial calibration prior to sample analysis	r >/= 0.995	Correct problem then repeat initial calibration;	Lab Analyst	
Second-source calibration verification (ICV)	Daily after initial calibration	+/- 10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.	Lab Analyst	90-110%R
Initial Calibration Blank (ICB)	After ICV	+/- RL (LOQ)	Correct problem then re-analyze; may report results > 10x contamination level or non-detects if biased high	Lab Analyst	< RL (LOQ)
MB	One per prep batch of </= 20 samples	+/- RL (LOQ)	Correct problem; if required, re-prep and re-analyze MB and all associated samples; may report results >10 x the contamination level or non-detects if biased high. If re-analysis cannot be performed, apply "B" qualification in all samples in associated preparation batch.	Lab Analyst	< RL (LOQ)
LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	80-120%R
Sample Duplicate or LCSD	One per prep batch per client request	RPD ≤ 20%	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	RPD ≤ 20%
MS	1 per preparatory batch (≤ 20 samples)	75-125%R	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	75-125%R

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
MSD	1 per preparatory batch (≤ 20 samples)	RPD ≤ 20%	For the specific analyte(s) in the parent sample, apply "*" flag if acceptance criteria are not met.	Lab Analyst	RPD ≤ 20%
Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analysis sequence	+/- 10% of known concentration	Correct problem then repeat the CCV/CCV and all samples since the last successful CCV/CCB; may report non-detects if CCV is biased high.	Lab Analyst	90-110%R
Continuing Calibration Blank (CCB)	After every CCV	+/- RL (LOQ)	Correct problem then re-read the CCV/CCB and all samples since the last successful CCV/CCB; may report results > 10x the contamination level.	Lab Analyst	< RL (LOQ)

Worksheet #28: Analytical Laboratory Quality Control and Corrective Action - #28g - Alkalinity

Matrix Aqueous

Analytical Group Wet Chemistry

Analytical Method/SOP Reference SM-2320B / UP-WC-Alkalinity

Lab QC Sample	Number/ Frequency	Method/SOP Acceptance Limits	Corrective Action	Person (title/position) Responsible for Corrective Action	Project-specific MPC
MB	One per prep batch of </= 20 samples	+/- RL (LOQ)	Correct problem; if required, re-prep and re-analyze MB and all associated samples; may report results >10 x the contamination level or non-detects if biased high. If re-analysis cannot be performed, apply "B" qualification in all samples in associated preparation batch.	Lab Analyst	< RL (LOQ)
LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	80-120%R
Sample Duplicate or LCSD	One per prep batch per client request	RPD ≤ 20%	Apply "*" flag if acceptance criteria are not met and explain in the case narrative.	Lab Analyst	RPD ≤ 20%

Worksheet #29: Project Documents and Records

During the Corrective Measure Implementation (CMI) process various documents will be prepared and submitted to EPA. These documents are divided into the following categories:

Project Planning Reports- Outline projected work (Why, How, Who, When).

Project Activity Reports – Summary report of completed tasks or activities, notice of deviation to planning documents, delivery of pertinent information/data.

Field Documentation and Records – Field generated information via, forms, field logging, data collection, measurements, etc. collected by Field Personnel.

Project Audits/ Assessments – Project Administrator review of management processes, Manager review of field collection documents and validation of data.

CMI Milestone Reports – CMI process reports on progress or completion of remedial activities.

All non-identical documents generated and submitted to EPA whether in part or whole, shall be retained until 10 years after the EPA issues an Acknowledgment of Termination (satisfaction of completion on the Administrative Order on Consent). Past provided documents, contractor generated documents and/or work-related records now in possession or control or that come into possession or control must also be preserved for 10 years after an Acknowledgment of Termination is provided by the EPA. At the conclusion of the record retention period a formal notice shall be provided to the EPA 90 days prior to any deletion or destruction of records.

Project Planning Documents			
Record	**Generation**	**Verification**	**Storage Location/Archive**
Updated CSM Report	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Corrective Measures Implementation Work Plan (CMI WP): Remedial Construction Phase I	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Uniform Federal Policy - Quality Assurance Project Plan (UFP-QAPP)	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Health and Safety Plan (HASP)	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)

Project Planning Documents			
Record	**Generation**	**Verification**	**Storage Location/Archive**
Community Participation Plan (CPP)	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Landfill Beneficial Use Determination (BUD) Study	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Corrective Measures Implementation Work Plan (CMI WP): Remedial Construction Phase II	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Hydrogeological Study and Groundwater Treatment Contingency Design Report	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)

Project Activity Reports			
Record	**Generation**	**Verification**	**Storage Location/Archive**
Technical Memorandum - Subsurface Structures and Disturbed Fill Survey	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum - Source Areas Geophysical Survey/ Source Area Boundary Survey	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum - Geotechnical Investigation for Building Design / Cap Construction Specification/ ISS	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Baseline Groundwater Sampling	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Preliminary Groundwater Treatment	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Source Area Remedial Action Completion	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Source Area Remedial Performance Report (Groundwater Monitoring)	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Material Acceptance/ LVA Manufacturing Start Up for Cap Construction	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)

Project Activity Reports			
Record	**Generation**	**Verification**	**Storage Location/Archive**
Technical Memorandum – Building and Hydraulic Control Design	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Building and Hydraulic Control Installation	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Groundwater Treatment System Installation	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Groundwater Enhanced Sulfate Reduction Injections	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Groundwater Treatment Performance Monitoring Report	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Technical Memorandum – Groundwater Treatment Contingency	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)

Sample Collection and Field Records			
Record	**Generation**	**Verification**	**Storage Location/Archive**
Field logbook/field sampling forms	Impact Environmental Field Team Leader	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Field Maps/ GIS Mapping and Models	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Equipment/instrument calibration and maintenance Sheets	Impact Environmental Field Team Leader	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
C-O-C forms	Impact Environmental Field Team Leader	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Field Change Records (FCRs)	Impact Environmental Field Team / Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Accident/incident reports	Impact Environmental Field Team Leader; HSO	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)

HASP Out of Compliance Actions	Impact Environmental Field Team Leader; HSO	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)

Sample Collection and Field Records			
Record	**Generation**	**Verification**	**Storage Location/Archive**
Laboratory data packages (to include C-O-C Sheet)	TestAmerica Laboratories, Inc	LDC Data Verification/Validation Project Manager	Laboratory server; FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Electronic data deliverables (EDD)	TestAmerica Laboratories, Inc	LDC Data Verification/Validation Project Manager	Laboratory server; FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Sample disposal records	TestAmerica Laboratories, Inc	TestAmerica Laboratories, Inc	Laboratory server

Project Audits/ Assessments			
Record	**Generation**	**Verification**	**Storage Location/Archive**
Field audit checklists/ reports	Impact Environmental Field Team Leader; HSO/ QA/QC Lead	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Field data verification checklists/reports	Impact Environmental Field Team Leader; LDC Data Management Task Lead	Impact Environmental Project Manager/ QA/QC Manager /ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Laboratory corrective action forms/reports	TestAmerica Laboratories, Inc	LDC Project Manager; Impact Environmental Project Manager/ QA/QC Manager /ECGP Project Administrator	Laboratory server; FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Data validation reports	LDC Data Verification Personnel	LDC Project Manager; Impact Environmental Project Manager/ QA/QC Manager /ECGP Project Administrator	LDC server; FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)/hardcopy)
Validated data	LDC Data Verification/ Validation Task Lead	LDC Project Manager; Impact Environmental Project Manager/ QA/QC Manager /ECGP Project Administrator	LDC server; FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)/hardcopy)
Data usability assessment report(s)	Impact Environmental QA/QC Manager	Impact Environmental Project Manager/ QA/QC Manager /ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)/hardcopy)

CMI Project Milestone Reports			
Record	**Generation**	**Verification**	**Storage Location/Archive**
Long-Term Monitoring and Maintence Plan Report	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Corrective Measures Implementation Report (Final Remedy Construction Completion Report)	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)
Quarterly Progress Reports	Impact Environmental Project Personnel	Impact Environmental Project Manager/ ECGP Project Administrator	FileShare site (posted upon approval); Impact Environmental server (electronic); Impact Environmental Bohemia, NY office (hardcopy)

Worksheet #31, 32, and 33: Assessments and Corrective Action

Audits/ Assessments					
Assessment Type	**Responsible Party/ Organization for Performance of Assessment**	**Number; Frequency**	**Estimated Date(s)**	**Assessment Deliverable**	**Deliverable Due Date**
Operational Readiness Assessment	Impact Environmental Project Manager and Field Operations Manager/ ECGP Project Administrator	TBD; Prior to beginning each major phase of work/sampling event of field program	TBD	Readiness review checklist/form	24 hours following completion of assessment
Field Audits	Impact Environmental Project Manager and/or Field Operations Manager	TBD; dependent on longevity of field activity/ conducted first day of task start/ conducted weekly if task is longer than a month	TBD	Field audit checklist/report	24 hours following completion of assessment
Laboratory Audits	LDC Data Verification/ Validation Project Manager	TBD; As needed based on performance of laboratory	As needed	Laboratory audit checklist/report	3 days following completion of assessment
Sample Collection Audits	Impact Environmental Project Manager and/or Field Operations Manager	TBD; As needed based on field sampling events	As needed	Management report/ email notification	Conducted on first day of sampling event – corrective action within 24hrs of event start
Management Review	ECGP Project Administrator	TBD; Management reviews following mobilization for major phases of field program. Management review upon coordination and completion of field work. TBD; Interim management reviews during preparation of CMI documents.	TBD	Management report/ email notification	48 hours following management review

Assessment Response and Corrective Action					
Assessment Type	**Responsible Party/ Organization for Responding to Findings**	**Assessment Response Documentation**	**Timeframe for Response**	**Responsible Party/ Organization for Implementing Corrective Action**	**Responsible Party/ Organization for Monitoring Corrective Action Implementation**
Operational Readiness Assessment	Impact Environmental Field Operations Manager and Field Team Leader	Corrective action responses documented on checklist/form and/or in email/memorandum	24 hours following receipt of checklist/form	Impact Environmental Field Operations Manager and Field Team Leader	ECGP Project Administrator
Field Audits	Impact Environmental Field Operations Manager and Field Team Leader	Corrective action responses documented on checklist/report and/or in email/memorandum	24 hours following receipt of checklist/report	Impact Environmental Field Operations Manager and Field Team Leader	ECGP Project Administrator
Laboratory Audits	TestAmerica Project Manager and LDC Project Manager	Corrective action responses documented on checklist/report and/or in email/memorandum	24 hours following receipt of checklist/report	TestAmerica Project Manager	LDC Data Verification/ Impact Environmental QA/QC Manager
Sample Collection Audits	Impact Environmental Operations Manager and/or Field Team Leader	Deficiency Response Report	24 hours following receipt of deficiency report	Impact Environmental Operations Manager and/or Field Team Leader	Impact Environmental Project Manager and Field Operations Manager/ ECGP Project Administrator
Management Review	Impact Environmental Project Manager and Field Operations Manager	Corrective action responses documented in email/memorandum	48 hours following receipt of email/ memorandum	Impact Environmental Project Manager and Field Operations Manager	ECGP Project Administrator / EPA

Worksheet #34: Data Verification and Validation Inputs

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)	Usability (Achievement of DQOs and MPCs)
Planning Documents/Records				
2	Approved Plans (see Worksheet #29)	X	-	-
3	Field Standard Operating Procedures	X	-	-
4	Laboratory Standard Operating Procedures	X	-	X
Field Records				
5	Readiness review checklists/forms	X	-	-
6	Field logbooks/field sampling forms	X	X	-
7	Field construction forms (well construction/abandonment, etc.)	X	X	-
8	Equipment/instrument calibration and maintenance forms	X	X	-
9	GPS coordinate log forms and electronic data compilation	X	X	-
10	Well survey log forms and electronic data compilation	X	X	-
11	Pneumatic Slug Test electronic data computation data compilation	X	X	-
12	Ex-Situ soil stabilization reagent source documentation/BOLs	X	X	-
13	Ex-Situ soil stabilization reagent dosage/application field log forms	X	X	-
14	In-Situ soil stabilization reagent source documentation/BOLs	X	X	-
15	In-Situ soil stabilization reagent dosage/application field log forms	X	X	-
16	Other field documentation (diagrams, reports, photographs, etc.)	X	-	-
17	Laboratory Chain of Custody forms	X	X	-
18	Material import documentation/manifests	X	-	-
19	Remedial derived waste manifests	X	X	-
20	Change orders/deviations	X	X	X
21	Relevant correspondence	X	-	-
22	Field audit reports	X	X	-
23	Field corrective action reports	X	X	-
Analytical Data Packages				
24	Cover sheet (laboratory identifying information)	X	X	X

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)	Usability (Achievement of DQOs and MPCs)
Analytical Data Packages (continued)				
25	Case narrative	X	X	X
26	Internal laboratory chain-of-custody	X	X	X
27	Sample receipt records	X	X	X
28	Sample chronology (date/time of receipt, preparation, and analyses)	X	X	X
29	Communication records	X	X	X
30	LOD/LOQ establishment and verification	X	X	X
31	Standards traceability	X	X	X
32	Instrument calibration records	X	X	X
33	Definition of laboratory qualifiers	X	X	X
34	Results reporting forms	X	X	X
35	QC sample results	X	X	X
36	Corrective action reports	X	X	X
37	Raw data	X	X	X
38	Electronic Data Deliverables	X	X	X
Reporting				
39	Event reports/Agency memorandums (quarterly)	X	X	X
40	Data Validation Report with third party DUSR	X	X	X
41	Secondary Data review and integration	X	X	X
42	Revised Electronic Data Deliverables (third party validation)	X	X	X
43	Final Report	X	X	X

Worksheet #35: Data Verification Procedures

Data review, validation, and verification procedures are presented in this section. Three types of data are collected for this project: continuous hourly data from PM_{10} monitors, speciation data from manual samplers, and continuous 5-minute data from meteorological sensors. The five-minute data are averaged into hourly values, which is the format for final reporting. Daily data review is the responsibility of the data management task leader for the project, in parallel with operations staff. The task leader also performs the routine monthly review and validation functions or delegates and supervises them.

In the event that the daily data review indicates a potential unusual or elevated result the reviewer (this can be the site operator, operations supervisor, or data analysis specialist, as all perform routine data review tasks) notifies the project manager and data management task leader. The data editor gathers all pertinent QC data for the date and time of the result of interest and reports to the project manager regarding the validity of the measured values. This typically occurs within 24 hours of first discovery of the situation. If the measurements are valid, the project manager immediately notifies the client and provides associated meteorological data so that the client may investigate any potential events or sources that could have contributed to the result of interest.

Analytical laboratory reports for speciation of manual samples will be forwarded in electronic format and loaded into the database using a custom loading script. The Project Manager, Quality Assurance Manager and Laboratory Project Manager are responsible for ensuring that the data are properly loaded and the supporting documentation is in the central project file.

Data will be declared invalid whenever documented evidence exists demonstrating that a continuous monitor or meteorological sensor was not collecting data under representative conditions or was malfunctioning. In rare cases where a consistent offset in continuous measurements can be verified, a factor may be applied to the averages in a data set with clear identification of the affected data. The project data documentation files will contain the supporting documentation of the use of and justification for the factor. Data are never declared invalid solely because they are unlikely to occur in nature, but may be flagged as suspect and be subjected to further review until the cause for the apparent anomaly is determined. The results from all quality control and quality assurance checks are evaluated to determine if the data quality objectives for each measurement are being met. Evidence of overwhelming measurement bias, external influences on the representativeness of the data, or lack of reproducibility of the measurement data may be cause for the data to be judged invalid.

After the edit and validation review is complete, the editor returns a set of instructions to the data manager for application to the data set. The final edited version of the data is then produced and peer reviewed to ensure that the edits were properly applied and that the validation process was consistent with project requirements. A record of the edit instructions is retained in the project files, as is the final data product. Once the project manager has reviewed and approved the edited data set, it is released and reported to the Agency.

It is the Project Manager, Project Quality Control Manager and Project Quality Assurance Manager's responsibility to evaluate the project's progress in meeting the project data quality objectives for the resultant laboratory data. Two areas will be reviewed: the performance of the project in respect to the quality goals specified in the QAPP and the limitations (if any) on the measurement data for their intended use. The results of this evaluation will be reported to the Agency.

If any of the data quality laboratory analysis/analyses indicate performance outside the desired objective (ex. an audit result outside the project specification, etc.) the data associated with that result are not considered useless. The burden is on the project team to determine the extent to which a quality issue affects the related data, and ultimately how the issue impacts the fitness for use of the data. Most often a single isolated incident in which the performance objective is not met does not automatically render the data useless, but rather slightly reduces the confidence that the measurement is reliable and indicates that increased quality control measures are needed. Any such data for which there is a question of confidence will be appropriately flagged in the data base. The data quality objectives are assessed periodically throughout the monitoring effort. A month in which the completeness statistic for a given site is below the objective is cause for concern and corrective action, but if the other months are within the objective the confidence in the complete data set should remain high.

Any potential limitations of the validated data set will be identified and communicated. The project team will present all known or potential limitations on the data with each data submittal and will clearly flag any such data so that users may determine if the data should be used for a particular conclusion or decision.

Worksheet #35: Data Verification Procedures

Verification Inputs	Required Documents	Process Description	Responsible Person (Name, Organization)
Field logbooks/ Field sampling forms	UFP-QAPP; Field SOPs	Verify records are present and complete for each day of field activities. Verify that all planned samples including field QC samples were collected as outlined in approved plans and that sample collection locations are documented. Verify changes/exceptions are documented and were reported/approved in accordance with project requirements. Verify any required field monitoring was performed and results are documented.	Project Manager, IEC Quality Assurance Manager, IEC Project Scientist, IEC
Field equipment/ instrument calibration and maintenance forms	UFP-QAPP; Field SOPs	Verify the completeness of chain-of-custody records. Examine entries for consistency with the field logbook. Check that appropriate methods and sample preservation have been recorded. Verify that the required volume of sample has been collected and that sufficient sample volume is available for QC samples (e.g., MS/MSD). Verify that all required signatures and dates are present. Check for transcription errors.	Project Manager, IEC Quality Assurance Manager, IEC Facility Operations Manager, IEC Project Scientist, IEC
Electronic Data Verification	UFP-QAPP; Field SOPs	Verification of data upload to data management system, data validity with regional datum (GPS) and surveyed elevations (groundwater water table measurement devices), review consistency of measurements from duplicate trials (PST), compare recorded electronic data against hard copy data.	Project Manager, IEC Quality Assurance Manager, IEC Quality Control Manager, IEC Facility Operations Manager, IEC Project Scientist, IEC Contracted Data Validator, TBD
Chain of Custody Forms	UFP-QAPP	Verify the completeness of Chain of Custody records. Examine entries for consistency with the field logbook. Check that appropriate methods and sample preservation have been recorded. Verify that the required volume of sample has been collected and that sufficient sample volume is available for QC samples (e.g., MS/MSD). Verify all required signatures and dates are present. Check for transcription errors.	Project Manager, IEC Quality Assurance Manager, IEC Contracted Data Validator, LDC CLP Lab Manager, TestAmerica

Verification Inputs	Required Documents	Process Description	Responsible Person (Name, Organization)
Sample Receipt and Laboratory Sample Logins	UFP-QAPP; Field SOPs Laboratory SOPs	Review Verification receipt of samples by the laboratory the day following shipment. Sample login information will be reviewed and verified for completeness in accordance with the chain-of-custody forms.	Project Manager, IEC Quality Assurance Manager, IEC Contracted Data Validator, LDC CLP Lab Manager, TestAmerica
Laboratory data completeness and accuracy	UFP-QAPP; Field SOPs Laboratory SOPs	All laboratory data packages will be verified for completeness and technical accuracy by the laboratory performing the work. Data packages will then be reviewed by the Quality Assurance Manager and Contracted Data Validator for completeness.	Project Manager, IEC Quality Assurance Manager, IEC Contracted Data Validator, LDC CLP Lab Manager, TestAmerica
Laboratory data consistency verification	UFP-QAPP; Field SOPs Laboratory SOPs	Select analyses that will undergo a data consistency review and verification. Perform consistency review of data transfer from the original laboratory bench sheets and instrument data to the result reports.	Project Manager, IEC Quality Assurance Manager, IEC Contracted Data Validator, LDC CLP Lab Manager, TestAmerica
Other field documentation (diagrams, reports, outputs, etc.)	UFP-QAPP; Field SOPs	Verify records are present and complete for each day of field activities as applicable. Verify changes/exceptions are documented and were reported/approved in accordance with project requirements.	Project Manager, IEC Quality Assurance Manager, IEC Facility Operations Manager, IEC Project Scientist, IEC
Event reports (QERs/FinaL)	UFP-QAPP; Field SOPs; HASP CMI Work Plan	Verify records are present and complete. Verify events (quality, H&S) are documented and were reported in accordance with project and corporate requirements. Verify any subsequent corrective actions are documented and were approved/implemented in accordance with project and corporate requirements.	Project Manager, IEC Quality Assurance Manager, IEC Health and Safety Manager, IEC Project Scientist, IEC
Relevant correspondence	UFP-QAPP; Field SOPs; HASP CMI Work Plan	Verify records are present and complete for each day of field activities as applicable. Verify changes/exceptions are documented and were reported/approved in accordance with project requirements.	Project Manager, IEC Quality Assurance Manager, IEC Facility Operations Manager, IEC Project Scientist, IEC

Verification Inputs	Required Documents	Process Description	Responsible Person (Name, Organization)
Field audit reports and corrective action reports	UFP-QAPP; Field SOPs; HASP CMI Work Plan	Verify all planned audits were conducted. Examine audit reports. For any deficiencies noted, verify that corrective action was implemented according to plan.	Project Manager, IEC Quality Assurance Manager, IEC Quality Control Manager, IEC Facility Operations Manager, IEC
Change orders/ deviations	UFP-QAPP; Field SOPs	Verify records are present and complete. Verify changes/exceptions are documented and were reported/approved in accordance with project requirements.	Project Manager, IEC Facility Operations Manager, IEC Facility Manager, IEC
Field and electronic data verification and upload	UFP-QAPP; Field SOPs	One hundred percent of manual data entries (in the field or from field forms) will be reviewed against the hardcopy information, and 10 percent of electronic uploads will be checked against the hardcopy. Verify the correct transfer of results from the laboratory deliverables into the USEPA Region 5 Database.	Project Manager, IEC Quality Assurance Manager, IEC Facility Operations Manager, IEC Project Scientist, IEC Contracted Data Validator, LDC CLP Lab Manager, TestAmerica

Worksheet #36: Data Validation Procedures

Data Validator: Laboratory Data Consultants, Inc., Carlsbad, CA

The chemical data results obtained during the investigation will undergo a systematic data review to provide assurance that the data are adequate for their intended uses. Pursuant to USEPA Region 5 SOP: Level 4 Validation Criteria, the following data validation percentages will be employed for this work[3]:

- Percent of data packages to be validated: 100% initial data evaluation, 100% full data validation
- Percent of raw data to be reviewed: 100% full data validation
- Percent of results to be recalculated: 10% full data validation

Data will be managed, reviewed, and verified in accordance with the requirements outlined in the table below.

Analytical Group [Equivalent Method [1]]	Data Deliverable Requirements [2]	Analytical Specifications/ Measurement Performance Criteria	Validation Procedure	Validation Code [4]
Total/Dissolved Metals Analyses: 6010B Prep: 3010A	**PDF**: Data Package Report (to include all elements specified in Worksheet #29, Laboratory Records and equivalent to USEPA Region 5 Contract Laboratory Program forms/package) **ELECTRONIC**: Staged Electronic Data Deliverable (SEDD) Stage 3, formatted to USEPA Region 5 EDD Template (EqUIS Version 6.6)	Worksheets #12, 15, 19, 24, and 28	*January 2017 Revised, USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (ISM02.4) document: Part A and Part B (ICP-AES Data Review)*	S4VEM

Analytical Group [Equivalent Method [1]]	Data Deliverable Requirements [2]	Analytical Specifications/ Measurement Performance Criteria	Validation Procedure	Validation Code [4]
Speciated Arsenic (As III/As V) Analyses: HPLC-ICPMS Coupled Speciation Prep: HPLC-ICPMS Coupled Speciation	**PDF**: Data Package Report (to include all elements specified in Worksheet #29, Laboratory Records and equivalent to USEPA Region 5 Contract Laboratory Program forms/package) **ELECTRONIC**: Staged Electronic Data Deliverable (SEDD) Stage 3, formatted to USEPA Region 5 EDD Template (EqUIS Version 6.6)	Worksheets #12, 15, 19, 24, and 28	*January 2017 Revised, USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (ISM02.4) document: Part A and Part B (ICP-AES Data Review)*	S4VEM
Total/Dissolved Phosphorus Analyses: SM4500P Prep: SM4500	**PDF**: Data Package Report (to include all elements specified in Worksheet #29, Laboratory Records and equivalent to USEPA Region 5 Contract Laboratory Program forms/package) **ELECTRONIC**: Staged Electronic Data Deliverable (SEDD) Stage 3, formatted to USEPA Region 5 EDD Template (EqUIS Version 6.6)	Worksheets #12, 15, 19, 24, and 28	*January 2017 Revised, USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (ISM02.4) document: Part A and Part B (ICP-MS Data Review)*	S4VEM

Analytical Group [Equivalent Method [1]]	Data Deliverable Requirements [2]	Analytical Specifications/ Measurement Performance Criteria	Validation Procedure	Validation Code [4]
Anions Analyses: SM4500 Prep: SM4500	**PDF**: Data Package Report (to include all elements specified in Worksheet #29, Laboratory Records and equivalent to USEPA Region 5 Contract Laboratory Program forms/package) **ELECTRONIC**: Staged Electronic Data Deliverable (SEDD) Stage 3, formatted to USEPA Region 5 EDD Template (EqUIS Version 6.6)	Worksheets #12, 15, 19, 24, and 28	*January 2017 Revised, USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (ISM02.4) document: Part A and Part B (ICP-MS Data Review)*	S 4 V E M
Sulfide (Titrimetric) Analyses: SM4500 Prep: SM4500	**PDF**: Data Package Report (to include all elements specified in Worksheet #29, Laboratory Records and equivalent to USEPA Region 5 Contract Laboratory Program forms/package) **ELECTRONIC**: Staged Electronic Data Deliverable (SEDD) Stage 3, formatted to USEPA Region 5 EDD Template (EqUIS Version 6.6)	Worksheets #12, 15, 19, 24, and 28	*January 2017 Revised, USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (ISM02.4) document: Part A and Part B (ICP-MS Data Review)*	S 4 V E M

Analytical Group [Equivalent Method [1]]	Data Deliverable Requirements [2]	Analytical Specifications/ Measurement Performance Criteria	Validation Procedure	Validation Code [4]
Total Organic Carbon Analyses: 9060A Prep: 9060A	**PDF**: Data Package Report (to include all elements specified in Worksheet #29, Laboratory Records and equivalent to USEPA Region 5 Contract Laboratory Program forms/package) **ELECTRONIC**: Staged Electronic Data Deliverable (SEDD) Stage 3, formatted to USEPA Region 5 EDD Template (EqUIS Version 6.6)	Worksheets #12, 15, 19, 24, and 28	*January 2017 Revised, USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (ISM02.4) document: Part A and Part B (ICP-MS Data Review*	S4VEM
Alkalinity/Bicarbonate Alkalinity Analyses: 2320B Prep: 2320B	**PDF**: Data Package Report (to include all elements specified in Worksheet #29, Laboratory Records and equivalent to USEPA Region 5 Contract Laboratory Program forms/package) **ELECTRONIC**: Staged Electronic Data Deliverable (SEDD) Stage 3, formatted to USEPA Region 5 EDD Template (EqUIS Version 6.6)	Worksheets #12, 15, 19, 24, and 28	*January 2017 Revised, USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (ISM02.4) document: Part A and Part B (ICP-MS Data Review*	S4VEM

Analytical Group [Equivalent Method [1]]	Data Deliverable Requirements [2]	Analytical Specifications/ Measurement Performance Criteria	Validation Procedure	Validation Code [4]
PFOA/PFOS Analyses: 537	**PDF**: Data Package Report (to include all elements specified in Worksheet #29, Laboratory Records and equivalent to USEPA Region 5 Contract Laboratory Program forms/package) **ELECTRONIC**: Staged Electronic Data Deliverable (SEDD) Stage 3, formatted to USEPA Region 5 EDD Template (EqUIS Version 6.6)	Worksheets #12, 15, 19, 24, and 28	*January 2017 Revised, USEPA National Functional Guidelines for Organic Superfund Methods Data Review (SOM02.4) document: Part A and Part B (Trace Volatile Data Review)*	S4VEM

1 See Worksheet #23 for laboratory-specific method/amendment designation.

2 Hardcopy data package report will be submitted as a Portable Document Format (PDF) file.

3 The first two packages from a specific type of sampling per event will undergo Level 4 validation, subsequent packages will undergo validation at 80% Level 2b and 20% Level 4. In addition, Level 4 validation may occur at a higher frequency, such as when (1) a Level 2b package showed sufficient issues to warrant further review and/or (2) earlier Level 4 packages revealed analytical problems..

4 Validation codes to be utilized for Data verification Performance are as follows (from EPA 540-R-08-005):
S4VEM Stage 4 Validation Electronic and Manual

* Validation of all isotopic dilution methods will follow the 5-times rule for blanks, utilizing the most elevated value in the associated blanks (for estimated or non-estimated values). Validation of all other, non-isotopic dilution methods will follow the 1-times rule for blanks, utilizing the most elevated value in the associated blanks.

Worksheet #37: Data Usability Assessment

Personnel responsible for participating in the data usability assessment will include:

- IEC Project Manager: Kevin Kleaka, P.G.
- IEC Quality Assurance Manager: Michael Bluight, P.G.
- IEC Quality Control Manager/Statistician: Xin Yuan, P.E.
- Eurofins TestAmerica Chicago (TestAmerica) Project Manager: Mr. Richard Wright
- Laboratory Data Consultants, Inc. (LDC) Principal Chemist/Program Director: Ms. Stella Cuenco
- Laboratory Data Consultants, Inc. (LDC) Project Manager: Ms. Christina Rink-Ashdown

The assessment will be conducted using the following steps:

Step 1	**Review Project Objectives and Sampling Design** *Review key outputs defined during systematic planning (i.e., DQOs, and MPCs) to make sure they are still applicable. Review the sampling design for consistency with stated objectives. This provides the context for interpreting the data in subsequent steps.*
Step 2	**Review Data Verification and Data Validation Outputs** *Review available QA reports, including data verification and validation reports. Perform basic calculations and summarize the data (using graphs, maps, tables, etc.). Look for patterns, trends, and anomalies (i.e., unexpected results). Review deviations from planned activities (e.g., number and locations of samples, holding time exceedances, damaged samples, and SOP deviations) and determine their impacts on data usability. Evaluate implications of unacceptable QC sample results.*
Step 3	**Verify Assumptions of Selected Statistical Method** *Verify whether underlying assumptions for selected statistical method(s) are valid. Depending on the robustness of the statistical method, minor deviations from assumptions usually are not critical to statistical analysis and data interpretation. If serious deviations from assumptions are discovered, then another statistical method may need to be used.*
Step 4	**Implement the Statistical Method** *Implement the selected statistical procedures for analyzing the data and review underlying assumptions. For decisions that involve hypothesis testing, consider the consequences for selecting the incorrect alternative; for decisions that involve estimation, consider the tolerance for uncertainty in measurements.*
Step 5	**Document Data Usability and Draw Conclusions** *Determine if the data can be used as intended, considering implications of deviations and corrective actions. Discuss data quality indicators. Assess the performance of the sampling design and identify limitations on data use. Update the conceptual site model and document conclusions. Prepare a data usability summary report.*

The data validator will perform Level IV validation on 100% of the data for the samples in Worksheet #36. As discussed previously in Worksheet #36, Level IV data review basically provides a review of QA/QC results with recalculations performed on 10% of the data set(s).

Usability will be documented within a data validation summary report. The validation report will also contain a discussion on precision, accuracy, representativeness, comparability, and completeness, sensitivity, and reconciliation.

Measurement Performance Criteria

Measurement performance criteria describe how the Project Quality Objectives (PQOs) will be satisfied. The number of samples and analytical parameters are described in each of the previous PQO discussions. The analytical data generated during sampling activities will be evaluated based on QA/QC criteria as described in this QAPP. In addition, QA/QC evaluation criteria are included on Worksheets 12, 15, 24, and 28. Only data qualified as unusable (R) will be omitted from data analyses as these data are considered rejected and unusable due to QA/QC failure and/or gross holding time exceedances.

Data quality and quantity are measured by comparison of resulting data with established acceptable limits for precision, accuracy, representativeness, comparability, and completeness (PARCC), and sensitivity. Data outside PARCC/sensitivity QA objectives will be evaluated, according to Worksheet 28 (for each parameter) of this document and the criteria contained in the specified analytical methods, to determine what, if any, aspects of the data can be defensibly used to meet the project objectives.

Precision

Precision criteria for each analysis methods to be used for the sampling activities are summarized on Worksheet 28. Precision measures the reproducibility of data or measurements under specific conditions. Precision is a quantitative measure of the variability of a group of data compared to their average value. Precision is usually stated in terms of RPD or percent relative standard deviation (%RSD). Measurement of precision is dependent upon sampling technique and analytical method. Field duplicate and laboratory duplicate samples will be used to measure precision for project samples. Both sampling and analysis will be as consistent as possible. For a pair of measurements, RPD will be used in this project. For a series of measurements, %RSD will be used. The total precision of a series of measurements can be related by the additive nature of the variances. Equations for RPD and %RSD are presented below:

$$RPD = \frac{D1 - D2}{\frac{D1 + D2}{2}} x\ 100\%$$

Where: D1 and D2 = the two replicate values

And

$$\%\text{RSD} = \text{S}/x \text{ x } 100\%; \text{ and S} = \frac{\sqrt{\sum_{I=1}^{n} \frac{(x_i - x)^2}{n-1}}}{x}$$

Where:

S = standard deviation

x_i = each observed value
x = the arithmetic mean of all observed values
n = total number of values

Accuracy

Accuracy criteria for each analysis method to be used for the sampling activities are summarized on Worksheet 28. Accuracy measures the bias in a measurement system that may result from sampling or analytical error. Sources of error that may contribute to poor accuracy are:

- Laboratory error;
- Sampling inconsistency;
- Field and/or laboratory contamination;
- Handling;
- Matrix interference; and
- Preservation

Equipment blanks, as well as matrix spike QC samples, and LCSs, will be used to measure accuracy for project

samples. Accuracy is calculated using the percent recovery (%R) equation below:

$$\%R = \frac{SSR - SR}{SA} * 100$$

Where:

%R = % recovery
SSR = spike sample result
SR = sample result
SA = amount of spike added to sample

Representativeness

Representativeness criteria for each analysis method to be used for the sampling activities are summarized on Worksheet 28. Representativeness expresses the degree to which sample data represent the characteristics of the media or matrix from which they are collected. Samples that are considered representative are properly collected to accurately characterize the nature and extent of contamination at a general sample location. Representativeness will be measured by using

standardized collection methods (e.g., sampling, handling, and preserving) and laboratory analytical methods. Only data qualified "R" as unusable will not be used.

Comparability

Comparability criteria for each analysis method to be used are summarized on Worksheet 28. Comparability expresses the confidence with which one data set can be compared with another data set from a different phase or from a different program. Comparability involves a composite of the above parameters as well as design factors such as sampling and analytical protocols. An acceptable level of comparability will be accomplished through the consistent use of accepted analytical and sampling methods.

Completeness/Usability

Completeness criteria for each analysis method to be used for the sampling are summarized on Worksheet 28. Completeness is defined as the percentage of data that is judged to be valid to achieve the objectives of the investigation compared to the total amount of data. Completeness is discussed on a per analyte basis. A sample will consist of several analytes and/or compounds and very rarely is an entire sample considered unusable. Discussing completeness on a per analyte basis allows for use of the majority of the data. Deficiencies in the data may be due to sampling techniques, poor accuracy, precision, or laboratory error. While the deficiencies may affect certain aspects of the data, usable data may still be extracted from applicable samples. An evaluation of completeness necessarily involves an evaluation of the impact of missing data on the ability of the project to achieve its goals. The goal for completeness/usability is 90%. The equation used for completeness is presented below:

$$C(\%) = \frac{D}{P\ x\ n} X\ 100$$

Where:

D = number of confident quantification's
P = number of analytical parameters per sample requested for analysis
n = number of samples requested for analysis

As indicated previously, assessment of completeness alone does not provide a comprehensive evaluation of data quality. Therefore, the percentage of usable and unusable data will also be calculated by the following equations:

% Usable Data = #Unqualified Positive + U + J+ UJ / Total Number of Results

% Unusable Data = R + UR/Total Number of Results

Separate % Completeness, % Usable Data, and % Unusable Data calculations will be performed for the project data.

Sensitivity

Sensitivity is defined as the ability to achieve the project-required method reporting limits as defined in Worksheet 15. Action limit goals for the samples are based on United States Environmental Protection Agency Maximum Contaminant Levels (published in June 2011). If the laboratory method reporting limits are greater

than the action limits because they not technically achievable, the affected compounds will be reported to the method detection limit.

Reconciliation

The PQOs described in Worksheet 11 will be examined to determine if the objective was met. Each analysis will first be evaluated for data quality in terms of impacts from the data validation process. Based on the quality of the data, its usability will be determined. Note, only data qualified "R" as unusable will be excluded from use in the project. Based on the number of unusable analyses it will be determined if the PQOs were met. As part of the reconciliation of the objective, conclusions will be drawn and any limitations on the usability of any of the data will be described. Data will be reviewed and reported as having either positive or negative bias (as appropriate). Trends in data results will be discussed as appropriate and discussed with the laboratory, if necessary.

ATTACHMENTS

Former DuPont East Chicago Facility

Attachment A: Project Team Qualifications

Attachment B: Field Standard Operating Procedures

Attachment C: Laboratory Standard Operating Procedures

Attachment A

Project Team Qualifications

Former DuPont East Chicago Facility

RICHARD PARRISH, P.G.

PRESIDENT/CEO

33 years EXPERIENCE

EDUCATION

Bachelor of Arts, Earth & Space Science Concentration in Environmental Geology Waste Management
Certificate Program, Waste Management Institute, (CED) Candidate. SUNY at Stony Brook (1989)

EXPERIENCE

1989-Present **IMPACT ENVIRONMENTAL** President/CEO

- Supervise geologist, engineers, environmental scientist & analyst to facilitate operations of a 100+ employee environmental engineering & waste management firm with $60 million in annual revenues.
- Served as supervisor on over 1000 petrochemical spill sites throughout NY State, representing both generator and government agencies
- Major Projects include the first Beneficial use determinations(BUDs) issued in the State of New York and the State of Indiana for utilization of non-hazardous petroleum hydrocarbon contaminated soils as an asphalt aggregate
- Authored a multitude of BUD petitions for various other solid waste related projects in NY,NJ &PA, including projects such as The East Side Access, The Air Rail Project and JFK International Jet Blue Terminal 5
- Senior Project Manager for Melody Dry Cleaners & Grand Machinery Inactive Hazardous Waste Disposal Sites
- Supervised RI/FS work plan development for over 2 dozen NYC "OER" E-Designated projects in NYC
- Provided professional witness testimony/deposition statements in many legal cases involving soil, air and/or groundwater pollution within Federal and State Jurisdiction

2001-Present **INCORPORATED VILLAGE OF POQUOTT, NY**
Commission of the Environment

- Appointed position
- Review & approve applications requiring review pursuant to the State Environmental Quality Review Act
- Author of Village Storm Water Control Plan
- Investigates environmental quality concerns
- Litigation support of Village of Poquott v. Keyspan Energy Corp.

1985-1988 **DEPARTMENT OF ENVIRONMENTAL PROTECTION**
Investigator/Aide

- Managed and enforced all town Health, Safety codes and Laws
- Prepare detailed violation reports
- Supervised all town sampling and analysis programs

KEY PROJECTS

- East Side Access MTA LIRR
- Columbia University- Manhattanville Campus
- Melody Cleaners Hazardous Waste Site
- WTC Reconstruction- Greenwich St. Corridor
- Jet Blue Terminal 5 JFK Construction

ORGANIZATIONS

- National Wellwater Association
- National Asphalt Manufactures Association
- Long Island Association
- Environmental Assessment Association
- NYS Council of Professional Geologists
- NYSDEC's Citizen Committees for Inactive Hazardous Material Waste Disposal Sites

CERTIFICATIONS/ ACHIEVEMENTS

- Certified Professional Geologist
- US EPA 40hr Hazardous Materials Response for First Responders Training
- US EPA 24hr Sampling for Hazardous Material Training
- NYS Law Enforcement Seminar
- Certified Environmental Inspector
- LIA Young Entrepreneur of the Year 1992
- Hofstra University School of Business Achievement Award 1992
- Lead Agent for a joint investigation between Town of Smithtown, NY and the Suffolk County DA to prosecute Chemtronics Corp. for illegal dumping activities
- National Groundwater Association, Groundwater Contaminant Modeling (CED)

KEVIN KLEAKA, P.G.

Executive Vice President/Senior Environmental Scientist

24 years EXPERIENCE

EDUCATION

State University of New York at Plattsburg,
Bachelor of Science in Environmental Science, 1995 Applied Environmental Science Program

EXPERIENCE

(1997-Present) **– IMPACT ENVIRONMENTAL CLOSURES Inc.,**
Executive Vice President, Senior Environmental Scientist

- Principally responsible for managing environmental assessment, investigation, construction and remediation projects in commercial and industrial markets for lenders, real estate investment/development firms, construction firms and government agencies.
- Manage Phase I and II Environmental Site Assessments, State Spill Investigation and Remediation, County and Federal Underground Injection Control Programs, State & City Voluntary/Brownfield Cleanup Programs, State & Federal Superfund Sites, Brownfield Environmental Restoration Programs, Federal RCRA Closure, City E-Designation Projects.
- Responsible for environmental compliance of construction projects for waste management.
- Quality control of work products and deliverables.
- Supervise staff of geologists, hydrogeologists, engineers, environmental scientists, and environmental technicians to develop and implement sampling and analysis plans, quality assurance programs, remedial action plans.
- Provide expert witness testimony/fact statements and support in litigation cases involving soil, air and/or groundwater pollution.

(1995-1997) – **WYETH AYERST LABORATORIES**, Chemist worked in chromatographic separations division performing quality assurance analysis.

- Performed laboratory procedures and analyses in accordance with USFDA analytical test methods by liquid, gas, and thin layer chromatography.

KEY PROJECTS

- East Side Access MTA LIRR
- Melody Cleaners
- ExxonMobil Spill- Valley Stream, NY
- Spartan Petroleum
- JFK 1020, Runway 13R-31L
- Rheingold Brewery Redevelopment Project
- WTC Greenwich Street Corridor Reconstruction
- Yankee Stadium Macomb's Park

ORGANIZATIONS

- New York City Brownfield Partnership
- New Partners for Community Revitalization
- ASTM Committee
- National Groundwater Association
- Environmental Bankers Association
- Vapor Intrusion Network
- Long Island Geologist Association
- Environmental Consulting Professionals
- Environmental Insurance Professionals

CERTIFICATIONS/ ACHIEVEMENTS

- Licensed Profession Geologist (NYS# 000735)
- Gold Certified Brownfield Professional 2012
- Advanced Tools for In-Situ Remediation Workshop
- ASTM Technical & Professional Training for Assessment of Vapor Intrusion into Structures of Property & New York State Department of Health, Vapor Intrusion Training
- New York Precision Equipment Global Survey Positioning Training
- MTBE & TBA Comprehensive Site Assessment and Successful Groundwater Remediation
- Environmental Data Resources, Due Diligence Workshop
- Advanced Technologies for Accelerated Natural Attenuation
- Eophysical Survey Systems, Theory and Practice of Applying Subsurface Interface Radar in Engineering and Geophysical Investigation.
- 40-Hour Occupational Safety & Health Administration

XIN YUAN

Quality Control Manager

9 years EXPERIENCE

EDUCATION

Masters of Science, Civil Engineering, UMass Amherst (2010)
Bachelor of Science, Environmental Engineering. Tsinghua University, Beijing, China (2008)

EXPERIENCE

2010-Present **IMPACT ENVIRONMENTAL** *Quality Control Manager/Environmental Analyst*

- Quality control of all waste management/brownfield redevelopment projects;
- Management of site remediation/waste management projects;
- Environmental compliance & permitting of waste management facilities
- Achieve and maintain appropriate and consistent application of environmental compliance for waste disposal/beneficial use facilities
- Achieve and maintain appropriate and consistent application of environmental compliance at the regional Levels for waste management projects
- Review & evaluate site investigation/waste characterization results for waste management projects and provide technical recommendations to project manager
- Authored a multitude of BUD petitions for various other solid waste related projects in NY,NJ &PA, including projects such as The East Side Access, The Air Rail Project and JFK International Jet Blue Terminal 5
- Design and perform waste characterization investigations for waste management projects

KEY PROJECTS

- Columbia University Manhattanville Development Project
- LIRR 3rd Track Expansion Project
- Atlas Quarry Reclamation Project
- Former New Jersey Zinc Company-West Plant Remediation Project
- Morris Blanchard Redevelopment Project
- Brooklyn Bridge Park Pier 1 Redevelopment Project
- Southwest Brooklyn Marine Transfer Station Redevelopment Project
- Doremus Avenue Redevelopment Project

ORGANIZATIONS

- Long Island Association of Professional Geologists
- American Chinese Real Estate Society

CERTIFICATIONS/ ACHIEVEMENTS

- US EPA 40hr Hazardous Materials Response for First Responders Training
- Professional Engineer in MA, PA, NJ & NY

MICHAEL BLUIGHT, P.G.

Technical Manager

19 years EXPERIENCE

EDUCATION

Masters of Science, Hydrogeology SUNY at Stony Brook (In Progress)
Bachelor of Science, Geology. SUNY at Stony Brook (2000)

EXPERIENCE

2013-Present **IMPACT ENVIRONMENTAL** *Technical Manager/Quality Service Manager/Project Manager*

- Directed environmental related tasks related to the redevelopment of New York State Voluntary Cleanup Program and Inactive Hazardous Waste sites for future retail and commercial use
- Managed a portfolio of retail petroleum/automotive service station remediation projects in the metropolitan New York City and Long Island regions.
- Constructed and implemented interim and operable unit remedial measures and performed contaminant migration investigations for New York State Superfund projects.
- Devised and implemented bioremediative and in-situ chemical oxidation subsurface injection remedial work for petroleum and chlorinated solvent impacted sites.
- Provided project manager support related to technical design and construction of soil, soil vapor and groundwater remediation systems.
- Mentored and provided support for junior-level staff related to Federal, State and local environmental regulations, protocols and procedures, remediation system design and technical specifications, regulatory report writing, contaminate transport and flow modeling software, and field work protocols and procedures.
- Conducted multiple UST removal/replacement assessments, closures and remedial actions, Phase I and Phase II environmental site assessments and investigation and soil vapor intrusion investigation projects in the metropolitan New York City and Long Island regions.

2000-2013 Experience as a Project Manager and Senior Hydrogeologist at leading metropolitan New York based environmental and engineering firms

KEY PROJECTS

- Dzus Fasteners (NYS Inactive Hazardous Waste Disposal) Site, West Islip, NY
- Melody Cleaners (NYS Voluntary Cleanup Program) Site, East Meadow, NY
- Gerdau Steel/Anaconda Copper Site, Perth Amboy, NJ
- Cerro Wire (NYS Inactive Hazardous Waste Disposal) Site, Syosset, New York
- Sid Harvey Industries (NYS Voluntary Cleanup Program) Site, Valley Stream, New York
- General Dynamics Armament and Technical Products Site, Glen Cove, New York
- Fujicolor Processing, Inc. Sites, Nationwide locations
- Fairchild Republic Aircraft Main Plant (NYS Inactive Hazardous Waste Disposal) Site, Farmingdale, New York
- Commercial Envelope Manufacturing (NYS Inactive Hazardous Waste Disposal) Site, Deer Park, New York

ORGANIZATIONS

- National Ground Water Association
- Long Island Association of Professional Geologists
- New York State Council of Professional Geologists

CERTIFICATIONS/ ACHIEVEMENTS

- OSHA 40-hour HAZWOPER Training
- OSHA 10-hour Construction Safety
- CPR & First Aide Training
- Undergraduate Excellence in Teaching – SUNY @ Stony Brook
- Professional Geologist NYS#000872

JOHN SMITH

Facility Coordinator

5 years EXPERIENCE

EDUCATION

Bachelor of Science, Earth & Environmental Science. Wilkes University (2004)

EXPERIENCE

2015-Present **IMPACT ENVIRONMENTAL** *Facility Coordinator*

- Manage all remediation activates at facility.
- Manages all truck activities.
- Maintains safety standards at facility
- Performs required sampling and submits for testing.

2014- **REILLY ENGINEERING ASSOCIATES** *Environmental Scientist*

- Field set-up testing and evaluation of hydraulic conductivity and infiltration rates for a 620-acre property.
- Ensure proper size drainage system installation for future use.

2012-2013- **NORTH BRANCH LAND TRUST** *Ecology Surveyor*

- Proper Identification and assessment of various plant, animal, fungi species at various land preserves.
- Utilize GPS equipment and GIS software to create baseline assessments for further ecological preservation.

2006-2010 **US NAVY** *Operation Specialist 2nd Class*

- Operation of radar, navigation and communications equipment in combat information centers. Detect and track , ships, aircraft and missiles.

KEY PROJECTS

- Former NJ Zinc Plant West, Palmerton, NJ
- Former Dupont Facility E. Chicago, IN

CERTIFICATIONS/ ACHIEVEMENTS

- OSHA 40hr HAZWOPER

DAN FRUHAUF

Associate Project Manager

6 years EXPERIENCE

EDUCATION

Bachelor of Arts, Ecosystems & Human Impact. SUNY at Stony Brook (2012)

EXPERIENCE

2014-Present **IMPACT ENVIRONMENTAL** *Associate Project Manager*

- Managed multiple Phase I, Phase II and remedial projects
- Assembled proposals and contracts for clients
- Performed multiple methods of soil, groundwater and air sampling
- Managed and collaborated with multiple NYC OER redevelopment projects
- Provided logistic coordination and oversite for multiple projects

2013-2014 **SOVEREIGN CONSULTING Inc.** *Environmental Scientist*

- Gather field data on NYSDEC spill sites
- Building and installing remediation systems
- Contamination concentration, plume direction reports related to petroleum spills
- Groundwater, soil & vapor sampling
- Contractor oversight for all spill site work
- Working with and building relationships with NYSDEC, EPA & DEP

KEY PROJECTS

- Former DuPont Facility East Chicago

CERTIFICATIONS/ ACHIEVEMENTS

- HAZWOPER 40hr + 8hr Refreshers
- OSHA 10hr Construction Safety
- OSHA 30hr Construction Safety
- Transportation Worker Identification Card (TWIC)
- NYC Office of Environmental Remediation (OER) Trained
- MTA/Amtrak Track Safety
- MTA/NYC Transit Track Safety
- LIRR Safety Blue Card
- NYSDEC SWPPP Certified Inspector
- Certified NYSDOL Asbestos Inspector

CHRISTOPHER TRIPOLI

Health & Safety Officer

31 years EXPERIENCE

EXPERIENCE

(2018-Present) **– IMPACT ENVIRONMENTAL CONSULTING Inc.,** *Site Manager*

- Supervise staff of laborers, operators and mechanics on heavy equipment operation.
- Manage activities of large scale remedial and construction sites.
- Maintain health and safety of crew and visitors to sites and surrounding areas.
- Plan implementation of earthwork and equipment use on site.

(2015-Present) – **TRIP FARMS Inc.**, *Owner/Operator*

- Interstate Transportation
- Responsible For all aspects of interstate transportation keeping in compliance with all State and Federal DOT regulations, FMCSA Laws, Product safety and condition.

(2004-2015) – **CT CONSTRUCTION COORDINATION Inc.**, *Owner*

- Consulting for excavation companies, sand mines, and environmental companies in the use, reuse, sale or disposal, and transportation of various solid waste and resources.

(2002-2004) – **SLATTERY SKANSKA Inc.**, *Environmental Safety Engineer*

- Responsible for field supervision, safety audit, accident investigation, activity planning, OSHA compliance, industrial hygiene monitoring, confined space monitoring, environmental monitoring in relation to contaminants of concern, soil identification NYSDEC TAGM qualification, noise dosimeter, identifying and correcting safety and environmental hazards on former manufactured gas plant site during redevelopment.
- Directed oversight of soil segregation for reuse of disposal and the tracking of excavation elevations and depths to ensure the proper removal of soil and expedite construction activities.

(2001-2002) – **IMPACT ENVIRONMENTAL.**, *Environmental Scientist/Project Coordinator/Maintenance Supervisor*

- Setup of projects, schedule of equipment, supervision of personnel, operation of Geoprobes and various sample equipment, compliance with HAZWOPER standards, DEC regulations.

(1996-2001) – **D.L.I. CONTRACTING.**, *Project Coordinator/Lead Operator/Maintenance Supervisor*

- Set up of all required activities for construction of housing subdivisions, operation of all excavation equipment, set up and operation of various screening plants, sale and reuse of materials generated, over-site of concrete installation, dealt with various governmental agencies for permits and approval of installations.

KEY PROJECTS

- Gerdau- Elm Street Redevelopment
- Dupont- Newark Redevelopment

CERTIFICATIONS/ ACHIEVEMENTS

- US Navy Propulsions Engineer Training
- 40-Hour Occupational Safety & Health Administration
- CPR/Basic Life Support, Standard Level First Aid Course
- National Safety Counsel Member
- Diesel Mechanic Training

Qualifications Summary

Mr. Healy has been in the environmental laboratory industry since 1982, that includes laboratory operations management; business development and business management; operating plan development and capital planning; acquisition(s) integration; human resource policy and benefits design/administration; facilities design and construction oversight; strategic planning; consulting; proposal preparation and project management/execution; Health and Safety; hazardous waste management; quality Assurance/Quality Control; procurement; presentations; training; laboratory analysis and field sampling.

Professional Experience

Laboratory Director – TestAmerica Chicago 1982 to present
Mr. Healy is responsible for the technical and administrative management of TestAmerica Chicago's full service analytical laboratory which includes chemists, scientists, field personnel and project managers. His other responsibilities include adherence to budget, staff development and control, quality assurance and quality control, scheduling, client support/liaison, as well as profit and loss responsibility for the Chicago facility. In addition, Mr. Healy has managed the closure and consolidation of 3 regional laboratories, successfully relocating equipment, personnel and client accounts.

General Manager
His responsibilities as General Manager for multiple facilities included the transition/integration of the Valparaiso laboratory into the Severn Trent Laboratory organization, ensuring timely compliance with existing corporate business practices related to accounting, Human Resources, Quality Assurance and Health/Safety.

Vice President and Operations Manager
Co-Lead on transition team assembled by Weston to identify and qualify potential buyers of the Weston laboratory assets. Key participant in subsequent due diligence activities and eventual integration process, which included standardization of operating and business practices, as well as procurement/implementation of an enhanced employee benefits package.

Laboratory Manager
Directed the application process and subsequent implementation of a SNM license, which allows the laboratory to accept/analyze samples that are considered to be mixed waste (i.e., samples that are both chemically and radiologically contaminated). Specific activities included interfacing with the State of Illinois Nuclear Regulatory Commission (NRC) officials during the application process, staff orientation and training, procurement of required monitoring equipment, facility design modifications, and creation of relevant standard operating procedures (SOPs) on sample handling, radiation safety, and waste disposal.

Gave a presentation to 30+ IEPA laboratory management staff on effective management of the laboratory as a business. Topics included management of capacity and production, management of operating costs, strategic planning, investment planning, and challenges/strategies for survival success.

Division Operations Manager
Directed the orderly and timely closure of WESTON's Stockton, CA laboratory which employed a staff of 50 and generated revenues in excess of $3 million per year. Specific responsibilities

included staff notification and design of outplacement activities; client, vendor and certifying agency notification; reallocation of contracts; equipment/inventory reallocation and sale; negotiations with landlord on lease termination and building restoration; and establishment of an ongoing service center that includes marketing and project management staff to serve regional client base.

Laboratory Manager
Responsible for all activities associated with the phased construction/renovation of 51,000 square feet (ft^2) of laboratory and office space. Responsibilities included conceptual design, budgeting, creation of bid specifications, contractor selection, and management oversight of the project, which cost in excess of $3.25 million and spanned a 4-year period.

Project Manager
Provided expert testimony pertaining to laboratory operations/practices in support of a remedial investigation/feasibility study (RI/FS) conducted by the WESTON Vernon Hills office for IDOT.

Responsible for oversight of analytical work conducted in support of cleanup activities at the Old Mill Superfund Site in Rock Creek, OH.

As Field Supervisor, acted in lead role on behalf of Waste Management, Inc. on an EPA Region V Groundwater Task Force investigation at ESL and CID landfills.

Member of a project team that designed and implemented the IEPA CLP Bottle Distribution Program. The program was created to ensure that certifiably clean sample containers are used for all analytical work performed in support of IEPA sampling activities. The project scope included specification of materials, creation of standard operating practices and documentation requirements, and the establishment and staffing of a remote, project-dedicated facility. In addition, the scope of work entailed the development and presentation of training sessions for IEPA staff and IEPA contract laboratories on procedures for ordering containers, shipping samples, and completing necessary documentation.

Member of a project team that organized and presented on-site groundwater monitoring seminars for Waste Management, Inc. personnel and contractors throughout the United States.

Member of a project team that wrote and compiled "The Manual for Groundwater Sampling" copyrighted by Waste Management, Inc., 1985.

Author

Wrote the Gulf Coast Laboratories, Inc. QA plan for combustible gas monitoring. Document specified instrumentation, standard operating practices, quality assurance/quality control (QA/QC) criteria, and documentation requirements.

Education

- B.S. in Environmental Biology (Minors: Botany, Zoology) – Eastern Illinois University (1982)
- Chairperson-Elect, Board of Advisors to College of Sciences – Eastern Illinois University

Qualifications Summary

Ms. Petruszak holds a B.S. in Biology from Illinois State University. She has experience in the environmental laboratory industry since 1989. Her years of experience in the laboratory working on the analysis of Volatile Organic Compounds by GC/MS have given her the expert knowledge she needs to be a productive leader. She is an Organic Extraction/concentration specialist and Gel Permeation Chromatography (GPC) including trouble-shooting and general maintenance.

Professional Experience

Operations Manager – TestAmerica Chicago – 2018 to Present
Supervises all operations laboratory personnel and provides professional development and direction to department supervisors. Evaluates laboratory processes to determine path of continuous improvement. Responsible for ensuring compliance and integration of facility operation with corporate and regulatory policies and procedures while managing supply, instrument, and personnel resources. Serves as a technical resource to department employees, as well as Project Managers, sales personnel, and clients. Coordinates workshare with sister Laboratories.

GCMS VOA Supervisor – 2000 to 2018
Ms. Petruszak has extensive experience as the GC/MS Unit leader, her management responsibilities include scheduling of analysis; overseeing standards preparation; review of analytical data and data books.

GC/MS Analyst – 1989 to 2000
She has experience in organic extractions performing methods from SW-846, 40CFR and CLP Protocols for BNAs, Pesticides/PCBs, Herbicides, PAHs and Petroleum Hydrocarbons by GC. Additional experience in the preparation of fish samples for Pesticide/PCB analysis. Her experience also involves clean-up procedures for Pesticides/PCBs analysis including but not limited to Sulfuric Acid Clean-ups and Florisil Clean-ups. As a laboratory technician she was designing and conducting experiments concerning the remodeling of spermatozoan plasma membranes, and general laboratory duties.

Education

- B.S. in Biology – Illinois State University (1989)

Professional Training

- Baxter Research Award
- Phi Sigma Honor Society
- Ethics Training

Qualifications Summary

Mr. Lang has a M.B.A. with a concentration in Project Management from Keller Graduate School of Management and a B.S. in Biology/Chemistry from Eastern Michigan University. He has been in the environmental laboratory industry since 1984. Mr. Lang manages the project management staff, he also serves as aproject manager for several large national industrial corporations and engineering clients. He previously managed the laboratory's metals section where his responsibilities included implementation of quality control procedures, data package review, training of analysts in instrument operation, supervision of metals personnel and method development for metals analyses. Mr. Lang initially served as a chemist, performing inorganic analyses on water and waste samples.

Professional Experience

Manager of Project Managers – TestAmerica Chicago -2004 to Present
Mr. Lang responsibilities include principal client contact, project coordination, project quotation, project tracking and report review. Responsible for laboratory project management staff activity, for both internal and external clients, including project assignment, forecasting revenues and workloads, planning, and continual improvement projects.

Project Manager – 1992 to 2003
Analytical work in support of construction activities, tank removals, site assessments and routine groundwater monitoring. Responsibilities included the coordination of all laboratory activities including project quotation; sample tracking, final data review and invoicing.

Analytical work in support of routine groundwater monitoring waste disposal permits, site remediation and emergency spill response. Responsibilities included coordination of all laboratory activities and tracking of subcontracted work.

Coordinator for analytical support for various projects for major environmental consulting firms. Responsible for NPDES monitoring, RCRA disposal, and RCRA closure activities for various sites. Oversite of all analytical activities for RCRA Facility Investigation.

Metals Section Manager – 1989 to 1992
Responsibilities included day to day organization of metals unit; implementation of quality control procedures; data package review; training on analysts in instrument operation and quality control procedures; procedure development for metals analyses; maintenance of instrumentation.

Chemist – 1984 to 1989
Responsibilities included performing inorganic analyses on water and waste samples; experience in ICP and Flame AA analysis and instrumentation on maintenance; experience in phenols; EPTOX extraction and metals preparation.

Education

- M.B.A. with concentration in Project Management – Keller Graduate School of Management (1995)
- B.S. Biology/Chemistry – Eastern Michigan University (1984)
- University of Michigan – Biology (1979-1981)

Professional Training

- Participated in over 10 professional training, conferences and expositions pertaining to analytical chemistry, laboratory management and personal development.
- Ethics Training
- Customer Service Training

Qualifications Summary

Mr. Wright holds a M.S. in Environmental Science from Governors State University. He has been with the Chicago laboratory since 1986 and has considerable environmental laboratory experience. Mr. Wright oversees analytical scopes for a variety of commercial and government projects working both direct to client and through engineering consulting firms. He has experience meeting the criteria in wide range of regulatory and state programs, including the Illinois EPA's Tiered Approach to Cleanup Objectives (TACO). His experience also includes laboratory project management; project pricing and proposal preparation; project methodology review; QAPP preparation; and sampling of groundwaters, soils, and industrial waste streams. He has expertise in sampling requirements and the design of sampling plans, and previously managed the field sampling department.

Professional Experience

Project Manager – TestAmerica Chicago - 2001 to Present
Project Manager duties include being the client interface for all aspects of project performance including defining laboratory scope and pricing, LIMS set-up, technical expertise and quality assurance support relevant to analytical methods/procedures, quality assurance policy and objectives, project prioritization and utilization of resources to ensure project execution, service evaluations, data deliverable and turnaround time requirements, report deadlines, QAPP input, certifications, and overall project review. Responsible for providing the laboratory staff with the project profile and background information necessary to implement analytical activities. Monitor the progress of analytical activities for quality, timeliness, changes in scope of work, and cost. Utilize and integrate managerial, technical and support personnel to ensure project execution.

Manager – Project Management – 1992 to 2001
Managed Project Management section, laboratory projects, and maintaining over-sight of Field Sampling operations. Responsible for laboratory project management staff activity, for both internal and external clients, including project assignment, forecasting revenues and workloads, planning, and continual improvement projects.

Field Manager – 1987 to 1992
Responsible for preparing proposals, planning, coordinating and monitoring field project activities. Administer project changes, provide technical and quality assurance support, Sampling Plan and QAPP input, audits, prepare and review billing. Supervise and staff field operations personnel. Review field documentation, work plans, operating practices, safety plans and project reports.

Field Technician – 1986 to 1987
Sampling groundwater monitoring wells, surface and industrial waters, leachates and soils. Experienced in landfill gas migration, groundwater levels, NPDES compliance monitoring, leachate levels, groundwater recharge data and monitoring well assessments. Responsible for documentation of field sampling procedures and recording of any deviations which may have occurred in the sampling process. Coordinated sampling efforts with the laboratory log-in and management staff.

Statistics Instructor – 1985 to 1986
Experience as a statistics instructor in self designed course which integrated theory with the use of computerized analysis packages.

Education

- M.S. Environmental Science – Governors State University (1985)
- B.A. Environmental Science – Governors State University (1983)

Professional Training

- Participated in over thirty professional training seminars, conferences and expositions pertaining to project management and field monitoring, analytical chemistry, supervision, health and safety and proposal administration.

Qualifications Summary

Ms. Preston has a B.A. in Biology from Jamestown College, Jamestown, ND. She has extensive experience in the environmental laboratory industry and has been with the Chicago laboratory since 1984. She is experienced in environmental laboratory quality assurance practices, management, communications and analytical chemistry. Ms. Preston is responsible for the development and management of the laboratory's quality assurance program. She has considerable experience in preparing and implementing laboratory quality assurance and project specific plans, which include RI/FS and other projects for both the IEPA and U.S. EPA Region V contracts. She is an experienced laboratory data auditor, and performs contract and method compliance monitoring.

Professional Experience

Quality Assurance Manager – TestAmerica Chicago 2001 – Present
Ms. Preston has extensive knowledge of QA practices and procedures in the laboratory and in the development and validation of analytical methods on the LIMS system; Proficient in the evaluation, development and implementation of various Agency programs and project/client specific Quality Assurance Plans. Her responsibilities also include the management of the Quality Assurance Department. She also works closely with the Project Management Department in evaluation, development and validation of Quality Assurance Plans or Project requirements.

Quality Specialist – 1985 to 2001
Her experience as the Quality Specialist includes all aspects of Quality Control practices in the laboratory. With a concentration of laboratory data audits; data package review; statistical control limit evaluation, and method validation. Routinely involved in the evaluation, development and implementation of project specific requirements in the form of contributions to a Quality Assurance Plan or Project Checklist. Her experience also includes the development and validation of analytical methods and criteria code associated with the LabNet LIMS system.

Analyst – 1984 to 1985
Ms. Preston experience included performing alkalinity, cyanide, phenol and nitrite analyses; operation of Graphite Furnace and Flame AA.

Education

- B.A. in Biology at Jamestown College (1984)

Professional Training

- Quality Assurance of Chemical Measurements – ACS short course
- Flameless AA Spectroscopy Training Course – Thermo-Jarrell Ash Corporation (1987)
- Managing Hazardous Wastes – APWA (1985)
- Management by Responsibility Seminar (1988)
- Northern Illinois Water Analysts Member (1986-Present)
- Ethics Training

Qualifications Summary

Ms. Johnson has a B.S. in Biology from Millikin University. She has been in the environmental laboratory industry since 1991. Ms. Johnson has an extensive background in inorganic metals analyses using SW-846 Methods, U.S. EPA CLP ILM04.0, Standard Methods for the Examination of Waters and EPA 600 Series Methods. Previously Ms. Johnson was a Lab Analyst for the Metals Department and her experience includes GFAA and Hg analysis, Sample Preparation and TCLP extraction. She has been with the laboratory since 1991.

Professional Experience

Metals Supervisor – TestAmerica Chicago - 2007 to Present
Ms. Johnson's responsibilities include supervising the activities of the Metals Group who are involved in the metals sample preparation, TCLP extraction, mercury analysis, trace metals analysis by ICP and GFAA, CLP data package generation and review.

Lab Analyst – 1991 to 2007
Responsibilities include generating and reviewing inorganic CLP packages, working in metals digestion, TCLP extractions, HG and GFAA analysis.

Education

- B.S. in Biology at Millikin University (1991)

Professional Training

- Ethics Training
- TestAmerica YOUniversity

Qualifications Summary

Mr. Kolarczyk has been in the environmental laboratory industry since 1990. He has a M.S. in Environmental Biology and a B.S. in Biology with a minor in Chemistry. Mr. Kolarczyk supervises the Wet chemistry personnel providing technical and operational support. His years of experience as an analyst working on a variety of analyses in the laboratory and various instruments has given him the expert knowledge needed to be a productive leader in the environmental field.

Professional Experience

Wet Chemistry Supervisor – TestAmerica Chicago - 2019 to present
Mr. Kolarczyk provides technical and operation support to his staff while also participating in daily sample production. He coordinates work projects with the Project Managers to appropriately prioritize laboratory workload to meet client requirements. He manages all projects for the department to ensure On Time Delivery and Turnaround Time requirements are met. Maximizes productivity and ensure appropriate testing procedures are in compliance with QA and SOP requirements. Reviews data produced in the department and authorizes its release.

Analyst – 1990 to 2018

- Experience on inorganic test for metals prep, ICP, AA, HG analysis as well as experience in wet chemistry tests.
- Data Review and report generation and review for inorganic tests.
- Supervised the metals department in absence of Metals Manager.
- Gather and organize information on problems or procedures for methods.
- Prepare manuals and train workers on new forms, reports, procedures or equipment, according to organizational policy.

Education

- M.S. Environmental Biology – Governors State University – University Park, IL 1998
- B.S. Biology – Valparaiso University – Valparaiso, IN – 1990
- Minor in Chemistry

Professional Training

- Ethics Training
- Customer Service Training

Qualifications Summary

Ms. Alikpala holds a B.S. in Chemistry from College of Holy Spirit. She has experience in the environmental laboratory industry since 1990. Her years of experience in the laboratory working on the analysis using and adhering with EPA methodologies 8260, 624, 8015, have given her the expert knowledge she needs to be a productive leader. Her skills include maintenance, troubleshooting and repair of autosamplers, sample concentrators, GC/FIDs and specially GC/MS instrumentations.

Professional Experience

GCMS VOA Supervisor – 2018 to Present
Ms. Alikpapa has extensive experience in the GC/MS VOA department, her management responsibilities include overseeing the day to day operations of the GCMS VOA department, scheduling of analysis; overseeing standards preparation; review of analytical data and data books. Ms. Alikpala is also responsible for compliance to EH&S and Quality Assurance programs, staff training and turnaround time commitments.

GC/MS VOA Analyst – 1997 to 2018
Her responsibilities included analysis of waters, soils and TCLP VOA samples for EPA method 8260 and 624; GC/FID VOA (GRO) analysis using EPA 8015 method. Making sure all analysis adheres to and follows laboratory SOPs and Client's QAPP; and that all analysis and data are scientifically sound and legally defensible. She was also responsible for the maintenance and troubleshooting of the instruments.

Education

- B.S. in Chemistry – College of the Holy Spirit – Manila, MetroManila, Philippines

Professional Training

- Philippine Professional Commission
- Professional License Chemist

Qualifications Summary

Mr. Rynkar holds a B.S. in Environmental Biology from Eastern Illinois University. He has been in the environmental laboratory business since 1988. His current position is Semi-Volatile Supervisor for the GC/MS Department. Previously he was Unit Leader for the GC/MS Semi-Volatiles Department; GC/MS analyst for Semi-volatile compounds; Wet chemistry analyst focusing on Standard Methods, EPA Methods, and ASTM Methods, using various gravimetric, titrimetric, colorimetric and instrumental techniques.

Professional Experience

GCMS and GC SVOA Supervisor – TestAmerica Chicago - 2000 to Present
His current position is Semi-Volatile Supervisor and his responsibilities include overseeing the day to day operations of the GCMS and GC SVOA department, scheduling of analysis; overseeing standards preparation; review of analytical data and data books. Mr. Rynkar is also responsible for compliance to EH&S and Quality Assurance programs, staff training and turnaround time commitments.

GC/MS Semi-Volatiles Unit Leader – 1991 to 2000
His previous experience as Unit Leader for the GC/MS Semi-Volatiles Department included GC/MS analyst for Semi-volatile compounds; Wet chemistry analyst focusing on Standard Methods, EPA Methods, and ASTM Methods, using various gravimetric, titrimetric, colorimetric and instrumental techniques.

Analyst – 1988 to 1991
Experience includes sample analysis, mass spectra interpretation, data review and instrument maintenance. Instrument experience includes Hewlett Packard GC/MS Models which utilize Model 5890 Series II GCs. The GC/MS department utilizes a Perkin-Elmer LIMS System with concurrent software and UNIX System. Method analysis include 40 CRF Part 136 Method 625; SW-846, Test Methods for evaluating Solid Waste, Physical and Chemical Methods.

Education

- B.S. in Environmental Biology from Eastern Illinois University (1988)
- A.S. Moraine Valley Junior College (1986)

Professional Training

- Phi Sigma Biological Honor Society
- National Honor Society
- Who's Who of America's High School Students (1983)
- Ethics Training

Qualifications Summary

Mr. Knieriemen has been in the environmental laboratory industry since 1990. His experience includes Unit Leader and Organic Extractions/Concentration Specialist. Performed analysis by Gas Chromatography (GC) and High Performance Liquid Chromatography (HPLC). Analytical Wet Chemistry analysis using EPA Standard Methods and SW-846 Methods. Techniques include spectrophotometric, titrimetric, gravimetric and various distillations. Mr. Knieriemen has a B.A. in Chemistry from Indiana University Northwest.

Professional Experience

Organic Prep Supervisor – TestAmerica Chicago - 1997 to Present
Mr. Knieriemen's current responsibilities include the overseeing of the day to day operations in the Organic Extractions department which performs organic extractions and concentrations. His experience includes performing extraction methods for SW-846, 40CFR, CLP Protocols for BNAs, PCB/Pesticides, Herbicides, PAHs, and Petroleum Hydrocarbons by GC.

Analyst – 1990 to 1996
His experience in extractions included analysis of various matrices such as soil, sediments, waters, wipe samples, waste samples and the preparation of fish samples for PCB/Pesticides analysis. He also has experience in Gel Permeation Cleanup (CPC) which included troubleshooting and maintenance. Experience analyzing samples by Gas Chromatography (GC) and Polynuclear Aromatic Hydrocarbons (PAHs) by High Performance Liquid Chromatography (HPLC). He also worked as a wet chemistry analyst testing ammonia, TSS, TDS, cyanide, sulfide, reactive cyanide, reactive sulfide, bromide/bromine, sulfate, TKN, BOLD, pH, hexavalent chromium, nitrite, and phosphorus.

Education

- B.A. in Chemistry, Junior Standing – Indiana University Northwest

Professional Training

- Ethics Training

Qualifications Summary

Mr. James holds a B.A. in Music Education from Eastern Illinois University. He has extensive environmental laboratory experience and has been with the Chicago laboratory since 1989. Mr. James previously served as a project manager for several large industrial programs, including NPDES, municipal and wastewater clients. He now manages the Sample Receipt Department. His expertise includes consultation on the most cost effective approaches for environmental sampling. His experience includes sampling of a variety of matrices, well development, combustible gas monitoring, and field data collection. He has extensive training in environmental health and safety procedures, and hazardous shipping. Mr. James also served as Field Sampling Unit Leader, Bottle Project Unit Leader, Facility Manager, and Field Technician.

Professional Experience

Sample Management/Field Services Manager – TestAmerica Chicago – 1999 to present
Mr. James experience includes Sample Log-in Manager and Bottle Supply Manager, Field Services Manager, Courier Manager, project management. Mr. James coordinates the sampling efforts of the laboratory, and maintains the scheduling of client sample pick up services. Oversees the sample receipt department, reviews and validates that the custody of the samples are not compromised.

Field Sampling Unit Leader – 1998 to 1999
Environmental sampling and data documentation for groundwater, surface water, soils, sediment, landfill gas, leachate, drinking water, gas condensate, HACH Kit analysis, and ISCO sampling. Lead in drinking water sampling. Calibration and application of Beckman pH Meter, Cambridge Conductivity Meter, YSI Dissolved Oxygen Meter, and Gastech NP-204 combustible gas meter.

Bottle Project Unit Leader - 1994 to 1998
Responsibilities include maintaining full stock of sample containers, preservatives; shipment of sample container orders; tracking of containers, preservatives and shipping containers. All sample containers are received pre-cleaned according to US EPA bottle washing procedures and certifications of analysis are available for both the containers and preservatives.

Field Technician - 1989 to 1994
Experience in the technical application, installation, maintenance and sampling of groundwater monitoring systems (QED, SIGMA) in Illinois and Indiana; application of GASTECH NP>204 for detection of methane gas via the barhole method and permanent probe monitoring; soil and sediment sampling and soil description via the bucket auger method and split spoon collection.

Education

- B.A. in Music Education at Eastern Illinois University (1983)

Professional Training

- WMI Groundwater Sampling Seminar (1990)
- 40-Hour Health & Safety Training (1989)
- 8 Hour Health & Safety Refresher Training Course (Annually, 1990-2003)
- 8 Hour CPR/First Aid Training (1989)
- 8 Hour CPR/First Aid Refresher Training Course (Annually, 1990-2003)
- Ethics Training

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Submittal for:

Data Validation Services for East Chicago, IN

SUBMITTED TO:

Impact Environmental
170 Keyland Court
Bohemia, NY 11716
Attn: Mr. Michael Bluight, PG | Technical Manager

PRESENTED BY:

Laboratory Data Consultants, Inc.
2701 Loker Ave. West, Suite 220
Carlsbad, CA 92010

April 9, 2019

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LDC Company Profile

LDC is a small, minority-owned (SBE/MBE) quality assurance and environmental chemistry company focused on data validation, data quality assessment, database implementation, and data usability. Our primary services include data validation, electronic transfer of data, oversight of quality assurance/quality control (QA/QC) programs, laboratory and field audits, technical support for litigation, and database management. Our corporate office located in Carlsbad, California is directed by Mr. Scott Denzer and Ms. Stella Cuenco, principal chemists with over 45 years of experience between them in the environmental laboratory and data validation industries

LDC is recognized as one of the leaders in the data validation industry through participation on major DoD and commercial projects such as:

- Army Corps of Engineers, DuPont Chambers (Baltimore District)
- Army Corps of Engineers, DuPont Chambers (Philadelphia District)
- Army Corps of Engineers, Various projects (New Mexico)
- Army Corps of Engineers, Camp Navajo (Tetra Tech)
- Army Corps of Engineers, Various projects, 8a Contract (Sacramento District)
- Army Corps of Engineers, Fort Ord (Shaw E&I)
- Las Vegas Wash Henderson Site (ERM)
- DOE NPR-1 Elk Hills (DOE direct and Ahtna)
- Nevada Environmental Response Trust (NERT) Henderson Site (Ramboll Environ)
- NOAA MDRA Mississippi Site (Entrix)
- Stringfellow Superfund Site (DTSC)
- BKK Landfill (Ramboll Environ)
- EPA Region IX ESAT QA Program (ICF)
- AFCEE/AFCEC, Andersen AFB (EA/Shaw)
- AFCEE/AFCEC, Loring/Pease AFB (Bechtel/MWH)
- AFCEE/AFCEC, Mather AFB (MWH)
- AFCEE/AFCEC, Army Corps of Engineers, Travis AFB (CH2M Hill)
- AFCEE/AFCEC, McClellan and Castle AFB (Jacobs Engineering Group)
- AFCEE/AFCEC, Beale AFB (Law/Crandall, Inc.)
- AFCEE/AFCEC, Andrews AFB (URS)
- Navy CLEAN Atlantic Division (EA Engineering)
- Navy CLEAN IV Southwest DIV (AECOM)
- Navy RAC Southwest Division (OHM Remediation/IT Group/Shaw)

LDC has successfully performed over 500 data validation projects worth over 10 million dollars for prime contractors servicing Air Force (AFCEE/AFCEC), Army Corps, Navy, and industrial activities.

LDC has developed well-documented procedures which support all facets of the data validation process. This includes critical steps such as:

- Project tracking
- Peer review for all data validation activities
- Internal training programs
- Internal and external audits
- Strict documentation
- Electronic deliverables

LDC as the "Best Value" Contractor

LDC is a data validation subcontractor with an impeccable track record for timeliness, quality, technical expertise, and the ability to mitigate complex data quality issues. Our clients will confirm our current and past performance under DoD (including USACE), DoE, and commercial programs. We have experience and a proven track record commensurate with the requirements of this RFP as demonstrated by the following:

- **LDC is the software developer and expert in the use of the Automated Data Review (ADR) software**. LDC has been using the ADR.NET version for over 3 years and has the current version in full implementation which meets USACE and current DoD QSM requirements. LDC has performed over 1000 ADR projects in the past 10 years, worth over $2,000,000 in revenue. LDC will provide technical support to the Client as needed for e-QAPP generation or EDD troubleshooting.

- Data validation experience as a subcontractor for more than 100 Army Corps sites, over 140 AFCEE/AFCEC sites, several EPA sites, and under 6 Navy CLEAN and RAC contracts and 150 Navy sites. This experience includes 15 years of data validation work under USACE direction and thorough understanding of the USACE Baltimore, EPA Region 2 and 3 validation guidelines, and the DoD QSM.

- Successful completion of USACE data validation activities since 1992 under subcontracts to various Districts including New England, Baltimore, Philadelphia, Omaha, Albuquerque, Seattle, Sacramento, and Jacksonville.

- Recent project experience in the Eastern region including support to four separate contractors on the Passaic River for varied projects and programs with revenues of 200K, and Gowanus Canal with GEI, revenues of 33K.

- **On-time delivery record of greater than 99%** with the ability to expedite turnaround as needed due to our large experienced staff as noted above.

- Successful completion of five DoD and two DoE audits to approve LDC's internal data validation procedures, QA program and documentation systems. (prior to 2000)

- Thorough secondary QA review program and **the capacity (33 full time chemistry staff) to handle a project of this magnitude and importance.** This significantly reduces additional work the consultant might otherwise need to do upon receipt of LDC reports.

Data Validation Capacity

LDC is continually evaluating and monitoring its capacity to meet client needs. It is company policy to not accept a project unless the service can be completed on-time with our expected quality of performance. This policy has proved very successful in meeting past project deadlines. Our client references will confirm our performance of on-time delivery.

Due to the versatile capabilities of our staff, personnel can also support multiple areas which are high in backlog. Our training program documents personnel approvals for all data review activities. All of our staff actively participate in the LDC training program.

LDC has met its contractual turnaround time requirement on over 99% of the projects completed. LDC has successfully completed projects which required data review capacity of as many as 2000 samples in one month.

Technical / Management Approach

LDC has established data validation and data management procedures which enable the thorough, consistent, timely, and efficient review of analytical data. Ms. Stella Cuenco, principal chemist, is responsible for all data validation related activities and has final authority for the company. The designated Project Manager will coordinate the day to day data validation activities and interface with the Client project chemist or PM as necessary. For day to day data review activities, data validators report directly to the senior chemist in the section of the review. Senior chemists report to the technical project manager. Data validation will be performed following the Client project specific requirements as stated in the Scope of Work (SOW).

As the Client alerts LDC of in-coming SDGs and associated ADR EDDs, the LDC project manager will log the order into the up-coming project list identified as the "LDC Project Backlog" form. This is now considered a booked order and is reserved a place in the schedule. The project manager will allocate and schedule staff resources for the project. He will generate a project specific summary which will detail the expected receipt date of the order, the due date, special method or QC requirements, and the data quality objectives (DQOs) of the project.

Once the data packages arrive, the packages are logged in according to LDC SOP 6.0.0 "Standard Operating Procedure for Sample Data Log-in". Computer generated worksheets for each SDG along with the "LDC SDG Table" and "LDC Sample Validation" spreadsheet are distributed to all project staff.

The "LDC SDG Table" spreadsheet is specific to each order and provides the project manager with an overview of individual SDGs and their associated analyses. Progress of projects is indicated daily on the spreadsheet. The "LDC Sample Validation" spreadsheet identifies individual analysis requested for all samples and supports the data reviewer in verifying that appropriate samples have been reviewed in each data package. The previously discussed tools and processes have been used to successfully meet deadlines and estimate project completion dates. Meetings are held routinely to assess the status of each project.

Throughout the data review process, the project manager monitors project status as stated above. If any scheduling or technical complications arise such that the quality of the review will be impacted, data review staff notify the project manager immediately for resolution. The project manager will keep the Client chemist current on the progress of all validation activities on a

routine basis via e-mail and telephone. Once the data review worksheets have been completed and approved by a secondary review, the final technical reports are written. All final technical reports are reviewed by at least two senior staff. This may include the Technical Project Manager, QA Director, or Lead Chemist. Upon shipping the final report, the Client project chemist will be contacted by phone.

Data Review/Validation Process

The data review and validation level of effort required for the Scope of Work outlined for this project will encompass several activities. The steps can be categorized in the following manner:

1) Sample Log-in

All samples submitted for data validation are entered into the LDC Log-in system. The system generates various spreadsheets for sample tracking, listings of laboratory and client identifications, sampling dates, analysis requested, matrix, and project due date. These tracking documents are distributed to all data validation, QA and project management staff.

2) Pre-screening of Data Packages

The pre-screening is performed concurrently with the sample log-in process. This task verifies sample chain-of-custody, data package completeness, and concurrence with the authorized delivery order.

3) Data Validation

The execution of the data review task requires the highest level of effort. The review process will be handled in a stepwise fashion including manual and automated data review. The validator will use manual review to document each finding on a Validation Findings form. Along with the finding, the reviewer will document the date of the occurrence, the lab reference identification, the validation criteria, the associated samples, and the qualification of the data. A Validation Checklist form is marked noting if validation criteria was met or exceeded. A Validation Checklist is enclosed for review (Exhibit A). These checklists are used as an inventory sheet to assure all samples were reviewed for each criteria. The findings documented on the Validation Findings form will be transcribed into the final summary report. Examples of recalculation and findings worksheets used for Level 4 validation are available for review upon request.

All initial validation performed by LDC has a secondary peer review. All final reports will be reviewed by a Senior Chemist or Principal Chemist.

4) First Report Review

The first review of the data validation report verifies that all findings and data qualification has been accurately transferred from the data validation worksheets. All sample identifications, methods, formatting, and general text are reviewed.

5) Senior Report Review

The senior review of the data validation report verifies that all findings, data qualification, and professional judgments previously integrated into the reports reflect the overall quality of the data. Any additional comments required to enhance the usability of the report will be inserted at this time.

6) QA Report Review

A QA check of selected data validation reports within an individual delivery order will be reviewed by the QA department. A formal nonconformance report will be generated for any identified deficiencies. The deficiency will be addressed with the appropriate staff and corrected prior to submittal to senior management for final review and signature.

7) Senior Management Review

The program/technical manager will perform an overall review of the final reports. He will sign the report cover letter and submit the report to the sample custodian for shipment to the client.

8) Electronic Data Deliverables (EDD)

This process will be initiated at step 1 with the receipt of disks from the client or loading EDDs to LDC's secured Internet portal. After automated verification of the EDD format, content, and fields, the EDD will be populated with the manual review for importing of the final data qualifiers. The final approval of qualifiers will occur after step 5.

LDC will self-perform the above tasks to maintain quality and control of the work product.

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Exhibit A

LDC #:____
SDG #:____
Laboratory:___

VALIDATION COMPLETENESS WORKSHEET

EPA Level IV

Date:_____
Page:_of_____
Reviewer:
2nd Reviewer:

METHOD: GC/MS VOA (EPA SW 846 8260B)

The samples listed below were reviewed for each of the following validation areas. Validation findings are noted in attached validation findings worksheets.

	Validation Area		Comments
I.	Sample receipt/Technical holding times	/	
II.	GC/MS Instrument performance check		
III.	Initial calibration/ICV	/	
IV.	Continuing calibration		
V.	Laboratory Blanks		
VI.	Field blanks		
VII.	Surrogate spikes		
VIII.	Matrix spike/Matrix spike duplicates		
IX.	Laboratory control samples		
X.	Field duplicates		
XI.	Internal standards		
XII.	Compound quantitation RL/LOQ/LODs		
XIII.	Target compound identification		
XIV.	System performance		
XV.	Overall assessment of data		

Note:
A = Acceptable
N = Not provided/applicable
SW = See worksheet
ND = No compounds detected
R = Rinsate
FB = Field blank
D = Duplicate
TB = Trip blank
EB = Equipment blank
SB=Source blank
OTHER:

	Client ID	Lab ID	Matrix	Date
1				
2				
3				
4				
5				

Notes:

LDC Corporate Resources

LDC personnel have experience and formal training in the areas of data validation, electronic data deliverables and laboratory QA/QC. LDC personnel have performed data validation in all analytical disciplines. These include, but are not limited to, GC/MS volatiles, GC volatiles, GC/MS semivolatiles, GC pesticides, ICP metals, ICP/MS metals, GFAA metals, GC petroleum hydrocarbons, GC/MS dioxins, explosives, radiochemistry, and wet chemistry. This versatility allows our organization to adapt to workload changes and allows for an excellent secondary review system. Our organization is structured to allow direct communication between project managers, data validators, and clerical staff which occurs on a daily basis.

With LDC's 25+ years as a national leader in the data validation industry and extensive experience supporting projects with multiple EPA regions, DoD and DOE facilities, LDC is confident our data validation services will successfully meet all project requirements. The validation group is managed by Ms. Stella Cuenco, principal chemist, who has over 25 years of experience, the software products and services group is managed by Mr. Scott Denzer, who has over 35 years of experience, and the overall operations are directed by Mr. Michael Takaki, president.

The validation group is divided into chemists by discipline, organics (GC/MS, GC and HPLC) and inorganics (wet chemistry, IC, ICP, ICP/MS). All chemists report to senior group leads. A separate group performs data package log-in to the LDC tracking system. Another group performs the EDD population and verification. Shauna McKellar, Chemist and Project Manager, leads this group and has over 6 years of experience in EDD population, preparation, and uploading to various databases.

The majority of the data validation staff at LDC have been employed for over 10 years with some senior staff over 15 years as noted in the attached resumes. This level of stability and experience will ensure project stability and consistency.

In addressing LDC's financial status, LDC has an excellent Dun & Bradstreet report and has been profitable for the past 15 years. LDC has grown at approximately 10% in each of the past 5 years and continues to be a leader in our environmental sector of the data quality business. References are available from our vendors and clients to confirm our business success. Our annual revenue of approximately $6,000,000 per year in data validation work makes LDC one of the largest independent data validation firms in the nation. In 2001, Mr. Richard Amano was the San Diego SBA Small Businessman of the Year through our sponsor Earth Tech.

LDC will commit the resources and materials to successfully complete this project with the required time period and with a high level of quality.

Project Team Summary

LDC personnel have hands-on experience in the areas of data validation, laboratory QA/QC, CLP SOWs, and environmental laboratory analyses. As documented in the resumes of our staff, the project team has significant experience with USACE and DoD protocols, current technology, SW-846, and all methods stated in the SOW.

LDC is presenting the following staff to perform key roles for this contract. The key staff of the project team and their experience are as follows:

- **Stella Cuenco, Principal Chemist/Operations Manager**
  Project Role: Principal Chemist/Program Manager
  Data Validation Experience: 22 years
  Overall Laboratory and Data Validation Experience: 27 years
  B.S. Chemistry, University of the Philippines, 1991

  Ms. Cuenco has over 27 years of environmental laboratory and data validation experience under DoD and EPA guidelines. Her experience includes performance of data validation in gas chromatography/mass spectrometry for volatile and semivolatile organics and extensive Navy and EPA data review and data verification for all organic and inorganic analyses. Her laboratory experience includes hands-on CLP and SW-846 GC/MS methods.

- **Pei Geng, Senior Chemist/Project Manager**
  Project Role: Senior Organic Data Validator
  Data Validation Experience: 21 years
  Overall Laboratory and Data Validation Experience: 28 years
  M.S. Chemistry, Sam Houston University, 1989

  Ms. Geng will perform the role of organic data validator for this project. She will perform data validation for GC/MS and gas chromatography analyses and serve as a peer reviewer in the initial validation review process.

  Ms. Geng has over 28 years of environmental laboratory and data validation experience. Her experience includes performance of data validation in the gas chromatography area for volatile and semivolatile organics and extensive DoD data review and data verification for all organic analyses. Her laboratory experience includes hands-on CLP and SW-846 GC/MS methods.

- **Richard M. Amano, Principal Chemist**
  Project Role: Senior Technical Reviewer/Director
  Data Validation Experience: 26 years
  Overall Laboratory and Data Validation Experience: 38 years
  B.S. Biochemistry, UCLA, 1979

  Mr. Amano has over 38 years of environmental laboratory, QA/QC, and data validation experience. He has managed data validation projects using the DoD QSM data validation guidelines for the past twenty years. Prior to founding LDC in 1991, he directed two major laboratories, Analytical Technologies, Inc. and Brown and Caldwell, from 1983 to 1991. His data validation experience includes oversight and direction of major efforts for Superfund sites, DoE sites, Navy RI/FS projects, Army Corps of

Engineers investigations, and AFCEE/AFCEC projects. He also has overseen several laboratory audits for major analytical testing programs for the Navy, Texaco, and Hewlett-Packard. His laboratory experience includes hands-on CLP and SW-846 GC/MS analysis, direction of GC/MS (including TO-14 air analyses) and radiochemistry groups, dioxins method development, and complex GC data interpretation of Aroclors. He has performed expert witness support for litigation purposes.

- **Erlinda T. Rauto, Principal Chemist**
  Project Role: Technical Reviewer
  Data Validation Experience: 25 years
  Overall Laboratory and Data Validation Experience: 38 years
  B.S Chemical Engineering, Feati University, Manila, 1967

  Ms. Rauto will perform the role of Technical Reviewer for this project. She will monitor schedules, compliance of the validation to the applicable documents, perform routine surveillance activities such as generation of nonconformance reports, validator training, and QA reports to management.

  Ms. Rauto has over 38 years of environmental laboratory and data validation experience. She has worked under the DoD QSM data validation guidelines for the past 10 years. Her experience includes performance of data validation in the GC, trace metals, and wet chemistry areas for major Federal projects. Her laboratory experience includes hands-on CLP and SW-846 ICP/GFAA analysis, pesticide/PCBs and wet chemistry analysis.

- **Christina Rink-Ashdown, Inorganic Chemist**
  Project Role: Inorganic Data Validator/Project Manager
  Data Validation Experience: 9 years
  Overall Laboratory and Data Validation Experience: 11 years
  B.S. Biology, University of California, San Diego 2006

  Ms. Rink-Ashdown will perform the role of day to day Project Manager for this project. She will monitor schedules, compliance of validation to the Required Guidelines, perform routine surveillance activities such as generation of non-conformance reports, validator training and QA reports to management.

  Ms. Rink-Ashdown has over 11 years combined environmental laboratory and data validation experience. Her experience includes performance of data validation in the trace metals, radiochemistry, and wet chemistry areas for major Federal and commercial projects. Her laboratory experience includes hands-on CLP and SW-846 ICP/CVAA analysis and overall technical review of data deliverables.

  Ms. Rink-Ashdown specializes in the data validation of radiochemistry, trace metals, wet chemistry, and methyl mercury and analyses under MARLAP and USEPA functional guidelines or equivalent protocol. Over the past two years, she has worked under various DoD, CERCLA and EPA data validation guidelines for the various CERCLA, Navy, Army Corps, AFCEE/AFCEC and commercial projects. She is also certified as a “Radiometric Data Validation Specialist” through course work and testing by the Radiochemistry Society.

- **Shauna McKellar, Chemist / Project Manager**
  Project Role: Chemist
  Data Validation Experience: 8 years
  Overall Laboratory and Data Validation Experience: 14 years
  B.S. Environmental Toxicology, UC Davis, 2006

  Ms. McKellar has over 14 years of environmental consulting and data validation experience. She has worked under EPA data validation guidelines for the past 6 years and has inorganic and organic data validation experience using USEPA functional guidelines, Navy procedures, project QAPPs, ADEC checklists, and other applicable documents for EPA, DoD and commercial projects.

  Ms. McKellar specializes in the data validation and contract compliance screening using LDC's Automated Data Review (ADR) software, and is familiar with a variety of different Electronic Data Deliverable formats, including SEDD and NEDD. She has supervised large data validation projects under the USACE and Navy Southwest Division RAC contracts

- **Linda Ta, Chemist / Project Manager**
  Project Role: Chemist
  Data Validation Experience: 1 year
  Overall Laboratory and Data Validation Experience: 5 years
  B.S. Geology, CSU Long Beach, 2012

  Although Ms. Ta has less than one year of experience at LDC, she is proficient in data validation for GC and GCMS methods for Level II and III.

  Ms. Ta has so far become responsible for writing project data quality assessment reports (DQAR), has learned to use ADR for validation, and is in training to perform ERPIMS database tasks.

- **Tony Rommelfanger, Data Control Manager**
  Project Role: Data Custodian

  Mr. Rommelfanger will perform the role of data custodian for this project. He will perform the log-in of all data packages into the LDC tracking system. This system will generate spreadsheets for identifying all samples, their collection date, analysis performed, matrix, and report due date. Upon the completion of each delivery order, he will archive and catalog all reports and data in a secured storage area.

  Mr. Rommelfanger has over 26 years of experience in laboratory and data management experience. He has experience in organizing, logging in, and tracking data packages for technical staff.

Resumes of Key Staff

- Stella Cuenco, Senior Chemist
- Pei Geng, Senior Chemist
- Richard Amano, Principal Chemist
- Linda Rauto, Principal Chemist
- Christina Rink-Ashdown, Inorganic Chemist
- Shauna McKellar, Chemist/EDD Specialist
- Linda Ta, Chemist

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RESUME
STELLA S. CUENCO

EDUCATION

B.S. Chemistry, 1991
University of the Philippines (UP)

PROFESSIONAL HISTORY

Laboratory Data Consultants, Inc.
Senior Chemist
1996 to present

Ceimic Corporation
GC/MS Chemist
1996

Analytical Technologies, Inc.
GC/MS VOA Group Leader
1992 to 1996

Analytical Technologies, Inc.
GC/MS Chemist
1991 to 1992

Natural Products Research, UP
Research Assistant
1990 to 1991

REPRESENTATIVE EXPERIENCE

Ms. Cuenco has over 27 years combined environmental laboratory and data validation experience. Her experience includes performance of data validation in the GC and GC/MS areas for major Federal projects. She has performed large validation projects under Boeing, Navy Southwest, Northwest and Pacific Division, EPA Region IX ESAT, USACE and AFCEE/AFCEC programs. Her laboratory experience includes hands-on CLP and EPA analysis of GC and GC/MS volatile organic compounds.

Specifically, Ms. Cuenco has over 22 years organic data validation experience using USEPA (including Region III) functional guidelines and other applicable documents.

- As senior chemist with LDC, Ms. Cuenco specializes in the data validation and contract compliance screening of gas chromatography-mass spectrometry analyses as well as gas chromatography analyses. She has a thorough knowledge and understanding of gas chromatography and gas chromatography-mass spectrometry (GCMS) and high resolution GCMS methods referenced in EPA CLP, SW-846, EPA 500, 600 and 1600 series documents. She has performed large data validation under Boeing, Navy Southwest and Pacific Divisions and EPA Region IX ESAT, USACE and AFCEE/AFCEC projects.

Ms. Cuenco has over 5 years experience in an environmental laboratory performing the analysis of organic parameters.

- As GC/MS chemist at Ceimic Corporation, a full service environmental analytical chemistry facility, Ms. Cuenco performed GC and GC/MS volatile analyses. She was responsible for the final reporting of analytical data for this section.

- As GC/MS VOA Group Leader at Analytical Technologies Inc., a full service environmental analytical chemistry facility, Ms. Cuenco was responsible for all GC/MS functions which included overseeing daily operations, training staff, final reporting of analytical data, and compliance with method requirements.

- As research assistant at Natural Products Research, UP, Ms. Cuenco researched chemical literature for plants with known medicinal properties as well as performed microbiological and pharmacological tests on plant extracts.

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RESUME
PEI GENG

EDUCATION

M.S. Organic Chemistry, 1989
Sam Houston State University

B.S. Environmental Chemistry, 1983
Nankai University

PROFESSIONAL HISTORY

Laboratory Data Consultants, Inc.
Senior Chemist
1997 to present

Ceimic Corporation
GC/MS and GC Chemist
1996 to 1997

PACE Analytical Service Inc.
GC/MS and GC Chemist
1990 to 1996

REPRESENTATIVE EXPERIENCE

Ms. Geng has over 28 years combined environmental laboratory and data validation experience. Her experience includes performance of data validation in the GC and GC/MS areas for major Federal projects. She has performed large validation projects under Boeing, Navy Southwest, Northwest and Pacific Division, EPA Region IX ESAT, USACE and AFCEE/AFCEC programs. Her laboratory experience includes hands-on CLP and EPA analysis of GC and GC/MS volatile organic compounds.

Specifically, Ms. Geng has over 21 years organic data validation experience using USEPA CLP (including Region III) functional guidelines and other applicable documents.

- As chemist with LDC, Ms. Geng specializes in the data validation and contract compliance screening of gas chromatography-mass spectrometry analyses as well as gas chromatography analyses. She has a thorough knowledge and understanding of gas chromatography and gas chromatography-mass spectrometry (GCMS) and high resolution GCMS methods referenced in EPA CLP, SW-846, EPA 500, 600 and 1600 series documents. She has performed large data validation under Boeing, Navy Southwest and Pacific Divisions and EPA Region IX ESAT, USACE and AFCEE/AFCEC projects.

Ms. Geng has over 7 years of experience in an environmental laboratory performing the analysis of organic parameters.

- As both a GC and GC/MS chemist at Ceimic Corporation, a full service environmental analytical chemistry facility, Ms. Geng performed GC and GC/MS volatile and semivolatile analyses.

- As both a GC and GC/MS chemist at PACE Analytical Service Inc., a full service environmental analytical chemistry facility, Ms. Geng performed GC and GC/MS volatile and semivolatile analyses as well as overseeing the final reporting of analytical data, and compliance with method requirements.

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RESUME
RICHARD M. AMANO

EDUCATION

B.S. Biochemistry
University of California, Los Angeles, 1979

A.A. Chemistry
El Camino College, 1977

PROFESSIONAL HISTORY

Laboratory Data Consultants, Inc.
Program Manager/Principal Scientist
2011-present
President/Principal Chemist,
1991 to 2011

Analytical Technologies, Inc
Laboratory Director
1986 to 1991

Brown & Caldwell
Laboratory Supervisor
1983 to 1986

West Coast Technical Service
Senior Chemist
1980 to 1983

University of California, Los Angeles
Laboratory Technician
1979 to 1980

REPRESENTATIVE EXPERIENCE

Mr. Amano has over 38 years of combined environmental laboratory, QA/QC, laboratory auditing, data management, environmental software development, and data validation experience. Prior to founding LDC in 1991, he directed to two major laboratories, Analytical Technologies, Inc. (San Diego) and Brown and Caldwell. His experience includes oversight and direction of major QA/QC and data validation efforts for confidential petroleum spill projects, Boeing sites, Superfund sites, DoE sites, Navy RI/FS projects, Army Corps of Engineers investigations, and AFCEE/AFCEC projects. He has also overseen several laboratory audits for major analytical testing programs and large scale environmental software development for the US Army Corps of Engineers (USACE).

Specifically, Mr. Amano has over 26 years of experience with validation of organic, inorganic, and radiochemical analyses using USEPA, Navy, USACE, DoD, AFCEE/AFCEC, and other applicable guidance documents.

- As program manager/principal scientist with LDC, Mr. Amano provides management and technical support to the data validation, data quality, and software group. He oversees and directs all environmental software projects developed for the USACE. Additionally, he acts as the primary LDC/USACE contract manager for software development projects. He is the primary author of the nationally distributed Automated Data Review (ADR) software used by the USACE, Navy, DTSC, and commercial clients.

- As President/principal chemist with LDC, Mr. Amano provided management and technical support to the data validation, data quality, and software group. He provided technical support in the organic, inorganic, and radiochemical areas. Under several major QA/QC and data validation programs, he provided, as needed, a final review of data validation and assessment reports. Mr. Amano specializes in the evaluation, validation, and interpretation of environmental testing data. Additional responsibilities include laboratory QA/QC and NELAC audits, implementation and support of QA/QC programs and data management support for engineering firms, environmental lab training, consultation on LIMS data base designs for environmental laboratories, and expert witness litigation support. Mr. Amano has managed and directed several major data validation and QA/QC projects for Army Corps, Navy, Air Force, and commercial contracts. Industrial projects include major petroleum oil spill related data validation and assessment of hydrocarbon analyses. The DoD projects include Southwest Division CLEAN 1 (Jacobs Engineering/IT Corporation/CH2M Hill), Southwest Division CLEAN 2 (Bechtel National), Pacific Northwest Division CLEAN (URS Greiner), Southern Division CLEAN (ABB Environmental), Atlantic Division CLEAN (EA Engineering), Southwest Division RAC (OHM Remediation), Pacific Division CLEAN (Earth Tech), AFCEE/AFCEC Mather AFB (Montgomery Watson), AFCEE/AFCEC Pease AFB (Bechtel Environmental), AFCEE/AFCEC England AFB (Law Environmental), Army Corps Travis AFB (CH2M Hill), Army Corps Hawthorne Army Depot (Tetra Tech), Nevada Test Site (IT Corp), and Army Corps Fort Ord (Harding Lawson). He provided oversight and direction for major USACE environmental software development including Automated Data Review (ADR), FUDSFORUM, MRSPP, and FUDSCHEM. He has a thorough knowledge and understanding of EPA CLP, SW-846, EPA 500, EPA 900, and EPA 600 series methods. He additionally has supported attorneys as an expert witness and has taught data integrity and lab ethics courses for several organizations.

Mr. Amano has over 12 years environmental laboratory experience in commercial laboratories supervising or performing the analyses of organic, inorganic, and radiochemical parameters.

- As laboratory director and technical director of Analytical Technologies, Inc, a full service environmental analytical chemistry facility, Mr. Amano was responsible for all facets of operations. These responsibilities include direct technical input for GC, GC/MS, and inorganic operations, personnel selection, assisting in method development, and selection of non-routine analysis. In addition, Mr. Amano was responsible for supervision of the 80 scientists employed at ATI's San Diego laboratory with all group supervisors, quality assurance and safety coordinators reporting directly to him. Mr. Amano has managed numerous analytical testing programs including the North Island Navy Confirmation Study, Miramar Air Force Base Confirmation Study, and investigations at several of the EPA Superfund sites. His environmental expertise focuses on the chemical testing related to hazardous waste investigations, site remediation, and groundwater monitoring programs.

- While at Brown & Caldwell, Mr. Amano's responsibilities encompassed supervision of daily operations of the laboratory, personnel staffing, technical advisor for operation of the gas chromatograph/mass spectrometer (GC/MS) section, maintenance of QA/QC programs, and coordination between engineers, clients, and laboratory analysts. Additionally, he supervised the daily operation of all radiochemistry activities which included alpha, beta, and radium analyses.

- At West Coast Technical Service, Mr. Amano was responsible for daily operation and quality control of the GC/MS group. Mr. Amano was highly involved with the USEPA hazardous waste contracts. Some special projects included dioxin selected ion monitoring analysis, EPA method 624 and 625 validation studies, and low level drinking water evaluations.

TECHNICAL PRESENTATIONS

"Understanding the Workings of an Environmental Laboratory"
Southern California Department of Health Services, 1984
Hargis & Associates, Inc, La Jolla, CA, 1987
Hargis & Associates, Inc, Tucson, AZ, 1987
Westec Services, San Diego, CA, 1987
Applied Hydrogeologic, Inc, San Diego, CA 1989

"Data Validation, QA/QC, and Environmental Analysis"
Van, Waters, and Rogers, Seattle, WA, 1990
ERC Environmental, Honolulu, HI, 1991
Harding Lawson Associates, Honolulu, HI, 1991
Pacific Division Naval Engineering Group, Honolulu, HI, 1991
OHM, Irvine, CA, 1996
Southwest Division Naval Engineering Group, San Diego, CA, 1996
Navy Public Works Center, San Diego, CA 1996

"GC versus GC/MS"
J.H. Kleinfelder & Associates, Artesia, CA 1986
Hargis & Associates, Inc, La Jolla, CA 1987

"Analytical Methods and QA/QC Procedures for Environmental Analysis"
County of San Diego Department of Health Services, San Diego, CA 1989
Regional Water Quality Control Board, San Diego, CA 1990
ERC Environmental, San Diego, CA 1990
Mittlehauser Corporation, Laguna Hills, CA 1991

"Hydrocarbon Testing Related to Underground Storage Tanks (UST)"
San Diego County DOHS, San Diego, CA, 1986
J.H. Kleinfelder & Associates, Artesia, CA 1986
Woodward Clyde Consultants, San Diego, CA 1987

Engineering Enterprises, Long Beach, CA 1987

"Quality Control/Quality Assurance in Laboratories"
Assoc of Hazardous Materials Professionals, Anaheim, CA 1986
R.L. Stollar & Associates, Santa Ana, CA 1989

"The Influence of Sample Matrix on Environmental Analysis"
Assoc of Hazardous Materials Professionals, San Diego, CA 1990

"Comparison of Air Sampling Media"
Assoc of Hazardous Materials Professionals, Anaheim, CA 1991

"Building a Second Generation LIMS for Commercial Laboratory Operations"
Pittsburgh Conference, New York, NY, 1990 (Invited Speaker)

"Employment Outlook in Environmental Laboratories"
Southern California American Chemical Society, 1985

"Opportunities in the Environmental Lab in the 1990's"
American Chemical Society, 1990

"Data Validation of Radiochemical Analyses"
Hargis + Associates, La Jolla, CA 1991

"Detection Limits - MDL, PQL, RDL, LOD ?"
Analytical Technologies, Inc., 1991

"Poor QA/QC or Laboratory Fraud: Have labs crossed the fine line?"
Environmental Professionals Organization, Newport Beach, CA 1996

"Electronic Data Deliverables and Automated Data Review/Validation"
Army Corps of Engineers, Sacramento District, Sacramento, CA 1996

"Navy Environmental Data Transfer Standards"
Kleinfelder, San Diego, CA 1997

"Laboratory QA/QC Update for DoD Programs"
ACTLabs, Long Beach, CA 1997

LECTURING AND TEACHING

"Instrumental Analysis of Hazardous Materials"
University of California, San Diego 1988 - 1995

"Field Monitoring & Laboratory Analysis of Hazardous Materials"

University of California, San Diego 1995 - 1998

California State Fullerton, Guest Lecturer, 1985 & 1990

San Diego State University, Hydrology Department, Guest Lecturer, 1988

"EPA Level 4 Data Validation" Workshop
Applied Geotechnology, Inc., Bellevue, WA, 1993

"Environmental Analyses in the 90's"

National University, Guest Lecturer, 1993

"Data Quality Objectives for Federal Environmental Programs"
University of California, San Diego 1993

"Data Integrity and Data Management for Federal Environmental Programs"
University of California, San Diego 1994

"Laboratory QA/QC and Electronic Data Requirements for DoD Programs"
University of California, San Diego 1995

"Application and Utilization of Department of Defense (DoD) Guidance Documents"
University of California, San Diego 1996

"Laboratory Quality Assurance for Department of Defense Programs"
University of California, San Diego 1997

PUBLICATIONS

"Managing an Environmental Chemistry Laboratory for Profit",
John H. Taylor, Jr and Richard M. Amano,
Journal of Chromatographic Science, 1987

MEMBERSHIPS AND AFFILIATIONS

American Chemical Society
Association of Hazardous Materials Professionals, (Steering Committee 1988-1994)
Association of California Testing Laboratories, (Board Member 1989-1991)
County of San Diego, Site Assessment and Mitigation Technical Forum (Steering Committee 1990-2000)
American Society Quality Control (1992-2005)

FOUNDATIONS

Golf for Autistic Children in America (GACA), Founder/President (2011)

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RESUME
ERLINDA T. RAUTO

EDUCATION

B.S. Chemical Engineering 1967
Feati University - Manila, Philippines

PROFESSIONAL HISTORY

Laboratory Data Consultants, Inc.
Senior Chemist/Validation Group Manager
1993 to present

Appropriate Technologies, Inc.
Chemist II
1992 to 1993

AECOS Inc.
Laboratory Supervisor
1989 to 1992

PWCSA #4 County Complex
Laboratory Analyst
1986 to 1989

Kalama Specialty Chemical
Chemist
1980 to 1982

REPRESENTATIVE EXPERIENCE

Ms. Rauto has over 38 years combined environmental laboratory, QA/QC, and data validation experience. Her experience includes performance of data validation in the GC, trace metals, and wet chemistry areas for major Federal projects. Her laboratory experience includes hands-on CLP and EPA ICP/GFAA analysis, pesticide/PCBs and wet chemistry analysis.

Specifically, Ms. Rauto has over 25 years of experience with organic data validation and assessment using USEPA (including Region III) functional guidelines and other applicable documents.

- As a Principal chemist with LDC, Ms. Rauto provides management and technical support to the data validation group. She specializes in the data validation and compliance screening of gas chromatography organic analyses. This validation includes EPA CLP, SW-846, and EPA Water and Wastewater methods. Over the past 16 years, Ms. Rauto has performed USEPA Level 3 and Level 4 (including NFESC Level C and D) validation for projects including Boeing SSFL, Southwest Division CLEAN 1 (Jacobs Engineering/IT Corporation/CH2M Hill), Southwest Division CLEAN 2 (Bechtel National), Pacific Northwest Division CLEAN (URS Greiner), Southern Division CLEAN (ABB Environmental), Atlantic Division CLEAN (EA Engineering), Southwest Division RAC (OHM Remediation), Pacific Division CLEAN (Earth Tech), DoE Atomic City (Jacobs

Engineering Group), Army Corps of Engineers, Travis AFB (CH2M Hill), Army Corps of Engineers, Camp Navajo (Tetra Tech), AFCEE/AFCEC Mather AFB (Montgomery Watson), AFCEE/AFCEC Pease AFB (Bechtel Environmental), AFCEE/AFCEC England AFB (Law Environmental), Army Corps of Engineers, Hawthorne Army Depot (Tetra Tech), Army Corps of Engineers, Fort Ord (Harding Lawson), Nevada Test Site (IT Corp), and AFCEE/AFCEC Beale AFB (Law/Crandall, Inc.).

Ms. Rauto has organic laboratory experience with over 13 years of experience in an environmental laboratory supervising or performing the analyses of organic parameters.

- As a chemist II at Appropriate Technologies, Inc., a hazardous waste disposal facility, Ms. Rauto was responsible for the operation of the gas chromatographs. Organochlorine pesticides and PCBs analysis was the primary method performed. In addition, Ms. Rauto performed ICP analyses for trace metals, as well as, supported engineers in developing waste treatment processes.

- As the laboratory supervisor at AECOS Inc., Ms. Rauto supervised and directed operation of gas chromatography, atomic absorption, and wet chemistry instrumentation. She interfaced with state and federal agencies to maintain certification and developed a written QA/QC plan for the laboratory.

- As chemist at Kalama Specialty Chemical, Ms. Rauto performed gas chromatography analysis on raw materials and finished products. She worked on the research and development of new chemicals.

Additionally, Ms. Rauto has 2 years inorganic/conventional analytical experience.

- While employed at the Prince William County laboratory, Ms. Rauto was involved in the analysis of water and wastewater for metals and wet chemistry parameters. This included BOD, COD, nitrate, nitrite, sulfate, chloride, fluoride, TDS, conductivity, pH, cyanide, and phenols analyses. She maintained the QA/QC program to assure compliance with EPA guidelines.

AFFILIATIONS
American Society for Quality Control

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RESUME
CHRISTINA RINK-ASHDOWN

EDUCATION

BS Biology, 2006
University of California, San Diego

PROFESSIONAL HISTORY

Laboratory Data Consultants, Inc.
Inorganic Chemist
2009 to present

Enviromatrix Analytical, Inc.
Metals Chemist
2007 to 2009

REPRESENTATIVE EXPERIENCE

Ms. Rink-Ashdown has over 11 years combined environmental laboratory and data validation experience. Her experience includes performance of data validation in the trace metals, radiochemistry, and wet chemistry areas for major Federal and commercial projects. Her laboratory experience includes hands-on CLP and SW-846 ICP/CVAA analysis and overall technical review of data deliverables. Specifically, Ms. Rink-Ashdown has over 6 years inorganic and radiochemistry data validation experience using USEPA (including Region III) functional guidelines and other applicable documents.

As chemist with LDC, Ms. Rink-Ashdown specializes in the data validation of trace metals, wet chemistry, methyl mercury and radiochemistry analyses using USEPA functional guidelines or equivalent protocol. She has worked under various CERCLA and EPA data validation guidelines for the various CERCLA, Navy, Army Corps, AFCEE/AFCEC and commercial projects. She is certified as a “Radiometric Data Validation Specialist” through course work and testing by the Radiochemistry Society. **Ms. Rink-Ashdown has validated over 2,000 samples for various isotopes in the last two years.**

Ms. Rink-Ashdown has over 2 years of environmental laboratory experience in a laboratory performing the analyses of inorganic parameters.

As lead inorganic chemist at Enviromatrix Analytical, Inc., Ms. Rink-Ashdown managed the inorganic chemistry section which performed techniques such as atomic absorption and inductively coupled argon plasma spectrometry. These analyses were performed from methods referenced in EPA CLP, SW-846, and Standard Methods documents.

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RESUME
SHAUNA McKELLAR

EDUCATION

B.S. Environmental Toxicology, 2006
University of California at Davis

PROFESSIONAL HISTORY

Laboratory Data Consultants, Inc.
Project Manager / Chemist
May 2010 to present

D-Max Engineering, Inc.
Assistant Project Scientist
January 2007 to May 2010

University of California at Davis
Undergraduate Researcher
March 2005 to June 2006

REPRESENTATIVE EXPERIENCE

Ms. McKellar has over 14 years combined consulting, field sampling, database management, data validation, and automated data review experience. Her experience includes performance of automated data validation for major Navy Southwest Division, US Army Corps of Engineers, and Alaska DEC projects as well as data management for commercial and litigation projects. Her field sampling experience includes surface water sampling in both wet and dry weather conditions, and her laboratory experience includes preparation and analysis of samples utilizing HPLC and UV-vis spectrometry, instrument maintenance, and data evaluation.

Specifically, Ms. McKellar has over 6 years of inorganic and organic data validation experience using USEPA functional guidelines, Navy procedures, QAPP, ADEC checklists, and other applicable documents, in addition to more than 3 years of experience working in the environmental compliance field, and over one year working in a research laboratory.

- As chemist with LDC, Ms. McKellar specializes in the data validation and contract compliance screening using LDC's Automated Data Review (ADR) software, and is familiar with a variety of different Electronic Data Deliverable formats, including SEDD and NEDD. She has supervised large data validation projects under the USACE and Navy Southwest Division RAC contracts.

- As an assistant project scientist with D-Max Engineering, Ms. McKellar performed wet and dry weather surface water sampling related to compliance with Regional Water Quality Control Board NPDES Permits. She also maintained large project databases related to stormwater inspection and monitoring programs for various municipalities.

- As an undergraduate researcher at the University of California at Davis, Ms. McKellar conducted an independent atmospheric chemistry research project utilizing HPLC and UV-Vis spectroscopy. She was responsible for the instrument calibration, verifying sample analyses, and routine instrument maintenance.

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RESUME
LINDA TA

EDUCATION

B.S. Geology, 2012
California State University Long Beach

PROFESSIONAL HISTORY

Laboratory Data Consultants, Inc.
Chemist and Project Manager
July 2018 to present

Eurofins Calscience
Project Manager Assistant
02/2014-07/2018

Eurofins Calscience
Chemist
10/2013-02/2014

REPRESENTATIVE EXPERIENCE

Although Ms. Ta has less than one year of experience at LDC, she is proficient in data validation for GC and GCMS methods for Level II and III.

- As a project manager with LDC, Ms. Ta assists the other project managers through project set-up, validation, report review, and writing project data quality assessment reports. Ms. Ta is also in training to perform ADR validation and ERPIMS database tasks. She is also the administrative support specialist for LDC Advantage secure data sharing portal where she assists with project and client set-up.

Ms. Ta has 5 years of experience in an environmental laboratory performing the analysis of organic parameters.

- As a GC/MS chemist at Eurofins Calscience, a full service environmental analytical chemistry facility, Ms. Ta performed GC/MS volatile analyses using various EPA Methods in accordance with standard operating procedures. Ms. Ta utilized Agilent Chemstation and Laboratory Information Management Systems (LIMS) to analyze and report data.

- As a Project Manager Assistant at Eurofins Calscience, Ms. Ta assisted multiple Project Managers to oversee all laboratory functions for various projects. In addition, she managed several minor projects for various Environmental consultants. She served as the secondary point of contact for clients, ensured that Chain of Custodies are accurate and analyses are logged in correctly, directed preparation of bottle orders, scheduled pickups and deliveries, coordinated subcontracted analyses, provided quality control review of project-related documents and compliance to project criteria, worked closely with lab group supervisors and executive managers in planning new projects and managed ongoing analytical work. Ms. Ta evaluated analytical data, prepared project

case narratives and summaries, compiled laboratory reports for external validation, and worked closely with chemists and lab group supervisors in resolving quality assurance and quality control issues. She prepared detailed project billing and generated multiple Electronic Data Deliverables. She was also responsible for training new Project Manager Assistants on various PM tasks, data review and compilation of laboratory Level III/IV QC Data Deliverables.

Below is a partial listing of clients and projects which Ms. Ta has assisted:

-Department of Defense Sites
- Edwards AFB
- George AFB
- Vandenberg AFB

-SSFL NASA
-BP/ARCO
-Aerospace Company

Below is a listing of various database management software which Ms. Ta has extensive training on:

-ERPIMS
-EQUIS
-Envirodata
-NEDD
-ADR
-Geotracker

Relevant Project Experience

LDC has performed data validation and Quality Assurance services for contaminated sites overseen by AFCEE/AFCEC, Navy Southwest Division, DoE, DoD, EPA Superfund projects overseen by EPA Regions II, III, IV, IX, X, USACE projects reviewed by the Alaska, Baltimore, Louisville, Albuquerque, Seattle, Philadelphia, and Sacramento Districts, and Navy projects reviewed by NFESC.

LDC is the software developer and expert in the use of the Automated Data Review (ADR) software. LDC has been using the ADR.NET version for over 2 years and has the current Version in full implementation. LDC has performed over 1000 ADR projects in the past 10 years' worth over $2,000,000 in revenue. ADR clients include, but are not limited to: Tetra Tech EC, Sealaska, AMEC, EPA, California DTSC, MWH, Trevet, Brown & Caldwell, AECOM, Shaw, ITSI, CDM, Weston Solutions and the San Gabriel Watermaster.

LDC has validated over 1,000,000 samples for analyses such as volatile organics (CLP, EPA Method 8240/8260), semivolatile organics (CLP, EPA Method 8270), organochlorine pesticides/PCBs (CLP, EPA Method 8081/8082), chlorinated herbicides (EPA Method 8151), purgeable halocarbons and aromatics (EPA Method 8021), trace metals (CLP, EPA Method 6010/6020/7000), PAHs by EPA 8310 and 8270,TOC analyses, hexavalent chromium, total petroleum hydrocarbons (EPA Method 8015/CDOHS LUFT), radiochemical constituents including gross alpha/beta, alpha spec, gamma spec, tritium, and uranium, and general minerals.

LDC has met their contractual turnaround time and quality requirements on over 99% of the projects completed.

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Project References/Experience

Name and Address, Contact Person, Telephone	Work Description and Location	Requested Deliverables	Number of samples/ Matrix	Value ($)	Start/Stop
Washington State Department of Transportation Environmental Services Office P.O. Box 47332 Olympia, WA 98504 ATTN: Mr. Brad Archbold ArchboB@wsdot.wa.gov 360-570-6636	WSDOT NPDES Stormwater Monitoring LDC performed Stage2A, 2B and 4 data validation for a full suite of analyses including GCMS, GC, Metals, and Wet Chemistry analyses.	Stage 2A, 2B, and 4 data validation reports. Work conducted under Washington State Department of Transportation Stormwater Monitoring	>3,800 Soil and Water	$48,332	04/2013-07/2016
Leighton Consulting, Inc. 17781 Cowan Irvine, CA 92614 ATTN: Mr. Mark Withrow mwithrow@leightongroup.com cell: 949-394-2194 office: 949-681-4211	San Onofre Nuclear Generating Station (SONGS) Mesa Facility LDC performed EPA Level III and IV equivalent data validation for a full suite of analyses. Analyses included GCMS, GC, Metals, and Wet Chemistry analyses.	EPA Level III and IV data validation reports. Work conducted under USEPA Contract Laboratory Program National Functional Guidelines (CLPNFG).	>3,600 Soil, Water, and Air	$66,225	09/2015-present
Leighton Consulting, Inc. 17781 Cowan Irvine, CA 92614 ATTN: Ms. Julie Harriman jharriman@leightongroup.com Direct : (949) 681-4264 Cell: (949) 572-8129	Aliso Canyon LDC performed EPA Level II equivalent data validation. Analyses included VOA, SVOA, Total Hydrocarbons, Isopropyl Alcohol, Total Dust, and Sulfur Compounds.	EPA Level II data validation reports and PARCC summary report. Work conducted under USEPA Contract Laboratory Program National Functional Guidelines (CLPNFG).	>1,200 Air, Wipe, and Disk	$15,749	07/2016-08/2016
Tetra Tech, EM Inc. 1999 Harrison Street, Suite 500 Oakland, CA 94612 ATTN: Ms. Sara Woolley Sara.Woolley@tetratech.com Direct: 510.302.6311 Main: 510.302.6300	Subcontract 161408 For Various project sites including: EAGLE NEST INVESTIGATION FORT IRWIN GOLD BEACH MILL HPNS MARE ISLAND MOTCO LITIGATION NAF EL CENTRO NWS CONCORD LDC performed Cursory and Full data validation for a full suite of analyses using specified EPA Guidelines, DoD QSM Version 4.2, and Tetra Tech EMI, Inc. validation documents.	TTEMI Format data validation reports and EDD using Tetra Tech's validate program.	>3000 Soil and Water	$39,785	10/2011 – 10/2013

Name and Address, Contact Person, Telephone	Work Description and Location	Requested Deliverables	Number of samples/ Matrix	Value ($)	Start/Stop
GEI Consultants, Inc. 455 Winding Brook Drive Glastonbury, CT 06033 (860) 368-5342 direct (860) 368-5300 main Jaimie Wargo JWargo@geiconsultants.com	Various NYSDEC sites LDC performed Category B equivalent data validation Analyses included: VOC, SVOC, Pesticide, PCB, Herbicide, Steroids, Metals, Wet Chemistry	Category B data validation and NYSDEC DUSR reports	>1,700 Soil and Water	$72,000	2010-present
TetraTech EC 17885 Von Karman Ave, Suite 500 Irvine, CA 92614 Attn: Lisa Bienkowski (949) 809-5028 Lisa.Bienkowski@tetratech.com	Tetra Tech Hunter's Point CA LDC performed EPA Level III and IV equivalent data validation for a full suite of analyses on more than 50,000 soil and water samples. Analyses included tritium, isotopic thorium, uranium and plutonium, and gross alpha/beta. Expedited turnaround times were included (5 day TAT)	EPA Level III and IV data validation reports. Work conducted under US Navy RAC program, Southwest Div.	>50,000 Soil and Water	$645,733	02/2001-present
AECOM (Earth Tech) 700 Bishop Street Honolulu, HI 96813 Contact: Scott Lewis (808) 523-8874 Scott.Lewis@aecom.com	Data validation per EPA level "3/C" and "4/D" guidelines for volatile organic, semivolatile organic, pesticides/PCBs, herbicides, phenols, phosphorus pesticides, dioxin, radiochemical, and trace metal analyses in soil, water, and tissue matrices. (Navy PACDIV CLEAN, Honolulu, HI)	LDC worksheets and validation reports	>10,000 samples Water/Soil/Air	$750,000	4/98-present
CBI (formerly Shaw E&I) 3347 Michelson Drive, Ste 200 Irvine, CA 92612 Contact: Mr. Dwayne Ishida Phone: (949) 660-7561 Dwayne.Ishida@CBIFederalServices.com	Data validation per EPA level "3" and "4" and AFCEE/AFCEC guidelines for volatile organic, semivolatile organic, pesticides/PCBs, herbicides, phenols, phosphorus pesticides, dioxin, radiochemical, and trace metal analyses in soil, water, and tissue matrices. (Navy Southwest Division RAC, San Diego, CA and various AFCEE/AFCEC projects)	LDC worksheets and validation reports	>5000 samples Water/Soil/Air	$350,000	6/06-present

LABORATORY DATA CONSULTANTS, INC.
2701 Loker Ave. West, Suite 220, Carlsbad, CA 92010 Bus: 760/827-1100 Fax: 760/827-1099

Name and Address, Contact Person, Telephone	Work Description and Location	Requested Deliverables	Number of samples/ Matrix	Value ($)	Start/Stop
Santa Clara Pueblo Office of Environmental Affairs 578 Kee Street Espanola, New Mexico, 87532 Ms. Ernestine Naranjo 505-692-6270 phone 505-747-2728 fax enaranjo@santaclarapueblo.org	Data validation per EPA level "III" SCP-OEA-DEPO, Data Validation using ADR For full suite of Organic, Inorganic, and Radiochemical analyses. Radiochemical analyses including Gross alpha & beta, Gamma Spectroscopy, Iodine, Radium-226/228, Strontium-90, Isotopic Pu, Th, and U, Tritium, and Americium by various EPA and GA methods.	Level III validation using ADR	>750 Soil, Water, and Air	$11,987.05	12/2015 - present
Anchor Environmental, LLC 720 Olive Way, Suite 1900 Seattle, WA 98101 Ms. Joy Dunay 206.287.9130, jdunay@anchorqea.com	Data validation per Level “C” Newtown Creek Phase 2: Third Party Data Validation of laboratory results, EDD population, and Data Quality Assessment Reports (DQAR) for various methods Subcontractor	LDC worksheets and validation reports	>63,000 Soil and Water	$743,793.88	6/14-1/16
Tradebe Environmental Services, LLC. 628 South Saratoga Street Cohoes, NY 12047 Attn: Accounts Payable Mr. Tom VanVranken (518) 235-0401 tom.vanvranken@tradebe.com	Norlite MACT Project LDC performed Category B equivalent data validation Analyses included: Metals, Mercury, Heat Content, Ash Content, Chlorine, Density, and Dioxins	Category B data validation and NYSDEC DUSR reports	11 Soil, Air and Water	$2,000.00	9/2013
P.W.Grosser Consulting2015 630 Johnson Ave, Suite 7 Bohemia, NY 11716 Attn: Mr. Derek Ersbak w. 631.589.6353 f. 631.589.8705 dereke@pwgrosser.com	Former Arkansas Chemical Co.Site and Former Ronkonkoma Wallpaper Site 203 Jay St. LDC performed Category B equivalent data validation Analyses included: VOC, SVOC, Pesticide, PCB, Metals, Wet Chemistry	Category B data validation and NYSDEC DUSR reports	>200 Soil and Water	$3,024.00	11/2014-present

LABORATORY DATA CONSULTANTS, INC.
2701 Loker Ave. West, Suite 220, Carlsbad, CA 92010 Bus: 760/827-1100 Fax: 760/827-1099

Name and Address, Contact Person, Telephone	Work Description and Location	Requested Deliverables	Number of samples/ Matrix	Value ($)	Start/Stop
Amec Foster Wheeler Environment and Infrastructure, Inc. 9210 Sky Park Court, Suite 200 San Diego, CA 92123 Attn: Mr. Rolf Schottle rolf.schottle@amecfw.com Tel +1 (858) 300 4300, Fax +1 (858) 300 4301, Direct +1 (858) 300 4323	Regional Harbor Monitoring Program (RHMP), San Diego, California Third party validation of LDC performed EPA Level III and IV equivalent data validation for a full suite of analyses.	LDC worksheets and validation reports	>200 Water	$9,011.40	3/15–6/16

Note: All above projects were 100% self-performed by LDC

Attachment B

Field Standard Operating Procedures

Former DuPont East Chicago Facility

SOP-01: FIELD DOCUMENTATION

1.0 Purpose

This standard operating procedure (SOP) provides programmatic criteria for the content of field log books.

An essential part of any environmental field project is proper documentation. The primary documentation used to record site data is field log books, which describe the history of field activities and summarize field measurements. This is necessary to demonstrate that the data are representative and have been obtained according to required procedures. The log books may be used as evidence in legal proceedings to defend procedures and techniques employed during site investigations. Therefore, it is important that documentation be factual, complete, accurate, consistent, and clear.

2.0 Scope

This procedure applies to all IEC personnel and subcontractors engaged in note taking and data collection to be recorded in field log books for Project Sites and site field tasks. The field documentation will be recorded per the following United States Environmental Protection Agency (USEPA) guidance documents:

- *Field Sampling and Measurement Procedures and Procedure Validation (USEPA, 2016), SESDPROC-012-R4*
- *EPA QA Field Activities Procedure (USEPA, 2005) CIO 14-004*
- *Operating Procedure: Logbooks (USEPA, 2013) SESDPROC-010-R5*

3.0 General

4.0 Document Sources

Field documents consist of the following hardcopy or electronic types:

- Field Notebooks
- Field Datasheets
- Soil Boring/Test Pit Log Sheets
- Field Calibration Sheets
- Photographs and Photographic Logs
- Global Positioning System (GPS) and Geographic Survey Coordinate Data
- Field Instrument Data (such as water-quality instruments and photoionization devices)
- Laboratory Chain of Custody Forms
- Shipping Waybill and Manifest Documents
- Any other field activity and/or field data documentation

5.0 Site Personnel

All site personnel who make log book entries are required to read this procedure before engaging in this activity. The FTL will inform personnel who will be responsible for log book entries, care, and maintenance.

6.0 PROCEDURE

6.1 Field Notebooks

Front Cover

Field Notebooks will be bound with lined, consecutively numbered pages. Record the following information on the outside front cover of all Field Notebooks:

- Project name (former Dupont East Chicago Facility, Indiana)
- Client name and contract number (East Chicago Gateway Partners, LLC)
- Log book activity title
- IEC project number
- Date of first and last entries in the log book

Project Reference Pages

Reserve the first couple of pages (pages 1-2) of the Field Notebook for important project reference information, including project-related contacts (such as contact names and phones for subcontractors, site access, project assistance, field team, and emergency use), special instructions, and/or any other valuable reference information.

Table of Contents

The next few pages (pages 2-5; fewer for smaller Field Notebooks) will be reserved and will consist of a Table of Contents.

Daily Entries

Following the Table of Contents, detailed entry of all field activities, events, data, and other relevant project task information will be documented daily (at minimum) throughout the course of field activities. The following minimum requirements must be followed when entering daily activities within Field Notebooks:

- The field activity and date must be recorded at the top of each page.
- The top page corner of each page will be consecutively numbered
- Entries in the field log book should be preceded with the time (written in military units). The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged.
- All changes must be made with a single, strike-out line through the deletion. Changes must be initialed and dated. Scribbling or blotting out deletions is unacceptable.
- Entries should be made in waterproof ink (unless inclement weather prevents pens from working).
- Entries must be written clearly and legibly enough so that any reviewer can read and understand the entry.
- A diagonal line or similar must be drawn through any space left at the bottom of the last page of field entries at the conclusion of daily site activities.
- The bottom of each page should be signed and dated by the author.
- No pages are to be removed from the Field Notebook.
- Events and observations that should be recorded should include, but are not limited to, the following:
    - The field activities/tasks with date and time.
    - The location(s) and field conditions in which the field task will be conducted.
    - The names and organization(s) of all task field staff and/or visitors, including the FTL, subcontractors, clients, and regulators.

    - Site conditions (upon arrival and departure) and any changes in site conditions.
    - Current weather and any changing weather conditions that might impact field activities.
    - All relevant field observations, major task decisions, comments, or other valuable site investigation information will be documented throughout the course of site activities. Entries will be as specific and detailed as possible and practical.
    - If field datasheets, soil boring log sheets, photographs, sample location coordinates, or other documentation types are specified by a procedure, the information need not be duplicated, but the relevant documentation type and/or forms must be referenced in the Field Notebook.
- Documentation of field instrument calibration or reference to any appropriate field calibration sheets.
- Field map sketches will be drawn with a North arrow and approximate scale. Boring or sample locations with measurements (swing ties) to at least two fixed objects to locate points for mapping.
- Changes and/or deviations from task protocols (such as sampling procedures) outlined in any governing planning documents.
- Reason(s) for any noted deviations, and whom the deviation was discussed with and authorized by.
- Any problems, downtime, or delays and the reasons for the problem or delay.
- Upgrade or downgrade of personal protective equipment.
- All equipment make, model, and property numbers or serial numbers used at the site.
- Health and safety monitoring equipment, including calibration procedures and results and actual and background readings.
- Start and end times of sampling.
- Sampling steady-state parameters.
- Decontamination times and methods.
- Type, amount, and disposal methods used for any investigation-derived wastes.
- When samples are collected, the following should be recorded in the log book or laboratory Chain of Custody form:
    - Sample location and depth
    - Sample identification number
    - Sample date and time
    - Sample methodology
    - Sample type and media
    - Field sampler initials
    - Sample analyses requested
    - Sample preservation type
    - Quality control sample numbers and types
    - Chain-of-custody number
    - Name of individual to whom the samples are relinquished
    - Laboratory service provider in which samples are to be relinquished
    - Shipping Service(s) or method(s) used for sample delivery
    - Date and time of shipment
    - Shipping waybill or manifest number

6.2 Field Datasheets and Forms

Other unbound data documentation types (including Field Datasheets, Soil Boring/Test Pit Log Sheets, Field Calibration Sheets, Photographic Logs, Laboratory Chain of Custody Forms, Shipping Waybill and Manifest Documents, and similar documents) are part of the field form records. Generally the use of these documentation types are task-specific and when used should be referenced within the field log books. However, specific data entered on these types of documents will not typically be documented in the log books, so document handling and archiving must be performed in the same manner as the log books.

6.3 Electronic Data Documents

Electronic data documents consist of photographs, GPS and survey coordinate data, field instrument data, and other electronic data files. Investigation field instruments and tools such as digital cameras, GPS units, water-quality meters, photoionization detectors (PIDs), pressure-transducers, and hand-held computers all store investigation data in electronic formats that can be later downloaded and stored electronically for future reference. Take care when retrieving, storing, and managing these electronic data. The FTL or designee will be consulted for electronic data management instruction before using any unfamiliar electronic instrument or tool requiring electronic data retrieval and storage. At minimum, Electronic Data Documents will be managed as suggested below:

- After collection, retrieve (download) all electronic data from the field instrument daily or as determined necessary by the FTL.
- After successful electronic data document retrieval, store all electronic data files at a digital location specifically reserved for that data document type. The data storage device must be reliable and secure. The data will be stored at a location that can be readily accessed by multiple team members (that is, network project server or file transfer protocol [FTP] site).
- Back up all electronic data documents or use in the event of data loss. Backup formats may include, but are not limited to, CDs, DVDs, flash memory cards, USB storage devices, and external hard drives. Whatever data backup format is used, the data backup must be managed for retrieval by the PM, FTL, and other responsible team members, if necessary.
- Name data files appropriately to easily identify the content and date of collection or download.
- It possible, include the following identifying information in data files:
    - Contractor name (IEC)
    - Client and project name
    - Investigation area name
    - Date and time
    - Project number
    - Location(s) of data collection
    - Any other information unique to the kind of data collected

6.4 Photographic Logging

Photographs should be obtained throughout all field activities and utilized to document field conditions and/or field conditions changes and unexpected occurrences. Furthermore, photographs should be utilized to verify field log notes, measurements and other field measured parameters.

Photographs should be accompanied with submission of all field notes and field documentation when provide to the field team leader or project manager.

7.0 Document Control

At the conclusion of a task or when a field log book, datasheet, and/or electronic data document has been completed, it will be submitted for records retention. Project files will be maintained by the PM, FM, or designee. Documents will be securely kept in the project files.

Project personnel may keep their own duplicate files; however, all original documents will be placed in the official project file. Field logs of boring, sampling, and well installation activities will be maintained by the FM and submitted to the project manager after the field effort.

8.0 Records

Documentation should follow all guidelines contained in this technical procedure.

9.0 References

Field Sampling and Measurement Procedures and Procedure Validation (USEPA, 2016), SESDPROC-012-R4

EPA QA Field Activities Procedure (USEPA, 2005) CIO 14-004

Operating Procedure: Logbooks (USEPA, 2013) SESDPROC-010-R5

10.0 Definitions

None.

11.0 Attachments

None.

SOP-02: FIELD PROCEDURE CHANGE MANAGEMENT

1.0 Purpose

This standard operating procedure (SOP) provides the process to modify field SOPs to address changing project needs and conditions. The field SOP change management process includes the following steps:

1. Identify a potential SOP change.
2. Analyze the SOP change request.
3. Evaluate and accept, reject, or modify the SOP change request.
4. Plan and implement the approved SOP change.
5. Review and close the SOP change.

The field SOP change management process includes the following responsibilities:

Change Requestor: Requests an SOP change because of issues encountered with the current procedure or new procedural requirements; initiates the change management process by submitting an SOP Change Request Form.

Change Manager: Responsible for determining the technical feasibility, costs, and benefits of the procedural change. The Project Manager (PM) will be the Change Manager; however, the PM may delegate the Change Manager role to the Field Manager (FM), Health and Safety Manager (HSM), Field Team Leader (FTL), or other appropriate team leader.

Change Committee: Decides if an SOP change request will be implemented. The PM is the default Change Committee. At the PM's discretion, the Change Committee may include other project stakeholders (for example, the client, and regulators), depending on the nature of the SOP change request. The PM will evaluate the magnitude and impacts of the SOP change request and organize the Change Committee, as appropriate.

Change Builder: Plans, documents, and implements the change. This role will reside primarily with IEC Project Management and subcontractors engaged in project activities.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in remedial and related construction activities at the {ŀúŜ. It is anticipated that this SOP will be used in conjunction with all existing and future project SOPs.

3.0 Procedures

3.1 Identify a Potential SOP Change

Changes to the SOPs may be initiated for many reasons including unanticipated problems, changes in site conditions, new project requirements, new technology, or improved methods. All changes to the field SOPs begin with submission of a completed SOP Change Request Form to the FM, who reviews it and forwards it to the PM. The PM may serve as the Change Manager or assign that role to the FM, HSM, FTL, or other appropriate team leader.

A copy of the SOP Change Request Form is provided as *Attachment 1: SOP Change Request Form*. Any person or organization, internal or external, may submit an SOP change request. SOP Change Request Forms will be recorded in the *SOP Change Entry Log* (see Attachment 2). Copies of all SOP Change Request Forms and the SOP Change Entry Log must be archived in the project records.

3.2 Analyze the SOP Change Request

The Change Manager will review the SOP Change Request Form and determine the practical and technical feasibility of the proposed change and evaluate the costs and benefits relative to project goals. The Change Manager will also determine the impact that the change will have on other project SOPs, tasks, and goals. The Change Manager will present this information to the Change Committee for evaluation.

The Change Manager may ask that the requested change be tested for technical feasibility, cost, and benefit. Tests should be conducted by a Change Builder (for example, an FTL). Test results should be communicated to the Change Manager for presentation to the Change Committee.

3.3 Evaluate and Approve the SOP Change

The PM will evaluate the impacts of the SOP change and organize the Change Committee to review the information and decide if the change will be implemented. Depending on the scope and magnitude of the proposed change, the Change Committee may comprise various project stakeholders (such as the client, and respective Federal and/or State regulators) or it may comprise only the PM or other IEC project staff. Based on the technical feasibility, costs, and benefits of the SOP change, the Change Committee will approve or disapprove the proposed change. The outcome of the SOP change request will be recorded in the SOP Change Entry Log.

3.4 Plan and Implement the SOP Change

After approval, the change will be planned and implemented by the Change Manager and Change Builders. Planning the change might include updating the existing SOP, developing a new SOP, or organizing staff, resources, and subcontractors to implement the changed SOP. All updated and new field SOPs will be added to the existing SOPs as an amendment. After the SOP change is planned and documented, the SOP change must be communicated to all affected field team members for review and implementation.

3.5 Review and Close the SOP Change

Implementation of the SOP change should be verified by the PM or his/her designee. If the change is acceptable, the SOP change request can be closed and documented as complete on the SOP Change Entry Log.

4.0 Records

A record of all submitted SOP Change Request Forms will be recorded in the SOP Change Entry Log. Copies of all SOP Change Request Forms must be maintained with the SOP Change Entry Log in the project records. All SOP Change Request Forms must be completed according to *SOP-XX, Note Taking and Field Log Books*.

5.0 References

None.

6.0 Definitions

SOP Change: Any alternative field procedure, method, or process step that is different than those currently outlined in the *Appendix H, Field Standard Operating Procedures.*

SOP Change Entry Log: A log book or database that catalogs multiple SOP change requests and tracks the decision and implementation process and final decision outcome of the request.

SOP Change Request Form: A form that identifies a potential need for an SOP change and requests that the change be considered for implementation. The form provides a method to record changes during the project.

7.0 Attachments

Attachment 1: *SOP Change Request Form*

Attachment 2: *SOP Change Entry Log*

IMPACT PROJECT MANAGEMENT

FIELD CHANGE REQUEST

PROJECT INFORMATION	
Project Name:	Permit #
Project Address:	Site Plan #_____

DESCRIPTION OF CHANGE REQUESTED:

PROBABLE IMPACT:

SUBMITTED BY PROJECT FIELD TEAM LEADER:

_____ **Date:** _____

AGREED BY PROJECT MANAGER:

_____ **Date:** _____

APPROVED BY PROJECT ADMINISTRATOR:

_____ _____

Date:

APPROVED BY OTHER:

_____ _____

Date:

_____ **NOT APPROVED.** This change must be submitted to USEPA for a site plan revision.

_____ **APPROVED.**

ALL APPROVED CHANGES MUST BE INDICATED ON A SITE PLAN REVISION APPLICATION PRIOR TO PROJECT CLOSE-OUT AND SHOWN ON THE CONSTRUCTION RECORD DRAWINGS.

SOP Change Entry Log- Impact Environmental

Facility		Subject of Log:	Month and Year

Date	Time	Code	Remarks	Initials

Date	Signature of Manager	Date	Signature of Maintenance Technician

SOP-03: SITE RECONNAISSANCE, PREPARATION, AND RESTORATION

1.0 Purpose

The purpose of this standard operating procedure (SOP) is to set programmatic criteria to support proper planning for sites before field activities, and to establish expectations for restoring sites to satisfactory conditions upon completion of field activities.

An essential component of the fieldwork portion of any environmental project is proper planning before field activities. Site reconnaissance (when possible) should be conducted during the planning stages of a project to ensure that there are no site-specific conditions that will need to be addressed before or during field activities. In addition, the site reconnaissance visit should be used to consider staging areas and to notify potentially impacted community members before starting field activities.

2.0 Scope

This procedure applies to all IEC personnel and subcontractors engaged in site reconnaissance, preparation, and restoration for the Site projects and tasks.

3.0 Procedure

3.1 Pre-planning Activities

Secure all necessary clearances and approvals before beginning fieldwork; if necessary, obtain written clearances and approvals. Determine vehicle access routes and keys or gate combinations to sampling locations and staging areas before any field activities. Survey areas designated for intrusive sampling for the presence of underground utilities. Conduct utility locations according to *SOP for Utility Clearance for Intrusive Operations.*

Complete the following tasks before field activities:

- Prepare Field Safety Instructions or a site-specific Health and Safety Plan (HASP)
- Perform a brief site reconnaissance
- Plan personnel and equipment mobilization
- Locate nearby essential facilities, such as communication and emergency facilities
- Verify that archaeological monitoring and endangered species work approvals have been secured, if necessary
- Mark and map proposed sampling locations
- Obtain all fieldwork permits
- Anticipate and document potential real property damage that could result from fieldwork, and how permanent damage will be mitigated
- Conduct physical clearance for utilities and, if necessary, unexploded ordnance
- Coordinate site access with operations such as Security, Liquid Fuels, Base Operations, and Emergency Response (as necessary)
- Establish that fieldwork plans are in compliance with the most current client policies

4.0 Site Reconnaissance

Each field team member should bring the following items:

- Waterproof log book
- Ink pens
- Digital camera
- Suitable clothing for rain or freezing weather

When conducting the site reconnaissance, it is important for the project team to pay particular attention to physical site features, such as locations and dimensions of former building footprints (if known), and current site uses. Record any observations that differ from available site maps (for example, demolished buildings).

Record all observations in a log book. Use the logbook to record such things as:

- Visual observations of the site and its surroundings
- Descriptions of photographs taken
- Conversations with site personnel or neighbors
- Visits to local authorities and information obtained
- House counts and other observations related to potential exposure assessments
- Freehand site sketches

Record the time of day for each activity or observation entered. The log book should be completed in waterproof ink (unless inclement weather prevents pens from working). Each person who enters information into the log book must sign and date after the last entry on the page.

At each site, document potential source areas, including location of storm water drains, stained soil, or stressed vegetation, using color photographs. Take a series of photographs showing a panoramic view of the entire site. Document other aspects of the site such as fencing, proximity of residences, signs of current usage, and proximity to surface water (Ex. Calumet River).

Document all photographs in sequential order in the log book. For each site, generate a table with photograph number, time taken, description of subject, and direction the photograph was taken. Mark the location and direction of each photograph on the site sketch or map.

Document site features pertinent to contamination migration on the site sketch or map. Document location and distance to nearby residences. Discuss typical use patterns with local authorities. Determine drinking water supply sources and location of any private wells.

5.0 Housekeeping

Maintain the site with good housekeeping at all times in all project work areas. Establish common paths of travel and keep them free from spills and the accumulation of equipment and materials. Keep access to aisles, exits, ladders, stairways, scaffolding, and emergency equipment free from obstructions and slip hazards and adequately

illuminated during work activities. Store tools, equipment, materials, and supplies in an orderly manner. Designate specific areas, as appropriate, for the proper storage of materials. Clean up spills and leaks quickly.

6.0 Traffic and Public Safety Management

If fieldwork is going to be conducted where traffic may pose a hazard (for example, in or on parking lots, roadways, flight lines), implement traffic controls. Discuss traffic controls with the Project-specific Health and Safety Officer before mobilizing to the field, and prepare a IEC Traffic Control Checklist (*Attachment 1: Traffic Control Plan*). If possible, identify traffic controls and include them in the project-specific HSP during the planning phase of the project. Stage barricades, safety cones, and personnel as necessary to direct traffic in an orderly and safe manner.

Be sure to address public safety during the planning phases of any field activities. If fieldwork is going to result in a temporary increase of noise in an area, notify residents and workers before the start of field activities. Mitigate public safety by setting up exclusion zones during field activities to protect the public from inadvertently becoming exposed to field equipment or potentially hazardous materials.

7.0 Restoration of Work Areas to Pre-fieldwork Conditions

Return each work site or sampling location as close to its original condition as possible. Make efforts to minimize impacts to work sites and sampling locations, particularly those in or near sensitive environments, such as wetlands or high-security areas. Following the completion of work at a site, remove and manage all investigation-derived waste (IDW) (such as drums, trash, and other waste) the *SOP for Investigative/ Remedial Derived Waste Managment.*

8.0 Records

Documentation should follow guidelines contained in this technical procedure and noted in the Field Log (see *SOP for Field Documentation*).

9.0 References

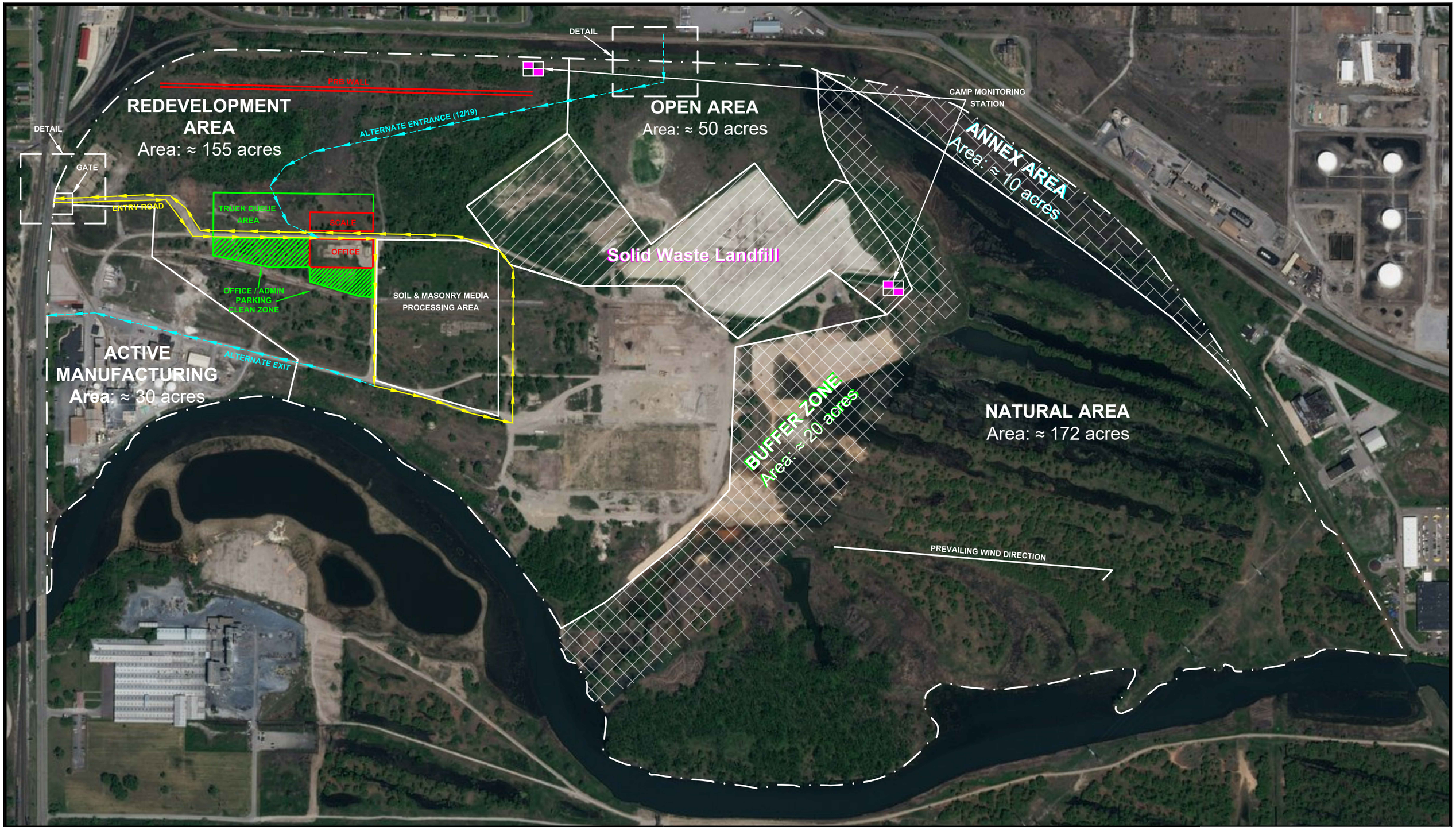
None.

10.0 Definitions

None.

11.0 Attachments

Attachment 1: *HSE-216 Traffic Control*



IMPACT ENVIRONMENTAL
170 KEYLAND COURT
BOHEMIA, NEW YORK 11716
TEL (631) 269-8800
FAX (631) 269-1599

Scale: 0 125 250 500 750 1,000 Feet

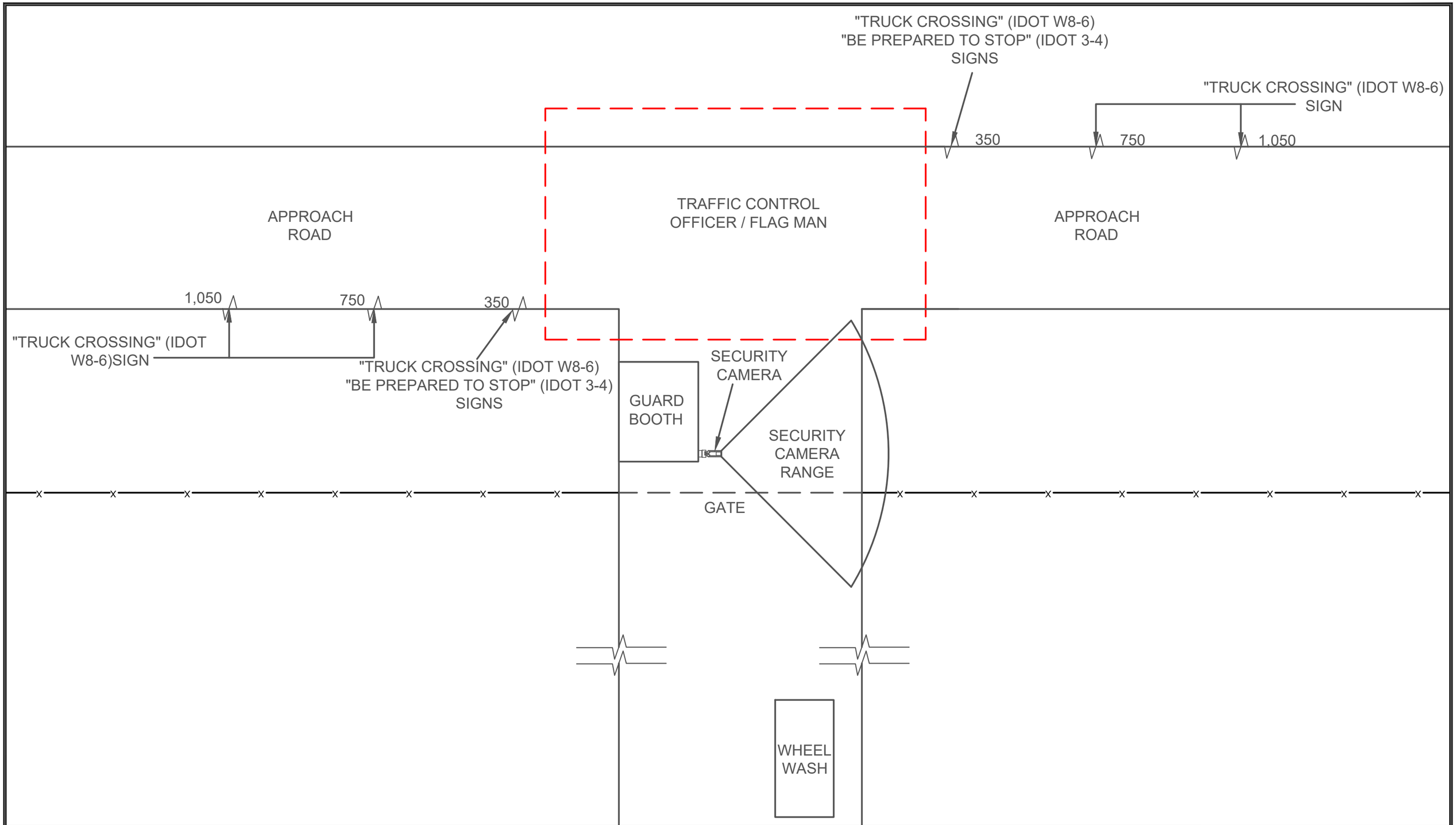
Prepared by:	Reviewed by:	Date:
Leif R.	Daniel F.	1/2/2019

PROJECT NORTH

Notes:

Designated Site area boundaries are approximate and are for visual reference.

Figure: 1
Traffic Control Map
(Phase I)



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Scale:	N.T.S		
Prepared by: Leif R.	Reviewed by: Daniel F.	Date: 1/2/2019	PROJECT NORTH

Notes:
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Figure: 3
Approach Road Detail

SOP-04: UTILITY LOCATION AND CLEARANCE

1.0 Purpose

This standard operating procedure (SOP) describes procedures to be used to positively identify and verify the location of above ground and buried utility lines in and around work areas. The purpose of this SOP is to establish operating requirements that will permit personnel to work safely in the vicinity of electrical, gas, steam, fuel, water/sewer and other utilities and utility installations. A secondary purpose is to prevent damage and disruption to existing utilities.

The Project Manager and Field Manager will Identify all utilities that may be affected by the project in advance so the presence and physical location of the utilities may be incorporated into project planning documents. The Field Manager will collect sufficient information to verify that field operations maintain the required separations from utilities and that site safety requirements are reflected in project planning documents. This approach will also prevent data gaps that may result from utility conflicts.

The potential for encountering unknown utilities is a hazard to be recognized. This SOP is to be used in conjunction with the project-specific Health and Safety Plan. The use of as-built drawings to locate subsurface utilities for clearance will require independent confirmation by land survey or geophysical methods. Whenever possible, an appropriate representative of the utility owner should provide utility clearance. Be sure to allow advance coordination and identification of lead time requirements, because not all utility owners have the required onsite representatives in the Site area.

2.0 Scope

This procedure applies to all IEC personnel and subcontractors engaged in utility clearance to support the Site Project. Utilities covered under this SOP include overhead, surface and subsurface areas. The term “clearance” indicates:

- The positive locating of utility systems in or near the work area.
- A signed statement by an appropriate representative attesting to the location of underground utilities and the positive de-energizing (including lockout) and testing of electrical utilities that may be encountered.
- In some cases, utility representatives may deem it appropriate or necessary to use insulating blankets to isolate a power line; this is an acceptable alternative to positive de- energizing, however only the utility representatives can make that determination.

Utility clearance is required before conducting any of the following work:

- Intrusive work of any nature, including, but not limited to, excavation, drilling, trenching, installing drive points, or penetrating the components of a building structure.
- Use of heavy equipment or undertaking raising/hoisting operations.
- Work in the vicinity of electrical lines or utility installations.

3.0 Procedures

3.1 Preparation and Initial Notification

- Call the Indiana 811 utility location request for initial notification. Indiana's "Call Before You Dig" law, Ind. Code ch. 8-1-26, requires everyone who digs to contact Indiana 811 at least two full working days before starting their project or within 10 working days in remote areas from the date of request. Registration with Indiana 811 is required prior to initiating said requests.
- When an Indiana 811 utility location request is initiated, the operator will list the member utilities that will be notified. If not, ask for a copy of the member utility list. Therefore, depending on the locate location, it may be necessary to independently contact individual non-member utility service providers in the area to conduct utility locates.

Indiana 811 Contact Information

Telephone numbers: 811 or 800-382-5544/877-230-0495

Fax: 877-230-0495

Website: https://indiana811.org

- Initiate a Utility Locate Form (Attachment 1) for each site or contiguous group of sites. The Utility Locate Form should be completely filled out to include the following:

    a. A description of the areal extent of the work area

    b. A sketch or map of the areal extent of the work area (if possible)

    c. The type of work being conducted

    d. For intrusive work the proposed location and depth

    e. Notes regarding the review of as-built drawings

    f. Notes of interviews with facility owners, occupants or employees.

    g. The name of the Facility Manager/Owner or other points of contact

    h. The owner of any utilities at or adjacent to the work site.

The Utility Locate Form is to be routed to Indiana 811 and the owner, manager and users of affected facilities. The date of an onsite locate is to be established and shared with the facility manager and owners.

3.2 Initial Utility Locate and Survey

With utility representatives, complete an initial utility locate and survey to physically locate known utilities. Participants may include the facility owners, managers, employees, representatives of site utility owners, subcontractors and others. Review site activities and the extent of intrusive activities. While onsite, review as-built drawings and identify surface features.

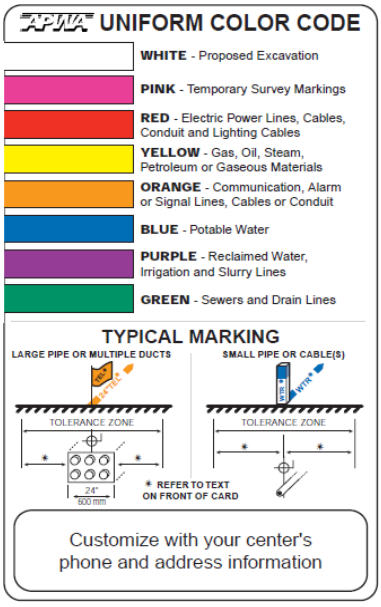
As needed, discuss potential utility outage requirements and complete an inventory of affected facilities. Identify outage notification requirements and lad times.

Identify and document potential Lockout/Tagout locations, procedures, outage notification and lead time requirements. When information is insufficient, it is important that the potential for concealed utilities are in the

area be identified, and actions necessary to protect the affected systems be discussed and identified in the Utility Clearance Form (Attachment 2).

3.3 Field Markings

Mark the presence and type of buried utilities on the ground according to American Public Works Association (APWA) color coding:



White – Proposed excavation/work location

Pink – Temporary survey markings

Red – Electric power lines, cables or conduits, and lighting cables

Yellow – Gas, oil, steam, petroleum or other hazardous liquid or gaseous materials

Orange – Communications, cable TV, alarm or signal lines, cables, or conduits

Blue – Potable water

Purple – Reclaimed water, irrigation and slurry lines

Green – Sewers, storm sewer facilities, or other drain lines

It is the contractors responsibility (IEC or subcontractor) to protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations or survey. If the markings of utility locations are destroyed or removed before activities commence or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.

3.4 Positive Response

In the event that utility locations do not result in a “positive response” Indiana 811 and/or utility service providers may not confirm that the locate has been completed. Locates are required by law to be completed in two working days, or within 10 working days in remote areas. It is IEC’s responsibility to maintain the markings and confirm that the utility locates have been conducted if necessary.

3.5 Surface and Overhead Utilities

Note the presence of surface and overhead utilities and potential limitations and impact to site operations, as well as potential impacts to site operations and equipment requirements which may result. For planning purposes, the minimum distances and clearances from energized overhead lines are shown in the tables below.

MINIMUM DISTANCES FROM POWERLINES

Powerline Nominal System (kV)	Minimum Required Distance (ft.)
0-50	10
51-100	12
101-200	15
201-300	20
301-500	25
501-750	35
751-1000	45

MINIMUM CLEARANCE FROM POWERLINES

Powerlines Nominal System (kV)	Minimum Required Distance (ft.)
0-50	10 feet or one mast length, whichever is greater
>50	50 kV + 10 feet plus 0.5 inch for every 1 kV over 50 kV or 1.5 mast lengths, whichever is greater

3.6 Site Operations

Before initiating site operations, the FM will verify a Utility Clearance Form (Attachment 2) is completed and includes signatures from appropriate representatives. In addition, the Utility Locate Form and Utility Clearance Form must be available onsite during work activities.

Brief personnel working onsite on the location and status of utilities that may potentially be affected by site activities. The briefing should include the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment.

The FTM should verify that work is planned and conducted according to the project-specific Health and Safety Plan.

4.0 Records

The following records are to be maintained in the project file and onsite during work activities:

- Utility Locate Request Form (Attachment 1)
- Utility Clearance Form (Attachment 2), with signatures of the required parties

5.0 References

Occupational Safety and Health Organization (OSHA) 1910.333 – Selection and Use of Work Practices in Subpart S – Electrical

Occupational Safety and Health Organization (OSHA) 1926.650 through 1926.652 – Excavations

Occupational Safety and Health Organization (OSHA) 1926.955 – Provisions for Preventing Accidents Due to Proximity to Overhead Lines

6.0 Definitions

None.

7.0 Attachments

Attachment 1 *Utility Locate Form*

Attachment 2 *Utility Clearance Form*

LOCATE REQUEST FIELD FORM

TICKET TYPE:(CIRCLE ONE)

- **NEW**
- **EMERGENCY**
- **RESTAKE**
- **2ND 3RD 4TH REQUEST**
- **RUSH**
- **DAMAGE**

COMPANY PHONE #(_ ___)_____

CALLER NAME_____

TYPE OF WORK_____

WORK BEING DONE FOR_____

COUNTY WORKING IN_____

CITY WORKING IN_____

IS THE ADDRESS INSIDE OR OUTSIDE OF THE CITY LIMITS?_____

MAIN ADDRESS (STREET #)_____STREET NAME_____

NEAREST INTERSECTING STREET TO THE MAIN ADDRESS_____

INDICATE THE NAMES OF AT LEAST TWO MORE INTERSECTING STREETS (UNLESS YOU ARE PROVIDING GRIDS)_____

(BE PREPARED TO GIVE SPECIFIC DIRECTIONS)

SUBDIVISION THAT THE MAIN ADDRESS IS IN (IF APPLICABLE)_____

INDICATE ANY SPECIFIC LOCATING INSTRUCTIONS_____

_____

FIELD CONTACT NAME_____PHONE#_(____)_____

WILL YOU BE DOING ANY HORIZONTAL BORING? (CIRCLE ALL THAT APPLY)

- ***ROAD***
- ***DRIVEWAY***
- ***SIDEWALK***
- ***OTHER_____***

WILL YOU BE BLASTING?_____

WILL YOU BE WORKING WITHIN TEN FEET OF ANY OVERHEAD POWER LINES?_____

IF YOU ANSWERED YES TO THE PREVIOUS QUESTION, COMPLETE A&B

A.) WHAT WILL BE THE BEGINNING DATE AND TIME THAT THE OVERHEAD PROTECTION WILL BE NEEDED?_____

B.) WHAT WILL BE THE DATE AND TIME THAT THE OVERHEAD PROTECTION WILL NO LONGER BE NEEDED?_____

HOW LONG WILL THE EXCAVATION PORTION TAKE?_____HOURS_____DAYS

ARE YOU PROVIDING GRID INFORMATION?_____LIST HERE_____

After giving the information on the front of the form, you will be given a list of the member utilities that will be notified for your requested work location. You will then be offered the opportunity for a courtesy call back from the members. The purpose of the call back is to let you know if no member facilities are involved in the requested location.

Now that all the requested information has been accurately provided, you shall be given a legal date and time to proceed with excavation. Write down the following information.

- **LIST OF MEMBERS**_____
- **LEGAL DATE AND TIME**_____
- **TICKET EXPIRATION DATE**_____
- **RESTAKE DATE**_____**BY 4:30 PM**

The operator will then verify the main address and provide a ticket number.

- **TICKET #**_____**TODAYS DATE**_____

THIS INFORMATION MUST BE KEPT ON SITE!

INSTRUCTIONS FOR PROPER CALL IN PROCEDURE

This format is provided for the excavator to document pertinent information **BEFORE** calling the Utilities Protection Center and **MUST** be made available on site throughout the entire process of excavation. It is imperative that you fill out all relevant fields accurately and completely. The entire process is negatively impacted as a result of inadequate information provided by **UNPREPARED** callers.
YOU MUST take the time to gather the correct information in order to have your request processed. Your call can be completed in as little as **THREE MINUTES** when you follow the procedures listed.
THE UTILITIES PROTECTION CENTER IS REQUIRED BY LAW TO ASK ALL OF THE QUESTIONS LISTED. Please be patient and answer all questions in the order they are asked. The operator taking your call is entering the information into a computer with preset fields and you will slow the process if you don't cooperate per the instructions.
It is **VERY IMPORTANT** that you provide accurate intersecting street information. Always try to give an intersecting street within a quarter mile of the main address. **YOU MUST** always provide additional intersecting streets in order to assist in proper gridding/mapping the work location. Please **REFRAIN** from using major highways or interstates as cross streets. Please take in **CONSIDERATION** that the operator taking your call must have exact information in order properly dispatch the ticket to the member utilities.
WHENEVER POSSIBLE, please try to narrow the scope of the request by simply indicating exactly where you will be digging. **WHITE-LINING** the proposed area of excavation with white (water-based) paint is the best method however, simply indicating **SPECIFIC LOCATING INSTRUCTIONS** on the locate request is recommended and appreciated. The time wasted marking unnecessary areas adversely impacts the entire industry.
Concerning **EMERGENCY LOCATES,** under Georgia Law, an **EMERGENCY** is defined as an immediate threat to life health or property. Please do not abuse this law. If your excavation meets the criteria for an emergency locate, please tell the operator the name of a field contact and their phone number and let the operator know if the crew is on site or in route. If your excavation does not meet the criteria for an emergency locate, and you need to dig sooner than the 72 working hour waiting period, ask the operator to dispatch the request as a **RUSH.** Although it is not guaranteed that the site will be located before the 72 working hour waiting period, the member utilities will try to accommodate your request when possible.

DATE:

SUBJECT: Utility Clearance Form- Chicago Project

County:

S.R., Section

MPMS No.

Federal Project No. (U):

(C):

TO:

FROM: BY:

The following is the utility clearance data (form D-419) for the above referenced project. This project is scheduled for a **[insert letting date]** letting.

This certifies that all written responses from all **underground** utilities within the project limits have been received, are on file in the District Office, and are available in the Utility Relocation - Electronic Document Management System (UR-EDMS) as of **[INSERT DATE].** Therefore, it is recommended that a certification of utility clearance be issued for this project.

Identify and contact all utilities having existing aerial and/or underground facilities located within the limits of work to arrange for marking of the field locations of these facilities before performing any excavation. Although no adjustments or relocations are anticipated for the aerial utilities, coordinate with them and all of the utilities within the project limits.

UTILITIES

Cooperate with the public utility companies and local authorities in the placement, replacement, relocation, adjustment, or reconstruction of their structures and facilities during construction. Contact all utility representatives at least fifteen (15) calendar days prior to starting operations.

COORDINATED: Phasing with specific construction operations. Number of calendar days required after completion of specific construction operations.

INCORPORATED: Utility relocation work to be incorporated into the prime highway construction contract.

NOT AFFECTED: Identifies UTILITY with facilities in the construction area not anticipated to be affected. Specific information may be provided by the UTILITY.

CONDITIONAL RESTRICTIONS AND TIME REQUIREMENTS:

Identify conditions affecting the utility's ability to perform a certain type of utility relocation work, i.e., certain times of the day, week, or year that a facility cannot be shut down, acquisition of right-of-way by the state, or demolition of buildings.

Water Authority
CONTACT:
INCORPORATED:

Borough
CONTACT:
INCORPORATED:

SOP-05: GEOPHYSICAL SURVEYING PROCEDURES

1.0 Purpose and Scope

This Standard Operating Procedure (SOP) provides technical guidance and methods that will be used for conducting surface geophysical investigations including electromagnetic (EM) surveys using the Geonics EM-31 or EM-34; EM surveys using the Geonics EM-61; magnetic surveys; and ground penetrating radar (GPR) techniques during site characterization field investigations. This SOP is intended to be used in conjunction with the other SOPs developed for the Project Site.

This SOP describes equipment, field procedures, and data reduction necessary to perform surface geophysical surveys. The locations and frequency of surface geophysical surveying will be specified in the Pre-work Workplan.

For purposes of this SOP:

- A "Station" is the predefined interval along a traverse where individual electromagnetic field measurements collected.
- A "Set of Traverses" are the lineal trends of station measurements conducted over a target investigation area. Traverses are set out by land survey methods to establish multiple parallel lines over the target investigation area. The distance between each parallel traverse is directly related to the station interval required for the investigation, the electromagnetic geophysical tools to be used, the size of the objects to be resolved and the depth of penetration of the electromagnetic methods employed.

2.0 Personnel Qualifications

A senior level geophysicist with knowledge and experience in the proposed geophysical surveying methods will oversee and/or perform the geophysical surveys.

3.0 Materials and Equipment

Various types of equipment and supporting materials will be needed for geophysical surveying. The geophysical survey instruments will be selected by the contractor depending on site conditions and project goals. Examples are:

- Geonics EM-31 or EM 34-3 terrain conductivity system or equivalent(depending on required depth of penetration and survey goals)
- Geonics EM-61
- Geometrics Model G858 Cesium Magnetometer (or equivalent)
- Geometrics Model G856 Magnetometer (or equivalent) for use as a magnetic base station
- Sensors and Software Pulse EKKO 100 or equivalent ground penetrating radar system
- Wood stakes or lath and pinflags (plastic pinflags if conducting magnetics or EM-61)
- Survey flagging
- Field logbook
- Waterproof and permanent marking pens

- Tape measure (200 feet minimum) (Note: for relatively smooth surfaces, a measuring wheel may be substituted)
- Extra paper and stylus for profile recorder when conducting GPR

4.0 Procedures

Surface geophysical techniques may be employed for several purposes. Subsurface features typically detected or revealed using an EM-31 or EM-34 include:

- Delineation of waste disposal areas
- Detection of buried metallic objects (including unspecified debris or buried drums)
- Delineation of variances in near surface soil densities due to previously excavated areas related to underground facilities removal (pipeline valve vaults, underground storage tanks, lift stations) or disposal activities, and or
- Resolution of the depth and orientation of some buried utilities. Subsurface features typically detected or revealed using an EM-61 include:
- Detection of buried metallic objects (including buried drums)
- Detection of irregularly-shaped metallic landfill debris or refuse
- Estimation of the lateral extent of subsurface materials that have metallic constituents, and or
- Ordnance detection.

Subsurface features typically detected or revealed using a magnetometer surveys include:

- Detection of burial metallic (ferrous) objects and debris (including drums and scrap metal)
- Delineate lateral extent of trenches or lineaments of buried utilities that have ferrous metal constituents
- Location of underground utilities such as pipes or tanks; and or
- Ordnance detection.

Subsurface features typically detected or revealed using ground penetrating radar surveys include:

- Delineation of disposal activities
- Detection of buried metallic objects (borehole clearing, landfill or trench mapping)
- Mapping of near surface stratigraphy, and or
- Delineation of previously excavated areas related to waste disposal activities.

4.1 Geonics EM-31 or EM-34

EM methods involving the use of the Geonics EM-31 or EM-34 or equivalent provide a rapid means of measuring the electrical conductivity of subsurface soil, rock, and groundwater.

These methods involve the induction of electrical current into the earth. A small alternating current is generated by a transmitter coil that transmits a primary, time-varying magnetic field into the ground. Through inductive coupling, the primary magnetic field produces small eddy currents in the subsurface, which in turn create their own secondary magnetic field. A receiver coil measures both the primary and secondary fields. The instrument measures variations in magnitude and phase of the individual currents voltage changes, which are related to the subsurface or terrain electrical conductivity. The conductivity values are recorded in a data logger, and subsequently downloaded to a computer and plotted on a map so that their variation over the site can be analyzed.

4.1.1 Preparation

A minimum amount of preparation will be made as a part of the geophysical surveys prior to any data collection. These may include a review and evaluation of all or part of the following:

- The purpose and expectations of the subsurface investigation will be defined.
- Existing relevant site, area, and regional soil characteristics, subsurface geologic and hydrogeologic information
- Site utility plans will be reviewed and utilities will be located in accordance and concurrent with SOP No. 17, Utility Clearance.
- Known hazards that pose a threat to the safety of field personnel will be defined.
- Appropriate field parameters will be defined, given the purpose of the survey (whether EM-31 or EM 34-3 is used, coil spacing, traverse spacing, station spacing, depth of penetration, etc.)
- The endpoints along each traverse will be surveyed and marked in the field with wooden lath or other wooden stakes.

Design of appropriate field or data acquisition parameters must consider the following:

- The coil spacing must be 1 to 1.25 times the required depth of penetration. If required depths are in excess of approximately 16 to 17 feet, an EM 34-3 must be used. If depths are less than approximately 16 to 17 feet, the EM-31 should be used. For some applications, such as bedrock investigations, the use of both instruments may be appropriate.
- Station spacing affects survey resolution. A station spacing of 5 to 25 feet is commonly used (spacing between parallel traverses). Actual spacing must consider instruments that will be used and take required resolution into account.
- Accurate definition of an EM profile anomaly requires several anomalous readings with adequate spacing along stations (data points along a traverse) that will overlap the feature by one-fourth to one-half its size in order to accurately resolve the anomaly.
- Background conductivity noise must be evaluated and/or determined to assess the potential usefulness of an EM survey. High noise levels can make interpretation difficult and can cause significant anomalies to be overlooked. Examples of EM noise include large ferromagnetic conductors such as railroad track or steel pipe, and above ground ferromagnetic conductors such as chain link fencing, steel monitoring well above ground completions, metal buildings, metal covered vaults, and reinforced concrete.

- Actual background electrical noise must be considered when collecting and interpreting the EM data. Background electrical noise can be from low voltage systems or from conventional AC electrical supply sources.

4.1.2 EM-31 or EM-34 Surveying Procedures

The field procedure for conducting an EM survey using the EM-31 or EM-34 is described below:

- A visual survey along the proposed traverses will be conducted. The visual survey will include notation of overhead wires, manhole covers, and indications of buried cables or gas lines.
- Excessive amounts or large pieces of metal on the ground surface will be noted in the field notebook.
- Large nearby variations in topography (within 50 feet) will be noted in the field notebook.
- The instrument battery will be checked for sufficient charge and the instrument tested using manufacturer's procedures for proper operation.
- The site survey traverse will be initiated with the EM instrument. When using the EM 34- 3, beginning with transmitter at the EM traverse endpoint, the receiver will be moved to the appropriate coil spacing, as indicated by the instrument meter. If the EM-31 is being used, coil spacing is fixed. (Note: The obtained reading is valid at the midpoint between the two coils).
- The obtained conductivity value will be recorded in a data logger or field notebook.

The above procedure will be continued for each station along each traverse. For two or more coil spacings or orientations at each station, multiple passes along each traverse will be required, ensuring that occupied stations are repeated through the entire traverse with each coil orientation.

Data will be downloaded from the data logger or field notebook to the computer for further analysis.

4.1.3 Data Processing and Interpretation

The standard procedure for processing and interpreting the EM data obtained using the EM-31 or EM-34 is described below.

- Conductivity values over the surveyed site for each coil spacing will be plotted.
- By comparing the results of all plots, the data will be contoured to determine what variations of conductivity exist laterally.

4.2 Geonics EM-61

The EM-61 is a time domain electromagnetic instrument that is specifically designed to discriminate between earth materials and highly conductive metallic targets that are buried within the earth. It is capable of detecting both ferrous and non-ferrous metallic objects. The instrument generates rapid electromagnetic pulses through a transmitter coil. These pulses induce secondary electromagnetic fields in the near subsurface materials. The secondary electromagnetic fields induced from moderately conductive subsurface materials (soil and rock) are of relatively short duration. However, the secondary electromagnetic fields induced from metallic objects such as a drum are of relatively long duration. The EM-61 measures this prolonged response from metallic objects after the electromagnetic response from conductive earth materials dissipates, allowing the resolution of buried metallic targets.

Depth of investigation of the instrument is relatively unaffected by site specific subsurface conditions and is reportedly capable of detecting a single 55 gallon drum to a depth of 10 feet. Using a data logger, the instrument records the electromagnetic responses in units of millivolts. The electromagnetic response values are then plotted on a map so that their variation over the site can be analyzed.

4.2.1 Preparation

Steps cited in Section 4.1.2 for the EM-31 or EM-34 will be performed prior to initiation of any data collection. Design of appropriate field or data acquisition parameters must consider the following:

- Station spacing affects survey resolution. A station spacing of 0.5 to 5 feet is commonly used. Actual spacing must take required resolution into account.
- Accurate definition of an electromagnetic profile anomaly requires three or more anomalous readings.
- Background electromagnetic response noise must be evaluated and/or determined to assess the potential usefulness of an electromagnetic survey. High electrical noise levels can make interpretation difficult and can cause significant anomalies to be overlooked. Actual background electrical noise must be considered when collecting and interpreting the electromagnetic data.

4.2.2 EM-61 Surveying Procedures

The standard field procedure for conducting an electromagnetic survey using the Geonics EM-61 is described below:

- Steps cited within Section 4.1.2 will be performed.
- If the survey is to be conducted using the measuring integrated trailer or wheel trigger mode, the instrument will be calibrated by conducting a test line of set length. Several passes will be conducted along the test line to calibrate the wheel trigger distance to the site-specific ground conditions. No other calibration of the EM-61 is required.
- The instrument battery will be checked for sufficient change and instrument tested using manufacturer's procedures for proper operation.
- The site survey traverse will be initiated with the EM-61 instrument.
- The obtained electromagnetic response values will be recorded in a data logger.
- The above procedure will be continued for each station along the traverse line.
- Data will be downloaded from the data logger to the computer for further analysis.

4.2.3 Data Processing and Interpretation

The standard procedure for processing and interpreting the electromagnetic data obtained using the EM-61 is described below.

- If data were collected using the wheel mode trigger, the data stationing will be corrected using the actual start and end station values.
- Electromagnetic response values over the surveyed site will be plotted.

By comparing the results of all plots, the data will be contoured to determine the lateral and vertical variations of the electromagnetic response over the site. Subsurface anomalies, such as lineaments, variations in soil densities, or buried objects, can be revealed during the data analyses and comparison.

4.3 Magnetic Survey

A magnetic survey involves the measurement of the earth's magnetic field at various points on the ground surface and delineation of the local variation of the magnetic field. Variations in magnetic susceptibility of subsurface materials will produce anomalies within the magnetic field that can be measured using a magnetometer. Both the total magnetic field data and the magnetic vertical gradient data can be measured with the magnetometer. The total field intensity is simply the magnitude of the earth's magnetic field vector and the magnetic vertical gradient is the difference in the total field measured at different heights above the ground surface. The magnetic total field and vertical gradient values can be plotted on a map so that their variation over the site can be analyzed. Note that non-ferrous metals, such as aluminum or brass will not create a response that the magnetometer can measure and must therefore be detected by other methods.

4.3.1 Preparation

Steps 1 through 6 in Section 4.1.1 will be performed prior to initiation of any data collection. Design of appropriate field or data acquisition parameters must consider the following:

- Station spacing affects survey resolution. A station spacing of 5 to 25 feet is commonly used. Actual spacing must take required resolution into account.
- A magnetic anomaly is defined by three or more contiguous anomalous readings.
- Background magnetic noise must be evaluated and/or determined to assess the potential usefulness of a magnetic survey. High noise levels can make interpretation difficult and can cause significant anomalies of interest to be overlooked. Actual background noise must be considered when collecting and interpreting the magnetic survey data.
- High resolution magnetic surveys require the use of an extra magnetometer as a magnetic base station to allow removal of drift and diurnal variations. On occasion, this requirement may be reassessed depending on survey objectives. If an additional magnetic survey base station instrument is not used, repeated ties to a field base station must occur approximately every one-half hour to allow for drift corrections.
- Survey and traverse endpoints used in the field should be with a wooden stake or plastic pinflag. Stations should be identified with a designation based on a coordinate system that is consistent with the location where the work is conducted and the requirements of the interpretive software to be used in data processing.

4.3.2 Magnetometer Surveying Procedures

A standard field procedure for conducting a magnetometer survey is described below:

- A visual survey along the proposed traverses will be conducted. The visual survey will include a review of site utility plans; notation of overhead wires, notation of manhole covers, buried cables, or indications of other buried lines. Utility locator services will identify telephone and utility features, if present.
- Excessive amounts or large pieces of metal on the ground surface will be noted in the field notebook.
- Large nearby variations in topography (within 50 feet) will be noted in the notebook.
- The instrument battery will be checked for sufficient charge and the instrument tested using manufacturer's procedures for proper operation.
- Prior to commencing of data collection activities, the operator will remove ferromagnetic objects from his/her body and clothing including but not limited to jewelry, steel toe boots, belt buckles, keys, coins and watches. These objects can cause interference resulting in erroneous data. The base station magentometer

will be placed in an area away from interference from ferromagnetic objects, including but not limited to buried waste, fences, automobiles and buildings. Base station readings can be obtained using a continuously recording base station magnetometer or by reoccupying a field base station using the mobile magnetometer. Regardless of the method used, base station data will be collected a minimum of once every 30 minutes.

- The base station magnetometer and the mobile magnetometer will be time synchronized and will be tuned to the value appropriate for the latitude and longitude of the area. Tuning of the instruments will be done in accordance with the manufacturer's procedures as described in the operation manual.

- The site survey traverse will be initiated using the mobile magnetometer. Depending on the exact make and model of the magnetometer, the sensor may have to be aligned with magnetic north.

- The obtained magnetic response values will be recorded in the magnetometer memory, in a data logger, or field notebook. If the instrument indicates a high noise level, a visual scan of the area will be made to try to identify the source of the noise. Then the reading should be repeated and an appropriate note made in the field book.

- The above procedures will be continued for each station along each traverse.

Upon completion of each day of data collection, the data will be downloaded from the magnetometer(s) or from the field notebook to a computer for further analysis.

4.3.3 Data Processing and Interpretation

The standard procedure for processing and interpreting magnetometer survey data is described below:

- Magnetometer survey response values must be corrected for magnetic drift according to standard geophysical practices. If a mobile magnetometer was used in conjunction with a base station magnetometer, correction of diurnal effects can be accomplished using the data reduction software provided with the instruments. If a single magnetometer was used, the total field data will be corrected using the reoccupied base station data.

- Plot the corrected values at each station location, producing a series of profiles or a grid, and contour the data to determine variations of the magnetic field.

- Using available information (borehole, geophysical, site conditions), interpret the magnetic anomalies with respect to possible sources.

4.4 Ground Penetrating Radar

Ground penetrating radar (GPR) involves a system that transmits electromagnetic pulses into the ground from an antenna near the surface. These pulses are reflected from a variety of subsurface interfaces back to the receiver. As the antenna is towed along a survey line, the GPR signals are processed and displayed on a graphic recorder. Data are displayed as two-dimensional continuous profiles along the surveyed line, depicting time versus distance. The display is similar to a geologic section, except that the record is a time section rather than a depth section. GPR can achieve excellent resolution of subsurface features when favorable conditions exist.

However, actual depth penetration is highly site-specific and depends on the near-surface soil conductivity. Highly conductive soils, such as clays, can reduce penetration to less than three feet. Less conductive soils, such as clean, well-sorted sandstone, will allow depth penetration of 30 feet.

4.4.1 Preparation

Two preliminary procedures must be conducted prior to GPR data collection. These procedures are:

- Design the appropriate field parameters, given the purpose of the survey (e.g., orientation of traverses or a grid, grid spacing, spot surveys, frequency of antenna, necessity of antenna shielding, etc.)
- Survey the traverse end points and mark these locations in the field with lath or wooden stakes. Transfer the traverse locations to the correct position on the base map.

Design of appropriate field or data acquisition parameters must consider the following:

- The antenna and associated transmitter frequency used must optimize the penetration depth and required resolution given the survey purpose. Typical antenna frequencies range from 50 Mhz up to 1000 Mhz. Higher frequency antennas allow greater subsurface resolution, but penetration is reduced compared to that allowed by lower frequency antennas. A minimum of two antennas should be mobilized and available for testing for a given GPR application.

- For surveys utilizing grids, the spacing of the traverse affects the survey resolution. A traverse spacing of 3 to 50 feet is commonly used. Actual spacing must take required resolution into account.

- The method of antenna towing must be evaluated given the site conditions. For smooth surfaces or terrain, the antenna can be towed directly on the surface. For areas with a significant cover of vegetation or with stones and rocks at the surface, the antenna may need to be suspended 6 to 18 inches above the ground or carried in a plastic, non- conductive wagon to prevent antenna damage and reduce or eliminate potentially dubious GPR data collection.

- Antenna shielding should be considered and designed to handle the field conditions. Surface features such as fences, powerlines, and trees can appear as prominent reflections on the GPR record.

4.4.2 Ground Penetrating Radar Surveying Procedures

A standard procedure for conducting a GPR survey is described below:

- A visual survey along the proposed traverses will be conducted. The visual survey will include notation of overhead wires, manhole covers, monitoring wells, and indications of buried cables or gas lines.
- Excessive amounts or large pieces of metal on the ground surface will be noted in the field notebook. Nearby buildings (within 50 feet) or significant variations in topography will be noted in the field notebook.
- The moisture content of the soil, alluvium, or investigated media, as well as relative clay content, may significantly affect the penetration depths, and should be noted.
- Conduct a test line using the instrument manufacturer's procedures. Instrument settings must be optimized to obtain appropriate data give project goals. Specific recording parameters that must be optimized include, but are not limited to, the following:

    - Radar scan speed
    - Signal range gain
    - High low pass filter settings
    - Transmitter pulse rate
    - Time range for recording
    - Recording printer speed
    - Antenna towing speed

Instrument settings should be varied during the surveying of the test area to determine the optimum recording settings. When evaluating GPR responses in a test area, the test should be conducted over a known buried feature in the survey area to help instrument setting optimization and to calibrate penetration depths. The GPR should be tested daily over the same features in the test area to use as a daily calibration and performance evaluation test.

- Initiate a site survey traverse. Beginning at the GPR line endpoint, tow the antenna along the appropriate line at a rate, and using the optimum instrument settings, determined from the test line.
- If hard copies of data from each traverse are printed or available, label all notations on the record to correspond to the notes made in the field book, including recording parameters.

Permanent copies of GPR data must be retained digitally on tape or disk, or on hard copy plots.

4.4.3 Data Processing and Interpretation

Data reduction of GPR data is limited. Most GPR data processing occurs in real-time (during data collection) through manipulation of the instrument settings. Interpretation requires the interpreter to consider all potential sources of a GPR anomaly, including interfering reflections from both surface and subsurface cultural features. For most GPR systems, additional processing techniques can be implemented if desired to reduce or eliminate noise effects from the data and enhance the results. Using site data, available borehole information (should it exist), or any other existing geophysical data, develop a subsurface model that is consistent with the available data.

5.0 Records

Oversight personnel will be responsible for documenting geophysical surveying. The documentation will be recorded at a minimum in the Field Notebook as discussed in *the SOP for Field Documentation* and on relevant data recording sheets accompanying the geophysical monitoring equipment. The information entered in the *Field Log* concerning geophysical surveying should include the following:

- Project/site location identification for geophysical survey
- Date and time (start and end, military time)
- Contract Task Order number
- Geophysical survey personnel (oversights name, operators name, company names)
- Geophysical survey equipment used (make and model)
- Equipment identification numbers
- Instrument specific data (instrument gain and time settings, instrument reading scale)
- General geophysical surveying methods and observations
- Weather and temperature
- Any deviations from the geophysical surveying methods outlined in SOP-XX

Dataloggers, hand-held GPS, or integrated personal digital assistants (PDAs) may also be utilized for additional field recording.

SOP-06: GEOGRAPHIC LAND SURVEYING

1.0 Purpose

This standard operation procedure (SOP) identifies requirements for land surveying by a certified or licensed land surveyor.

Establishing standardized protocols for collecting spatial data in the field using land surveying technology is imperative to the success of any project. The guidelines in this section have been developed to verify consistent spatial data collection and post-processing techniques across projects, staff, and geographic locations. These procedures are to be used as a reference tool in conjunction with specific land surveying and job procedure training.

Surveying involves the science and techniques for accurately determining the terrestrial or three-dimensional space position of points and the distances and angles between them. These points are usually used to establish the locations of monitoring devices (including wells, soil borings), site boundaries and topography for land maps. The following are tasks that may require surveying:

- Horizontal positions of Source Area extent boundaries (unsaturated soil excavation)
- Horizontal positions of estimated extent of Source Area in-Situ treatment boundaries
- Vertical elevation and horizontal positions of fill utilized at the Site

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in land surveying activities at the Project Site and associated site tasks. This SOP focuses on the most commonly used land surveying tasks and applications anticipated for the project SOW and should be used in conjunction with other applicable project SOPs, including the following:

- *SOP- Field Documentation*
- *SOP- Hollow Stem Auger and Direct Push Drilling Methods*
- *SOP- Discrete Surface and Subsurface Soil Sampling*
- *SOP- Monitoring Well/Piezometer Installation*
- *SOP- In-Situ Soil Stabilization*
- *SOP- Geophysical Survey*
- *SOP- Groundwater Level Measurement*
- *SOP- Continuous Water Level Monitoring*
- *SOP- Groundwater Sample Procedures*

3.6 Land Surveyor

All work should be conducted using equipment, personnel, and procedures that will verify compliance with the accuracy standards as defined below. It is the responsibility of the supervising Land Surveyor to verify that all work under this agreement complies with all state and local regulations. The Land Surveyor will be adequately trained in the use and data recovery of the land survey tools used. The Land Surveyor will document all land surveying activities in a Field Notebook according to *SOP for Field Documentation*. All documents submitted should bear the surveyor's seal, signature, and a certificate that all work was done under the surveyor's supervision and that all information contained in the document is true and is accurately shown.

4.0 Procedures

4.1 General Surveying

A licensed land surveyor will measured all surveying locations as the distance in feet and meters from a reference location that is tied to the WGS84/DAT84 coordinate system. The subcontractor will be responsible for identification of existing

benchmarks and establishing temporary control points. The subcontractor will perform elevation (vertical) and positional (horizontal) surveying according to the following guidelines:

- All survey equipment should be of the proper type and should be in good operating condition to verify that the work can proceed without interruption.
- Survey instruments should be inspected and calibrated by an authorized manufacturer's representative in accordance with the manufacturer's specifications regarding procedures and frequencies.
- At a minimum, instruments should have been calibrated no more than 6 months before the start of the survey work.
- An X, Y coordinate system will be used to identify locations.
- The latitude coordinate will be the east-west axis; the longitude coordinate will be the north-south axis.
- Coordinates of all points X, Y, and Z will be measured to the nearest 0.01 of a foot.
- The units of measure should be U.S. Survey Feet.
- Survey data should be provided in the Indiana State Plane coordinate system.
- Horizontal Positional (X,Y) data should be referenced to the North American Datum of 1983 (NAD 83, Latest Adjustment). Required precision is 0.01 foot (0.003048 meters).
- Vertical elevation data (Z) should be referenced to the North American Vertical Datum of 1988 (NAVD88 in mean sea level (msl) datum. Required precision is 0.01-foot (0.003048 meters).
- Vertical control networks should be verified between at least two published benchmarks.
- All level and horizontal traverse networks should be closed to the starting point.
- The horizontal accuracy of the control should be Second Order Class II, and the Vertical Accuracy should be Second Order, Class II, as outlined in the *FGDC Geospatial Positioning Accuracy Standards, Part 4: Standards for Architecture, Engineering, Constructions (A/E/C) and Facility Management* (Attachment 1).

The following information should also be provided:

- Survey method
- Survey date
- Data source (organization reporting the data)
- Comments on any notable issues (benchmarks used, etc.).

4.2 Surveying Monitoring Wells and Other Environmental Monitoring Points

At each groundwater monitoring well location, measure the ground elevation, the measuring point elevation, and top of casing. The measuring point elevation of all newly installed wells is the most critical measurement; survey the measuring point elevation at the water-level measuring point (notch) on the riser pipe. If the measuring point is not clearly marked, the surveyor should mark a location on the north side of the riser pipe and survey that location. The vertical accuracy of well

measuring point elevations should be 0.01 foot. The surveyors will report X, Y, and Z coordinates for the measuring point, ground surface, and top of casing at all monitoring wells. Surveying of subsurface soil and groundwater boring locations only requires X and Y data, unless otherwise noted.

4.3 Mobilization, Demobilization, Equipment Supply, and Storage

Before beginning surveying activities, the surveyor should coordinate with the IEC FM or PM, after which a IEC representative (for example, the FM or FTL) and the surveying subcontractor may elect to visit all or some of the locations to be surveyed. The land surveyors will then be allowed to complete the survey without further direct supervision from IEC. The surveying subcontractor should provide all the necessary labor and equipment to complete the survey.

Throughout the period of surveying, keep the worksite free and clear of all rubbish and debris; implement protective barriers and other safety protection necessary to protect the public and workers, as necessary. Conduct all surveying activities in a manner that protects all existing site fences, walls, buildings, trees, and landscape throughout the process of work. In the event of damage to such property, the surveyor(s) should notify IEC FM or PM immediately. After completion of the work, remove all materials, tools, and debris from the premises and work areas.

5.0 Records

- The subcontractor will be required to provide Licensed Land Surveyor certification documentation in the State of Indiana.
- Document all land surveying activities in a Field Notebook according to *SOP for Note Taking and Field Logbook*. Include the date, names of the crew, weather conditions, and all collected survey data information in the field notes. In addition, download survey data files daily and manage them according *to SOP for GPS*
- Store Global Positioning System (GPS) data files at a digital location specifically reserved for that data document type and verify that it is named appropriately to easily identify the content and date of collection or download. Submit all electronic files in Microsoft™ Excel or ASCII format listing all X, Y, and Z coordinates, and the coordinate system used for all data points, to IEC within the timeframe identified in the scope of work prepared for the surveyor purchase requisition.

6.0 References

Federal Geographic Data Committee (FGDC). 2002. *Geospatial Positioning Accuracy Standards PART 4: Standards for Architecture, Engineering, Construction (A/E/C) and Facility Management*. Document Number: FGDC-STD-007.4-2002.

Nielsen, D.M. 1991. Practical Handbook of Ground-Water Monitoring. Lewis Publishers. Pages 343-346.

Urquhart, L.C. 1962. Civil Engineering Handbook, 4th Edition. Pp. 96-97.

7.0 Definitions

Accuracy - An indication of how closely a measurement is to the true value.

Universal Transverse Mercator (UTM) – UTM is a coordinate system that uses a grid-based method of specifying locations on the surface of the Earth that is a practical application of a 2-dimensional Cartesian coordinate system. It is used to identify locations on the earth, but differs from the traditional method of latitude and longitude in several respects. The UTM system is not a single map projection. The system instead employs a series of sixty zones, each of which is based on a specifically defined secant transverse Mercator projection.

World Geodetic System (WGS) - is a standard for use in cartography, geodesy, and navigation. It comprises a standard coordinate frame for the Earth, a standard spheroidal reference surface (the datum or reference ellipsoid) for raw altitude data, and a gravitational equipotential surface (the geoid) that defines the nominal sea level. The latest revision is WGS 84 (dating from 1984 and last revised in 2004), which will be valid up to about 2010. Earlier schemes included WGS 72, WGS 66, and WGS 60. WGS 84 is the reference coordinate system used by the Global Positioning System.

8.0 Attachments

Attachment 1 *FGDC Geospatial Positioning Accuracy Standards*

Geographic Positioning Accuracy Standards

Log of Comments

Log number	Comment	Substantive	Resolution	Status
1	The standard requires tested data products to be labeled, "Tested ___meters horizontal at 95% confidence level."My question: Can any accuracy number be input, such as 2.31 meters? Or must this number be rounded up to some level such as 2.4, 3 or 5? Or can it be rounded off, say to 2.3 or 2 meters? Note that a 1:2400 product satisfying NMAS requirements meets a 2.03 meter CE 90% or a 2.31 meter CE 95% requirement, so the example is relevant to present-day products. For this example, rounding up to 5 meters, as is done for NSRS control points, would greatly understate the accuracy of the product. I believe 2.3 or 3 meters are reasonable answers, but would like to know the NSSDA position on this issue.	Y	Insert in Section 3.2.3, “The number of significant digits in the accuracy value shall be equal to the number of significant digits in the data set point coordinates.”	COMPLETE
2-1	The relationship between the parts is not clear. A diagram showing the relationship of the parts might help.	Y	The diagram will be developed in parallel as the Geospatial Positioning Accuracy Standard goes forward for final draft. Words to explain the relationship among the parts will be added to Section 1.1.2, Scope	COMPLETE
2-2	Standards should stand on their own. FGDC might want to have a separate glossary document, but not as part of the standard.	Y	A glossary will be added as an informative appendix to Part 1, Geospatial Positioning Accuracy Standards.	COMPLETE
2-3	Page 1-1 bottom of 1st paragraph--The phrase ‘represent the *best* estimate of the *true* value’ is confusing - suggest it be replaced by ‘are suitable.’	Y	Delete quotation marks from sentence. Replace “numerical” by “coordinate.” The sentence will now read: It is increasingly important for users to not only know the coordinate values, but also the accuracy of those coordinate values, so users can decide which *coordinate* values represent the best estimate of the true value for their applications.	COMPLETE
2-4	On page 1-1 and repeated on page 2-1 *Geodetic control surveys are usually performed to establish a basic control network (framework) from...* This might better be said as *Geodetic control surveys are performed to establish accurate spatial referencing, a framework from...*	Y	Leave as is.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
2-5	On page 1-5 reference to the obsolete vertical datum NGVD 29 should not be encouraged, thus the mention of NGVD 29 as the National coordinate system for vertical coordinates is inappropriate. It is preferable to use NAVD 88.	Y	Many legacy maps and data sets are based on older National datums, such as NAD 27 and NGVD 29. The final draft is rewritten to clarify this point: "Coordinate values should be based on National datums. Horizontal coordinate values should preferably be referenced to the North American Datum of 1983 (NAD 83). Vertical coordinate values should preferably be referenced to North American Vertical Datum of 1988 (NAVD 88). However, it is recognized that many legacy maps and geospatial data are referenced to older national datums, such as the North American Datum of 1927 (NAD 27) and the National Geodetic Vertical Datum of 1929 (NGVD 29)."	COMPLETE
2-6	Part 2: The Title *Standards for Geodetic Networks* should be expanded to include Spatial Referencing. New title could be *National Standards for Geodetic Networks and Spatial Referencing.*	Y	Leave title as is.	COMPLETE
2-7	On page 2-1, section 2.1; Are the requirements established by the NGS adopted or approved by the FGCS? If so, this should also be stated.	Y	Change from "National Geodetic Survey (NGS)" to "Federal Geodetic Control Subcommittee (FGCS)."	COMPLETE
2-8	On Standards Development Procedures, page 2-2, section 2.4; How do we get new standards or make changes?	Y	The reviewer is referred to the FGDC Standards Reference Model	COMPLETE
2-9	Twice in section 2.5 Accuracy Standards, the phrase *horizontal, ellipsoid height and orthometric height* is used, also on page 2-5. Why not use *horizontal and vertical?*	Y	To educate users, it is necessary to make the distinction between GPS-derived (ellipsoidal) heights and traditionally derived (orthometric) heights.	COMPLETE
2-10	In section 2.5 Accuracy Standards: What is the relationship of the new accuracy standard to the old accuracy standard? Some comparisons and contrasts would be useful (could be an appendix) .	Y	This topic will be addressed in new field specifications being developed by the FGCS.	COMPLETE
2-11	Section 2.5 Accuracy Standards: Where are the level of accuracy recommendations for application such as GPS, leveling, and gravity surveys? (Note this is recommended in part 1 section 1.6.)	Y	This topic will be addressed in new field specifications being developed by the FGCS.	COMPLETE
2-12	Page 2-5, last paragraph: Should the local accuracy along measured lines be part of this standard? Perhaps it should be an appendix. It does not seem to fit.	Y	The paragraph on local accuracy along measured lines has been deleted.	COMPLETE
2-13	What statement should accompany geodetic control data to reflect the accuracy standard?	Y	Section 2.3.2 has been added to provide guidelines on accuracy reporting for geodetic data.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
2-14	In section 3.2.1--It seems that the reported accuracy is not the cumulative result of all uncertainty, but rather the result of a test.	Y	Change phrase to “The reported accuracy value *reflects* all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values for the product.” While the reported accuracy is the result of a test, that result reflects uncertainties introduced by the process.	COMPLETE
2-15	In section 3.2.3 -- The first paragraph seems to conflict with the last paragraph.	N	Delete “the amount of testing” to resolve the conflict.	COMPLETE
2-16	In several sections the accuracy of the check source is stated as within one-third the accuracy of the data set, this seem confusing. Perhaps saying the check data should be three times more accurate would be clearer or instead give a specific numeric example.	N	Reference to a *specific* level of accuracy of the independent check source has been deleted; instead, the final draft will say that the independent check source of higher accuracy must have the highest accuracy feasible and practicable to evaluate the accuracy of the data set.	COMPLETE
2-17	In 3.2.4 first sentence: What are ground units? This not clear at all.	Y	Change “in ground units” to “in ground distances.”	COMPLETE
2-18	The appendices that explain the other accuracy standards are a good addition to part 3.	N	NONE	COMPLETE
3-1	I believe that some formulas in Appendix A, "Explanatory Comments" are incorrect. . . The mean discrepancy is Sum[d(i)] / n, not d(i) / n as stated	N	NONE - the omission of the summation symbol probably was an error in transmission.	COMPLETE
3-2	The referenced formulas calculate the standard deviation of the point errors about the average point error. Thus if the project had a large datum shift but small deviations about that datum shift, it would be evaluated as having small circular errors.	Y	Formulas have been changed to RMSE to account for bias and precision.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
3-3	The referenced formulas calculate deviations in radial distance, r(i), from some unstated origin of the (x,y) coordinate system. Here is a pathological example showing the weakness of this calculation: An (x,y) origin is established and a GPS reference station is placed at the origin with x defined to be north and y defined to be east. The entire survey is North and East of the base station by a kilometer or two. Using differential GPS techniques, the survey is carried out to centimeter accuracy. A catastrophic blunder in the data processing reverses a sign in the (x,y) data. So all of the data points are at very precise radial distances from the coordinate system origin so the accuracy check calculates small errors. This despite the fact that all points are several kilometers in the wrong direction from the base station!	Y	This statement has been included in the final draft: "Errors in recording or processing data, such as reversing signs or inconsistencies between the data set and independent source of higher accuracy in coordinate system definition must be corrected before computing the accuracy value."	COMPLETE
3-4	The vertical accuracy calculation has a similar problem for vertical data errors. If the entire project is done to an incorrect vertical datum, the standard deviation about the average error might be small and yet the average vertical error might be large.	Y	See resolution to comment 3-3	COMPLETE
3-5	The horizontal RMSE calculation does not appear to have the radial problem, but it does have the datum shift problem. Deviations should be differences from the true value, not about the average error.	N	RMSE calculations are not computed about an average error.	COMPLETE
3-6	The vertical RMSE calculation has a similar datum shift problem.	N	See resolution to comment 3-3.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
3-7	Alternative proposal: Let: N = number of check points i = index of check points, i = 1, ... N Xmi = x-coordinate of check point i, as measured in data being transferred Xci = x-coordinate of check point i from more accurate, check, method such as differential GPS Ymi = y-coordinate of check point i as measured in data being transferred Yci = y-coordinate of check point i from more accurate, check, method such as differential GPS The root-means square error and circular error at 95% probability can now be calculated as RMSE = Sqrt[Sum[((Xmi - Xci)^2 + (Ymi - Yci)^2) / (2 N)]] CE95 = 2.447 * RMSE.	Y	The equation for RMSE given here is mostly correct, except that the denominator should be N, not 2*N. The RMSE formula has been adopted for estimating accuracy.	COMPLETE
3-8	Similarly for vertical calculations: Zmi = x-coordinate of check point i as measured in data being transferred Zci = x-coordinate of check point i from more accurate, check, method such as differential GPS The root-means square error and linear error at 95% probability can now be calculated as RMSE = Sqrt[Sum[((Zmi - Zci)^2) / N]] LE95 = 1.960 * RMSE	Y	This equation has been adopted for estimating vertical accuracy.	COMPLETE
3-9	The proposed formulas (comments 3-7, 3-8) include errors both in absolute datum position and relative positioning of points about that datum when evaluating error statistics. I believe these are more realistic measures of absolute accuracy.	Y	See resolution for comments 3-7 and 3-8.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
4-1	In the 1995 version, errors were defined in terms of "root mean square errors" (rmse) which imply no characteristics of dispersion. However, in the referenced draft, the error definitions have been changed to 95% confidence level values taken about the sample mean. Biases that may exist between the sample point position and the check value for the same point are eliminated (see Appendix 3 A 1.: the mean discrepancy [d] is removed from each observation). I do not believe that this is what is intended since in most cases the simple bias may be quite large.	Y	The RMSE formula has been adopted for estimating accuracy.	COMPLETE
4-2	. . .the distribution characteristics of the deviations are usually not known; as a consequence, statements that depend on knowledge of distribution such as "95% confidence level" must be questioned.	Y	It is assumed that systematic effects have been eliminated as much as possible; therefore, only random error remains and accuracy computations are based on normally distributed error. These assumptions have been made explicit in the final draft.	COMPLETE
5	There appear to be multiple errors in the equations on page 3-9, item 1, of the Draft Geospatial Positioning Accuracy Standards document, dated December 1996. I believe correct statistics for Horizontal Accuracy requires that the radius r be computed after the other listed computations are first performed separately for x and y.	Y	Agreed. Changes made accordingly.	COMPLETE
6-1	Section 3.2.3, Page 3-3: Accuracy Test Paragraph 2--Select the check source so that its accuracy is within one-third the accuracy of the data set at the 95% confidence level. 1. This wording is also used on page 3-4. It implies that you already know the 95% level. However, that value is still unknown, which is why you are testing it. 2. Better wording is found on page 3-10 under Check Survey Design. To be consistent, the wording on pages 3-3 and 3-4 should read, "within one-third the intended accuracy for the data set at the 95% confidence level."	Y	See resolution to Comment 2-16. Please note that while the estimated accuracy value has not been computed (and is “unknown”), there is a conformance level in the product specification for the data set that the data producer intends-or expects - to achieve. Terms such as “intended accuracy” or “expected accuracy” will be omitted to minimize confusion.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-2	Section 3.2.3, Page 3-3: Accuracy Test Paragraph 3--The horizontal position of the ground point of elevations may be shifted in any direction by an amount no more than twice its expected accuracy at 95% confidence level. 1. What statistic are you using for “expected accuracy”? 2. Two times the 95% confidence level is much more lax than the current NMAS where permissible horizontal movement is essentially only the 90% limit. In previous ASPRS documents on interim standards, the 2X rule was based on a limiting RMS, not a 95% statistic. To provide consistency with previous standards, and with expected horizontal accuracy of the product, the permissible horizontal shift applied to vertical should not exceed the 95% confidence level. Permissible movement should be kept to a maximum of the 95% confidence level.	Y	1. See resolution to comment 6-1 2. Reference to shifting horizontal position has been deleted on recommendation from comment 16.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-3	Section 3.2.3, Page 3-3: Accuracy Test Paragraph 4--Errors two times or more than that allowed for the intended accuracy at the 95% confidence level are blunders and must be corrected. 1. Is “intended accuracy” the same as “expected accuracy” in paragraph 3 and is that the same as the maximum allowable error in accuracy? 2. The criteria for shifting test points in paragraph 3 and that for correcting test points considered to be blunders in paragraph 4 seem to be in contradiction, because the two sets of criteria overlap. 3. Elaboration is needed here. This is an accuracy test. Individual errors may well exceed twice the 95% level and thus be reflected in the statistic. Is the intent to find and reject bad check points or to correct the product?. The introduction to the standard already states that the "user" must set his or her own pass/fail standards. What if you know that the check points are good and photoidentification is good? The way this paragraph is worded sounds like a holdover from mapping where we can go back to the compilation/collection phase and fix a problem. It is only within production standards based on accuracy testing where blunders should be identified and corrected. However, this is an accuracy standard which indicates how good or bad the data are in reality.	Y	1. See resolution to comment 6-1 2. Please note that the criterion for shifting the position of well-defined points has been deleted (see resolution to comment 16), so that conflict has been eliminated. 3. The accuracy standard “indicates how good or bad these data are in reality.” See resolution to Comment 3-3 to indicate which errors should be corrected. Concerning the comment that “the ‘user’ must set his or her own pass/fail standards,” the NSSDA states that “Agencies are encouraged to establish thresholds for their product specifications and applications and for contracting purposes.”	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-4	Paragraph 5--Test a minimum of 20 check points, distributed to reflect the geographic extent and the distribution of error in the data set. It is not uncommon to find a data set with fewer than 20 independent, well-defined check points. The standard makes no provision for reporting the accuracy of such data sets. In fact, the standard fails to indicate whether or not these data sets should even be labeled. It is recommended here that all data sets be labeled in some way (the label need not be a "statistical" label). Consider the following cases: A. If a data set, regardless of the number of check points, is the product of a process that is being statistically controlled, then the data set can be labeled with the same statistical accuracy as all other data sets produced by the process. In this case, a data set with fewer than 20 check points can thus be labeled with a statistical accuracy statement. B. Similarly, if a data set is "accepted" as part of a batch, then the data set (as recommended in an earlier remark) could be labeled with a common batch statistical accuracy statement. (See comments on Section 3.2.4 below.) C. If, however, a data set with less than 20 valid check points needs to be tested individually (like a one-off data set, or a contractor-delivered data set that is not part of a batch), then there are at least two ways of reporting the data set accuracy. One way would be to label the data set with a non-statistical, qualified accuracy statement. For example, the following general statement could be issued (note the use of the word "typically"): Because this product contains, or is the derivative of a product that contains, an insufficient number of independent, well-defined check points, no statistical accuracy statement is provided. However, the process used to produce this product typically has an accuracy of .... In this way, the user is at least provided with an empirically based, "good faith" (albeit non-statistical) representation of quality.	Y	The “compiled to meet” statement is used to handle cases A, B, and C. To clarify this point, the guidelines for showing this note have been changed from “*produced to established procedures*” to “*produced according to procedures that have been demonstrated to produce data with particular…accuracy values.”* Appropriate wording has been added to the final draft about evaluating accuracy when fewer than 20 well-defined points can be identified for testing.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-5	A second way of reporting the accuracy of a data set with fewer than 20 check points would be to issue a statistical accuracy statement. In this situation, it is usually inappropriate to base the accuracy on percentage points from a normal distribution. Instead, some type of sampling distribution (such as a Student's t, a Chi-Square, or a Snedecor's F) that is more sensitive to small sample sizes should be used. This is particularly the case when parameters of the normal distribution (mean and standard deviation) are unknown and must be estimated from sampled data (sample average and sample standard deviation). For data sets with less (sic) than 20 check points, the development of a standard based on a sampling distribution should be investigated, particularly when reporting vertical accuracy, where the number of qualified vertical check points is typically limited.	Y	See response to Comment 6-4.	COMPLETE
6-6	Section 3.2.4, Page 3-4: Accuracy Reporting (See also comments on Section 3.2.3, paragraph 5 above regarding the accuracy reporting of data sets with fewer than 20 valid check points.) Provision is made for reporting horizontal and/or vertical accuracy for a data set that is (1) individually tested (i.e., no inferences are drawn about the population from which the data set is selected), or (2) produced by a process that is monitored in such a manner that the process is "statistically guaranteed" to produce data sets of a prescribed quality (i.e., the data set in question may or may not have been tested, but the process used to produce the data set is continually tested). However, no provision is made for reporting the accuracy of a data set that has been "statistically accepted" as part of a batch (or lot) of data sets. In this case, a given data set may or may not have been individually tested, but the batch of data sets has been tested, and each data set in the batch should be labeled with the same quality statement (inferred from the acceptance test performed on the batch). This type of labeling should be addressed in the standard.	Y	For a data set that has been accepted as part of project, but was not tested, use the “compiled to meet” statement.	COMPLETE
6-7	Appendix 3-A and 3-B, General Comment Change “Appendix A” and “Appendix B” to “Appendix 3-A” and “Appendix 3-B” in headers.	Y	Change implemented.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-8	Appendix 3-A, Section 1, Page 3-9: Horizontal Accuracy The terms used in the definitions for obtaining horizontal accuracy need to be clarified. It is unclear as to whether individual coordinates (X or Y) are being considered, or whether a radial distance is being considered. If individual X or Y coordinates are being referenced, then use of the term "r" should be avoided. Even the use of "d" for "discrepancy" could be confused with "diagonal."	Y	The variable d has been deleted from the equation. However, the variable r is retained to represent radial error, which, in turn, is computed from errors in x and y components.	COMPLETE
6-9	Appendix 3-A, Section 1, Page 3-9: Horizontal Accuracy 1. The difference is defined as $d_i = r_{data1} - r_{check1}$, where r_i is defined as $r_i = sqrt(x_i^2 + y_i^2)$. This indicates that a diagonal distance is to be computed. As defined, the accuracy test appears to be based on absolute distance from the origin of the ground coordinate system, not the straight-line distance between the data point and the check point. This is incorrect. If diagonal error (radius) is to be determined, the formula should be expressed as: $\mathbf{d_i = sqrt((x_{idata} - x_{icheck})^2 + (y_{idata} - y_{icheck})^2)}$	Y	This equation is correct and has been incorporated in the final draft; however, we are deleting the variable d to avoid confusion.	COMPLETE
6-10	2. The formula used for calculating sigma determines the dispersion of the errors about a mean. There is an implied assumption here that the mean error is zero. This is the case for randomly distributed linear errors having equal numbers of negative and positive results. The problem here is that diagonal errors (radius) are always positive, therefore, the mean error can never be zero. The statistic called sigma (circular) is a statistic about the variation in the errors themselves. There is no accounting for the mean error of the sample. This must be accounted for in the 95% confidence level statistic. All the statistic "2.4477 * $sigma_r$" indicates is that the expected variation in errors "about the mean" should include 95% probability. However, two samples could have mean diagonal errors of 10 feet and 100 feet respectively, while the sigmas are identical. The RMS formula takes this into account.	Y	The RMSE formula has been adopted.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-11	What is the point of the accuracy statistic? Is it to inform the user about the positional accuracy of the data or the standard error of the error? If the diagonal error is to be used to express accuracy, then the equation for determining the 95% confidence limit should be: **$Accuracy_r = d + 2.4477 * sigma_r$** where, **d = average diagonal error**	Y	The purpose of the accuracy statistic is to provide the user an estimate of the accuracy of the data set. Since the true value is not known, accuracy can only be estimated. The RMSE statistic is actually a measure of precision that can be used to estimate accuracy if biases and systematic errors have been removed.	COMPLETE
6-12	In any event, the circular standard error (sigma) has probably been misdefined. The ACIC (Aeronautical Chart and Information Center) publication Principles of Error Theory and Cartographic Applications, 1962, makes a point of defining circular standard error ($sigma_c$) in terms of $sigma_x = sigma_y = sigma_c$. In fact, a great deal of effort was spent on treating those cases where $sigma_x <> sigma_y$. While several step functions were developed based on the min/max ratio of the two sigmas, a rapid approximation can be used where circular error is approximated as equal to the mean of $sigma_x$ plus $sigma_y$. This approximation is fairly accurate for min/max ratios higher than 0.5. I would suggest that this approach is the better method of determining circular standard error, and thus, the 95% statistic. The formulas would then be **$Accuracy = 2.4477 * sigma_c$** where **$sigma_c = 0.5 * (sigma_x + sigma_y)$** and, **$sigma_{x \text{ or } y} = sqrt[\Sigma(dx_i - \mu_{dx})^2 / (n-1)]$** or **$sqrt[\Sigma(dy_i - \mu_{dy})^2 / (n-1)]$** where **Discrepancy in X or Y (dx, dy) = $(X_{data} - X_{check})$** or $(Y_{data} - Y_{check})$ and **Mean discrepancy in X or Y (μ_{dx}, μ_{dy}) = $\Sigma dx_i / n$** or **$\Sigma dy_i / n$**	Y	The formula $sigma_c \sim 0.5 * (sigma_x + sigma_y)$ for $sigma_x <> sigma_y$ has been adopted where $sigma_c$ is the circular standard error at 39.35% confidence and $sigma_{min} / sigma_{max}$ ($sigma_{min}$ being the smaller of $sigma_x$ and $sigma_y$ and $sigma_{max}$ the larger) is between 0.6 and 1.0.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-13	Appendix 3-A, Section 3, Page 3-10: Well Defined Points When making statistical inferences, assumptions are usually made that ultimately place constraints on the testing procedure. For example, in the vertical case, the assumption is typically made that the residual difference between the data (observed) elevation and the true (known) elevation is normally distributed with mean zero and standard deviation sigma. Irrespective of whether or not this assumption is correct, the assumption itself has an impact on the testing procedure. One of the constraints stemming from the assumption is that the well-defined test points used to evaluate the accuracy of the data set must be independent. These test points should not be used to control any mathematical (or other) solution upon which elevation values are derived. For example, a control point used in a least squares adjustment or a point used as a node in an interpolation polynomial cannot be subsequently used as a test point. The use of such a point in the testing procedure compromises the validity of the test and any inferences drawn. *Therefore, it is recommended that this constraint be explicitly stated in defining the criteria for a well-defined test point*.	Y	This sentence has been added to the final draft: “The independent source of higher accuracy shall be acquired separately from data used in the aerotriangulation solution or other production procedures.”	COMPLETE
6-14	Appendix 3-A, Section 3, Page 3-10: Well Defined Points Paragraph 1 -- Well-defined points identified within a precision of one-third of the maximum uncertainty for the data set. 1. A precision of one-third of the 95% level to identify check points is too broad. Too much of the allowable error budget is taken up by "guessing" the point location. If the 95% level for 24K mapping is 45.6 feet, this would allow up to 15.2 feet in identification error. Even with NAPP photography, centerline intersections can be located more accurately than that. Criteria of 15% would yield about 7 feet in the above example. This is a reasonable expectation. 2. This criteria needs to be further explained. Is this criteria intended for locating the check point on the ground or for locating the point in the geospatial data set (map, DOQ, DLG, etc)?	Y	See resolution to comment 2-16.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-15	Appendix 3-A, Section 3, Page 3-10: Well Defined Points Paragraph 2 -- For small-scale products, acceptable features could include approximate right-angle intersections of roads and railroads; small isolated shrubs or bushes; and corners of structures or buildings. 1. There is no definition in the document for small-scale. A statement should be added to indicate what scales are considered small-scale and large-scale. 2. If small-scale includes 1:24,000-scale, the acceptable features for well-defined points should not include small isolated shrubs or bushes, and corners of structures or buildings.	Y	This section has been rewritten, based on resolutions to comments 12-29 through 12-35. Statements such as “large scale” and “small scale” have been replaced by scale values.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-16	Appendix 3-A, Section 4, Pages 3-10 and 3-11: Check Survey Design Paragraph 1 -- Check survey points must have an accuracy of one-third or better of the intended accuracy of the data set at 95% confidence level. (Also stated in Section 3.2.3, Pages 3-3 and 3-4: Accuracy Test.) 1. This error allowance for check point accuracy is too broad. Without sufficient accuracy in the check point survey, the results of the accuracy test are meaningless. ASPRS interim standards did mention designing a check survey with one-third of the "limiting rms error." This was in linear x or y, not circular. This ratio cannot be blindly transferred to a 95% statistic. Assuming that an NMAS accuracy of 40 feet is equivalent to a standard error (limiting error) in x or y of 18.6 feet, the accuracy for the check point survey would be 6.2 feet in x or y or 8.8 feet diagonal. This value is 22% of the NMAS limit of 40 feet. Using the same approach with the 95% statistic (45.6 feet), 22% would give 10 feet (diagonal) as the check point accuracy. Modern survey techniques can easily produce accuracies of 3 or 6 feet. 2. Under this standard, with another third allowed for choosing a well-defined point (see above), two-thirds of the permissible error is already "soaked up." The accuracy test noise level is so high that only errors that exceed two-thirds of the expected 95% confidence level are meaningful. For example, with a 95% level set at 45.6 feet (NMAS 40 feet) which gives up to 15 feet for check point accuracy and 15 feet for identifying accuracy, only errors in excess of 30 feet are above the noise level. 3. A second consideration should also be that modern survey technology provides much more accurate results. One meter and two meter accuracies are easily and quickly obtainable as are submeter surveys. A two-meter diagonal error in a check point would translate to only 15.5% of a 95% statistic for 1:24000 mapping. It has become much more realistic to expect higher accuracy field surveys.	Y	See resolution to comment 2-16.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-17	Paragraph 2 -- Check Survey Design indicates that all check point accuracies are referenced to Continuously Operating Reference Stations (CORS). 1. Why specifically require reference relative to a CORS when many surveys are local networks adjusted prior to use of any CORS? Since surveying requirements may not include GPS adjusted in relation to a CORS, use of GPS at all, or even network surveys, why must one indicate accuracy with reference to a CORS? Since the check point accuracy is one-third of the maximum error expected at 95%, check point accuracy can be very rough. For example, for an NMAS 40 foot product, the equivalent 95% might be 45.6 feet. The allowable check point error is then 15 feet. There are several techniques that would provide that accuracy without needing to be referenced to a CORS.	Y	References to CORS in Part 3 have been deleted.	COMPLETE
6-18	Paragraph 2 -- Check Survey Design 2. Would not references to general positional accuracy (network, traverse, or otherwise) standards be more applicable, cover more cases, and make it less restrictive for data providers to test their data?	Y	This approach to data acquisition for the independent source of higher accuracy is only one of many possible approaches - it is intended to be merely informative.	COMPLETE
6-19	Appendix 3-B, Section1.1, Page 3-14: Explanation of RMSE Component Accuracy 1. Many accuracy tests have been reported in diagonal RMS. While the X or Y RMS gives a more accurate conversion to NSSDA, shouldn't a factor also be derived for diagonal RMS where the component RMS values are unknown? X or Y RMS can be approximated from Diagonal RMS by assuming that the component RMS values are equal. Then **Accuracy = 2.447 * sqrt(diagonal RMS^2 / 2)**	Y	Radial RMSE can be derived from RMSE's in each of the x and y components *or* computed from straight line measures between the data set and the check source. This is included in the final draft.	COMPLETE
6-20	Appendix 3-B, Section1.1, Page 3-14: Explanation of RMSE Component Accuracy 2. What is the purpose of the second to the last sentence of paragraph 1.1? The explanation of the cumulative errors in the RMS calculation applies just as well to the NSSDA.	Y	This sentence has been deleted. Since the NSSDA statistic has been changed to RMSE, repeating this statement is redundant.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
6-21	Appendix 3-B.1.4, Page 3-15: RMSE Accuracy Reporting Change “as described in Section 2.4" to “as described in Section 3.2.4.”	Y	Change implemented, but section 3.2.4 has been renumbered as 3.2.3.	COMPLETE
7-1	3.1.1 1st paragraph change statistic to statistical (statistic is a noun not an adjective)	Y	Change implemented.	COMPLETE
7-2	3.1.1 1st paragraph I assume the spatial data is derived from sources such as aerial photographs, satellite imagery, and maps. This is not really clear from the wording of the 1st sentence. It could be interpreted as the testing methodology is derived from sources such as	Y	This has been revised as follows: “The NSSDA applies to fully georeferenced maps and digital geospatial data, in either raster, point, or vector format, derived from sources such as aerial photographs, satellite imagery, and ground surveys. It provides a common language for reporting accuracy to facilitate the identification of spatial data for geographic applications.”	COMPLETE
7-3	In 3.1.1, switch the position of the 2nd and 3rd paragraphs. It makes more sense to describe the type of standard and then discuss the limits.	Y	Change implemented.	COMPLETE
7-4	3.1.4 Spell out FGCS.	Y	Change implemented.	COMPLETE
7-5	3.2.1 Change smaller to greater. The accuracy should be greater than the reported value.	Y	The sentence has been rewritten as, “Accuracy reported at the 95% confidence level means that 95% of positions have an error …smaller than or equal to the reported accuracy value.”	COMPLETE
7-6	3.2.4 Accuracy Reporting Does the standard need to specify “@95% confidence level”? We don’t print the 90% figure on our maps that meet NMAS. Seems like the 95% is part of the definition of the NSSDA. Specifying 95% implies that there might be some other percent that could be used.	Y	The standard needs to specify 95% confidence level, as quantitative accuracy values are being reported.	COMPLETE
7-7	3.3 NSSDA AND OTHER MAP ACCURACY STANDARDS The NSSDA by itself doesn’t report anything. In the 1st sentence change ‘reported by’ to ‘reported according to the’. Second sentence insert ‘as specified’ between ‘reported’ and ‘by’.	Y	Changes implemented.	COMPLETE
7-8	I assume there are standards for the format of FGDC documents and that this one follows the standards. There are no headers or footers and the footnote figures are not in the right format. Presumably they will be in the final document.	N	The final draft will conform to Directive #6 on Formatting FGDC Standards Documents, issued by the Standards Working Group.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
8-1	The proposed statistics for horizontal and vertical accuracy (forth on pages 3-9 and 3-10) are essentially measures of dispersion or variation about a mean value. Such a statistic reflects *precision* but does not take into account the possibility of *bias* in the data. If the mean discrepancy is not small (and, in general, the radial discrepancy associated with the horizontal measure will have non-zero mean), then the proposed accuracy value could provide a very misleading idea of the reliability of the map. As an extreme example, a map whose mean locational error is 100' (a very large bias) and standard deviation is 2' (high precision) would be deemed more accurate under the proposed standard than one whose mean error is 2' and standard deviation is 10' (low precision). The *accuracy* of spatial data should reflect both bias (mean) and precision (variation about that mean value). Reporting the standard deviation only, as suggested in the proposed standard, neglects the potential influence of bias. In order to faithfully reflect both the bias and precision it is necessary to report two values; the mean and standard deviation are often employed (Eisenhart in Ku, H. H. 1969. *The Measurement Process*. National Bureau of Standards, Special Publication No. 300 and Deming, W. E. 1950. *Some Theory of Sampling*, page 129). In a national standard, where simplicity and ease of application are required, a single statistic will probably have to suffice. A more meaningful and useful way to characterize accuracy (instead of the standard deviation) is through the use of the root mean square error statistic, or RMSE. The RMSE takes into account both the bias and the precision of the data in a single number. The appropriate RMSE for horizontal discrepancy can be defined as follows: $RMSE_r = sqrt[\sum r_i^2/n]$ where, $r_i = sqrt[(x_{data,\,i} - x_{check,\,i})^2 + (y_{data,\,i} - y_{check,\,i})^2]$, the radial error at check point i $x_{data,\,i}$, $y_{data,\,i}$ are the data set coordinates of the *i* th check point	Y	This RMSE formula has been adopted.	COMPLETE
8-1 (continued)	$x_{check,\,i}$, $y_{check,\,i}$ are the coordinates of the *i* th check point from the check survey n = the number of points being checked.			

Log number	Comment	Substantive	Resolution	Status
8-2	In the case of the vertical error, the quantity r_i would be replaced by linear difference between the elevation value from the data and the (known) more accurate check value.	Y	See response to comment 8-1.	COMPLETE
8-3	Similarly, accuracy reporting (set forth on pages 3-4 and 3-5) should use the RMSE value instead of the standard deviation. Mention of confidence intervals (95% or whatever) should probably be deleted from the standard. It may be misleading to build such statistical conclusions into the national standard when the empirical error data may not (and often will not) warrant (Deming, page 502).	Y	The 95% confidence level is essential to this standard. The assumptions underpinning the application of confidence intervals are explicitly stated in the final draft.	COMPLETE
8-4	. . . the assertions at the top and in the middle of page 3-15 and elsewhere--that the RMSE and standard deviation are nearly equivalent when sample sizes are large--probably depends on the assumption of a zero-mean distribution. [This assumption is not valid for radial distance errors, which are strictly non-negative.] While the errors may or may not have a zero mean in a given situation, the standard should explicitly acknowledge the assumption.	Y	Assumptions about normally distributed values will be explicitly stated in the final draft.	COMPLETE
8-5	A key point concerning the factors used to produce the 95% confidence levels from the sample standard deviations (pages 3-9 and 3-10) is the assumption that the errors are normally distributed. This assumption of normality should be stated in some way.	Y	Assumptions about normally distributed values will be explicitly stated in the final draft.	COMPLETE
8-6	I suspect the definitions of the quantities related to horizontal accuracy, section 1 on page 3-9 need to be revised. One way they might be redefined is as follows: $sr = sqrt[\sum(r_i - r_{mean})]$, where $r_i = sqrt[(x_{data,\,i} - x_{check,\,i})^2 - (y_{data,\,i} - y_{check,\,i})^2]$, the radial error at check point i $r_{mean} = \sum r_i / n$ $x_{data,\,i}$, $y_{data,\,i}$ are the data set coordinates of the *i* th check point $x_{check,\,i}$, $y_{check,\,i}$ are the coordinates of the *i* th check point from the check survey n = the number of points being checked.	Y	The RMSE equation will be adopted as the accuracy statistic.	COMPLETE
9-1	In Appendix B, pg. 15, in item 2.1: I believe the terms smaller and larger, in reference to the scale tolerances are switched, OR the values 1/30 and 1/50 need to be switched to the proper sentence.	Y	The referenced statements were accurately copied from the National Map Accuracy Standards.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
9-2	Similarly in item 2.2 in the last 3 lines The math (1.14*S/360) AND (1.14*S/600) need to be switched to go with the proper larger/smaller terms.	Y	These statements are correct as written, given that the referenced statements in comment 9-1 are correct.	COMPLETE
10-1	I have reviewed the Draft GPAS document. I find it to be an excellent piece of work with extensive guidance for the survey community.	N		COMPLETE
10-2	The mapping and GIS community needs a little more work. This document has one major deficiency, the draft GPAS is to replace the National Mapping Accuracy Standards (NMAS). Unfortunately the GPAS only covers one minor aspect of the NMAS, that is the method of reporting accuracy. I do comment this move, 95% is more widely used and is clearly moving spatial integrity to a higher lever of accountability. The issue of mapping ethics and the appropriateness of display at a specific scale or scale compatibility completely missing. While there is some attention given in Introduction Part 3 of GPAS, this is wholly inadequate. We the users of these standards do not expect and statement [sic] of recommended scales for specific data or data types. We do need a method of stating the appropriate scale of use for a data set who's level of accuracy is clearly known. Please, do not assume that the mapping community knows right from wrong when is comes to ethical or appropriate use of spatial data. With the mass influx of individuals, with no formal training, into the Geographic Information Systems field individuals need appropriate guidance. The guidance provided in the NMAS will be missed. Please continue to provide the kind of guidance to those who don't have a strong back ground in the spatial sciences and sorely need to make informed decisions. Help those of us who do have the back ground in the spatial sciences by providing us with a standard that we can use as a tool to improve or maintain a minimal level of mapping quality and integrity.	Y	It was realized that it was impractical to replace NMAS, because many legacy maps and geospatial data use NMAS criteria. However, once the NSSDA is endorsed as an FGDC standard, positional accuracy for new and revised maps or digital geospatial data products shall be reported according to the NSSDA. The NSSDA puts the onus on producers to define appropriate scales and conformance quality levels for positional tolerances in their product specifications. If producers determine that conformance quality levels and appropriate scales from standards such as the NMAS or American Society for Photogrammetry and Remote Sensing (ASPRS) Accuracy Standards for Large-Scale Maps are acceptable, they may incorporate them into their product specifications.	COMPLETE
11-1	PART 1: Reporting Methodology EPA rarely deals with nice well-defined and small area points. Defining accuracy of a facility centroid or “front gate” in these specific terms may not be appropriate.	N	Since Geospatial Positioning Accuracy Standards applies to well-defined points, the kind of positional accuracy the reviewer requires seems to be outside the scope of the GPAS.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
11-2	PART 1: Reporting Methodology In addition to geospatial phenomena/accuracy topics, have other data quality elements such as completeness, logical consistency, temporal accuracy, and thematic accuracy been considered?	N	The Subcommittee for Base Cartographic Data will develop standards for *all* data quality elements identified in Content Standards for Digital Geospatial Metadata.	COMPLETE
11-3	PART 1: Reporting Methodology Will there be a published product specification for all geospatial products, covering regulatory, monitoring, and base framework data? Does this already exist?	N	The reviewer should be directed to current FGDC standards projects.	COMPLETE
11-4	PART 3: National Standard for Spatial Data Accuracy Standard is weak on details on defining the methodology for determination of accuracy. Discussion sounds great in theory, but it doesn't say much in real life practice.	N	An example of accuracy calculations will be included in an informative appendix to Part 3.	COMPLETE
11-5	PART 3: National Standard for Spatial Data Accuracy Another weak area is how to deal with uncertainty in boundary or edge values, that tend to have higher error rates associated with them, than center values of classified polygons.	N	Boundary or edge values are outside the scope of Part 3, National Standard for Spatial Data Accuracy.	COMPLETE
11-6	PART 3: National Standard for Spatial Data Accuracy The standard cites preference for using National coordination systems. A discussion is omitted concerning coordinate conversion, and the source and method to make the conversion.	N	Coordinate systems and coordinate conversion are beyond the scope of this standard.	COMPLETE
11-7	GENERAL COMMENTS Most current EPA applications might not meet this standard. Might be useful to show examples of projects that currently record data that 'meets' the standard and projects that record something different from the standard.	Y	A decision tree will be included in a subsequent version of Part 1 so that there are guidelines for determining which part of Geospatial Positioning Accuracy Standards should be used for a particular application.	COMPLETE
11-8	GENERAL COMMENTS Authors should include a short discussion of more casual types of locational data efforts, such as most of the ones being run by states. Is the level of accuracy proposed appropriate in these cases?	N	See response to comment 11-7	COMPLETE

Log number	Comment	Substantive	Resolution	Status
11-9	GENERAL COMMENTS The new FGDC Geospatial Positioning Accuracy Standard will probably be as expensive to perform the prescribed accuracy determinations as it was to do the original GPS data collection. The standard requires you to be able to determine, on a statistically representative sample of original locational data points, a much more accurate coordinate (+/- cm's). The deviation from the more accurate positioning is the accuracy of the original data collection effort. The difference in cost for acquiring a +/- 5.0 meter point and a +/- 5.0 cm point is considerably greater than a factor of 10. It would make things less expensive under this procedure if the 'statistically representative sample' could be a less rigorous (i.e smaller), number of the original points.	N	Please note that testing by an independent source of higher accuracy is only the *preferred* method of estimating accuracy. Testing does not necessarily have to be done by executing an independent field survey: a data producer may select high accuracy points from a pre-existing data base.	COMPLETE
12-1	The NSSDA does not provide a real target value or a pass-fail criterion for agencies to achieve. It is intended to replace a standard that does provide a pass-fail standard level of accuracy in national spatial data products. We believe that the proposed NSSDA is not really an accuracy standard, and that we're inviting confusion if it were to be called one. We believe a national accuracy standard should be setting guidelines to establish a level of consistency for both the measurement of accuracy and for the interpreting of accuracy values. As stated in the first paragraph of the purpose, "It provides a common language to **report** accuracy to facilitate the identification of spatial data for geographic applications." (Our emphasis). Therefore, we recommend that a more descriptive and truthful title of the document is: "National Standard for Reporting Spatial Data Accuracy."	Y	The title will remain as is, because the geospatial data community has become accustomed to this name.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-2	It is stated that the NSSDA is intended for use with new and revised spatial data. This is a good statement, however an assumption is being made that all new spatial data are being collected directly from recent observations of the ground, as was in the past when graphic maps were manually produced. We would suggest that spatial data has a much more broader meaning today, in that many new spatial data products are now derived from other spatial data products. Even though an accuracy test that references the data to the ground with regards to what is true is by far the best way to determine accuracy, it is also far from being a reality in terms of what technology allows us to do today. The trend that has actually taken place for spatial data is that users are testing for "Relative Accuracy", i.e. digital spatial data are tested against the source from which they were derived as a check on the process used to make the product. This is part of what makes spatial data so popular. … we believe that due to a growing lack of resources in government and in the absence of field parties to collect ground test points, "Relative Accuracy" would be the most common measurement used for comparing the accuracy of spatial data in both government and the private sector of the mapping industry.	Y	The final draft of the NSSDA makes provision for estimating positional accuracy using methods other than comparison with an independent source of higher accuracy.	COMPLETE
12-3	We suggest that consideration be made to broaden this standard for inclusion of "Relative Accuracy" conditions. If this were to be done, data producers would also be required to report the existing accuracy of the source from which the data was derived. Along with the spirit of truth-in-labeling, perhaps another label could be applied that would state something to the effect that "This data set has been derived with a relative accuracy of ____ feet from various source data."	Y	Introducing another label would needlessly complicate accuracy reporting.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-4	This standard does not really define what *accuracy* is, with regards to the true meaning of the term. The term "Accuracy" actually has a broad usage and as a result has many meanings under its umbrella, with all of them being somewhat correct. Please reference sections 11.0 through 11.8 (pages 15-17) of the FGDC Draft Content Standards for Digital Elevation Data, Jan. 1997 version. The DEM standard offers some very excellent definitions for what accuracy truly is and also references different types of accuracy measurements. It seems that these same kind of definitions belong in the NSSDA. We believe that defining the different types of accuracies that are in use will make it less likely for a user to misinterpret the true meaning of the term and its intended usage within this standard.	Y	A glossary of terms will be added as an informative appendix to Part 1. See response to comment 2-2.	COMPLETE
12-5	Given that this entire section suggests what the NSSDA is and is not, concerning spatial accuracy, we question whether it is in the best interests of the nation to propose a ***replacement*** of NMAS, (which does contain accuracy thresholds), with a national standard that provides no accuracy thresholds. The NMAS may have some faults, however, to suggest that it is obsolete and no longer applicable for stating the accuracy of map information is far-reaching and potentially impacts every federal mapping agency. We recommend that the NSSDA ***supplement*** or be an addition to the NMAS as a standard means agencies can use to state and report the accuracy of their products. We do not question the need to have a national reporting standard for accuracy. We believe replacing NMAS will negatively impact the users of data from federal agencies because each agency potentially may determine different specific accuracy tolerance levels, even within the same product series. The result of having a variety of accuracy tolerances throughout the federal community has the potential to cause less cooperation and data sharing. This is because the accuracy of data from different producers and cooperators will vary and be inconsistent from one data set (or even feature or theme) to another.	Y	See resolution to comment 10-2. NMAS measures are not fully applicable to digital geospatial data because digital data is not constrained by map characteristics such as publication scale and contour interval. Also, the geospatial data community has expanded to include many more data producers with different product specifications and many more data users with different application requirements. The NSSDA was developed to provide a common reporting method so that users can directly compare data sets for their applications.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-6	It is possible that our agency would not adopt a specified accuracy tolerance value to be applied across all products and product series. We would end up with a product line that has every imaginable accuracy level and would no longer be consistent. Our customers have come to rely on the dependable accuracy of our products. We believe our reputation for having a consistent and defined accuracy tolerance will be eroded by the replacement of NMAS with a standard that does not define a national accuracy tolerance value as opposed to a value named after our agency and which could be confused with a value determined by a different agency.	Y	The NSSDA encourages your agency to set accuracy threshold values for its product specifications.	COMPLETE
12-7	We are also concerned with the legality and authority of the FGDC replacing the NMAS through the issuance of a new standard. The NMAS was established by an act of Congress through the US Bureau of the Budget (now Office of Management and Budget - OMB). Has this been addressed and are there any legal or political implications which could arise through the "automatic" replacement of NMAS with the NSSDA?	Y	This issue is beyond the authority of the panel adjudicating comments from public review. If reviewers feel strongly about this issue, they should raise it with the FGDC Secretariat.	COMPLETE
12-8	It is unclear to us if the NSSDA is intended to apply to graphics products which may be derived from image or digital geospatial data. If so, we have concerns for applying strict accuracy criteria to representative information that is occasionally displaced and generalized for cartographic symbolization and presentation of data onto hardcopy media. We recommend that this be addressed in the standard and that strict accuracy specifications may not necessarily apply to some derivative products which are subject to generalization and symbolization.	Y	The NSSDA applies to maps as well as digital geospatial data: read Section 3.1.1. It merely provides an estimate of how close the point coordinates on the map or in the data set are to ground position.	COMPLETE
12-9	Sections 3.1.4 and 3.1.5, pg 3-2 We are assuming that FGCS stands for the Federal Geodetic Control Subcommittee, however, from the text on this page, that is unclear. Please list agency or committee acronyms by "full name, (abbreviation)", the first time it occurs in each part of the standard.	Y	See Resolution to log number 7-4.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-10	Section 3.2.3, Accuracy Test The first paragraph states: “The producer of spatial data will determine the geographic extent of the data to be tested and the amount of testing”. At the same time in the last paragraph the statement is made: “Test a minimum of 20 check points...”. We suggest that a minimum size for the geographic extent, based on scale, also needs to be specified. This would establish a pattern of consistency between the spacing of test points by scale. The following two examples show the extremes that could occur: 1-Degree x 1-Degree area with 20 test points **vs.** 7.5-minute x 7.5-minute area with 20 test points	Y	This information is more appropriate for inclusion in product specifications than in a national standard. Because of the diversity of users’ requirements, it is not realistic to include statements that specify the spatial distribution of check points.	COMPLETE
12-11	Section 3.2.3, Accuracy Test The 2nd sentence of paragraph 2 should read, “Select the check source so that its accuracy is within one-third the **intended** accuracy of the data set at the 95% confidence level.”	Y	See resolution to comment 2-16.	COMPLETE
12-12	Section 3.2.3, Accuracy Test In paragraph 3, sentence 1, well-defined points don’t exist with regards to graphic contour data and vector hypsographic data. To obtain a single linear value for vertical accuracy, an elevation value from a digital derivative product can only be compared against the source at the same exact X-Y coordinate. In other words, vertical measurements are a point-to-point linear value of the same X-Y coordinate. Therefore, we recommend rewording to: “Test vertical accuracy for Z by comparing the elevations of the source and check source against the same X-Y coordinate value of each data set.	Y	The following wording has been added to the draft: “For data such as gridded digital elevation data or topographic contours, which most likely do not contain well-defined points, test vertical accuracy by comparing the elevation of a point in the data set with the elevation at the same position in the independent source of higher accuracy.”	COMPLETE
12-13	Section 3.2.3, Accuracy Test Paragraph 3, sentence 3 should read, “Select the check sources so that accuracies at check point locations are within one-third the data set’s **intended** accuracy at the 95% confidence level.”	Y	See resolution to comment 2-16.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-14	In the last paragraph, some 24K and 100k series maps and their corresponding digital products do not always have enough geographic area to be able to fit 20 check points, for example, quadrangles with large void areas due to bounding limits of Canada, Mexico and large open water such as occurs with the Atlantic and Pacific Oceans. Therefore, we recommend adding wording such as: "When the geographic extent contains an excessive amount of area that is void of data coverage, due to things like national boundaries or water bodies, then the producer may proportion the number of collected test points with that of the coverage which does exist."	Y	The sentence has been rewritten as: "A minimum of 20 check points shall be tested, distributed to reflect the *geographic area of interest* and the distribution of error in the data set." Areas void of coverage would not be in the geographic area of interest. Similarly, if an urban area is the geographic area of interest, the urban area would have a higher concentration of sample points than rural areas.	COMPLETE
12-15	Section 3.2.4, Accuracy Reporting Statements The second paragraph (page 3-4) may read better by prefacing it with "There are three conditions for reporting accuracy:" and then list each sentence as a separate bullet below.	Y	Each sentence has been listed as a bullet item in the final draft: "Below are guidelines for reporting accuracy of composite data sets:" followed by the bullet items.	COMPLETE
12-16	Section 3.2.4, Accuracy Reporting Statements We do not believe the statements provided for reporting accuracy are very meaningful in their current form. In fact, to an average lay person who is not necessarily a scientist or statistician, they are rather confusing. Most map and data producers have little room left on their product to be wordy and to include lots of references. We believe these statements should be simple and easily express what the producer actually intends to say about the accuracy of their product.	N	See responses to comments 12-17 to 12-21.	COMPLETE
12-17	Section 3.2.4, Accuracy Reporting Statements We also question whether or not a user may interpret the "tested by..." statement to mean tested against ground truth. Many accuracy tests will be against some comparison source other than ground truth. Perhaps the statement more specifically state the source used to test the data?	Y	"Tested" means that the data set has been compared against an independent source of higher accuracy. The higher accuracy data need not be surveyed positions, but it should provide higher accuracy positions than the data set. Information about the source will be included in Metadata.	COMPLETE
12-18	Section 3.2.4, Accuracy Reporting Statements The NSSDA has not established the pass-fail accuracy threshold, only the data producer has. Including the line "National Standard for Spatial Data Accuracy 1997" is not meaningful and adds nothing of value. In fact it may create confusion again, because someone might assume that the given thresholds were taken from NSSDA. Therefore, we recommend deleting the line.	Y	The line "National Standard for Spatial Data Accuracy 1997" has been deleted.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-19	Section 3.2.4, Accuracy Reporting Statements We also recommend removing the "( )" around the words 'horizontal' and 'vertical' and to incorporate these words directly into the statement.	Y	Change implemented.	COMPLETE
12-20	Section 3.2.4, Accuracy Reporting Statements We recommend using the following statements for reporting accuracy: Tested data are within _____ meters/feet of true horizontal position, 95% of the time. Tested data are within _____ meters/feet of true vertical position, 95% of the time. Well-defined points are compiled within _____ meters/feet of true horizontal position, 95% of the time. Well-defined points are compiled within _____ meters/feet of true vertical position, 95% of the time.	Y	The accuracy reporting statements will be left as they are. "Confidence level" has a particular statistical meaning from which we can draw inferences about *all* items of interest (well-defined points or elevations) in the data set, not merely the sampled items.	COMPLETE
12-21	Section 3.2.4, Accuracy Reporting Statements The last sentence on page 3-5 suggests that data sets not containing vertical information be labeled as such. The same could hold for vertical data sets which do not contain horizontal accuracy information, as in DEM products. Therefore, add the following sentence: "If a data set does not contain horizontal information, label for vertical accuracy information only".	Y	This sentence has been added: "Conversely, if a data set, e.g., a gridded digital elevation data set or elevation contour data, does not contain well-defined points for horizontal accuracy testing, label for vertical accuracy only."	COMPLETE
12-22	Bibliographic References, pg 3-7 We strongly recommend adding complete bibliographic information for all sources and references used to obtain the equations, statistics information, and constants used in every occasion throughout this document. This will lend credibility to the document, will allow readers to verify all mathematical and theoretical references, and will cover the authors against potential copyright infringements.	Y	Complete citations and references have been added.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-23	Appendix A, 1. Horizontal Accuracy We strongly recommend that <u>all</u> terms used, including subset terms, be completely described in the definition of the equations. For example, in the "where" statement, $r_{data\ I}$ and $r_{check\ I}$, as well as r_i do not show up in the main equation and there is no explanation defining these terms. Likewise, the x_i and y_i have not been defined.	Y	All variables have been defined in the final draft.	COMPLETE
12-24	Appendix A, 1. Horizontal Accuracy In our interpretation of the "where" statement, the equations $d_i =$ and $r_i =$ are used to determine the same value, that is, the linear distance between to (X,Y) coordinate pairs. The need for the term "r" actually is not necessary. Therefore, the need for two equations can be reduced from two to one (d_i = sqrt [$x_i^2 + y_i^2$]).	Y	The variable d has been deleted to eliminate confusion. The variable r is retained to signify radial error.	COMPLETE
12-25	Appendix A, 1. Horizontal Accuracy We recommend the equation to determine the standard deviation for the horizontal coordinates be changed to: $$sigma = \sigma = \pm \sqrt{\frac{\sum (d_i - d)^2}{(n - 1)}}$$ where: $d_i = \sqrt{(x_s^2 - x_{cs}^2) + (y_s^2 - y_{cs}^2)}$ $d = \sum d_i / n$ (the mean discrepancy) n = total number of points checked and where: i = one point from the domain of test points x_s and y_s =data set coordinates x_{cs} and y_{cs} = check source coordinates	Y	RMSE based on radial error has been adopted as the accuracy statistic.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-26	Appendix A, 1. Horizontal Accuracy We also recommend that a small sample data set, data table, and set of calculations for about 20 test points be included in the Appendix to illustrate the use of each equation that needs to be used for determining circular error and comparing that result to a 95% confidence level. This would help facilitate explaining how this system works to all users of this standard and how it is different from currently established accuracy standards.	Y	An example of computing positional accuracy according to the NSSDA will be included as an informative appendix.	COMPLETE
12-27	Appendix A, 1. Horizontal Accuracy We recommend rewording the last sentence of the first paragraph to: "The standard deviation for the set of horizontal test points are:" The standard deviation is used to evaluate a set of horizontal test points, i.e. for 20 data points together with 20 corresponding check points, not just one coordinate pair. The singular reference to a horizontal coordinate is incorrect.	Y	The erroneous wording has been deleted in the final draft.	COMPLETE
12-28	Appendix A, 1. Horizontal Accuracy After the "where" section, it states "NSSDA horizontal accuracy is:" Since NSSDA is not a pass-fail system . . ., it is incorrect to make the statement that the result is NSSDA accuracy. . . Therefore, the statement should read (in this case): "The circular horizontal accuracy which would be reported according to NSSDA specifications is:" Please also correct this for section 2, Vertical Accuracy, (pg 3-10).	Y	The sentences have been changed to read "according to the NSSDA" in the final draft.	COMPLETE
12-29	Appendix A, 3. Well-Defined Points Well-defined test points must not only be easily visible or recoverable on the ground, they must also be easily visible and recoverable on sources which are used to produce and/or test the product and on the product itself. If a test point is not recoverable on any of these three items, the test point could become invalid, especially if there are problems or errors associated with the point. Persons performing the accuracy test must be able to validate all test points and be able to check the locations of the points on all sources as well as the final product, as necessary. Therefore, we recommend rewording the second sentence as: "These features must be easily visible or recoverable on the ground, on the sources used to produce the product, and on the product itself."	Y	The wording, "well-defined points must be readily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself," has been included in the final draft.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-30	Appendix A, 3. Well-Defined Points The document is correct in stating that features selected for well-defined test points will differ depending on the data source and the product scale. However, the test points will also differ depending on the product being produced. Test point requirements are different for image products (such as orthophotos) than they are for paper topographic map products and for elevation products. We recommend that this paragraph be redeveloped and expanded to provide examples of the kinds of test points that are suitably well-defined for typical geospatial products.	N	More specific recommendations are provided in subsequent comments.	COMPLETE
12-31	Appendix A, 3. Well-Defined Points …for orthophoto (or image) products, suitable well-defined features, visible on the ground as well as the source and product, include small isolated shrubs or bushes, right-angle intersections of roads and railroads, and other linear planimetric features that intersect at or near right angles, such as canals, ditches, trails, fence lines, and pipelines.	Y	These ideas have been added to the final draft.	COMPLETE
12-32	Appendix A, 3. Well-Defined Points For graphic map products, suitable well-defined features, visible on the ground as well as the source and product, include right-angle intersections of roads and railroads, and other linear mapped planimetric features that intersect at or near right angles, such as canals, ditches, trails, fence lines, and pipelines.	Y	These ideas have been added to the final draft.	COMPLETE
12-33	Appendix A, 3. Well-Defined Points For much larger scale map products such as engineering plats or property maps, suitable well-defined features, visible on the ground as well as the source and product, may include additional features such as utility access covers, intersections of sidewalks, curbs, or gutters as long as they are visible on both the source and the product.	Y	These criteria has been added to the final draft. Note: Engineering plats or property maps have been identified at being scales of 1:5,000 or larger. Terms such as “large scale” and “small scale” mean different things for different applications.	COMPLETE
12-34	Appendix A, 3. Well-Defined Points Based on our experience, the “corners of structures or buildings” are not good test points because of radial distortion on imagery, shadows, and that it is very difficult to get a good position on the feature, especially with GPS (much of the satellite view may be blocked). Also, these features typically are symbolized with an exaggerated symbol size and may be displaced from roads, railroads, or other “more important” features during mapping which would provide false positioning errors	Y	Corners of structures or buildings have been deleted as examples of well-defined points.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-35	Appendix A, 3. Well-Defined Points Our experience also shows that “monuments or markers, such as bench marks and property boundary monuments” will not be visible on source imagery because they are too small. The only time they might be appropriate is if they are already mapped and that map product is used as the source of higher accuracy. However, one must use caution if one does not know how accurately these features have been plotted on that source. There are numerous other features that make much better test points.	Y	Monuments or markers have been deleted as examples of well-defined points.	COMPLETE
12-36	Appendix A, 3. Well-Defined Points Also, well-defined points do not exist with regards to graphic contour data and digital hypsographic data. We recommend that this section clarify that it is applicable only to horizontal data.	Y	The sentence, “Graphic contour data and digital hypsographic data may not contain well-defined points,” has been added to clarify this point.	COMPLETE
12-37	Appendix A, Check Survey Design In the second paragraph, we have concern with the statement that the positional accuracy of the data set should be compared with the FGCS network accuracy for the check source and that network accuracy of a control point is the uncertainty of its coordinates with respect to the nearest Continuously Operating Reference Station (CORS). The CORS network is currently operating in an experimental mode. NGS will not guarantee the accuracy of the data. Also, positional coordinates for the CORS stations are continually refined, although the changes are minute. We believe the use of CORS data should be reevaluated as the “ultimate” accuracy source.	Y	Reference to CORS has been deleted in Part 3.	COMPLETE
12-38	Appendix A, Check Survey Design We are unclear as to why horizontal check surveys cannot be tied to <u>any</u> horizontal station published by NGS, or established using real time DGPS that guarantees (at the 95% confidence level) an accuracy better than 1/3 the proposed accuracy of the product being tested. Vertical accuracy should not be tested using real time DGPS unless the correctors used can meet the necessary vertical requirements, which is more questionable than the horizontal component.	Y	Using National Spatial Reference System (NSRS) points as an independent source of higher accuracy is only one of many possible ways to estimate the accuracy of a data set.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
12-39	Appendix A, FGCS Accuracy Classification chart, pg 3-11 We recommend the entire chart be completed rather than using the "etcetera". For an official national document such as this, we don't believe items should be left to chance or assumption about interpretation and comprehension by the user.	Y	The chart has been deleted.	COMPLETE
12-40	Appendix B, Section 1.2, pg 3-14 After the "where" section, it states "RMSE may then be converted to NSSDA horizontal accuracy". . . . it is incorrect to make the statement that the result is NSSDA accuracy. . . Also, the conversion is to a circular error rather than a straight RMSE. Therefore, the statement should read (in this case): "The RMSE value may be converted to a circular accuracy value and reported according to NSSDA specifications, " Please also make a similar correction for Appendix B, Section 1.3, RMSE Vertical Accuracy, (pg 3-15).	Y	Since RMSE has been adopted as the accuracy reporting statistic for NSSDA, this is no longer an issue. The final draft contains methods for converting between radial RMSE and RMSE in each x, y component. The wording has been changed to "can be converted and reported *according to the* NSSDA."	COMPLETE
12-41	Appendix B, Section 2.2, pg 3-16 As similarly stated in previous comments, the NMAS are not converted to NSSDA, rather, NMAS is converted to CMAS. . . it is incorrect to make the statement that the result is NSSDA accuracy. . . Therefore, the sentences beginning "The quantity sqrt..." should be changed to read: "The quantity sqrt[*equation*] is a factor in CMAS horizontal accuracy. Therefore, the CMAS can be converted to a 95% confidence level, $Accuracy_r$:" After the equation, it should read: "Therefore, NMAS converted to circular error at a 95% confidence level is:" Please make similar corrections in section 2.3 (NMAS vertical accuracy, pg 3-16, section 3.2 (ASPRS horizontal accuracy, pg 3-19), and section 3.3 (ASPRS vertical accuracy, pg 3-20).	Y	The wording has been changed to "can be converted and reported *according to the* NSSDA" for all occurrences.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
13-1	Comments on Draft Geospatial Positioning Accuracy Standards, Part 3: National Standards for Spatial Data Accuracy We question the validity of this being a standard without their being some kind an expected accuracy specification for everyone to hold to. Webster's dictionary defines a standard as "An accepted measure of comparison for quantitative or qualitative value." Were the specification's contained within the NMAS so bad that we had to discard them in their entirety? Was the 40 foot rule for horizontal and the one half contour interval rule for vertical too strident (sic)? If it was indeed considered to be stringent, then we should of explored the possibility a larger value to measure against, like maybe 50 feet or more, instead of a total omission. We believe that this National Standard should be setting guidelines to establish a level of consistency for both the measurement of accuracy and for the interpreting of accuracy values. Recommend: That an accuracy specification be identified and hence, included within the content of this standard. This would establish a set level of consistency among all producers of spatial data.	Y	See resolution to comments 10-2, 12-5, and 12-6.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
13-2	It is written that the NSSDA is intended for use with new and revised spatial data. This statement makes the assumption that all new spatial data are being collected directly from recent observations of the ground, as it was in the past when we were manually compiling graphic maps. It should be recognized that spatial data has a much more broader meaning by today's standards; in that many spatial data products are now derived from other spatial data products. Even though an accuracy test that references the data to the ground in regards to what is true, is by far the best way to determine an "Absolute Accuracy;" it is also far from reality in terms of what the technology allows us to do today. The trend that has actually taken place for spatial data, is that users are testing for "Relative Accuracy", i.e. digital spatial data are tested against the source from which it was derived, as a check on the process used to make the product. This is in part, what makes spatial data so popular. USGS Examples are: DLG's are collected from base topographic maps (manuscript) DEM's are collected from DLG hypsographic overlays DOQ's are made from NAPP aerial photos and DEM's DRG's are a raster scan of a graphic map. In essence, all spatial products currently being produced within NMD production units are now tested for a "Relative Accuracy" in terms of how well the digital product represents the source from which it was derived. Given the absence of field parties to collect ground test points and the growing lack of resources in government; it is likely that you will find "Relative Accuracy" is the most common measurement being used for spatial data in government today. <u>Recommend</u>: That the focus of this standard be broadened to also include the condition for "Relative Accuracy." With the understanding, that the data producer be required to report the existing accuracy of the source from which the data was derived.	Y	See resolution to comment 12-2	COMPLETE

Log number	Comment	Substantive	Resolution	Status
13-3	The standard doesn't really define what accuracy is, in regards to the true meaning of the term "Accuracy." The term Accuracy actually has a broad usage and as a result has many meanings under its umbrella, with all of them being correct. Please reference to the sections 11.0 through 11.8 (pages 15-17) of the FGDC, Draft Content Standards for Digital Elevation Data, Jan. 1997 version. This standard offers some very excellent definitions for what accuracy truly is and also identifies the different types of accuracy for which measurements are in reference to. With the inclusion of these definitions within a National Standard of this type, it is less likely that a user will misinterpret the true meaning of the term "Accuracy" and its intended usage within this standard. Recommend: That the definitions being used within the FGDC, Standards for Digital Elevation Data; also be adopted for inclusion within this standard.	Y	See resolution to comment 12-4	COMPLETE
13-4	Section 3.2.3, Accuracy Test First paragraph states "The producer of spatial data will determine the geographic extent of the data to be tested and the amount of testing" while at the same time in the last paragraph to this section makes the statement that the user must "Test a minimum of 20 check points..." We should be specifying a maximum size for a geographic area to be tested based on extent and/or scale to which 20 check points are applied. This would establish a pattern of consistency between the spacing of test points by either scale or extent. The following two examples show the inconsistency and the extremes that can occur with the current wording in the standard: 1-Degree x 1-Degree area with 20 test points 7.5-minute x 7.5-minute area with 20 test points Recommend: That the first paragraph be deleted and hence, replaced with a specification that designates a maximum geographic extent for the containment of test points, based on either geographic extent, scale, or both.	Y	See resolution to comment 12-10	COMPLETE

Log number	Comment	Substantive	Resolution	Status
13-5	Section 3.2.3, Accuracy Test Paragraph 3, sentence 1, page 3-4 states: "Test vertical accuracy by comparing the elevations of well-defined points with the same points as determined from a source of higher accuracy." Well defined points don't exist in regards to graphic contours, DLG hypsographic data, or with any kind of elevation data. An elevation value from a digital derivative product can only be compared against the source, of the same exact X-Y coordinate, in order to obtain a single linear value for vertical. In other words: Vertical measurements are a point-to-point linear value of the same X-Y coordinate. Reword to: "Test vertical accuracy for Z by comparing the elevations of the source and check source against the same X-Y coordinate value of each data set."	Y	See resolution to comment 12-12	COMPLETE
13-6	Section 3.2.3, Accuracy Test, Paragraph 3, Last paragraph, sentence 1 For some of 24K- and 100k-scale maps and their corresponding digital products, there is not always enough geographic area available to allow for 20 check points, i.e. specifically for quadrangles with large void areas due to the bounding limits of Canada, Mexico and large open water areas (such as along the coasts Atlantic and Pacific Oceans, and etc). Add: When the geographic extent contains an excessive amount of area that is void of data coverage, due to either national boundaries or a large water body; then the producer may proportion the number of collected test points with that of the coverage that does exist.	Y	See resolution to comment 12-14.	COMPLETE
13-7	Section 3.2.4, Accuracy reporting Second paragraph would be easier to read if it was depicted with bullets. Add the following sentence to the end of the first paragraph and then show the three "if conditions" as bullets as follows: ...data set coordinates are in feet. Conditions for reporting accuracy are: • If data of varying accuracies can be identified separately..... • If data of varying accuracies are composited and cannot be separately identified..... • If a composited data set is not tested, ...	Y	See resolution to comment 12-15.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
13-8	Section 3.2.4, Accuracy reporting To be consistent with section 3.1.4; for the second and third examples, change wording from "intended" to that of "expected." I believe the word "expected" might better identify with an existing accuracy from the source to which the data was collected from.	Y	"Expected" has a specific meaning in statistics. All references to "expected accuracy" or "intended accuracy" will be changed to refer to the accuracy value given by product specifications.	COMPLETE
13-9	Section 3.2.4, Accuracy reporting For USGS DEMs and probably some other products, we only test for a vertical RMSE value, i.e. a point-to-point linear value of the same X-Y coordinate. Hence, we do not test for horizontal accuracy. Therefore, add the statement: "If a data set does not contain horizontal information, label for vertical accuracy information only" to the statement, "If a data set does not contain vertical information, label for horizontal accuracy information only"	Y	See resolution to comment 12-21	COMPLETE
13-10	Section 3.2.4, Accuracy reporting Recommend that "Relative Accuracy" also be allowed as a condition within the labeling. This would support the concept of "Truth in Labeling." Instead of forcing a user into finding a work around that allows them to report their measurement as an Accuracy; allow for both conditions of "Accuracy" and "Relative Accuracy."	Y	See resolution to comment 12-2.	COMPLETE
13-11	Appendix A, Section 1, Horizontal Accuracy Standard deviation evaluates a set of horizontal test points, i.e. for 20 data points together with 20 corresponding check points, and not just one coordinate pair. The singular reference to horizontal coordinate is incorrect. Reword sentence from "The standard deviation for the horizontal coordinate r is:" to: "The standard deviation for the set of horizontal test points are:"	Y	See resolution to comment 12-27	COMPLETE

Log number	Comment	Substantive	Resolution	Status
13-12	Reference; "where: d_i=, r_i=" Basically both of these equations are used to determine the same value, i.e. the linear distance (diagonal) between two X-Y coordinate pairs. As it was pointed out in the previous rewording, the need for the term "r" is not necessary. Therefore we can reduce the need from two equations to that of one, being ($d_i = \text{sqrt}[x^2_i + y^2_i]$). Further, It is believed, that not everyone reading this standard will have the background or experience to understand the intended usage of the subscripts, and etc. Therefore, we also suggest that the equations should be simplified as much as possible for easier interpretation, while at the same time explaining the nature of the subscripts. To summarize these comments, we recommend the following. <u>RECOMMEND:</u> The standard deviation for the set of horizontal test points are: $\sigma = \pm \text{sqrt}[\Sigma (d_i - d)\ 2 /(n-1)]$ where $d_i = \text{sqrt}[(x^2_s - x^2_{cs}) + (y^2_s - y^2_{cs})]$ $d = \Sigma d_i / n$, the mean discrepancy n = total number of points checked subscripts: i = one set of points of a domain s = data set coordinate cs = check source coordinate	Y	See resolution to comments 12-23 and 12-25	COMPLETE
13-13	<u>Appendix A, section 3, Well-Defined Points</u> As it was explained earlier; well defined points don't exist in regards to graphic contour data and DLG hypsographic data. <u>Recommend</u>: That a note be added that makes it clear to the user that this section is only applicable to horizontal data points.	Y	See resolution to Comment 12-36	COMPLETE

Log number	Comment	Substantive	Resolution	Status
14-1	In general this new standard is more flexible, and the standard is very readable. It allows agencies to clearly define a "pass/fail# criteria as the current NMAS does, however it is more of a reporting standard, as there are no defined accuracy specifications. Although the current title is adequate it is suggested that consideration be given to a different title such as National Standard for *Reporting* Spatial Data Accuracy.	Y	See resolution to Comment 12-1	COMPLETE
14-2	Part 1- Reporting Methodology, pg 5, last full paragraph "The method used to determine accuracy should be defined. Examples include: ... estimation." This seems like a drastic departure from set amounts to a guess? Is this reference appropriate?	Y	This reference is appropriate. Accuracy values obtained through any of the referenced methods are estimates, as the true ground position can only be estimated.	COMPLETE
14-3	Part 1 Section 1.6 The BLM Geographic Coordinate Data Base does not, at the present time, provide relevant vertical data.	N	Then report for horizontal accuracy only. To clarify this point, this wording is contained in the final draft: "The standard for reporting positional accuracy is defined for horizontal and/or vertical coordinates, depending on the characteristics of the data sets."	COMPLETE
14-4	Part 2 Geodetic Networks: General In general, we concur. The concept of new accuracy standards is elegant in its simplicity.	N		COMPLETE
14-5	Part 2 Section 2.1 Purpose Many BLM conventional and GPS surveys fall within the accuracy of Table 2.1, yet do not fit the definition of a geodetic control surveys in Section 2.1.	Y	Accuracy of cadastral surveying data will be reported according to Table 2.1, Accuracy Standards, in Part 2, Geodetic Networks, according to Ken Bays of BLM.	COMPLETE
14-6	Part 2 Section 2.5 Accuracy Standards The second paragraph of section 2.1 implies that three-dimensional network accuracies are not being considered, although GPS is a three-dimensional measuring system. (Our understanding is that a three-dimensional accuracy standard is not being considered because although GPS is a three-dimensional system, the horizontal component is more accurate than the vertical component. Many in the GPS user community expressed a desire to report a separate horizontal and vertical accuracy in order not to dilute the horizontal accuracy with the vertical component.)	N	It is correct that GPS users prefer to report separate horizontal and vertical accuracies because the vertical component is considerably less accurate than the horizontal component. Furthermore, we reference ground points to a horizontal datum (NAD 83 or NAD 27) and a vertical datum (NAVD 88 or NGVD 29).	COMPLETE

Log number	Comment	Substantive	Resolution	Status
14-7	Part 2 Section 2.6 National Spatial Reference System The section describes a four-step procedure to classify surveys and is generally well written. Some terms should be better defined, i.e., local and network accuracy measures. How do you define "the approximate average"?	Y	The term "approximate" has been deleted.	COMPLETE
14-8	Part 2 Section 2.6 National Spatial Reference System Surveys are examined to "verify compliance with the specifications for the intended accuracy of the survey," yet no specifications exist which are written which provide guidelines for achieving the new accuracy standards in Table 2.1. The existing Federal Geodetic Control Committee GPS specifications only address the old 1st , 2nd, and 3rd-order accuracy standards, as well as new Order AA, A, and B-order geodetic surveys. Therefore, this element of accuracy evaluation cannot be performed unless new specifications are also written.	Y	The procedure leading to accuracy classification is outlined in Section 2.3, National Spatial Reference System, in Part 2, Geodetic Networks.	COMPLETE
14-9	Part 2 Section 2.6 National Spatial Reference System Local and network accuracies are defined. Network accuracy is defined with respect to the Continuously Operating Reference Stations (CORS). In many states, common survey practice is to establish control in relation to the High Accuracy GPS Reference Networks (HARNs), because the CORS stations are too distant. For example, if a geodetic network in were established in southeast Oregon, the nearest CORS station would be several hundred kilometers away on the Oregon coast, yet HARN stations are available within 50 Km. Common practice is to establish the network using HARN stations. Should there be a third definition of accuracy with respect to the HARN, or will CORS stations be densified to such a level as to make the question irrelevant?	Y	CORS stations will be densified from 104 to 200 within two to three years so that they are spaced 100-200 km.	COMPLETE
14-10	Part 2 Section 2.6 National Spatial Reference System It was recommended that the final document include a chapter addressing topics such as network error ellipses, local error ellipses, and error circle radii. Such information would better define how to classify a survey under the new accuracy standards.	Y	These topics may be included as part of a separate FGCS document.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
14-11	Part 3 - National Standard: General It is noted that this standard represents a significant departure from previous views of accuracy standards. The standard dictates that accuracy should and must be reported, but does not make recommendations on the data accuracy as far as usability is concerned. This is somewhat of a buyer beware.	N	See resolution to comments 10-2 and 12-6.	COMPLETE
14-12	Part 3 - Sec 3.2.4, Accuracy Test Second sentence of paragraph 2 change: “Select the check source so that its accuracy is within one-third the data set’s intended accuracy at the 95% confidence level.	Y	See resolution to comment 2-16.	COMPLETE
14-13	Part 3 - Sec 3.2.4, Accuracy Test Paragraph 3, sentence 3 change: “Select the check sources so that accuracies at check point locations are within one-third the data set’s intended accuracy at the 95% confidence level.”	Y	See resolution to comment 2-16	COMPLETE
14-14	Part 3 - Sec 3.2.4, Accuracy Reporting statements, pg 3-5 To the lay person this may be confusing. These statements should be simplified and express the intent of the producer regarding the accuracy of the information contained in the product. As this does not seem to be an accuracy standard, but more of a reporting standard, does the statement “National Standard for Spatial Data Accuracy 1996" mean anything? Consider something like: “Tested data are ___ meters/feet of true vertical/horizontal position, 95% of the time.” and “Defined points are compiled to meet ___meters/feet of true horizontal/vertical position.”	Y	See resolution to comments 12-18 and 12-20	COMPLETE
14-15	References should be inclusive of equations, statistics, etc. used in producing this standard. This will allow users to verify mathematical references and lend credibility to the standard.	Y	See resolution to comment 12-22	COMPLETE
14-16	Under Appendix A, after the “where” section it states, “NSSDA horizontal accuracy is:” This is confusing, since it implies that there is an accuracy result from NSSDA when actually it is a reporting mechanism and the authority for the accuracy value comes from the producer of the data.	Y	See resolution to comment 12-28	COMPLETE

Log number	Comment	Substantive	Resolution	Status
14-17	The document in Appendix A, 3 under Well-Defined points needs to clarify test points. Test points will differ depending on the product being produced. This may need to be clarified and include examples of the kinds of test points that could be used and are suitable for spatial products.	Y	See resolutions to comments 12-29 through 12-36.	COMPLETE
14-18	In Appendix A page 11 the classification stops at 10 meters. Classification should reflect any accuracy or circle of error that might be used for digital mapping, GIS, and LIS. Admittedly, a circle of error accuracy value of 300 feet for a single point entity may not be desirable, it may indeed be the best available. Knowing that accuracies may be very poor is valuable information for all users of the data. It is in fact an inventory of where accuracies are reliable and where they are not. Ultimately, data users must identify acceptable accuracies for their applications.	Y	Table has been deleted: see resolution to comment 12-39	COMPLETE
15-1	Is there a formal definition of spatial data?	Y	A definition will be included as a part of a glossary that will be included as an informative appendix to Part 1.	COMPLETE
15-2	Should more attention be given to the difference between primary (measured) data and derived (computed) data? It makes a difference in error propagation?	Y	This standard is concerned only with the accuracy of point coordinates in the final data product, after all process steps.	COMPLETE
15-3	Past practice has been to store spatial in analog form on flat maps. Current practice is to store spatial data in digital form in an electronic data base. The interaction of issues - digital/analog and primary/derived should be discussed further?	Y	See response to comment 15-2.	COMPLETE
15-4	Is it correct to say network accuracy is defined by the standard deviations of geocentric X/Y/Z coordinates of a point and that local accuracy is derived using the covariance values of a point pair? . . . For myself, I'd feel better with more mathematical specificity than just saying local accuracy expresses an average of local uncertainties.	Y	See response to comment 17-1	COMPLETE
15-5	What accuracy standards were published by the Federal Geodetic Data Subcommittee (sic)?	Y	See references for Part 2, Standards for Geodetic Networks	COMPLETE
15-6	Address comments to FDGC Secretariat?	N	Once the FGDC has endorsed the standard, please direct questions to the agency identified in the "Maintenance" section of each part of this standard.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
15-7	Page 2-5: Did someone miss the superscripts in the equation for local accuarcy?	Y	Superscripts have been added to the final draft.	COMPLETE
15-8	Page 3-9: Where does the number 2.4477 come from? I think I know, but I couldn't find it in the document. What assumptions are implicit in its use?	Y	2.4477 is the factor for circular error at the 95% confidence level. It assumes that error is equal and independently distributed in the x, y coordinate. There will be citations and bibliographic references for this factor.	COMPLETE
16	As for horizontal shifting of the well-defined point, we believe it probably should not be done and … now recommend that you remove that from the standard. It is a difficult concept to understand and would need some very hard and fast rules. As it is now, people in NMD don't really understand it and sort of interpret it in various ways. Realize too that this shift was an imaginery (sic) shift. We really did not shift the feature on the map or digital product. During testing, we basically measured a circle around the feature and re-interpolated the elevation depending on where that circle fell with respect to the contour lines. We had specific criteria for when and how much a feature could be horizontally shifted to help it pass the vertical test. In the [USGS] Procedure Manual for Map Accuracy Testing, 5/87, on pages 32 - 36, there are instructions and a table that gives the shift values we were allowed for our tests. The amount of horizontal shift was also dependent on the spacing of the contours. Since there may be a wide variety of producers having various scales and contour intervals, etc. I think it would be difficult for FGDC to define something that all producers could consistently apply.	Y	Reference to shifting the position of the well-defined point to re-interpolate the elevation has been deleted.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
17-1	The way I read and understand the proposed geospatial positioning accuracy standards, the network accuracy of a point would be given by the standard deviations… The standard deviation of the inverse distance between points would be the local accuracy between points not directly connected as stated on page 2-5. But since these two points were directly connected by a simultaneous GPS survey, correlation does exist and the local accuracy is determined as per the example in the second attachment. But, the proposed accuracy standards say something about "average" local accuracy on page 2-4. Is that really the way it should be done? I get the feeling someone is trying to do too much thinking for the user. Doesn't the user community deserve to know specifically what equations and methods are being used to determine this thing called local accuracy?	Y	There still may be some confusion about network accuracy. Basically, network accuracy represents how accurate a point's coordinates are relative to the coordinate system. Since the coordinate system will be realized through the national network of GPS Continuously Operating Reference Stations (CORS), the length accuracy of a point relative to the nearest CORS (with the assumption that the CORS has "zero" uncertainty, i.e., its coordinates are fixed) provides the network accuracy. That's why network accuracy is defined that way. . . . local accuracies are computed using all covariance information. Covariance information is used in the computation of the length (or distance) relative accuracy between two points. That's what local accuracy is: the length relative accuracy between two points. Because users want a single horizontal classification for a point, the local accuracy of a point (not a very scientific statistic) is the average of all local accuracies to nearby, directly connected (via observations in our data base) points. Because there are usually more than one nearby, directly connected point, we decided that an average was a "fair" number to represent the local accuracy of a point. However, all local accuracies at a point to nearby, directly connected points (up to a maximum of some reasonable number, probably about 20) will also be provided to users ("published") with the adjusted coordinates. Therefore, users will have the "real" local accuracy value between any two NGS-directly-connected points they're using. Please note that we will not be providing local accuracies (length relative accuracies) between nearby UNCONNECTED points. If users request this information between a specific pair of points, we should be able to "grab" a piece of the network containing these two points, do a quick adjustment, and provide an estimate. This may not be a rigorous solution, but the estimate will be an excellent approximation, which is really all that accuracies are anyway.	COMPLETE

Log number	Comment	Substantive	Resolution	Status
17-2	Multiple accuracy (3.2.2) acknowledges different accuracy for horizontal and vertical. Radical thought - Why not just use accuracy in each component separately. It simplifies the statistics (one does not need to worry about that factor of 2.4477 I asked about earlier) and the GSDM [Global Spatial Data Model] competently tracks spatial accuracy in all three dimensions while permitting the user to look at standard deviations of all three local components with equal ease. That may be too big a jump to do now? We are all still hung up on horizontal and vertical as opposed to considering accuracy component by component? Have I misunderstood anything?	Y	Regarding stating a single horizontal accuracy (in terms of the radius of a circle) versus separate x and y values, … users are still "horizontal" and "vertical" oriented and for now that was the way to go. Also, the ISO (International Standards Organization) uses this methodology… We discussed with our photogrammetry friends for over a year which method to use (since they originally proposed separate x and y accuracy values), but all agreed in the end that a single horizontal value was more "user friendly." Also, we debated the 1-sigma (67-percent) versus the 2-sigma (95-percent) confidence levels, but the 2-sigma level won out. So the thoughts you now raise were carefully considered during the development of these accuracy standards.	COMPLETE
17-3	You asked about primary spatial data versus secondary spatial data. In my opinion, the difference lies in its creation. Spatial data are created by the physical measurement of some combination of fundamental physical quantities. Distances (spatial data) computed from those measurements have an accuracy determined by the measurement configuration and the competent propagation of uncertainty to the computed result. Those are primary spatial data. Secondary spatial data are those derived from primary spatial data by computation, transformation, or other manipulation. In the simplest case, secondary spatial data can be used and discarded because the only investment in their creation is copying the data from some primary source.	Y	This standard is concerned with estimating the accuracy of point coordinates in the final data product, after all process steps have been completed, not with the process by which point coordinates are derived.	COMPLETE

Key to comments: by prefix

1	Gene Dial, Space Imaging, Colorado
2	Milo Robinson, State Geodetic Advisor, Vermont
3	Gene Dial, Space Imaging, Colorado
4	Dean Merchant, Topo Photo, Inc., Ohio
5	Mr. Arliss Whiteside, GDE Systems, Inc
6	Mid-Continent Mapping Center, USGS
7	Jo Anne Stapleton, Mapping Applications Center, USGS
8	Rob Schmidley, Senior Research Associate, Center for Mapping, OSU
9	Larry Christenson, via Karen Schuckman, Piedmont Aerial Surveys
10	James Robeson, State of Florida Department of Environmental Protection
11	Environmental Protection Agency
12	Tom Schulz, Rocky Mountain Mapping Center (RMMC), USGS (in response to request for clarification)
13	Ken Osborn, Chair, RMMC Elevation Team
14	Ken Bays and Dave Meier, Bureau of Land Management
15	Earl F. Burkholder, Global COGO
16	Tom Schulz, Rocky Mountain Mapping Center (RMMC), USGS
17	Earl F. Burkholder, Global COGO (in response to requests for clarification)

SOP-07: GLOBAL POSITIONING SATELLITE SYSTEM (GPS)

1.0 Purpose

This standard operation procedure (SOP) outlines the protocols and general procedures for operating a mapping grade global positioning satellite system (GPS) handheld instrument. Establishing standardized protocols for collecting environmental data in the field using Global Positioning System (GPS) technology is imperative to the success of any project. The guidelines in this section have been developed to ensure consistent GPS data collection and post-processing techniques across projects, staff, and geographic locations. The methods described are based on Trimble submeter mapping grade GPS devices and Trimble Pathfinder Office software. These procedures are to be used as a reference tool in conjunction with specific GPS and job procedure training.

GPS is divided into three fundamental aspects: control, space, and user (Trimble, 2006).

- Control is the central "brain" of the GPS system. A GPS controller monitors the satellites' transmission of navigation messages and sends adjustments, if necessary. The U.S. Department of Defense (DoD) operates this segment from Falcon Air Force Base in Colorado Springs, Colorado. Control also includes four monitoring and upload stations distributed throughout the world, with each satellite passing over a monitoring station twice a day.

- Space is the Navigation Satellite Timing and Ranging (NAVSTAR) constellation of satellites that broadcast GPS signals. When the system is at full operational capacity, there are 24 operational satellites. This number changes constantly as satellites are commissioned and decommissioned. These satellites orbit 20,200 kilometers (km) above the earth and make one complete revolution approximately every 12 hours.

- Users include all civilian and military personnel worldwide, who use GPS to calculate global spatial positions using many applications. Civilian users currently outnumber military users worldwide for applications such as agriculture, aviation, emergency services, recreation, and vehicle tracking.

GPS is based on satellite ranging, which is the measurement of how much time it takes a radio signal to reach the GPS receiver from a satellite and then a calculation of distance using that time. In satellite ranging, the GPS receiver compares digital codes generated at precisely the same time by a GPS satellite and the GPS receiver (Trimble, 2006). Identical “pseudorandom” codes are generated by all GPS equipment (satellites and receivers) every millisecond. Time is calculated as the difference between when the satellite generated the code and when the receiver receives the code. Trilateration is then used to measuring the distance from at least three satellites to establish a position on Earth. However, the accuracy of a measurement based on three satellites may be diminished because of non-synchronization of clocks in the GPS satellites and the receiver (Trimble, 2006).

An accurate position is calculated by using four satellites. Four imperfect measurements can eliminate timing offsets and microprocessors in the GPS receiver recognize timing offset when it receives a series of measurements that it cannot intersect at one point (Trimble, 2006). The GPS receiver then automatically starts subtracting the same amount of time from all of the measurements until a position on Earth is determined. Trimble GeoXT and GeoXH receivers have at least twelve parallel channels to receive radio transmissions from up to twelve GPS satellites simultaneously.

The orbits of all GPS satellites are measured constantly by the DoD, which determines satellite ranging and calculates the exact location of each satellite as ephemeris data (Trimble, 2006). The ephemeris information is a data file that contains orbit information for one particular satellite. The DoD then transmits the ephemeris data to the satellites, which then transmit it to GPS receivers. This information is used by the GPS receivers along with their internal almanac to establish precisely the position of the satellite.

Differential GPS is used to determine the precise measurement of the relative positions of two receivers tracking the same GPS signals (Trimble, 2006). This requires a receiver to be placed as a base station over a known coordinate benchmark. The base station determines what errors the satellite data contains and then that of other GPS rovers then uses this corrected information to eliminate error in their measurements. Differential GPS measurements are much more accurate than standard GPS measurements and when taking measurements in the differential mode, GPS spatial accuracy of less than one meter can be achieved. However, the ultimate accuracy of a GPS position is determined by the sum of several sources of error, the contribution of which varies depending on atmospheric and equipment conditions (Trimble, 2006). Sources of error that affect the results of GPS data collection include atmospheric conditions and physical objects causing obstructions and reflected signals. Source errors can be minimized by applying rigorous data collection techniques to equipment setup and obtaining satellite lock.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in environmental investigation activities at the Former DuPont East Chicago Facility, Indiana (DuPont EC) site. This SOP focuses on the most commonly used site redevelopment surveying and environmental surveying and sampling tasks and applications anticipated at DuPont EC and should be used in conjunction with other applicable project SOPs, including the following:

- *SOP- Field Documentation*
- *SOP- Hollow Stem Auger and Direct Push Drilling Methods*
- *SOP- Discrete Surface and Subsurface Soil Sampling*
- *SOP- Monitoring Well/Piezometer Installation*
- *SOP- In-Situ Soil Stabilization*
- *SOP- Geographic Land Surveying*
- *SOP- Geophysical Survey*
- *SOP- Groundwater Level Measurement*
- *SOP- Continuous Water Level Monitoring*

3.0 Procedures

3.1 Equipment and Software

A GPS system has three components: data collector, GPS receiver, and TerraSync™ or similar control software. A GPS handheld device that combines the GPS receiver and data collector is known as a “Rover” (Trimble, 2006). A rover with the Trimble TerraSync™ software makes up a complete GPS data collection system. A Trimble GeoXT combines all these elements into one unit.

3.1.1 Hardware

There are a number of different GPS system configurations available; this SOP focuses on the handheld Trimble GPS Pathfinder receivers such as the Trimble GeoXT and GeoXH GPS rovers. These 12-channel devices allow for 2D RMS sub-meter accuracy (within 1 meter of the indicated position 95 percent of the time) following post-processed differential correction. *Attachment 2: Trimble GPS Receiver Comparison* provides a comparison of the various Trimble GPS rovers. *Attachment 3: Trimble GPS Hardware and Software* provides details on the Trimble GeoXT and GeoXH GPS rovers.

3.1.2 TerraSync Software

Trimble GeoXT and GeoXH GPS rovers running Trimble TerraSync™ software are designed for collecting and updating GIS and spatial data by transferring files between a GPS rover and an office computer. The TerraSync™ software acts as the controlling software (user interface) and communicates with the Trimble GeoXT or GeoXH to set GPS parameters in the receiver, record GPS positions on the data collector, and maintain existing GIS data (Trimble, 2006). Transferring TerraSync™ software files between a GPS rover and an office computer requires the Microsoft® ActiveSync® software and either GPS Pathfinder Office Software (version 3.10 or later) or the Trimble Data Transfer utility, which is available for free download from the Trimble website (Trimble, 2010b; Microsoft, 2007).

3.1.3 GPS Pathfinder Office software

After GPS data is collected and transferred to a computer, the information can be processed and exported using the GPS Pathfinder Office software (Trimble, 2006). The GPS Pathfinder Office software provides the tools needed to effectively do the following:

- Use task planning software to find the best times of day to collect data
- Create data dictionaries that describe the features you want to collect
- Edit attributes and offsets and delete erroneous positions
- Importing data updates from GIS
- Transfer data files between a field computer and your office computer
- Differentially correct data
- Export data to a Computer Aided Design (CAD) system or Geographic Information System (GIS).

Sections 5.2 and 5.3 and *Attachment 4: TerraSync™ and GPS Pathfinder Office Software and Orientation Guide* provide additional instructions on using the GPS Pathfinder Office Software. *Attachment 3: Trimble GPS Hardware and Software* provides details about the GPS Pathfinder Office Software.

3.2 Pre-Field Planning

Project planning is critical to GPS data collection. Several steps should be completed before deployment to the field. Many items need to be considered before field data collection, including the incorporation of existing data resources and the preparation of field tools towards appropriate integration into future data deliverables. Before field data collection the following data requirements should be considered and planned.

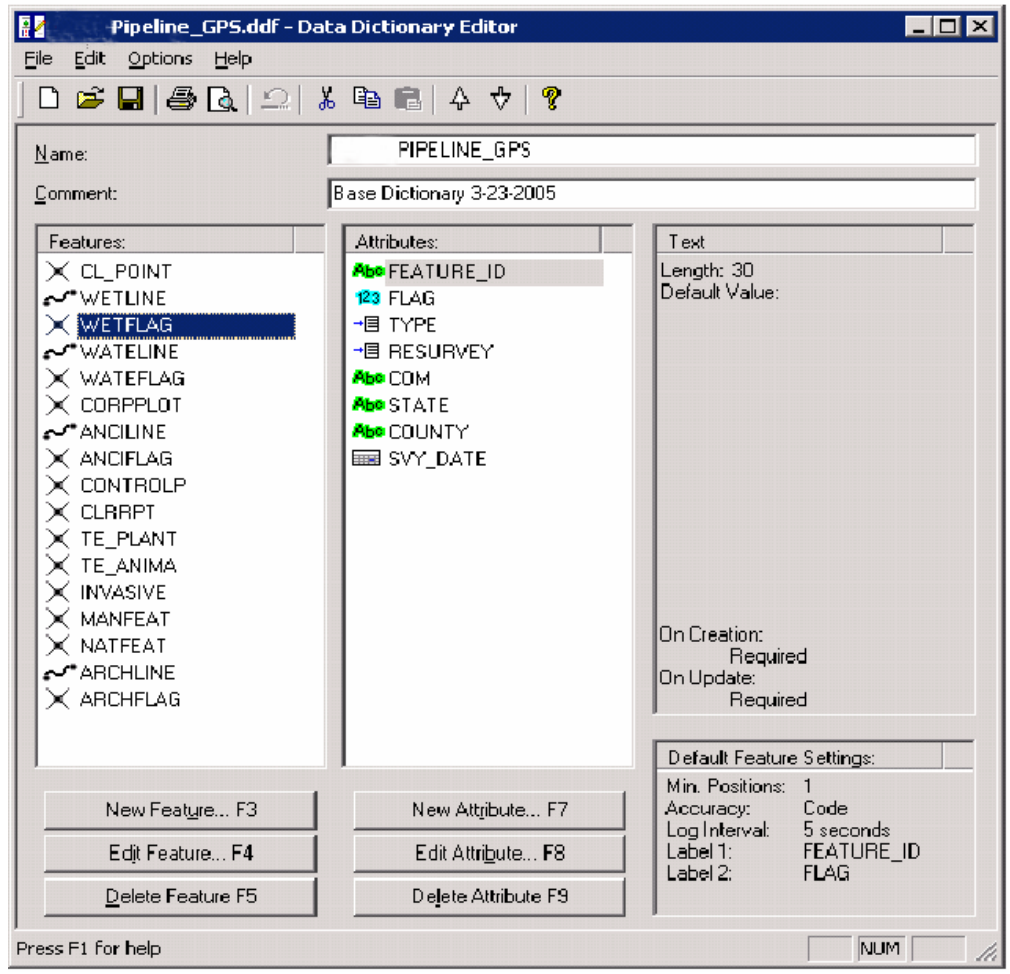
3.2.1 Data Standards

Determine the GPS data collection data standards before using the GPS in the field. The Spatial Data Standard for Facilities, Infrastructure and Environment (SDSFIE) is the common standard for U.S. military and other federal clients and is a template for creating standardized geospatial information.

3.2.2 Data Dictionaries

Develop data dictionaries before field data collection to help increase data collection efficiency and integrity of the data. Data dictionaries can supply order to GPS data collection tasks. As an example, they use dropdown menus with defined attributes to standardize data collection. Other examples include required fields, automated fields for date and time generation, standardized symbology, and standard logging (recording) intervals to meet specific accuracy requirements. SDSFIE data dictionaries can automatically be generated using the SDS2DDF application. The SDS2DDF application imports data into the Trimble Data Dictionary Editor, which can then be uploaded into a Trimble GPS unit for field collection.

The proper data dictionary file must be transferred from a computer to the GPS device before any data collection. Whenever possible, do not use the default data dictionary on a GPS rover. IEC has standardized data dictionaries for environmental investigation projects in addition to customized dictionaries that can be tailored to project or client specific requirements. Use of the correct and current data dictionary will directly affect the entire data collection process. In addition, it is important to note that if multiple field teams will be collecting data on a project, it is critical for each team to be using the identical data dictionary. If all teams are not using identical data dictionaries, it will substantially increase the post data collection processing time and delay project deliverables. Because of this, it is highly recommended to coordinate GPS needs with the GISM early during the planning stages of a GPS data collection task. All data dictionaries should be developed by or with the assistance of the GISM before field data collection.



Example Data Dictionary.

3.2.3 Photograph Collection

Based on the project needs, photographs can be linked to the corresponding spatial data locations via both X and Y coordinates, as well as by time. There are a variety of GPS/software/camera combinations available; consult the GISM before field data collection if this feature is necessary.

3.2.4 Data Management Guidelines

Reliable and secure data management practice is essential to quality data collection and future data use and should be maintained during all preparation, data collection, and post- processing stages. If quality data management practices are not followed, significant amounts of valuable and often irreplaceable data can be lost or significant effort may be required to post-process data. GPS data management includes managing data within the standardized directory structure, setting up the GPS device, and verifying data backup as well as data flow from project planning though correction and export to GIS production data. Generally, proper data management includes daily downloading and delivery of GPS files to the GISM. The GISM should be consulted regarding any data management procedures or issues.

3.2.5 Configuring Critical Settings in the TerraSync software

There are some critical settings in the TerraSync software that must be configured before collecting GPS data; these critical settings include GPS settings, logging settings, real-time settings, coordinate settings, and unit settings. Critical settings can be configured in the office or in the field, and non-critical settings can be set to suit the task-specific application or needs. However, it is recommended that the critical settings be configured by or with assistance from the GISM before field data collection. In addition, the critical setting should remain the same throughout the project or task and should not be altered before each data collection session. *Attachment 4, TerraSync™ and GPS Pathfinder Office Software and Orientation Guide* provides detailed instruction on how to configure the critical settings in the TerraSync™ software.

3.2.6 Pre-Event PDOP Planning

To gain the most accurate GPS data possible, determine times for best satellite coverage before GPS data collection. Trimble Planning Software (or the Quickplan application in previous versions of the Trimble GPS Pathfinder Office software) should be used to predict if any downtime will occur, based on satellite ephemeris data (Trimble, 2008). These applications will graph the number of satellites available at any given time during the day as well as the PDOP (Position Dilution of Precision) for the satellite configuration. When the satellites are spread around the sky, the PDOP is low and GPS accuracy is higher. When the satellites are close together, the PDOP is high and GPS accuracy is lower. A PDOP below 6 is required for submeter accuracy on a Trimble GeoXT or GeoXH GPS rover; therefore, a PDOP reading of less than 6.0 will be required to collect rover data. For the most accurate planning, latest ephemeris data file should be downloaded from the Trimble website (Trimble, 2010a)

3.3 Field Use and Data Collection

3.3.1 GPS Status and Startup

Follow the below general procedures and guidelines for checking the GPS system status and starting to use the GPS rover in the field (Trimble, 2006):

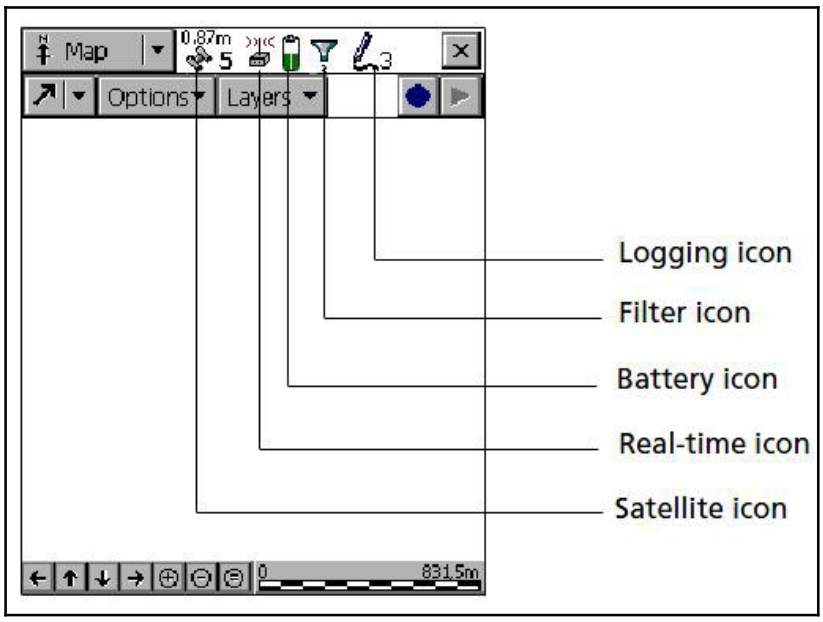
- Before data collection, check the status of your receiver. Begin by going outdoors and when ready, turn on the Trimble GeoXT or GeoXH and start the TerraSync™ software to allow it to begin satellite tracking. The GPS receiver should activate automatically. This is done using the GPS rovers stylus (plastic pen) to tap the "Windows Start" button on the Microsoft Windows® or Windows Mobile® taskbar and then selecting *Programs* → *TerraSync*. While the software is loading, the Trimble identification screen appears followed by (typically) the TerraSync™ *Skyplot* status screen.

- Next, obtain a clear view of the sky by moving to a location where the receiver has clear line of sight to the sky. Signals can be received from any direction but can also be blocked by people, buildings, heavy tree cover, large vehicles, or powerful transmitters. Because of this, optimal locations include open fields,

parking lots, or other open spaces free of obstructions above the horizon. GPS signals can go through leaves, plastic, and glass if necessary, but these signals are weakened. The receiver typically gets the best reception when facing south.

- Next, begin to check the GPS status. Once the TerraSync™ software starts, it automatically connects to the GPS receiver and begins to track visible satellites and to calculate its current position. Use the *Satellite* icon on the *Status Bar* to check whether the receiver is computing GPS positions. The software provides information about the geometry of the satellites that are being used to compute GPS positions.

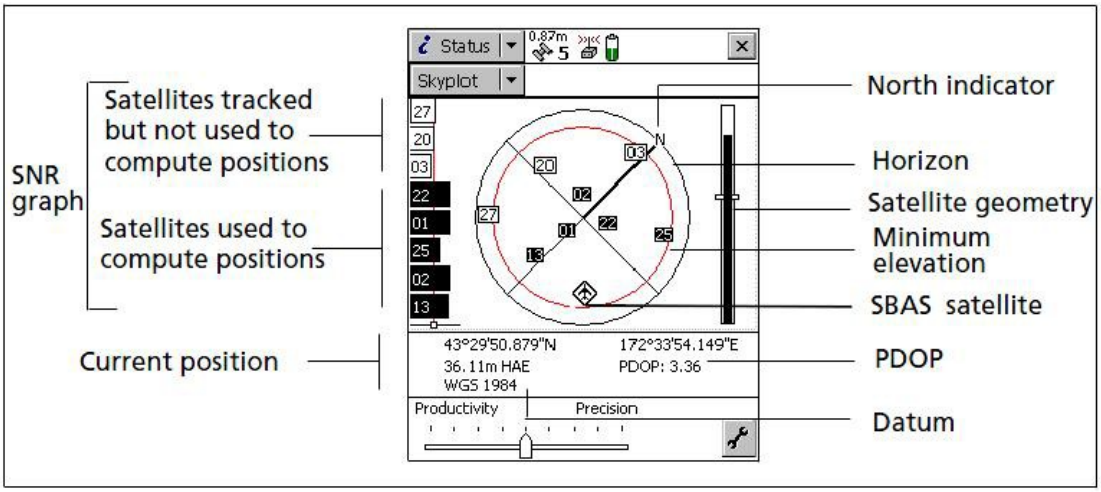
- The *Status Bar* appears in the top row of the TerraSync™ screen. It is always visible, but the icons displayed depend on the current status of the system. The *Status Bar* provides basic information about the status of the TerraSync™ software. Figure 3 below shows the icons in the *Status Bar*. (Note this shot is the Map view).



TerraSync™ Status Bar (Trimble, 2006).

- Use the *Status* button to view the satellites currently tracked and those that are being used to calculate the current position. To view the GPS status, do the following:

- The *Skyplot* screen typically is the default screen that appears when you first run the TerraSync™ software. If this screen is not visible, tap the *Section* list button (upper left corner), select *Status*, tap the Subsection list button and then select *Skyplot*. Figure 3 shows the parts of the *Skyplot* screen.
- Use the Skyplot screen to check the satellites that are being tracked and to see your current position. Filled black boxes represent satellites that the receiver is using to compute its current GPS position. White boxes represent satellites that the receiver is getting signals from but is not using because the signals are too weak. If an SBAS satellite is being tracked, its location is indicated by the “Airplane” icon as shown in Figure 4. The current GPS position is displayed at the bottom of the screen.



Example Skyplot screen showing eight GPS satellites, of which five are being used to compute the current GPS position (Trimble, 2006).

A minimum of four satellites with good geometry are required to compute a three- dimensional GPS position and collect X, Y, and Z spatial data. Note that Z data is not submeter accuracy with a mapping grade GPS unit such as the GeoXT. Use the Satellite icon in the status bar to check whether the receiver is computing satellite positions. If the Satellite icon and the number below it are solid (not flashing), the receiver will allow data to be collected. The number above the Satellite icon shows the CEA (Current Estimated Accuracy), which is an indication of the horizontal accuracy (RMS) of the current GPS position. If the satellite geometry is poor or if there are too few satellites available to compute GPS positions, adjust the GPS Slider as described in the critical settings configuration in Attachment 4 or wait until conditions are more favorable.

More advanced instructions are provided in the *Attachment 4: TerraSync™ and GPS Pathfinder Office Software and Orientation Guide.*

3.3.2 Basic Data Collection

The following general procedures and guidelines provide basic instruction for GPS data collection using a Trimble GeoXH or GeoXT GPS rover in the field (Trimble, 2006).

Additional data collection instruction is available in *Attachment 4*.

Creating a New Data File

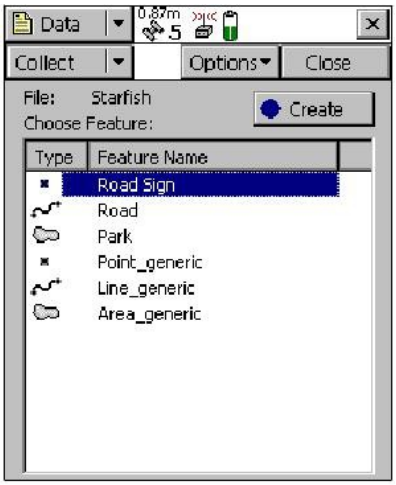
Before starting the data collection session, use the *Data* screen to create a new data file (know as a Rover File) to store the new features and attributes collected. Create a new Rover File by doing the following (Trimble, 2006):

- Tap the *Section List* button and then select *Data*.
- Tap the *Subsection List* button and then select *New*. The *New File* screen appears and the TerraSync™ software automatically enters a default name in the *File Name* blank. If desired, create a new File Name by using the TerraSync™ keyboard. Typically a filename including the date and initials of field collector should be used.



New File screen (Trimble, 2006).

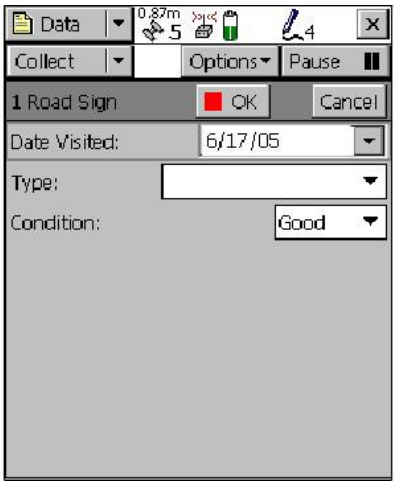
- In the *Dictionary Name* field, select a data dictionary.
- Tap *Create*. The *Collect Features* screen appears. This screen shows a list of all the features in the data dictionary. A new data file has now been created and data features can start to be collected.



Collect Features screen (Trimble, 2006).

When you record a point feature, you must remain stationary for the duration for which the TerraSync™ software logs a number of GPS. These positions are averaged together to compute the final GPS position of the point feature. When the TerraSync™ software is logging GPS positions, the *Logging* icon appears in the *Status bar*. The number beside the icon indicates how many positions have been logged for the selected feature. Record a point feature by doing the following:

- Make sure the *Collect Features* screen is open. If it is not, tap the *Section List* button and select *Data*. Then tap the *Subsection List* button and then select *Collect Features*.
- In the *Choose Feature* list, highlight an appropriate point feature and then tap *Create*. The point attribute entry form for the feature type appears.



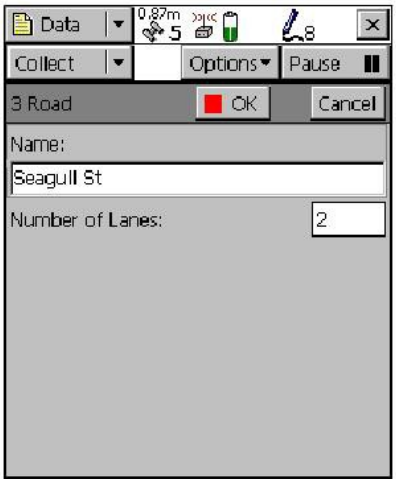
Point Attribute Entry Form (Trimble, 2006).

- Fill in the attribute fields with the appropriate values. As the software logs GPS positions, the counter beside the logging icon increases incrementally. It is suggested that at least 15 count increments using a 1-second interval are collected for reliable and efficient data collection; 30 count increments are recommended for the most accurate data collection.
- When recording the point feature has finished and all attributes have been entered, tap, *OK* to close the point feature. The attribute entry form closes and you are returned to the *Collect Features* screen.

Collecting a Line Feature

To record a line feature, you need to travel along the line. As you do so, the TerraSync™ software records a GPS position at the configured interval, which was set when the feature was created in the data dictionary. These positions are joined together to form a line. Create a new line feature by doing the following (Trimble, 2006):

- Make sure the *Collect Features* screen is open. If it is not, tap the *Section List* button and select *Data*. Then tap the *Subsection List* button and then select *Collect Features*.
- In the *Choose Feature List*, highlight an appropriate line feature.
- Tap *Create*. The line attribute entry form for the feature appears.



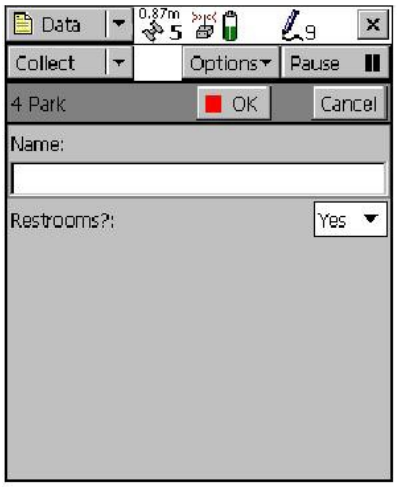
Line Attribute Entry Form (Trimble, 2006)

- Begin slowly traveling along the line feature to be collected making sure the GPS is logging positions. When you reach the end of the line feature being logged, tap *OK* to close the line feature. The attribute entry form closes and you are returned to the *Collect Features* screen.

Collecting an Area Feature

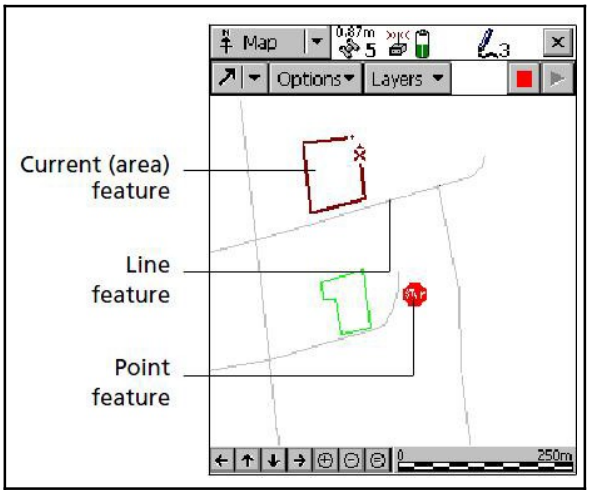
To record an area (polygon) feature, the GPS rover will need to travel around the perimeter of the area to be surveyed. As the GPS rover travels, the TerraSync™ software will log the GPS positions at the logging interval set in the data dictionary during configuration of the critical settings. When travel around the perimeter of the area has been completed, the first and last GPS positions are joined together by a straight line to close the area and form the area feature. Therefore, in some instances there is no need to return to the exact starting point to complete the feature. Create a new area feature by doing the following (Trimble, 2006):

- Make sure the *Collect Features* screen is open. If it is not, tap the *Section List* button and select *Data*. Then tap the *Subsection List* button and then select *Collect Features*.
- Tap *Options* and then select *Log Now*.
- In the *Choose Feature* list, highlight an appropriate area feature.
- Tap Create. The attribute entry form for the area feature opens, and the TerraSync software starts to log positions.



Area Attribute Entry Form (Trimble, 2006).

- Logging can be paused at anytime. For example, if you are traveling around the perimeter of an area and you want to stop and examine an object some distance away; you would pause logging positions for the area perimeter boundary while you investigate the object. Logging can also be paused if time is needed to enter attribute values. To pause logging, tap *Pause*. The TerraSync™ software stops logging positions and a pause icon flashes in the *Status Bar*. To continue collecting the area feature, tap *Resume* to resume logging again. The pause icon will disappear.
- A map of the area feature can also be viewed while collecting features. To do this, tap the *Section List* button and then select *Map*. The features that have been collected will appear on the map, along with the area perimeter that you are currently collecting.



Map View will collecting features (Trimble, 2006).

- In addition, the map can be viewed at different scales. To do this, tap the *Zoom In* or *Zoom Out* button on the Command Bar. Or alternatively, tap the *Map Tools List* button, select *Zoom In* or *Zoom Out*, and select the point on the map that you want to zoom in or out from.
- To go back to the *Data Section*, tap the *Section List* button and select *Data*. The attribute entry form will still be active and the TerraSync™ software will still be logging positions for the area feature.
- When you have traveled around the perimeter of the area, tap *OK* to close the area feature. The attribute entry form closes and you are returned to the *Collect Features* screen.

Ending the Data Collection Session

Once complete, a data collection session can be ended by closing the data file and exiting the TerraSync™ software. Close your data collection session by doing the following (Trimble, 2006):

- Once in the *Collect Features* screen, tap *Close,* making sure you are not in the process of collecting a feature.
- A message will appear, asking you to confirm that you want to close the open file. To close the current data file and return to the *New File* screen, tap *Yes*.
- To close the TerraSync™ software, tap the Microsoft Windows close-out "X-box" button in the top right corner of the screen. A message will appear, asking to confirm that you want to exit the TerraSync™ software.
- Tap *Yes* to confirm.
- Press to power button on the GPS unit to turn off. Make sure you do not hold the power button in for any length of time as this will reboot the unit and potential loss of data can occur.

3.4 Data Download, Post-Processing, Validation, and Correction

3.4.1 Data Download

Collected GPS data including data files, base data, data dictionaries, and almanacs can be transferred from a Trimble GeoXT or GeoXH GPS rover to the GPS Pathfinder Office software via a desktop or laptop computer (Trimble, 2006).

Connecting the GPS rover to an office computer

- Turn on the desktop or laptop office computer and verify that Microsoft ActiveSync technology software and GPS Pathfinder Office software are installed (Microsoft, 2007).
- Place the GPS unit in the provided cradle and make sure power is being supplied to the cradle via a power outlet. Turn off the GPS rover and connect the GPS rover cradle to the office computer using the USB data cable supplied with the GPS rover. The Microsoft ActiveSync software should automatically establish a connection with the GPS rover and the GPS rover will also automatically turn on at this time. When connected, the message *Connected* appears in the main Microsoft ActiveSync window, and its taskbar icon turns green. Make sure to not sync the GPS unit with the office computer or laptop when the ActiveSync synchronization setup wizard dialog box shows. Select the cancel button and the GPS unit will be connected via a guest connection and will not sync the two devices. See screenshot below.

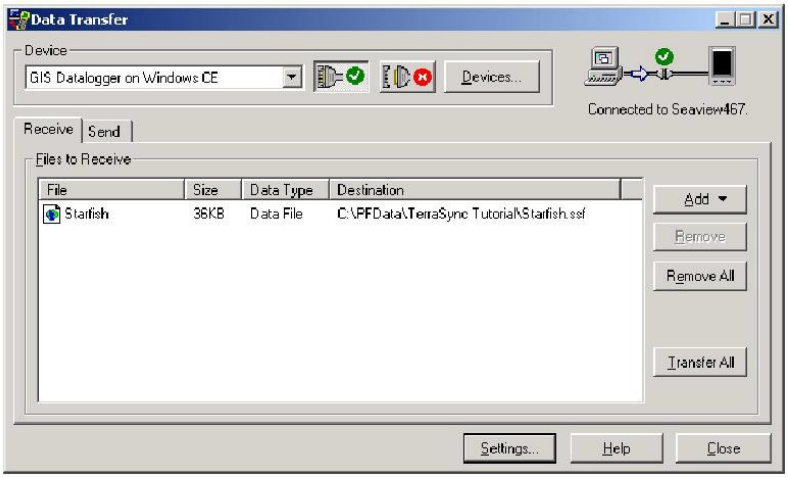


- If the Microsoft ActiveSync software does not connect automatically, connect to the GPS rover manually. For more information, refer to the Microsoft ActiveSync software *Help*. The screenshot below shows a properly connected Microsoft ActiveSync icon (Green circle with arrows). The icon is grey when the GPS is not connected to the computer.



Transfer Rover Files to the Office Computer

- Open the GPS Pathfinder Office software on the office computer.
- In the GPS Pathfinder Office software, select *Utilities* → *Data Transfer*. The Data Transfer dialog screen appears.
- From the *Device* list, select the device called *GIS Datalogger* on the Microsoft Windows CE operating system. Alternatively, if you have set up a device name for the GPS rover, select that device name from the list. The Data Transfer utility automatically connects to the GPS rover.
- Select the *Receive* tab, and click *Add* and then select *Data File* from the drop-down list The *Open* dialog screen appears. Note that the files that appear are those in the TerraSync software data folder on the GPS rover.
- Highlight the rover file and then click *Open*. The Open dialog screen disappears and the selected file appears in the *Files to Receive* list.



GPS Pathfinder Office Data Transfer Utility (Trimble, 2006).

- Click *Transfer All*. The data file is then transferred to the office computer and a message showing summary information about the transfer appears.
- Click *Close*.
- To exit the Data Transfer Utility, click *Close* again.
- For more information, refer to Attachment 9 and/or the GPS Pathfinder Office Help.

3.4.2 Post-Processing

Post-processing includes differential correction of the collected GPS data collected. Differential correction in the GPS Pathfinder Office software is the most accurate way to process GPS data (Trimble, 2006). Differential correction reduces atmospheric errors and therefore is necessary for achieving the most accurate GPS position data possible. Within IEC, differential corrections are typically conducted in the office by GIS staff once the data is transferred from the GPS rover.

4.0 Records

Document all GPS data collection activities in a Field Notebook according to *SOP-XX, Note Taking and Field Log Books*. Download GPS data files daily, including rover files, and manage them according to SOP-XX. Store GPS data files at a digital location specifically reserved for that data document type and name them appropriately, so that the content and date of collection or download can be easily identified.

5.0 References

Microsoft Corporation (Microsoft). February 13, 2007. *Microsoft ActiveSync 4.5*. http://www.microsoft.com/downloads/details.aspx?displaylang=en&FamilyID=9e641c 34-6f7f-404d-a04b-dc09f8141141..

Trimble Navigation Limited (Trimble). 2010a. *GPS Data Resources*. http://www.trimble.com/gpsdataresources.shtml .

Trimble Navigation Limited (Trimble). 2010c. *Mapping & GIS: Field Computers with GPS*. http://www.trimble.com/mgis_fcgps.shtml

Trimble Navigation Limited (Trimble). 2010d. *Mapping & GIS: Software*. http://www.trimble.com/mgis_software.shtml

Trimble Navigation Limited (Trimble). 2008. *Trimble Planning Software Downloads.*

http://www.trimble.com/planningsoftware_ts.asp

Trimble Navigation Limited (Trimble). 2006. *TerraSync™ and GPS Pathfinder® Office Software; Orientation Guide*. Version 1.00, Revision A. December

6.0 Definitions

Accuracy: An indication of how closely a measurement is to the true value.

Almanac: Data transmitted by a GPS satellite, which includes orbit information on all the satellites, clock correction, and atmospheric delay parameters. The almanac is used to facilitate rapid SV acquisition. The orbit information is a subset of the ephemeris data with reduced precision.

Attribute: Characteristics of features in a Geographic Information System (GIS) or Coordinate Geometry (COGO) package. Every identifiable feature has attributes. One common attribute of all survey features is geographic position. Other attributes depend on the type of feature. For example, a road has a name or designation number, surface type, width, number of lanes, and so on. Each attribute has a range of possible values, called a domain. The value chosen to describe a particular feature is called the attribute value.

Attribute Value: A particular value for a feature, chosen from the domain of an attribute. For example, road is the feature. surface type is an attribute, gravel is an attribute value chosen from the domain of bitumen, gravel, and concrete.

Windows mobile device: A small, usually palm-size or handheld, computer that is capable of running the Microsoft Windows CE operating system. A Windows Mobile device usually has a small screen and limited memory and storage space.

Data collector: In TerraSync™ documentation, a data collector is any computer that has the TerraSync™ software installed. The computer must either be a computer running a supported Microsoft Windows desktop operating system (for example, a tablet computer, laptop, or notebook computer running Windows 2000 or greater) or be a supported mobile CE device.

Data dictionary : Information that describes features that will be located in the field. This description includes feature names, data type classification (point, line, or area), attribute names, attribute types, and attribute values. After being created on a computer, a data dictionary is transferred to a datalogger and used when collecting data in the field.

Differential correction: Differential correction is the process of correcting GPS data collected on a rover with data collected simultaneously at a base station. Because it is on a known location, any errors in data collected at the base station can be measured, and the necessary corrections applied to the rover data. Differential correction can be done in real time, or after the data has been collected by postprocessing.

Dilution of Precision (DOP): An indicator of the quality of a GPS position, which takes account of each satellite's location relative to the other satellites in the constellation, and their geometry in relation to the GPS receiver, A low DOP value indicates a higher probability of accuracy. Standard DOPs for GPS applications are:

- PDOP: Position (three coordinates)
- RDOP: Relative (position averaged)
- HDOP: Horizontal (two horizontal coordinates)
- VDOP: Vertical (height only)
- TDOP: Time (clock offset only)
- GDOP: Geometric

Ephemeris: The current satellite position predictions that are transmitted in the NAVDATA message.

Feature: A physical object or location of an event. A feature can be a point, a line, or an area.

Global Positioning System (GPS): Based on a constellation of 24 satellites orbiting the earth at a very high altitude.

Horizon: The line at which the earth and sky seem to meet.

NAVDATA: The Navigation Message broadcast by each GPS satellite on both the L1 and L2 beacons. This message contains system time, clock correction parameters, ionospheric delay model parameters and the vehicle's ephemeris and health. A GPS receiver can use this information to process GPS Signals and thus obtain user position and velocity.

NAVigation Satellite Timing And Ranging (NAVSTAR): The name given to GPS satellites.

Position Dilution of Precision (PDOP): A unitless figure of merit expressing the relationship between the error in user position and the error in satellite position. Geometrically, PDOP is proportional to one divided by the volume of the pyramid formed by lines running from the receiver to four satellites observed. Values considered good for positioning are small, such as 3. Values greater than 7 are considered poor. Therefore, small PDOP is associated with widely separated satellites.

Postprocessing: The processing of satellite data after it has been collected in order to eliminate error. This involves using office software to compare data from the rover to data collected at the base station. Because the base station is on a known location, any errors can be determined and removed from the rover data

Rover: Any combination of mobile GPS receiver and data collector collecting data in the field.

Trilateration: The measurement of a series of distances between points on the surface of the earth, for the purpose of establishing relative positions of the points in surveying.

7.0 Attachments

Attachment 1: *Trimble GPS Receiver Comparison*

Attachment 2: *Trimble GPS Hardware and Software*

Attachment 3: *TerraSync™ and GPS Pathfinder Office Software and Orientation Guide*

GPS Receiver Comparison

	R1	R2	Geode	Catalyst	Geo 7X Centimeter	Geo 7X	Juno 5 and Yuma 2	T10	TDC100	Nomad 1050	Mesa 2	Archer 2 and Allero 2	MobileDemand xTablet T7200 and T1550	Mobile Demand xTablet T1600 and T8650
Post- Processed Accuracy[1,3]	N/A	N/A	N/A[1]	N/A[1]	1cm[8] + 1 ppm	10-50 cm + 1ppm	2-4m[2]	N/A[1]	N/A[1]	1-3 m	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Real-Time DGPS Capable[4]	SBAS or External Source	SBAS, External Source, Omnistar®	SBAS	SBAS, RTX, and VRS Now	SBAS or External Source	SBAS or External Source	SBAS	SBAS	SBAS	SBAS	SBAS	SBAS	SBAS	SBAS
Real-time Accuracy[3]	<1m	1cm-<1m	<60cm	1cm + 1ppm - 1m	1cm[8] + 1 ppm	10cm-1 m	2-4m (1-2m Enhanced version)[5]	2-5m	<2-5m	2-4 m	2-5m	1-2.5[6] m Archer2 2m[6] Allegro2	<2m[6] T7200 and 2-5m[6]T1550	2-5m[6]
EVEREST™ multipath rejection technology	NO	YES	NO	YES	YES	Optional (H-Star)	NO	NO	NO	NO	NO	NO	NO	NO
GLONASS tracking	YES	YES	YES	NO	YES	YES	NO	YES	YES	NO	YES	YES	NO	YES
Floodlight[7] Technology	NO	NO	NO	NO	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO
H-Star™ Technology	NO	NO	NO	NO	YES	Optional	NO	NO	NO	NO	NO	NO	NO	NO
RTX Correction[9]	ViewPoint	CenterPoint®, FieldPoint, RangePoint, and ViewPoint	NO	CenterPoint®, FieldPoint, RangePoint, and ViewPoint	CenterPoint®	FieldPoint, RangePoint™ (H-Star Option) and ViewPoint™	NO	NO	NO	NO	NO	NO	NO	NO
Galileo & BeiDou tracking[10]	YES	YES	NO	Galileo	YES	YES	NO	BeiDou	BeiDou	NO	YES	YES	NO	NO
External Antenna	NO	NO	Optional	DA1 Required	YES, Zepryth Model 2 recommended for highest accuracy	Optional	Optinal	NO	Optional	NO	NO	NO	NO	NO
NMEA Output	YES	Optional	YES	YES	YES (10cm accuracy)	YES	YES	YES	Optional	YES	YES	YES	YES	YES

1. These receivers output NMEA data only and cannot be post-processed with Trimble post-processing software.
2. Requires Trimble® DeltaPhase technology, as supported in the GPS Pathfinder® Office software version 4.20 or later, or the GPS Analyst® Extension for Esri® ArcGIS® Desktop software version 2.20 or later.
3. The distance between the base station and the rover affects accuracy. There is a degradation of 1 part per million (1ppm) as the distance between the base station and rover increases. Therefore, one millimeter of degradation occurs for every kilometer between the base and rover. The following factors increase the availability of 10 cm accuracy after H-Star™ post-processing: use of optional external antennas, longer elapsed time tracking uninterrupted L1/L2 carrier phase data, tracking of more GPS or GLONASS satellites with L2 measurements, shorter distance to the base station(s), and use of more than one base station for post-processing.
4. SBAS (Satellite Based Augmentation System). Includes WAAS available in North America, EGNOS available in Europe, and MSAS available in Japan. External real-time correction sources include VRS or real-time connection to a local base station. Requires H-Star data to be collected for up to 2 minutes. Requires a minimum of 3 good quality dual frequency reference stations within 200 km, or one good quality reference station within 80 km. With one reference station, accuracy degrades by 1ppm beyond 80km. Code processing reduces accuracy to 50 cm.
5. Enhanced GPS in the Juno 5 and Yuma 2 requires SBAS corrections (WAAS or EGNOS) to achieve the 1-2 meter accuracy.
6. Trimble specifies accuracy to RMS (Root Mean Square), meaning a 68% confidence interval. This indicates that 68 out of every 100 positions should meet the accuracy specifications. The Juniper and MobileDemand accuracy specifications are using CEP (Circular Error Probability). CEP only specifies that 50% of collected positions will be within spec. Be aware of the difference when comparing accuracies.
7. Floodlight satellite shadow reduction technology allows receivers to compute positions even with very weak satellite signals. Floodlight technology increases the number of positions that are gathered in difficult locations and boosts accuracy in those places where normally only low accuracy data is available.
8. How accurate is the Geo Centimeter edition?

   The accuracy users obtain depends on multiple factors including the environment, workflow, method of use, and GNSS conditions. As a general guide, the following accuracies are achievable over baselines of less than 30 km or when using VRS:

Configuration	Real-time accuracy (RMS)	Post-processed accuracy (RMS)
With Zephyr Model 2 antenna	Horizontal: .....1.0 cm + 1.0 ppm Vertical: .....1.5 cm + 2.0 ppm	Horizontal: ..... 1.0 cm + 1.0 ppm Vertical: ..... 1.5 cm + 1.0 ppm

9. RTX is a real-time Trimble correction service available through cellular and/or WWAN. There are four levels of RTX CenterPoint, FieldPoint, RangePoint, and ViewPoint. For more information and requirements on each level, please go to http://www.trimble.com/positioning-services/mapping-gis-applications.aspx.
10. Galileo is the GNSS system currently being developed and used in Europe. BeiDou is the GNSS system currently being developed and used in China.

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TRIMBLE M7 GPS SURVEY (GPS-S) SYSTEM

KEY FEATURES

Precise Positioning Service capable GPS receiver for surveying

Trimble Access field software designed for Military use

Field tested, ruggedized Survey System built to Military standards

Compatible with conventional (optical) equipment and construction machine control systems

Power office software used for processing and adjustment of both GPS and conventional data

Support both Military and Trimble data radios

Designed for tough conditions anywhere in the world, the Trimble® M7 GPS-Survey System provides a complete, light-weight yet rugged solution for military surveying and positioning requirements.

The M7 GPS-S system is a turn-key solution for the precise positioning and orientation of artillery weapon systems and for geodetic and construction survey applications. At the heart of the system is Trimble's M7 GPS-S Receiver with SGE-41 24 Channel SAASM GPS Engine, capable of Precise Positioning Service (PPS) surveying; accurate to 5 mm (postprocessed) and 10 mm (real-time). The brain of the system is the Trimble TSC3 Handheld Data Collector. The TSC3 is capable of supporting both GPS and conventional (optical) surveying, to include full interoperability with existing Trimble military surveying and construction machine control systems. The TSC3's simple Graphical User Interface (GUI) is tailored to support any military survey mission.

REAL TIME AND POSTPROCESSED PERFORMANCE

Reduce the duration of survey missions while accessing outstanding positioning results in real-time and through postprocessing applications. Initialization time is typically less than 8 seconds with a 99.9% reliability performance.

The Trimble TSC3 handheld data collector is loaded with Trimble Access™ Surveying software for performance in the field, and Trimble Business Center software is provided for postprocessing. This software provides a streamlined interface with a simplified setup, collection, postprocessing, and adjustment system. The TSC3 handheld collects all field data and measurements, to include RTK vector data for use in least squares adjustment. Upload GPS data files or RINEX files without the need for conversion.

This system supports the use of military map standard coordinates systems (UTM/UPS and MGRS/USNG), along with all other defined coordinate systems throughout the world, and supports the use of local and worldwide geoid models.

FIELD TESTED RUGGED FOR MILITARY USE

This system is designed for rugged field operation. The receiver, handheld, and other hardware components are fully sealed and environmentally tested under MIL-STD-810G guidelines.

The system is designed to be both man-portable and vehicle mounted. Using the supplied brackets, quick release and magnetic mount, the GPS receiver, handheld and radio can remain in the vehicle, while the range pole and GPS antenna are the only items outside the vehicle.

Long life battery support includes two rechargeable, removable lithium ion batteries in the receiver, which also includes a 10-year memory battery; and a rechargeable, 34-hour battery in the handheld data collector. The Trimble M7 GPS-S receiver has been granted Security Approval by the GPS Directorate.



Trimble

TRIMBLE M7 GPS SURVEY (GPS-S) SYSTEM

SYSTEM COMPONENTS

- Trimble M7 GPS-S Receiver with SGE-41 24 Channel SAASM GPS Engine capable of Precise Positioning Service (PPS) tracking (Receiver Part Number 100010-XX)
- Trimble TSC3 Handheld Data Collector with Trimble Access Surveying Software
- Trimble Zephyr™ 2 GPS Micro-centered Antenna
- Trimble Business Center Office Software package for post processing of Survey data
- Capability with Military Radios[1]
  - AN/PRC-117
  - AN/PRC-152
- Mounts on Range Pole with Handheld and GPS Antenna
- Kit includes all components required to deploy as a base station or rover receiver
- Walk around weight of Rover System (without Radio) is less than 6.8 kgs (15 lbs)
- Complete system fits in one transport case[2]

TECHNICAL SPECIFICATIONS

Physical

Receiver . . . . . 18.5 cm W x 6.7 cm D x 18.0 cm H (7.3 in W x 2.6 in D x 7.1 in H) 2.2 kg (4.4 lb) with batteries

Handheld . . . . . 14.1 cm W x 6.4 cm D x 27.8 cm H (5.6 in W x 2.5 in D x 10.9 in H) 1.04 kg (2.3 lb)

Antenna . . . . . 16.5 cm diameter x 7.6 cm (6.5 in x 3.95 in) height 0.64 kg (1.4 lb)

Electrical

Receiver

- 2 Rechargeable, removable 7.4 V, 2.4 Ah Lithium-Ion battery in internal battery compartments
- Power consumption is 3.2 W in base or rover mode
- Operating times on internal battery is 4 hours each (8 hours total)
- Internal 10 year memory battery
- Ruggedized all aluminum housing
- Supports CMR+, RTCM type 1 and 2 messages (base / rover), RTCM type 9 messages (rover)
- Complies with a requirements with GPU-03-105

Antenna

- Low voltage, low power consumption with an operating range of 3.5 V DC to 20 V DC input, 125 mA maximum current
- 13 dB amplifier margin supports cable runs of over 60 m without special coaxial cable or in-line amplifiers
- 50 dB signal gain for reliable tracking in difficult environments
- Integral advanced LNA (low noise amplifier) to reduce jamming by high power out-of-band transmitters
- 5/8" x 11 female threaded stainless steel mount point

Handheld

- Processor: Texas Instrument Sitara™ 3715 series ARM® Cortex™–A8 Processor (800 MHz)
- 8 GB non-volatile NAND Flash onboard for data storage
- SDHC memory slot for expanded storage
- 11.1 V, 2.6 Ah, 28.9 Wh Li-Ion rechargeable pack
- Battery life of 34 hours under normal operating conditions[3]
- Display: 4.2 in (107 mm) landscape VGA display, 640 x 480 pixels; Sunlight-readable color TFT with LED backlight, resistive touchscreen
- I/O: USB Host (full speed), USB Client (high speed), DC power port, 9-pin serial RS-232
- Optional I/O: Bluetooth®, Wifi and 2.4 GHz radio can be added to the handheld, as per military requirements.
- Supports all datums listed in NIMA Technical Report (TR) 8350.2 and user-defined datums
- Supports the use of military map standard coordinates systems (UTM/UPS and MGRS/USNG), along with all defined coordinate systems and datums listed in National Imagery and Mapping Agency (NIMA) Technical Report (TR) 8350.2
- Supports the use of worldwide geoid models and local geoid models

Environmentals

Meets or exceeds

Operating Temperature . . . . . –22 °F (–30 °C) to +120 °F (+49 °C) IAW MIL-STD-810G, Low Temp Operation (Method 502.5, Procedure II) High Temp Operation (Method 501.5, Procedure II)

Storage Temperature. . . . . –40 °F (–40 °C) to +158 °F (70 °C) IAW MIL-STD-810G, Low Temp Operation (Method 502.5, Procedure I) High Temp Operation (Method 501.5, Procedure I)

Humidity. . . . . 100% RH temp cycle –20 °C/60 °C (–4 °F/140 °F) MIL-STD-810G, Method 507.5

Sand & dust . . . . . 12 hour exposure with dust concentrations of 0.3 ± 0.2 grams per cubic foot and air velocity from 300 ft/min (1.5 m/sec) to 1750 ft/min (8.9 m/sec) IAW MIL-STD-810G, Method 510.5, Procedure I

Water . . . . . .5 minute submersion unprotected in fresh or salt water at a depth of 1 meter (in transit case) IAW MIL-STD-810G, Method 512.5, Procedure I

Rain . . . . . exposure to rain at a rate not less than 4 in/hr (10 cm/hr) with a wind velocity greater than 40 mph (18 m/sec) IAW MIL-STD-810G, Method 506.5, Procedure II

Salt Fog . . . . . (in transit case) IAW MIL-STD-810G, Method 509.5

Drop . . . . . System on a range pole meets standard 2 meter pole drop onto plywood over concrete and standard free fall drop from desk height 0.76 m (2.5 ft) onto plywood over concrete

Shock . . . . . 26 drops at room temperature from 1.22 m (4 ft) onto plywood over concrete (in transit case). MIL-STD-810G, Method 516.6, Procedure IV

Fungus . . . . . survives 28 day fungi test outlined in MIL-STD-810G, Method 508.6

Solar Radiation . . . . . survives exposure to solar radiation of up to 1120 Watts per square meter. IAW MIL-STD-810G, Method 505.5, Procedure I

Vibration. . . . . General Minimum Integrity and Loose Cargo test MIL-STD 810G, Method 514.6, Procedures I. MIL-STD 810G, Method 514.6, Procedures II, Cat. 5

Altitude . . . . . 4,572 m (15,000 ft) at 23 °C (73 °F) and 12,192m (40,000 ft.) at –30 °C (–22 °F) MIL-STD-810G, Method 500.5, Procedures I, II, III

Electromagnetic radiation . . . . . conform to the performance specified for RE102 [(2 MHz up to 1 GHz or 10 times the highest intentionally generated frequency within the Equipment Under Test, whichever is greater Measurements beyond 18 GHz are not required.); RE102 limit for ground applications (Navy Mobile & Army)] and RS103 [(2 MHz to 18 GHz); RS103 limit levels for ground platform – Army (50 volts/meter)] when tested in accordance with the test methodologies in MIL-STD-461F IAW MIL-STD-464C, Section 5.3, Table 4 for ground systems IAW the test methodologies for RE102 and RS103 in MIL-STD-461F

- Complies with comply with applicable sections of 42 United States Code (U.S.C.) 4321-4370d, 40 Code of Federal Regulations (C.F.R.) 1500-1508, MIL-STD-882D, and Executive Order (E.O.) 12114. No hazards above medium.
- Complies with human factors engineering guidance contained in MIL-STD-1472F.
- Complies with Authority to Operate (ATO) in accordance with DoD 8500.

POSITIONING PERFORMANCE[4]

Absolute Survey Positioning (averaged autonomous position)

Horizontal. . . . . .0.8 m RMS

Vertical . . . . . .1.2 m RMS

Local Area DGPS Positioning[5]

Horizontal. . . . . 0.25 m + 1 ppm RMS

Vertical . . . . . 0.50 m + 1 ppm RMS

Static GPS Surveying

Fast Static Horizontal . . . . . .5 mm + 0.5 ppm RMS

Fast Static Vertical. . . . . 5 mm + 1 ppm RMS

Real Time Kinematic Surveying

Single Baseline <30 km Horizontal . . . . . 10 mm + 1 ppm RMS

Single Baseline <30 km Vertical . . . . . 20 mm + 1 ppm RMS

Initialization time[6] . . . . . typically <8 seconds

Initialization reliability[6] . . . . . typically >99.9%

Relative azimuth accuracy. . . . . typically <0.3 mils at 100 meters or greater

1 Any military radio capable of Asynchronous data transmission using 4800 bps baud rate.
2 All items except the Tripod, Range Pole with Bi-pod and Base Station battery fit into the transport case. Fully loaded transport case weighs less than 16.8 kg (37 lb).
3 Unit is idle with backlight turned on, moderate temperatures.
4 Precision and reliability may be subject to anomalies due to multipath, obstructions, satellite geometry, and atmospheric conditions. The specifications stated recommend the use of stable mounts in an open sky view, EMI and multipath clean environment, optimal GPS constellation configurations, along with the use of survey practices that are generally accepted for performing the highest-order surveys for the applicable application including occupation times appropriate for baseline length.
5 Local Area DGPS positioning is only available in SPS mode.
6 May be affected by atmospheric conditions, signal multipath, obstructions and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.

Note: U.S. Government policy restricts the sale of Precise Positioning Service (PPS) equipment to those authorized by the U.S. Department of Defense. Non-U.S. authorized users must purchase PPS equipment through the Foreign Military Sales (FMS) process.

Please visit our website at www.trimble.com/defense for sales information. Made in U.S.A.
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ORIENTATION GUIDE

TerraSync™ Software and GPS Pathfinder® Office Software

Orientation Guide Version 7.0
Revision A / May 2012
Version 5.3 TerraSync
Version 5.3 GPS Pathfinder Office

Trimble

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Release Notice

This is the May 2012 release (Revision B) of the *TerraSync Software and GPS Pathfinder Office Software Orientation Guide*. It applies to version 5.30 of the TerraSync software and version 5.30 of the GPS Pathfinder software.

The following limited warranties give you specific legal rights. You may have others, which vary from state/jurisdiction to state/jurisdiction.

Product Limited Warranty Information

For applicable product Limited Warranty information, please refer to Legal Notices in the *TerraSync Software Getting Started Guide* and the *GPS Pathfinder Office Getting Started Guide* or consult your local Trimble authorized dealer.

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CHAPTER

1

Introduction

In this chapter:

- Course objectives
- Course materials
- Internet resources
- Technical assistance
- Important GNSS contacts
- System components

Course objectives

The course objectives include learning to:

- Associate GNSS fundamentals with the criteria of a TerraSync software mapping project
- Identify TerraSync system components
- Configure your data collector with data collection parameters
- Record GNSS data with the TerraSync software
- Process your field data with GPS Pathfinder Office software

Course materials

Material provided for the TerraSync software training course includes this document, the *TerraSync Software and GPS Pathfinder Office Software Orientation Guide*. Use it during the training as well as on the job. It provides GNSS fundamentals, instruction for the classroom, and field exercises. A glossary of terms is included for your reference during and after the course.

Internet resources

The ***Trimble Knowledge Network Learning Center*** offers a portfolio of training courses for Mapping & GIS. A powerful, effective and interesting way to learn, courses are presented as web-based tutorials, webinars, on-demand training, and webcasts. To access the Trimble Knowledge Network Learning Center, go to www.trimble.com/tkn.

The ***Support*** page on the Trimble website provides access to the newest customer support tools. To access the Support page:

- Go directly to www.trimble.com/support.shtml
- Click **Support & Training** on the Trimble home page
- Click **Support** in the top navigation bar on the Trimble website

On the Support page, click a product name to access support resources for that product.

Support notes and FAQs

Support Notes and FAQs (Frequently Asked Questions) include product information, troubleshooting instructions, and answers to common questions. Trimble recommends that you check the Support Notes and FAQs before you seek direct assistance.

To view or download the available support documents for your product, go to the Support page on the Trimble website (www.trimble.com/support.html) and then click the product name.

Technical assistance

If you have a problem and cannot find the information you need in the product documentation, ***contact your local dealer***. The **Dealer Locator** page on the Trimble website (www.trimble.com/locator/sales.asp) provides contact details for your local dealer:

Dealer name: _____

Phone number: _____

Email: _____

Alternately, you can purchase Priority Support.

Priority Support

If time is crucial, and your staff field needs their technical GNSS questions answered quickly, you can purchase Priority Support. You will receive a direct dial phone number and an email address to contact dedicated Priority Support staff to access the help you need immediately.

Note – Priority Support is currently available only to customers who live in the USA. If you live outside of the USA, please contact your local Trimble Dealer to discuss the support options they offer.

There are two types of Priority Support:

- ***Annual Priority Support***. Purchase Annual Priority Support for each person who requires direct access to experienced Trimble support specialists. This option provides 12 months of unlimited technical support, covering all Trimble Mapping & GIS equipment. You will receive a free-phone number so you can communicate directly with GNSS/GIS support specialists from Monday to Friday, 9am - 7pm Eastern Time and have a "High priority" status for all your enquiries, ensuring your questions get answered first. Annual subscription rates begin at US$495.00.
- ***Pay as you go Priority Support***. Call 1-866-560-6200 to purchase Priority Support when you require it. You pay using a credit card when you make the call. Each call costs US$49.95.

Important GNSS contacts

The following contact numbers are useful for obtaining GNSS and control point information, primarily in the United States. For information about your region, ask your trainer.

U.S. Coast Guard

The U.S. Coast Guard is a source for current GNSS and satellite information. You can obtain information on the number of operational space vehicles (SVs) and the times and dates they will be available (the NANU status), as well as launch dates for new and replacement SVs. You can also get information on the U.S. Coast Guard beacons.

Recorded Message: 1-703-313-5907
Live Voice: 1-703-313-5900
Internet: www.navcen.uscg.gov

National Geodetic Survey (NGS)

Call the National Geodetic Survey department for the location of control points in your geographic area (within the United States).

Information Center: 1-301-713-3242
Internet: www.ngs.noaa.gov

System components

The TerraSync software with a GNSS receiver and a handheld data collector is a GIS data collection system.

There are a number of different system configurations available.

TerraSync software

The TerraSync software collects geographical data (GIS and spatial data) on a data collector. The TerraSync software acts as the *controlling software*. It communicates with a GNSS receiver, connected to the data collector, allowing you to set GNSS parameters in the receiver, record GNSS positions on the data collector, and collect and update existing GIS data.

The TerraSync software can be used with a wide variety of real-time sources of differential corrections, including:

- Integrated SBAS (Satellite Based Augmentation Systems) receiver
- Integrated beacon receiver
- Integrated OmniSTAR receiver
- External source connected to the GNSS receiver (for example, a GeoBeacon™ receiver, a DGPS radio, or a VRS™ server over the internet)

GPS Pathfinder Office software

Back in the office, you can process the information that you collected, and export it to your GIS, using the GPS Pathfinder Office software.

The GPS Pathfinder Office software provides the tools needed for data dictionary creation, differential correction, and export to a Computer Aided Design (CAD) system or Geographic Information System (GIS).

With the GPS Pathfinder Office software you can:

- Create data dictionaries that describe the features you want to collect
- Create TerraSync Studio files that define the viewable TerraSync functionality
- Import data from your GIS for update
- Transfer files between a field computer and your office computer
- Differentially correct your data
- Edit attributes and offsets, and delete erroneous positions
- Export your data to a GIS or CAD

The GPS Pathfinder Office software makes exporting GNSS data to your GIS a simple process. Parameters for exporting data can be set up in the software and saved for use on future projects. The GPS Pathfinder Office software exports files to most GIS and CAD systems.

CHAPTER

2

GPS and GNSS Fundamentals

In this chapter:

- GNSS Segments
- Why Satellites
- Satellite ranging
- Differential GNSS
- Sources of Error

The Global Positioning System (GPS) is a constellation of at least 24 NAVSTAR satellites that provide worldwide accurate position coordinates. Uses satellites and computers to compute positions anywhere on Earth. The system is owned, operated and controlled by the United States Department of Defense (DoD). It can be used worldwide by any civilian free of charge.

GNSS segments

GNSS is divided into three segments: control, space, and user.

Control

The control segment is the “brain” of GNSS. A controller monitors the satellites’ transmission of navigation messages and sends adjustments, if necessary. The DoD operates this segment from Falcon Air Force Base in Colorado Springs, Colorado, USA. The segment also includes four monitoring and upload stations distributed throughout the world. Each satellite passes over a monitoring station twice a day.

Space

The space segment is the NAVigation Satellite Timing And Ranging (NAVSTAR) constellation of satellites that broadcast GNSS signals. When the system is at full operational capacity, there are a minimum of 24 operational satellites. This number changes constantly as satellites are commissioned (put into operation) and decommissioned (removed from operation). The satellites orbit approximately 20,200 km above the Earth and make one orbit approximately every 12 hours.

User

Many applications use GNSS to calculate positions. Civilian users currently outnumber military users worldwide. Applications include agriculture, aviation, emergency services, recreation, and vehicle tracking. For more information about GNSS applications, visit the Trimble website (www.trimble.com).

Why satellites?

GNSS is an effective mapping tool because:

- Line of sight between the unknown and a known location is *not* necessary. You only need line of sight to the sky.
- When used properly, GNSS satellites provide accurate positioning, user mobility, and rapid data collection.

While satellite-based positioning has revolutionized the GIS mapping data collection industry, it is important to note that GNSS is only a useful tool. You cannot use it to perform every mapping task.

Satellite ranging

GNSS is based on satellite ranging. This measurement is determined by timing how long it takes a radio signal to reach the GNSS receiver from a satellite, and using that time to calculate the distance.

Measuring satellite distance

Two factors are involved in measuring the distance from a satellite:

- The *speed* of the radio signal, which equals the speed of light (300,000 km per second)
- The *time* it takes the signal to travel from the satellite to the GNSS receiver

The GNSS receiver compares digital codes generated at precisely the same time by a GNSS satellite and the GNSS receiver. Identical “pseudorandom” codes are generated by all GNSS equipment (satellites and receivers) every millisecond. The travel time is calculated as the difference between when the satellite generated the code and when the receiver receives the code.

Trilateration refers to measuring the distance from at least three satellites to establish a position on Earth. Trigonometry requires three perfect measurements to define a point in three-dimensional space. However, the accuracy of a measurement based on three satellites may be diminished due to non-synchronization of clocks in the GNSS satellites and the receiver.

Calculating an accurate position

Four imperfect measurements can eliminate timing offsets. The microprocessor in the GNSS receiver recognizes a timing offset when it receives a series of measurements that it cannot intersect at one point. It automatically starts subtracting the same amount of time from all of the measurements until one point is determined.

An accurate position is calculated by using four satellites. Currently, all Trimble mapping receivers have at least twelve parallel channels to receive radio transmissions.

Almanac information

Some GNSS receivers have an almanac programmed into their microprocessor’s memory. The almanac specifies where each GNSS satellite will be at any given moment in the future. It is a set of parameters used to calculate the *general* location of each satellite. Almanacs are used while planning a work project, and for quick acquisition of satellite positions by the receiver. Preprogrammed almanacs suffer over time, as SVs are set operational and not operational, and as SVs' orbits drift. Each NAVSTAR satellite transmits the current almanac for all satellites continuously, taking approximately 12 minutes to complete.

Ephemeris information

The orbits of all GPS satellites are measured constantly by the DoD. They determine satellite ranging and calculate the *exact* location of each satellite. The adjusted measurement is transmitted from the DoD to the satellites. These minor corrections are then transmitted by the satellites as ephemeris information.

The ephemeris information is a data file that contains orbit information for one particular satellite. This information is used by the GNSS receivers along with their internal almanac to establish precisely the position of the satellite.

Differential GPS

Differential GPS is the precise measurement of the relative positions of two receivers tracking the same GPS signals. This requires a receiver to be placed as a base station over a known coordinate. The base station determines what errors the satellite data contains. Other receivers (rovers) then use this corrected GPS information to eliminate error in their measurements.

Differential GPS measurements are much more accurate than standard GPS measurements. When taking measurements in the differential mode, you can achieve accuracy of better than one meter. These measurements are based on the accuracy of the reference position (coordinate) used at the antenna of the base station.

Sources of error

Ultimately, the accuracy of a GNSS position is determined by the sum of several sources of error. The contribution of each source varies depending on atmospheric and equipment conditions.

There are several sources of error that affect the results of GNSS data collection. Environmental factors, such as physical objects causing obstructions and reflected signals, cause errors in data collection. Errors are minimized by applying rigorous data collection techniques to equipment setup and obtaining satellite lock.

Obstruction

In general, GNSS signal reception is better in an open field than under tree canopy or in a natural or urban canyon. If the GNSS receiver is tracking four satellites and then loses lock on a satellite that passes behind an obstruction, then you must wait for the receiver to regain that satellite before you can continue to log 3D positions.

Therefore, try to avoid obstructions caused by buildings or vegetation during data collection. If you cannot avoid them, plan to collect data at these locations when there are a maximum number of satellites in the sky. Greater sky visibility at the antenna location provides more accurate data.

Multipath

Multipath error occurs when the GNSS signal is reflected off an object before it reaches the GNSS antenna. Multipath error occurs without warning. The error can be minor, or can result in several meters of accuracy degradation. High multipath surfaces include urban canyons and dense foliage.

Currently, there is no way to prevent multipath from occurring. However, field techniques and receiver firmware can reduce its effects. Serious multipath errors are usually recognizable and easily edited in the office processing software.

Atmospheric delay

GNSS signals bounce around when traveling through the ionosphere and troposphere. As the signal bounces, the amount of time it takes to reach the Earth is altered. This can change the calculated position.

Atmospheric delay is largest during the heat of the day when ionospheric activity is greatest. Furthermore, weather patterns in the troposphere can be different at the base and rover receivers. Although atmospheric delay is a solvable error, differences in atmospheric conditions over large distances may not be totally resolved in a differential solution.

Note – GNSS works in all weather conditions.

CHAPTER

3

Configuring the TerraSync Software

In this chapter:

- TerraSync system components
- Using the TerraSync software
- Exercise 3.1: Assemble the equipment

Before collecting your field data, it is important to set up the equipment correctly. This includes configuring the TerraSync software settings and assembling the hardware.

In this section, you will learn the recommended settings when working in optimal conditions and with obstructed views. An appropriate TerraSync software configuration can make your data collection session easier and your data more accurate.

Configure these settings in the office, or in the field. You can also set other (non-critical) settings to suit your application or preferences.

TerraSync system components

A TerraSync system has three components:

- Data collector (field computer)
- GNSS receiver
- TerraSync software

To transfer the TerraSync software version 5.00 files between a data collector and an office computer, you need one of the following installed on the office computer:

- Version 5.00 or later of the GPS Pathfinder Office software
- The Trimble Data Transfer utility, which is available for free download from the Trimble website at www.trimble.com/datatransfer.html.

You also need one of the following installed on the office computer:

- ActiveSync technology, version 4.5 or later, if you are running a Microsoft Windows operating system other than the Windows Vista operating system.
- Windows Mobile Device Center, if you are running the Windows 7 or Windows Vista operating system.

Connecting to ActiveSync technology

When the data collector is physically connected to the office computer, it usually initiates connection automatically. To force a data controller to re-initiate connection, remove it from the support module and then replace it in the support module.

For more information on using ActiveSync technology, refer to the *ActiveSync Help*.

Connecting to the Windows Mobile Device Center

When the data collector is physically connected to the office computer running the Windows Vista operating system, it usually initiates connection automatically.

Note – If the Autoplay window appears, you must close the window.

For more information on the Windows Mobile Device Center, refer to the *Windows Mobile Device Center Help*.

Using the TerraSync software

The TerraSync software consists of five sections:

Section	Function
Map	View features, background files, and the GNSS trail graphically. ***Note** – Some options in the Map section may be hidden. This customization is done using the TerraSync Studio utility in the GPS Pathfinder Office software.*
Data	Work with data files: • create a new data file or open an existing data file • collect new features or maintain existing features • move, copy, delete, or rename data and background files ***Note** – Some options in the Data section may be hidden. This customization is done using the TerraSync Studio utility in the GPS Pathfinder Office software.*
Navigation	Navigate to features using the *Direction Dial* and *Close-up* screen. Create and edit waypoints. ***Note** – The Navigation section, and all navigation options, may be hidden. This customization is done using the TerraSync Studio utility in the GPS Pathfinder Office software.*
Status	View information about: • the satellites the TerraSync software is tracking, their relative positions in the sky, and your current position • the GNSS receiver and real-time correction source • the TerraSync software version and trademark information ***Note** – Some options in the Status section may be hidden. This customization is done using the TerraSync Studio utility in the GPS Pathfinder Office software.*
Setup	Configure the TerraSync software. ***Note** – The Setup section may be hidden. This customization is done using the TerraSync Studio utility in the GPS Pathfinder Office software.*

One of these sections is always active and visible. The *Section list button* shows the section that is currently active. You can move between sections at any time without closing any open forms or screens. To switch to a different section, tap the Section list button and then select the section you want from the drop-down list. For example, to switch from the *Map* section to the *Data* section, tap the Section list button and then select *Data*. The button now shows **Data** and the *Data* section becomes the active section. When you return to the *Map* section, the screen or form that was open when you left appears again.

Configuring critical settings in the TerraSync software

There are some critical settings in the TerraSync software that you should configure before collecting data (for example, the GNSS settings). In this section you will learn the recommended settings to make your data collection session easier and your data more accurate.

Configure these before leaving the office, or in the field. You can also set other (non-critical) settings to suit your application or preferences.

Configuring GNSS settings

Using Smart Settings available with the GeoExplorer 6000 for instance, the GNSS receiver generates the best possible position for any given environment, without the need for you to adjust receiver settings to match the conditions. Regardless of whether you are working under canopy, in wide open spaces, or somewhere in between, Smart Settings automatically generates the best solution possible.

Using traditional mask techniques in open conditions, weak signals can accidentally degrade the accuracy of the position if masks are too relaxed, whereas in obstructed conditions, more satellites are needed to help maintain optimum accuracy if masks are set too strictly. Using Smart Settings, the receiver uses all available GNSS information to determine which combination of satellites to use to deliver the best position. Once you set the receiver to use Smart Settings, the receiver does the rest.

By default, the receiver is configured to use Smart Settings as show in the top example to the right. In this mode, the receiver will track all visible satellites, and determine which to use in the position solution to automatically generate the most accurate position possible.

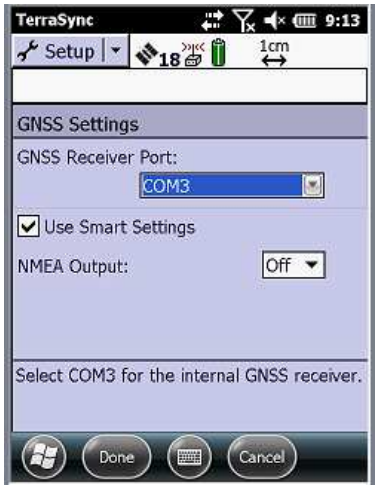
To open the GNSS Settings form, do one of the following:

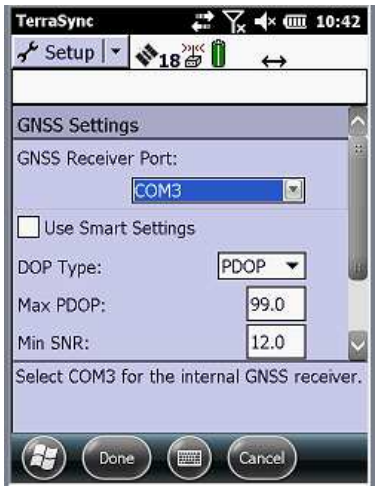
- Tap **GNSS Settings** in the Setup section.
- Tap in the Skyplot, Satellite Info, or Plan section.

To enable Smart Settings, select the Use Smart Settings check box.

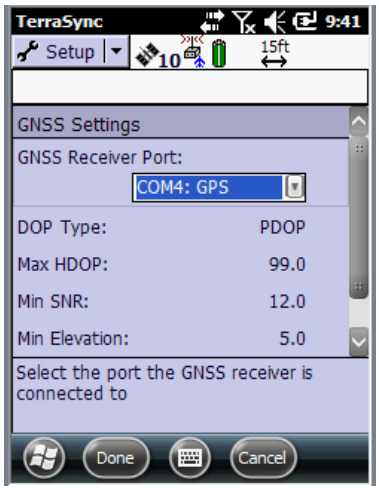
To define custom GNSS settings, clear the *Use Smart Settings* check box as shown in the middle example to the right. You can now enter values in the editable fields to specify the required GNSS quality settings.

Other receivers, such as the Juno 3 Series do not permit any alteration of the GNSS settings on the receiver itself, as shown in the lower example to the right, in order to simplify and maximize high yield GNSS collection capabilities.





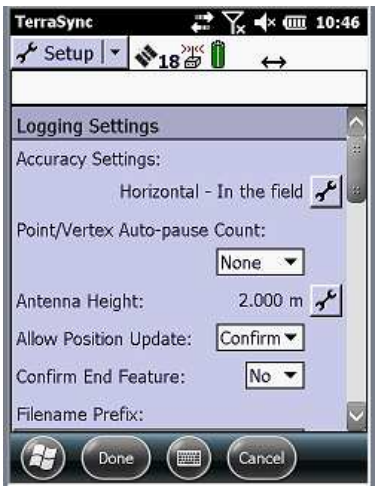
Examples above: GeoExplorer 6000 Series



Example above: Juno 3 Series

Configuring the logging settings

To open the *Logging Settings* form, tap **Logging Settings** in the *Setup* screen. Use this form to configure settings that control what data is stored, and how.



Use the *Logging Settings* form to configure how additional data is collected:

- *Accuracy Settings*. This read-only field displays the parameters that the TerraSync software will use to determine the estimated accuracy of the current GNSS position. If you are using accuracy-based logging, the required accuracy is also displayed in this field.

  To specify the accuracy settings, tap the Setup button beside this field. The Accuracy Settings form appears.

- *Point/Vertex Auto-pause Count*. This field specifies the number of positions that the software will log for a point feature or an averaged vertex in a line or area feature, before automatically pausing logging. When the number of positions specified in this field is reached, the *Minimum Positions Stored* event sounds and logging is paused. You can resume the feature to continue logging positions, or close the feature.

- *Antenna Height*. The height of the GNSS antenna. This field is read-only. To specify antenna details, such as the height and correct type of external antenna if using one, tap the **Setup** button beside this field. The *Antenna Settings* form appears.

Note – Configuring an incorrect antenna type may degrade the accuracy of your postprocessed GNSS data (particularly H-Star or Carrier data). Ensure that you select the correct antenna type.

- *Allow Position Update*. The conditions where updating of feature position information is allowed. The options are:
  - *Yes* - Position information for existing features can always be updated.
  - *No* - Positions cannot be updated.

  - *Confirm* - Confirmation is required before you are allowed to update the position.

- *Confirm End Feature* - The options are:
  - *Yes* - Select this option to display a confirmation message when you close an updated feature. The message asks you to confirm that you want to end the current feature and save any changes to the attributes or position information of the feature.
  - *No* - Select this option to disable the confirmation message.
- *File Prefix* - The prefix to be included at the beginning of the default name of each new data file. The prefix may be any alphanumeric string between 1 and 30 characters long.

Note – The prefix that you define in this field is for rover files only. The default filename prefix for base files is Base. You cannot change this default prefix. However, when you create a new base file, you can edit the default filename.

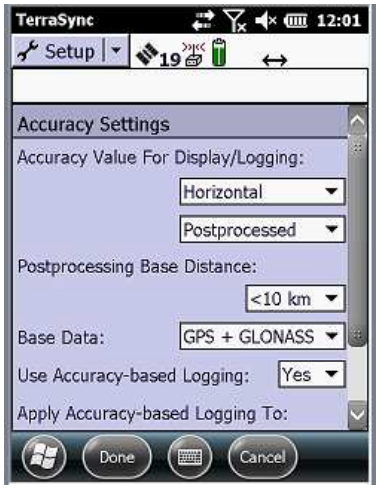
- *Waypoint Filename Prefix* - The prefix to be included at the beginning of the default name of each new waypoint file. The prefix may be any alphanumeric string between 1 and 30 characters long.
- *Style* - The method of measurement for between feature positions. The options are:
  - *Time* - A position is logged after a specified time has elapsed since the last position logged.
  - *Distance* - A position is logged once you have traveled a specified distance from the last position logged.
- *Interval* - The logging interval for the between feature positions:
  - If you selected *Distance* from the *Style* list, enter the distance between logging positions, or select an existing value from the list.
  - If you selected *Time* from the *Style* list, enter the number of seconds between logging positions, or select an existing value from the list.
  - Select *Off* to turn off between feature logging.
- *Style* - The method of measurement for the specified feature type. The options are as for Style above. This field only appears if a data file is open. It is repeated for each feature type in the file.

Note – If the feature is a point feature, this field is set to Time and cannot be changed.

- *Interval* - The logging interval for the specified feature type. The options are as for Interval above. This field only appears if a data file is open. It is repeated for each feature type in the file.

Configuring Accuracy settings

1. To open the *Accuracy Settings* dialog, tap the **Setup** button beside the *Accuracy* field in the *Logging Settings* dialog:



2. In the *Accuracy Value for Display / Logging* field, select the parameters that the TerraSync software will use to determine the estimated accuracy of the current GNSS position. The value is displayed by the Estimated Accuracy icon on the status bar. Select two out of four available parameters. The options are:

   – Horizontal - Use the horizontal estimated accuracy of the current GNSS position.

   – Vertical - Use the vertical estimated accuracy of the current GNSS position.

   – In the field - Use the current estimated accuracy of the current GNSS position. The value calculated depends on several factors, including satellite geometry and the type of GNSS receiver that is connected.

   – Postprocessed - Use the predicted estimated accuracy of the current GNSS position, which is the estimated accuracy that is likely to be achieved after the field data has been postprocessed.

3. In the *Postprocessing Base Distance* field, select the estimated distance to the base station that will be used during postprocessing.

4. In the *Use Accuracy-based Logging* field, select whether the calculated estimated accuracy determines whether the GNSS position is logged. The options are:

   – No - GNSS positions are always logged if they can be calculated.

   – Yes - GNSS positions are only logged if they can be calculated and they meet the estimated accuracy specified in the *Required Accuracy* field. The *Required Accuracy* field appears at the bottom of this form once you select Yes in this field.

The following two fields only appears if you select Yes in the *Use Accuracy-based Logging* field above.

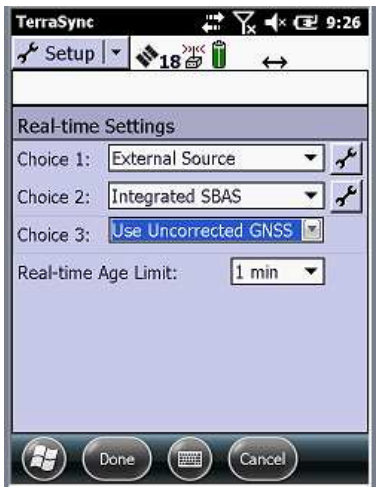
5. Select the feature types that the accuracy requirements will apply to in the *Apply Accuracy-based Logging To* field. Features of the selected type will only contain GNSS positions that meet the estimated accuracy specified in the *Required Accuracy* field above. The options are all features, point features and averaged vertices, or line and area features.

6. In the *Required Accuracy* field, select or enter the estimated accuracy that is required before the current GNSS position is logged. If the current GNSS position has a poorer estimated accuracy than the value specified in this field, the GNSS position is not logged.

Note – The estimated accuracy of a GNSS position depends on several factors, including the satellite geometry, the type of GNSS receiver that is connected, and whether you are using real-time differential corrections.

Configuring real-time settings

To open the *Real-Time Settings* form, in the Setup screen tap *Real-time Settings*. Use this form to configure settings that control the sources of real-time differential GPS that you use, if any, and how your system communicates with each source:



The TerraSync software always uses the highest priority real-time source available, according to your list of preferences. If the source it is currently using becomes unavailable, the TerraSync software switches to the next choice. Whenever the TerraSync software acquires a higher priority real-time source, it switches back to this source. For example, the TerraSync software will not use your second choice if your first choice is available.

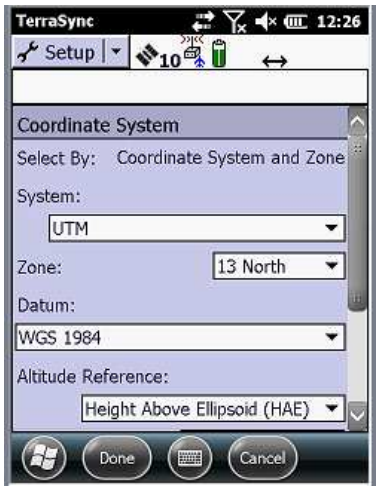
Real-time Datum selection. The real-time correction source must be in the same coordinate system, datum, and reference frame as the GIS database you are using. For example, if a base station has coordinates in terms of ITRF2000 but your GIS is in terms of NAD83, this can introduce up to a meter of error.

Tip – To record uncorrected GNSS positions only, without using any real-time corrections, select Use Uncorrected GNSS from the Choice 1 field. You can correct these positions back in the office using the GPS Pathfinder Office software.

For more information on real-time settings, refer to the *TerraSync Software Getting Started Guide*.

Configuring coordinate settings

To open the Coordinate System form, in the Setup screen tap Coordinate System. Use this form to specify the coordinate system that you want the TerraSync software to use to display foreground and background files:



A coordinate system is a three-dimensional frame of reference that can be used to describe the location of objects. Many different coordinate systems can be chosen. Each is appropriate depending upon the map projection and region in which you are collecting data.

Setting your coordinate system in the TerraSync software for postprocessed data collection is a display setting only. All GNSS data is collected in the World Geodetic Datum of 1984, the latitude/longitude coordinate system, and the Height Above Ellipsoid altitude reference. Configuring the TerraSync software to a different coordinate system only affects the display of your coordinates. It does not convert the data. However, this setting is critical when navigating. If you are navigating or looking for a location on a paper map, the coordinates will not match unless the TerraSync software is configured to the same coordinate system as the paper map.

Datums are fundamental to GNSS. To compare GNSS data with locations from an existing map, both must be referenced to the same datum. Different datums provide different coordinates for any location. GIS users choose to convert their data to a datum matching their existing GIS database during the export process. Each datum has a unique point of origin, which is why one point displayed in two different datums yields two different sets of coordinates.

Examples of datums:

- WGS-84 – worldwide
- NAD-83 – region-wide
- EUROPEAN 1950

Examples of coordinate systems:

- Latitude, Longitude, Altitude – 3D-based
- UTM – Grid Squares – 2D-based
- State Plane - each US state has created its own grid system

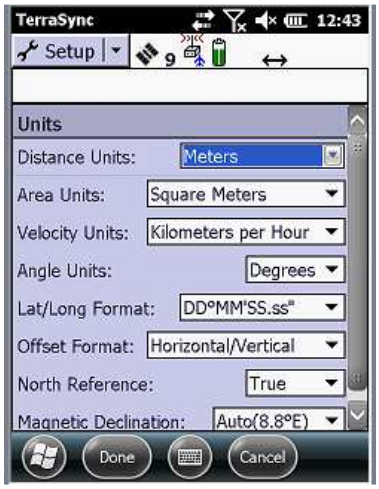
Height values can be expressed as a height above the ellipsoid (HAE) or as a height above mean sea level (MSL). GNSS works in HAE, but many Geographical Information Systems are set up using MSL. You can convert between the two for display in the TerraSync software, and for map display and map export in the GPS Pathfinder Office software:

- Ellipsoid – a mathematical model of the Earth's size and shape. HAE equals the distance from the ellipsoid to the geoid (MSL) surface.
- Geoid – considers the gravitational pull to model the Earth's "true" size and shape. The Earth is not uniformly dense. Gravity is a function of mass; therefore, gravitational pull varies from place to place.

Note – The geoid height equals the separation between the geoid and the ellipsoid. This distance approximates mean sea level (MSL).

Configuring unit settings

To open the Units form, in the Setup screen tap Units. Use this form to specify the units used for measurements and display.



The following fields are available:

- Distance Units
- Area Units
- Velocity Units
- Angle Units
- Lat/Long Format
- Offset Format
- North Reference
- Magnetic Declination

Change the units as appropriate. Changing unit settings does not affect data quality. However, unit settings are critical when specifying an accurate antenna height, or when navigating.

Exercise 3.1: Assemble the equipment

Before assembling the equipment, confirm the following:

1. Data dictionary is transferred to the TerraSync software.
2. Satellite availability is optimal.
3. The TerraSync software settings have been configured and tested.

Before going out into the field with the TerraSync software, you should check that you have all the necessary GNSS hardware, batteries, and cables. Trimble recommends that before you leave the office you:

- Set up your entire GIS/GNSS data collection system and test it to make sure that everything is connected correctly
- Make sure that the data collector's battery is charged

CAUTION *– After testing the system, remember to turn off the data collector and any other equipment (such as radios) before proceeding to the start point of your field work. Leaving equipment powered up wastes battery life, especially if it will be some time before you need to use the equipment.*

CHAPTER

4

Field Session

In this chapter:

- GNSS status
- Status bar
- Data collection guidelines
- Basic data collection
- Logging H-Star data
- Exercise 4.1: Field data collection

After the Trimble TerraSync software is configured and the hardware is assembled, you are ready for the field. Upon your arrival at the field site, first check the status of your receiver to see which satellites it is tracking. This section will show you how to view this information in the field. Then it will teach basic and advanced data collection techniques.

GNSS status

Upon arriving at the field site, start the TerraSync software to allow it to begin satellite tracking. Before data collection, it is useful to check the status of your receiver. Make sure that the receiver is tracking at least four satellites for data collection. Check that all precision standards are met.

Starting the TerraSync software

When you get outside, switch on your data collector and start the TerraSync software: The GNSS receiver should activate automatically.



To start the TerraSync software, do one of the following:

- Tap the *GNSS Application Launcher*
- Tap **GNSS** (bottom of screen)

While the software is loading, a Trimble identification screen appears. The software always opens at the *Skyplot* subsection of the *Status* section.

Getting a clear view of the sky

Move to a location where you have a clear view of the sky.

Signals can be received from any direction. Satellite signals can be blocked by people, buildings, heavy tree cover, large vehicles, or powerful transmitters. Anything that blocks light also blocks signals. GNSS signals can go through leaves, plastic, and glass, but these all weaken the signal.

Checking the GNSS status

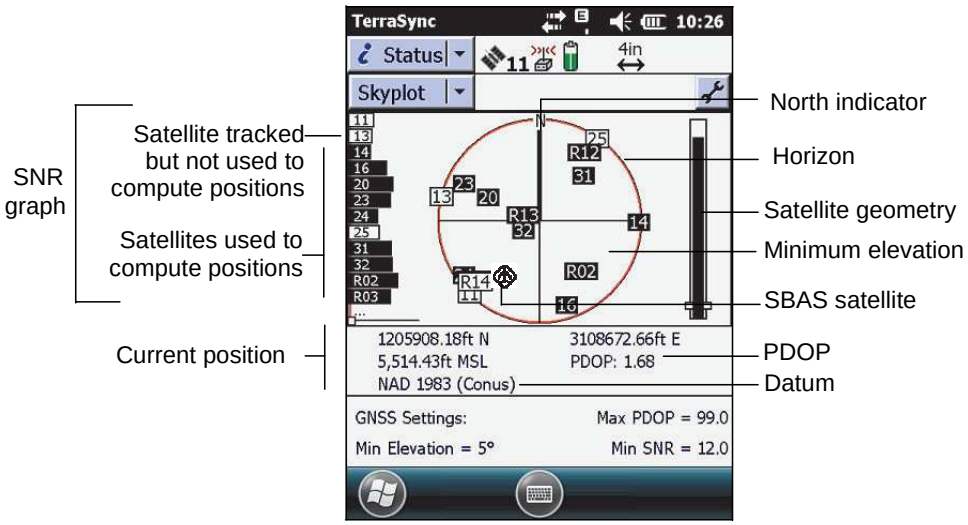
When you start the TerraSync software, it automatically connects to the GNSS receiver, and begins to track visible satellites and to calculate its current position. Use the satellite icon on the status bar to check whether the receiver is computing GNSS positions. It provides information about the geometry of the satellites that are being used to compute GNSS positions.

Use the *Status* section to view the satellites currently tracked and those that are being used to calculate the current position.

Note – For a further explanation of satellite geometry and how this can affect GNSS data collection, refer to the Mapping Systems General Reference.

To view the GNSS status:

1. The *Skyplot* screen appears when you start up the TerraSync software. If this screen is not visible, tap the Section list button and select *Status*, then tap the Subsection list button and select *Skyplot*. The following figure shows the elements of the *Skyplot* screen:



2. Use Skyplot to check the satellites that are being tracked and to see your current position.

Filled black boxes represent satellites that the receiver is using to compute its current GNSS position. White boxes represent satellites that the receiver is getting signals from but is not using because the signals are too weak, or because real-time corrections are required and none are being received for that particular satellite. In the example above, eight GNSS satellites and one SBAS satellite are being tracked, and seven of these satellites are being used to compute GNSS positions.

If a SBAS satellite is being tracked, its location is indicated by this icon:

Satellites that have an “R” prefix are GLONASS satellites. These satellites appear only if the receiver you are using can track GLONASS satellites (for example, the GeoExplorer 6000 receiver), and the *Use GLONASS* option is enabled in the *GNSS Settings* form.

Note – Numbers without a box indicate that the almanac tells TerraSync software that there are satellites available, but that the TerraSync software is not receiving signals from them.

Your current GNSS position is displayed at the bottom of the screen.

Tip – For detailed information on satellite positions and signal strengths, use the *Satellite Info* subsection of the *Status* section.

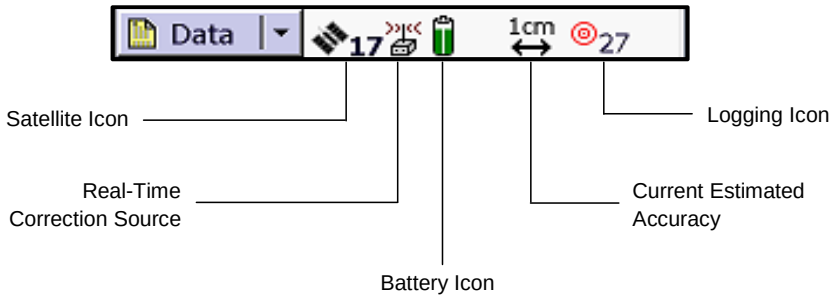
You need a minimum of four satellites, with good geometry, to compute a 3D GNSS position. When you turn on the GNSS receiver, it automatically starts to track visible satellites and to calculate its current position. Use the satellite icon in the status bar to check whether the receiver is computing satellite positions. If the satellite icon and the number below it are solid (not flashing), the receiver is computing GNSS positions.

- Required Accuracy. You can choose to use the *Accuracy Settings* dialog in the TerraSync software (select *Setup / Logging Settings/Accuracy Settings*) to prevent the logging of GNSS positions that do not meet your accuracy requirements.

If the estimated accuracy of any GNSS position is greater than the configured value, the software will not log the position. If the satellite geometry is poor or there are too few satellites available to compute GNSS positions, adjust the GNSS slider or wait until conditions are more favorable.

Status bar

The status bar appears in the top row of the TerraSync screen. It is always visible, but the icons displayed depend on the current status of the system. The status bar provides basic information about the status of the TerraSync software. The following figure shows the icons in the status bar:



The status bar is always visible, but the icons displayed depend on the current status of the system. Table 4.1 shows the icons that can appear.

Table 4.1 Status bar: Icons

Icon	Name	Description
	Satellite icon	Shows whether the geometry of the satellites is good or bad, as configured in the GNSS settings area of the software. The satellite icon flashes when the geometry of the satellites (their PDOP or HDOP) is poor. The number next to the icon indicates how many satellites are being used to compute GNSS positions. The number flashes when not enough satellites are available. You need at least four satellites to compute GNSS positions.
	Connect icon	When the TerraSync software is trying to connect to a receiver, the connect icon appears instead of the satellite icon. If the TerraSync software cannot connect to the GNSS receiver, the connect icon flashes.
	Antenna icon	If the TerraSync software connects to the receiver but cannot find a GNSS antenna, the antenna icon appears instead of the satellite icon. This icon flashes to warn you that there is a problem. If no icon appears in this position, no GNSS receiver is connected.
	Real-time external icon	Shows that the TerraSync software is receiving real-time corrections from an external source, such as a radio.
	Integrated RTK radio icon	Shows that the TerraSync Centimeter edition software is receiving RTK corrections through the GNSS receiver's integrated radio.
	External RTK icon	Shows that the TerraSync Centimeter edition software is receiving RTK corrections through an external radio.
	Real-time external beacon icon	Shows that the TerraSync software is receiving real-time corrections from an external beacon receiver such as a GeoBeacon receiver.
	Real-time beacon icon	Shows that the TerraSync software is receiving real-time corrections from a beacon.
	Real-time satellite icon	Shows that the TerraSync software is receiving real-time corrections from a satellite differential service.
	Real-time SBAS icon	Shows that the TerraSync software is receiving real-time corrections from an SBAS satellite.
Note – *If the real-time signal is lost, the current real-time icon flashes. If the icon is flashing and the number of satellites being used is greater than 0, the TerraSync software is using autonomous (uncorrected) GNSS to calculate its position. If no icon is visible, the TerraSync software has not been configured to use a real-time correction source.*		
	Battery icon	The left half of this icon indicates the charge level of the GNSS receiver battery, if one is connected. If the connected receiver does not provide battery status information to TerraSync, the left half of the battery icon is empty. The right half indicates the charge level of the field computer battery. When the battery of the GNSS receiver or field computer is fully charged, the corresponding half of the battery icon appears green. The level of green drops as the corresponding battery charge level drops. When the power level is low, the corresponding half of the battery is yellow. When the power level is critical, the corresponding half of the icon is red and the icon flashes. If the GNSS receiver is powered by the field computer or is integrated with the field computer (for example a GeoExplorer series handheld), both halves of the battery icon show the same level and indicate the battery status of the field computer.
	Filter icon	Indicates that a filter has been applied to the open data file. When this icon is not displayed, no filter has been set up.

Table 4.1 Status bar: Icons (Continued)

Icon	Name	Description
	Estimated Accuracy icon	Shows the estimated accuracy of the current GNSS position. The type of estimated accuracy value shown depends on the settings in the *Accuracy Settings* form. The estimated accuracy value may be the estimated accuracy in the field, or it may be the predicted accuracy after postprocessing. To show the predicted postprocessed accuracy, there must be a data file open and the software must be logging GNSS positions. By default, this icon shows the estimated accuracy in the field. The direction of the arrow indicates whether the estimated accuracy shown is for the horizontal or the vertical accuracy of the current GNSS position. ***Note –*** *The value shown depends on several factors, including satellite geometry and the type of GNSS receiver that is connected.* The estimated accuracy value flashes if the required accuracy set in the *Accuracy Settings* form is not met. An arrow with no estimated accuracy value indicates that the software is unable to calculate the estimated accuracy. Tap the icon for more information.
	Logging icon	Shows that the TerraSync software is logging a feature with code accuracy. The number at the bottom of the icon indicates the number of positions logged. The number above the icon indicates the predicted postprocessed accuracy in the configured distance unit. The width of the pen indicates code or carrier logging.
	Logging static icon	Shows that the TerraSync Centimeter edition software is logging a point feature or vertex in ***static mode***, which is available only when the TerraSync software is receiving RTK corrections. In static mode, only the GNSS position with the best precision estimate is logged. All other positions are discarded. The number to the right of the icon indicates whether a position has been logged. If the required precision has not been achieved, the number is 0 and no position is logged. If a position with the required precision has been logged, the number is 1. If a position with a better precision is received, it replaces the previously logged position.
	Logging vertex icon	Shows that the TerraSync software is logging GNSS position information for an averaged vertex (including point features). The number to the right of the icon indicates the number of positions logged for this vertex or point feature.
	Base logging icon	Shows that the TerraSync software is logging positions to a base data file, or that is generating correction messages.
	Digitizing icon	Shows that the TerraSync software is in Digitize mode and GNSS logging is paused, so tapping the map will result in a digitized position being recorded for the open feature. The number to the right of the icon indicates the number of digitized positions logged for this feature.
	Pause icon	When logging is paused, the pause icon flashes.
	Memory icon	When storage space is low, the memory icon appears. If memory gets low while you are logging positions, the memory icon flashes alternately with the logging icon. If you are not logging, the memory icon appears alone and flashes. ***Note –*** *When no icon appears in this position, memory space is sufficient, and the TerraSync software is not logging position data.*

Tooltips

A tooltip is a yellow message that contains information about an item on the screen, or about the current system status.

Tooltips appear:

- When you tap on an icon in the status bar
- As transient messages in the status bar
- When you tap on an item on the map
- When you measure distances and areas on the map

To close a tooltip, tap it, or tap anywhere else on the screen.

Table 4.2 shows the status bar icons and the tooltips that describe them.

Table 4.2 Status bar: Tooltips

Icon	Behavior	Tooltip
	Solid	GNSS is calculating positions
	Flashing	Poor satellite geometry (PDOP) ***or*** Poor satellite geometry (HDOP).
	Note – *The message that appears depends on whether a maximum PDOP or HDOP value is configured.*	
	Flashing satellite count	Too few satellites.
	Solid	Estimated accuracy in the field and estimated accuracy after postprocessing.
	Flashing	The estimated accuracy value flashes if the required accuracy set in the *Accuracy Settings* form is not met.
	Animated	Attempting to connect to GNSS receiver.
	Flashing	No GNSS detected. Check cables and batteries.
	Flashing	Antenna is not connected to GNSS receiver.
	Solid	Applying real-time corrections from external source.
	Flashing	Waiting for real-time corrections.
	Solid	Applying real-time corrections from VRS™.
	Flashing	Waiting for real-time corrections.
	Solid	Applying RTK corrections from an external RTK source.
	Flashing	Waiting for RTK corrections.
	Solid	Applying RTK corrections from a VRS.
	Flashing	Waiting for RTK corrections.
	Solid	Applying real-time corrections from the external beacon receiver.
	Flashing	Waiting for real-time corrections.
	Solid	Applying real-time corrections from the receiver's integrated beacon differential receiver.
	Flashing	Waiting for real-time corrections.

Table 4.2 Status bar: Tooltips (Continued)

Icon	Behavior	Tooltip
	Solid	Applying real-time corrections from the receiver's integrated OmniSTAR receiver.
	Flashing	Waiting for real-time corrections.
	Solid	Applying real-time corrections from the receiver's integrated SBAS differential receiver.
	Flashing	Waiting for real-time corrections.
	Solid	Applying RTK corrections from the receiver's integrated RTK radio.
	Flashing	Waiting for RTK corrections.
	Solid	GNSS receiver battery is good (75%). Field computer battery is good (75%).
	Solid	GNSS receiver battery is low (25%). Field computer battery is low (25%).
	Flashing	GNSS receiver battery is critical (10%). Field computer battery is critical (10%).
Note – *The battery icons and tooltips in this table show both batteries at the same level of charge. However, each half of the battery icon can appear in green, yellow, or red, independently of the color and level of the other half.*		
	Solid	Filter is applied.
	Animated pen, and number increments	Positions are being logged.
	Flashing pen	GNSS is not available.
	Animated circle decreases in size	Vertex/point feature capture in progress.
	Solid	Ready to digitize.
	Flashing	Position logging is paused.
	Flashing	Memory is full.

 **Tip –** A tooltip also appears when you tap a graphical item in the *Skyplot* screen.

Data collection guidelines

Observing a few simple practices in the field can save you time and effort in the long run. To get good results first time, Trimble recommends that you do the following when using the TerraSync software in the field:

- If you are using a handheld GNSS receiver, make sure it is clear of your body. As with any GNSS receiver, the antenna requires a clear view of the sky.

- Whenever possible, collect good GNSS measurements for 30-60 seconds before and after collecting a feature. For example, stay in an open environment on the way to the next feature, and do not drop the handheld to your side. These measurements will be used by the processing engine in the GPS Pathfinder Office software to improve the positions captured within the feature.

- Use the Log Now / Log Later function to pause and resume logging when appropriate. It is useful to control GNSS logging to prevent unwanted positions being logged to the feature. For example, you can pause to go around an obstacle when logging a line, then resume once you are back on track. Pausing when stationary - at traffic lights for example - will prevent a small drift from being recorded as part of the feature.

- Minimize constellation changes. Each constellation of satellites gives a slightly different position solution. Provided the PDOP values fall within the default values, then no solution is significantly more accurate than any other. However, there is often a relative shift between one constellation and another. Therefore, within a feature, try to avoid objects that block the view of the sky intermittently and cause constellation changes.

Basic data collection

The primary objective of this exercise is to become familiar with basic data collection techniques. You will revisit the field and perform these techniques a second time for practice and perfection. During this exercise, just concentrate on logging point, line, and area features, using a data dictionary.

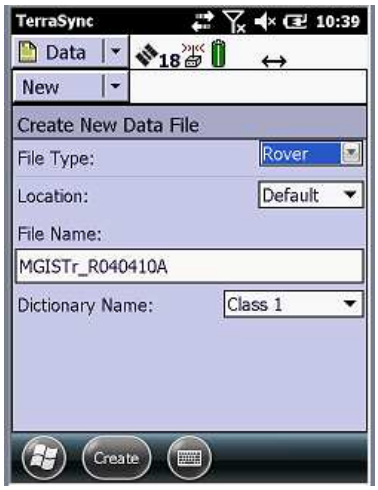
This exercise shows you how to collect point, line, and area features.

Creating a new data file

Before starting the data collection session, you need to create a new data file to store the new features and attributes you collect. Use the *Data* section to do this.

To create a new file:

1. Tap the Section list button and then select *Data*.
2. Tap the Subsection list button, select *New*. The *Create New Data File* screen appears:

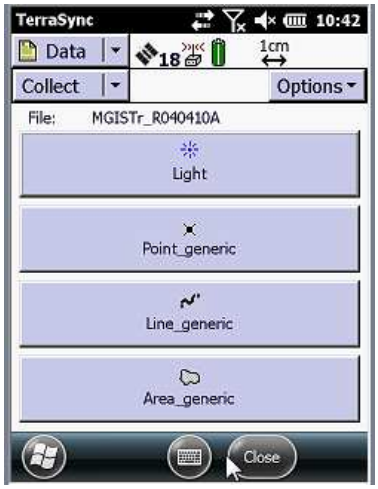


3. The TerraSync software automatically enters a default name in the *File Name* field. Replace the default name with an appropriate name.
4. In the *Dictionary Name* field, select the appropriate data dictionary.

Note: The data dictionary may vary by trainer and not follow the examples shown

5. Tap **Create**.
6. The *Confirm Antenna Height* form appears. If necessary, enter the correct antenna height, antenna type and measurement point and then tap **OK**.

   The *Collect Features* screen appears. This screen shows a list of all the features in the data dictionary:



You have now created a new data file and can start collecting features.

Log Now, Log Later and QuickPoint

The TerraSync software provides two closely-related options for logging GNSS data. These options differ in their timing of GNSS data collection relative to the start of a feature. The options are:

- Log Now – start a feature and simultaneously start collecting GNSS positions.

  If you select the *Log Now* option, the TerraSync software begins logging positions for a new feature as soon as you select the feature type and tap **Create**. You can enter attribute values while positions are being recorded.

  Log Now is the default logging option. When Log Now is selected, a bullet (•) appears beside it in the option list.

  To select Log Now, tap **Options** in the *Collect Features* screen and then select *Log Now* from the option list.

Note – Log Now applies only to new features. When you open an existing feature for update, logging is paused and the pause icon flashes in the Status bar. New positions are logged for an existing feature only after you tap Log in the attribute entry form and select the Update position option

- Log Later – start a feature, and start collecting GNSS positions later.

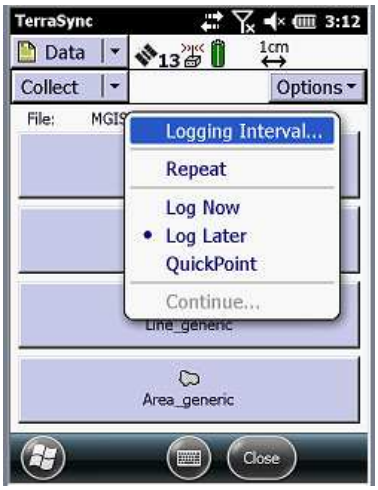
  If you select the Log Later option, the TerraSync software begins logging positions for a new feature only after you tap Log in the attribute entry form. Until you begin logging, the pause icon flashes in the Status bar.

  When Log Later is selected, a bullet (•) appears beside it in the option list.

  To select Log Later, tap **Options** in the *Collect Features* screen and then select *Log Later* from the drop-down list.

TerraSync also allows you to use the QuickPoint button and the QuickPoint Feature Capture button to capture QuickPoints from the Map screen. The TerraSync software must be in QuickPoint data collection mode. When you tap the QuickPoint button, a drop-down list appears, showing each point feature type that is defined in the data dictionary of the open file. Select a point feature type from this list to enable you to quickly log features of this type. To log each feature, tap the QuickPoint Feature Capture button.

Each of the feature collection options detailed above may be accessed through the Options found in the Collect Features screen:



Collecting a point feature with Log Now

To record a point feature, remain stationary while the TerraSync software logs GNSS positions. These GNSS positions are averaged to compute the final feature position of the point feature.

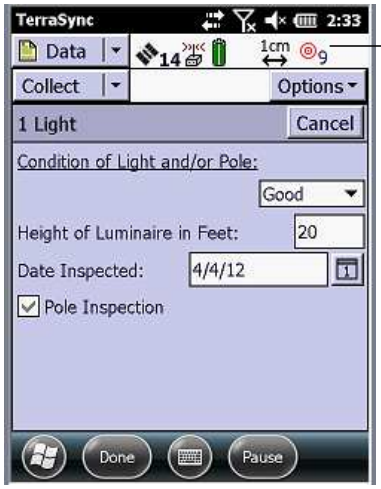
When the TerraSync software is logging GNSS positions, the logging icon appears in the status bar. The number beside the icon indicates how many positions have been logged for the selected feature.

To record a point feature:

1. If the *Collect Features* screen is not already open:
   a. Tap the Section list button and then select *Data.*
   b. Tap the Subsection list button and then select *Collect Features*.
2. To make sure that the default logging option is selected, tap **Options** and then select *Log Now*.
3. Move close to the feature.
4. From the *Choose Feature* list, select the appropriate point feature. The attribute entry form for the Light feature type appears.

Note – Try to keep the antenna still during these next steps.

As the software logs GNSS positions, the counter beside the logging icon increments, as shown below:



5. Enter all the required attribute information.
6. Once you finish entering the attributes, tap **OK** to save the feature and return to the *Collect Features* screen.
7. Later you can navigate back to a sign that needs to be replaced, and update its attributes. You need to collect this light feature now. Repeat Step 1 through Step 5 to log another light feature. When you reach Step 4, change the *Condition* field to *Needs replacing*.

Collecting a line feature with Log Later

The next feature you need to record is a line feature – for example, an irrigation main trench. To record a line feature, you must travel along the line. As you travel, the TerraSync software records a GNSS position at the configured logging interval, which defaults to the value that was set when the feature was created in the data dictionary. These positions are joined together to form a line.

By default the TerraSync software begins logging GNSS positions as soon as you open a new feature. For this feature you will use the Log Later option to delay logging of positions until you have entered the attributes for the feature and you have reached the start of the feature.

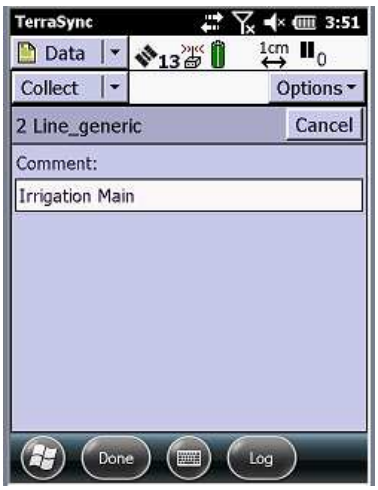
To record a line feature with the Log Later option:

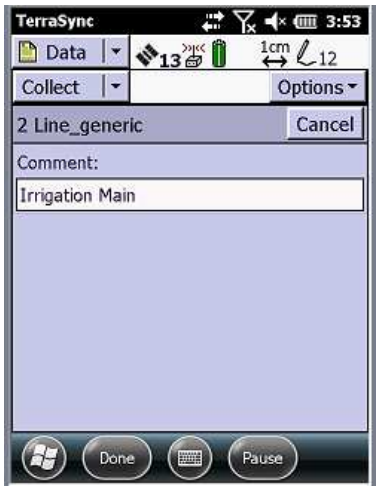
1. If the *Collect Features* screen is not already open:
   a. Tap the Section list button and then select *Data.*
   b. Tap the Subsection list button and then select *Collect Features*.
2. Tap **Options** and then select *Log Later*.
3. From the *Choose Feature* list, select the appropriate line feature.

   The attribute entry form appears.

Note – When you use the Log Later option, the pause icon ▮▮ flashes in the status bar to let you know that the TerraSync software is not logging GNSS positions.

4. Fill out the required attributes.
5. Move to the start of the feature and then tap **Log** to begin logging GNSS positions for the feature.



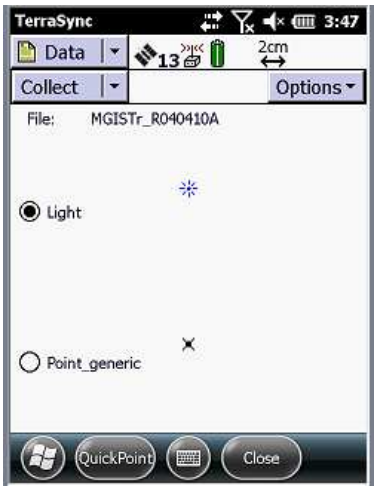


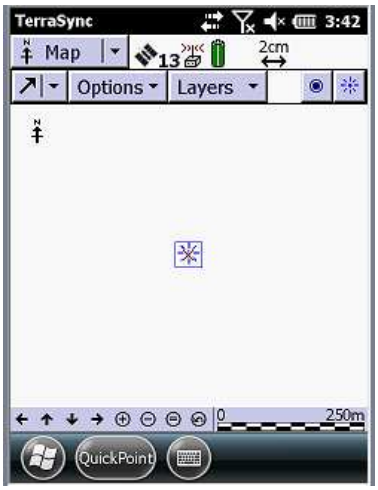
   The pause icon disappears from the status bar and the number on the logging icon increments as each position is recorded.

Continue down the irrigation line trench. When you reach the end of the line you are logging, tap **OK** to save the feature and return to the *Collect Features* screen.

Collecting a point with QuickPoint

If the TerraSync software is in QuickPoint data collection mode, the Collect Features screen shows only point features. To log a QuickPoint, select the required point feature, and then tap QuickPoint.





Tip – The Map screen also has a QuickPoint button

Collecting an area feature

Similar to the examples above, to record an area feature, you must travel around the perimeter of the area. As you travel, the TerraSync software logs GNSS positions at the logging interval set in the data dictionary. The first and last GNSS positions are joined together to form the perimeter of the area, so there is no need to return to the exact start point.

To collect an area feature:

1. If the *Collect Features* screen is not already open:
   a. Tap the Section list button and then select *Data.*
   b. Tap the Subsection list button and then select *Collect Features*.
2. Tap **Options** and then select *Log Now*.
3. Move to where you want to record the first perimeter position.
4. From the *Choose Feature* list, select an appropriate area feature.

   The attribute entry form opens, and the TerraSync software starts to log positions.

   You can pause logging at any time. For example, if you are driving around the perimeter of the park and you want to stop to examine a sign some distance from the park, you can stop logging positions for the park boundary. You can also pause logging if you want some time to enter attribute values.
5. To pause logging, tap **Pause**. The TerraSync software stops logging positions and a pause icon flashes in the status bar. To continue collecting the feature, tap **Resume** to resume logging. The pause icon disappears.

6. To view the map while collecting features, tap the Section list button and then select *Map*. The features that you have collected are displayed on the map, along with the feature that you are currently collecting.

7. If you cannot see your current position or a selected feature on the map, tap **Options** and then select *Auto Pan to GNSS Position* or *Auto Pan to Selection*:



   To view the map at different scales, tap the Zoom In or Zoom Out button on the Command bar.

   Alternately, tap the Map Tools list button, select Zoom In or Zoom Out and then select the point on the map that you want to zoom in to or out from.

8. Tap the Section list button and then select *Data* to go back to the Data section. The attribute entry form is still active and the TerraSync software is still logging positions.

9. Enter the attributes of the feature.

10. When you have travelled around the perimeter of the area, tap **OK** to save the feature and return to the *Collect Features* screen.

11. Tap **Close** in the *Collect Features* screen.

Ending the data collection session

When the data collection or update session is completed, exit the TerraSync software. You will be prompted to confirm that you wish to close the (data) file and exit TerraSync.

Logging H-Star data

By connecting the TerraSync software to a receiver with H-Star technology, you can collect high-accuracy GNSS data. You can achieve horizontal accuracies (RMS) of up to 10cm (4 inches) + 1ppm.

A receiver capable of real-time H-Star technology uses base station data from a VRS or a nearby single base station (within 80 km) to generate H-Star positions in the field.

- For real-time H-Star operation, a wireless data link is required between the roving GNSS receiver and either a nearby base station or a VRS network.

- For postprocessed data, three or more good quality dual-frequency (L1/L2) base stations within 200 km are required. Alternatively, one good quality dual-frequency base station within 80 km is required.

The coordinate of each base station must be in the same coordinate system, datum, and reference frame, as one another, and as the GIS database you are using. For example, if a base station has coordinates in terms of ITRF2000 but your GIS is in terms of NAD83, this can introduce up to a meter of error. Also, if one base station has coordinates in terms of ITRF2000 but another is in terms of NAD83, this can also introduce significant error.

Note – Accuracy estimates for GNSS positions logged while moving may be larger than 10 cm (dual frequency) or 30 cm (single frequency).

Data collection best practices

Trimble recommends the following to help ensure successful high accuracy data collection:

- Collect good quality GNSS measurements between features. For example:
  a. Collect good measurements in the open, while walking towards the 'tough' feature under a tree.
  b. Collect the feature.
  c. Collect more good measurements while walking away towards the open.

  Collecting good measurements requires orienting the GNSS antenna to have a good view of the sky; do not drop it to your side, or point along or down, as you walk.

  There are several reasons for this practice. The good measurements can help to smooth out poor quality measurements at the feature. In postprocessing, this effect applies both forwards and backwards in time, so good measurements after the feature are important. Ideally you should aim for 30 to 60 seconds of good measurements between more difficult locations.
- Log a point feature for 5 seconds in good conditions. This is enough data when the accuracy estimate is sufficient, as indicated by the CEA (Current Estimated Accuracy) or PPA (Predicted Postprocessed Accuracy) values. This assumes you have collected good data before the feature. It is also an efficient workflow - there is no point taking longer to log a feature when the accuracy does not improve.
- In difficult conditions, or if the accuracy is less than desirable, log for 15 or 30 seconds, or even longer if necessary, until the estimated accuracy is good enough. Or you could cancel the existing feature, and try walking into the open and carefully back to recollect the GNSS measurements for the feature.
- Position the antenna appropriately over the target:
  – Set the correct antenna height if there is an offset.
  – Hold the antenna directly over the target feature.
  – Use a range pole for accurate vertical measurements.
- Avoid blocking satellites (five or more satellites are recommended):
  – Avoid harsh GNSS environments when collecting H-Star data.
  – Use a range pole and an external antenna to get the antenna above your body.

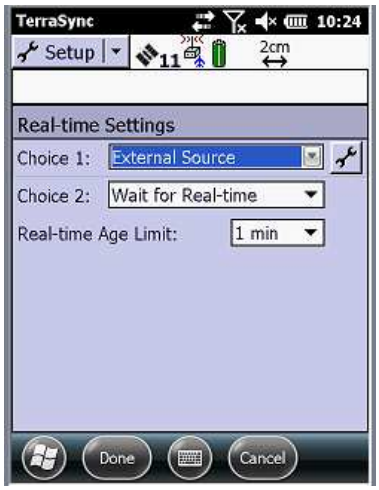
Status information

When collecting data, the TerraSync software provides additional status information - an estimated in-the-field or postprocessed accuracy value for the feature appears on the status bar.

Note – The estimated accuracy value is only an indicator of accuracy that can be achieved with H-Star postprocessing. The accuracy indicated is not guaranteed.

Configuring the TerraSync software to collect H-Star data for real-time H-Star technology

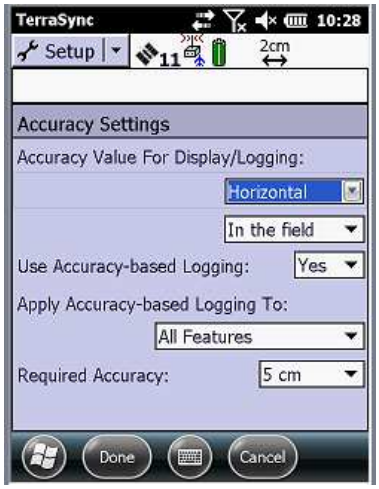
1. Tap the Section list button and then select *Setup*.
2. Tap **Real-time Settings**. The *Real-time Settings* form appears.
3. From the *Choice 1* field, select *External Source*.
4. Tap the Setup button  beside the *Choice 1* field to configure the correction source and then select the appropriate settings depending on the correction source and the communication method used. When you have finished configuring the external source, tap **OK**.
5. From the *Choice 2* field, select *Wait for Real-time*.



6. Tap **OK** to confirm the real-time settings and return to the main *Setup* screen.
7. Tap **Logging Settings**. The *Logging Settings* form appears.

8. To use accuracy-based logging:

   a. Tap the Setup button in the *Accuracy Settings* field. The *Accuracy Settings* form appears:



   b. From the *Accuracy Value for Display/Logging* fields, select *In the Field* and whether the TerraSync software should calculate the estimated horizontal or vertical accuracy.

   c. From the *Use Accuracy-based Logging* field, select *Yes*.

   d. From the *Apply Accuracy-based Logging To* field, select the feature types that will use accuracy-based logging — select *All Features*.

   e. In the *Required Accuracy* field, enter the accuracy you require.

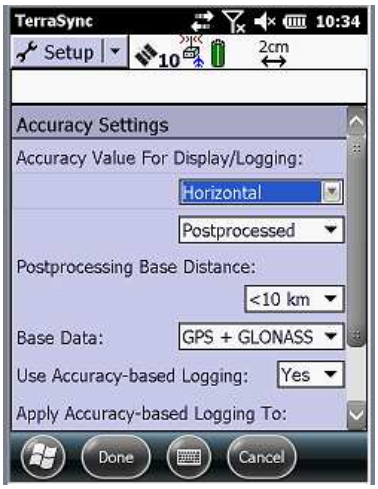
Note – Check that your receiver is capable of this accuracy in the field. Consult your Trainer if required.

   f. Tap **OK** to save the accuracy-based logging settings and return to the *Logging Settings* form.

9. Tap **OK** to close the *Logging Settings* form and confirm the changes you have made.

Configuring the TerraSync software to collect H-Star data for postprocessed H-Star technology

1. Tap the Section list button and then select *Setup*.
2. Tap **Logging Settings**. The *Logging Settings* form appears.
3. To use accuracy-based logging:
   a. Tap the Setup button in the *Accuracy Settings* field. The *Accuracy Settings* form appears:



   b. From the *Accuracy Value for Display/Logging* fields, select *Postprocessed* and whether the TerraSync software should calculate the estimated horizontal or vertical accuracy.
   c. If you selected In the office, select the distance to the base station from the *Postprocessing Base Distance* field.
   d. From the *Use Accuracy-based Logging* field, select *Yes*.
   e. From the *Apply Accuracy-based Logging To* field, select the feature types that will use accuracy-based logging — select *All Features*.
   f. In the *Required Accuracy* field, enter the accuracy you require.

Note – Check that your receiver is capable of this accuracy in the field. Consult your Trainer if required.

   g. Tap **OK** to save the accuracy-based logging settings and return to the *Logging Settings* form.

4. Tap **OK** to close the *Logging Settings* form and confirm the changes you have made.

Collecting features

As you log a feature, the estimated accuracy value appears in the status bar. The value of the estimated accuracy correlates directly with the length of time that you have continuously collected data. To collect H-Star data you must:

- be connected to a receiver that has H-Star technology
- maintain carrier lock on the required number of satellites

When using a real-time correction source, configure the Estimated Accuracy icon to show an estimate of the accuracy being achieved for that position in the field. When the value shown in the Estimated Accuracy icon reaches the accuracy you require for the feature, you can stop logging. Collect 30 to 60 seconds of good GNSS measurements before and after a feature. When estimated accuracies are good, collect 5 to 10 positions at the feature, and then pause GNSS logging and move away if there are obstructions.

When you are logging data for subsequent processing, configure the Estimated Accuracy icon to show a prediction of the accuracy that will be achieved after postprocessing. For carrier-capable GNSS receivers, the longer the duration of carrier lock, the better the accuracy, which is indicated by a decreasing estimate. The predicted accuracy applies to all positions logged since you acquired carrier lock on the required number of satellites. The accuracy estimate has a 68% confidence level, which means that 68% of the time the position will be within the estimated value shown when the position was collected, providing that the data is processed against base stations that meet H-Star technology requirements

Note – If you lose carrier lock while collecting a feature, the accuracy estimate increases, and you must reacquire satellites and remain at the feature until the estimated accuracy value decreases to the required accuracy, or cancel the feature and move away from obstructions and then move back in once you have recorded 30 to 60 seconds of good GNSS measurements.

When collecting data for postprocessing, you do not have to remain at the same feature until the required predicted accuracy value is reached. If you are collecting a series of features, attempt to maintain a clear view of the sky between features.

Exercise 4.1: Field data collection

You can now go out into the field to collect data with the TerraSync software. Make certain that you have the required GPS hardware, batteries, and cables.

CHAPTER

5

Data Processing with the GPS Pathfinder Office Software

In this chapter:

- Exercise 5.1: Transfer field data
- Differential correction
- Exercise 5.2: Differential Correction Wizard
- Exercise 5.3: Create a GIS export setup

Postprocessed differential correction in the GPS Pathfinder Office software is the most accurate way to process GNSS data. In the field, you collected autonomous and/or real-time corrected data, while base data was stored at base stations nearby. The data sets are loaded into the GPS Pathfinder Office software where corrections are applied. Any real-time data that has been collected can be "recorrected" in the GPS Pathfinder Office software to achieve the best possible results. After you display your corrected data file, you can:

- Edit any unwanted positions
- Verify that the feature information is correct, and edit any attributes
- Export your data to a format that integrates with your software requirements

Exercise 5.1: Transfer field data

Use this exercise to practice transferring field data to the GPS Pathfinder Office software. You can transfer:

- Data files
- Base data
- Waypoint files
- Data dictionaries
- Almanacs

This exercise shows you how to transfer a field data file to the GPS Pathfinder Office software.

Connect the data collector to the office computer

To connect the data collector to the office computer:

1. Switch on your data collector and your office computer and connect the two computers.

   The Microsoft ActiveSync technology (for all Windows operating systems except the Windows 7 and Windows Vista operating system) or the Windows Mobile Device Center (for the Windows 7 and Windows Vista operating systems) should automatically establish a connection with the data collector. When ActiveSync or the Windows Mobile Device Center is connected to a data collector, the message Connected appears in the relevant window, and its taskbar icon is green.

2. If ActiveSync or the Windows Mobile Device Center does not connect automatically, remove and then re-insert the USB connection. For information on connecting with the different technologies, refer to the relevant Help.

Transfer a rover file to the office computer

To transfer the rover file from your data collector to the office computer:

1. In the GPS Pathfinder Office software, select *Utilities* / *Data Transfer*.

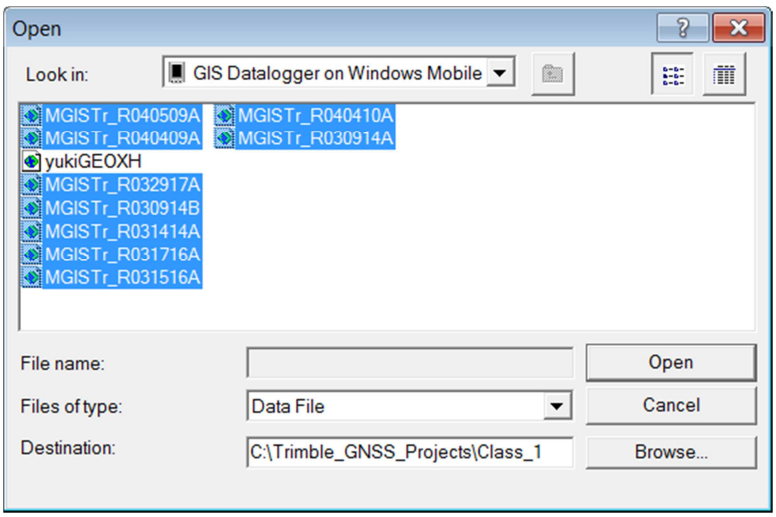
   The *Data Transfer* dialog appears.

2. From the *Device* list, select *GIS Datalogger on Windows Mobile*. Alternatively, if you have set up a device definition for your data collector, select that device name from the list.

   The Data Transfer utility automatically connects to the data collector.

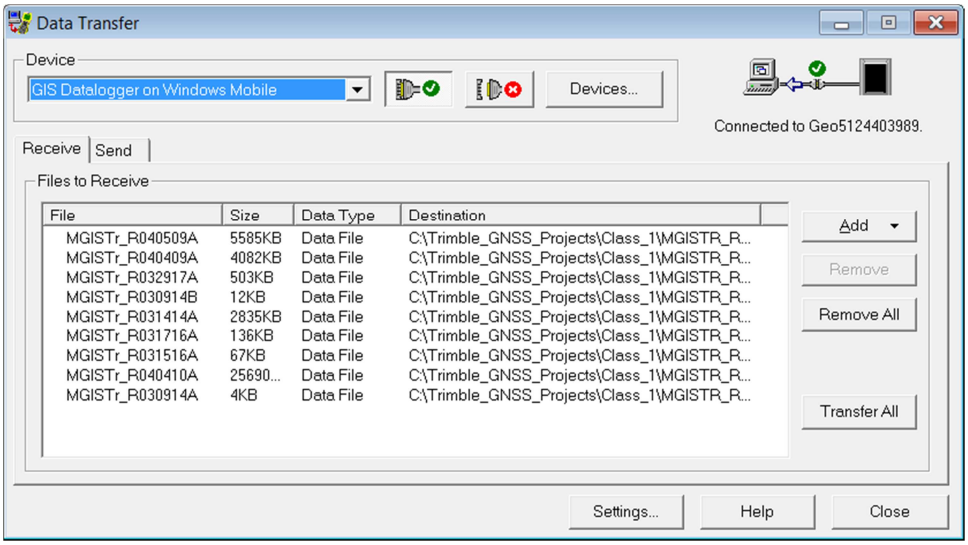
3. Select the *Receive* tab.

4. Click **Add** and select Data File from the drop-down list. The *Open* dialog appears:



Note – The files that appear are the files in the TerraSync software data folder on the data collector. Files that are highlighted have not been previously transferred from the datalogger.

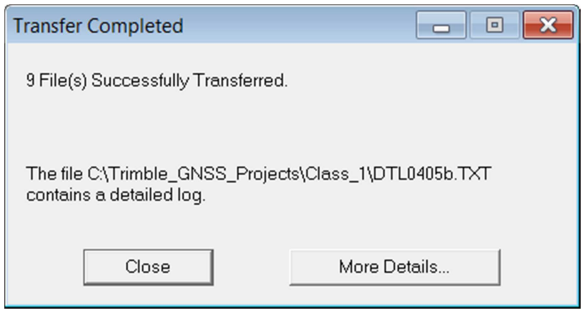
5. Highlight the rover file, and then click **Open**. The *Open* dialog disappears and the selected file appears in the *Files to Receive* list:



6. Click **Transfer All**.

   The data file is transferred to the office computer.

7. A message box showing summary information about the transfer appears. Click **Close** to close it:



8. Click **Close** to exit the Data Transfer utility.

For more information, refer to the *GPS Pathfinder Office Help*.

Differential correction

Differential correction reduces atmospheric errors; therefore, it is necessary for achieving submeter accuracy for a C/A code position and decimeter accuracy for a H-Star processed position. Differential correction can be performed in real time, or back in the office with the GPS Pathfinder Office software. For optimal results, you can use both.

For a differential correction to be performed, a dual-frequency base station must be running at the same time as a rover in the same vicinity. Both base and rover must track the same satellites at the same time and therefore record the same errors from regional atmospheric conditions. The base station is set up over a known reference position and can compare positions computed with errors to “truth”. Differential correction then adjusts for errors in the rover file, based on a time tag for each position.

You can use real-time differential corrections from the following sources:

- Integrated SBAS receiver
- Integrated beacon receiver
- Integrated OmniSTAR receiver
- External source connected to the GNSS receiver (for example, a GeoBeacon receiver or a DGPS radio, or a VRS correction)

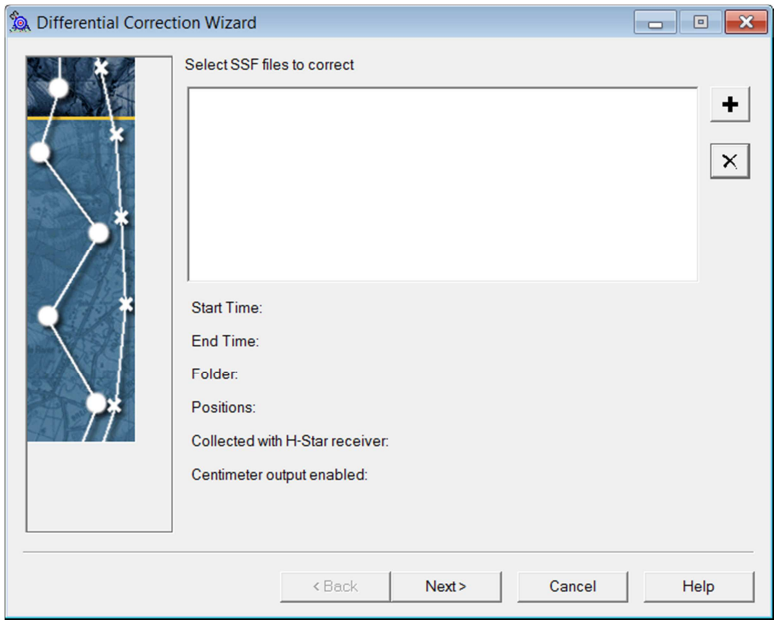
For *postprocessing*, corrections are logged in a base file that is transferred when you return from the field.

Note – With high accuracy data collection, it is very important to understand how error can be introduced through incorrect datum transformations. Please inquire with your Trimble Dealer or Trimble Certified Trainer to learn more about typical correction workflows in your region – or visit Pathfinder Office Technical Support http://www.trimble.com/mappingGIS/PathfinderOffice.aspx?dtID=technical_support for more information about reference frames and their current status.

Exercise 5.2: Differential Correction Wizard

To start the Differential Correction Wizard from the main GPS Pathfinder Office menu bar, select *Utilities* / *Differential Correction*.

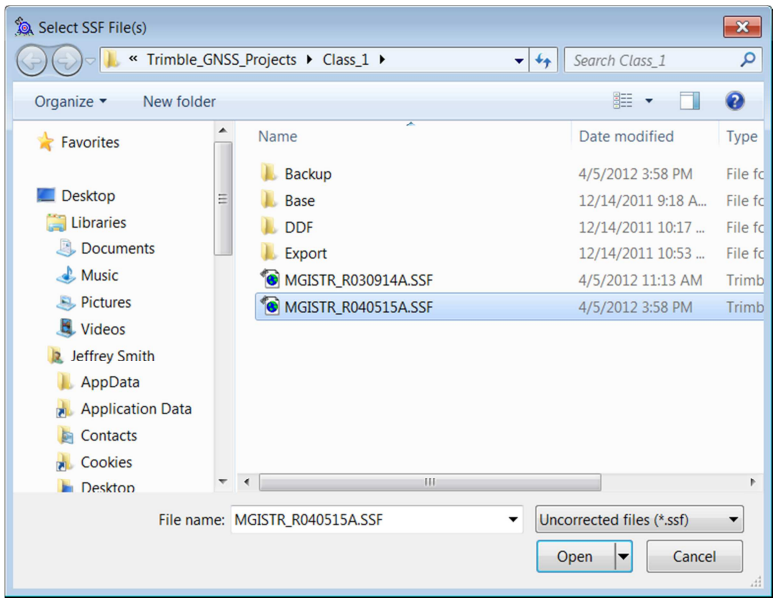
The *Differential Correction Wizard*:



Select rover files

The *Select SSF files to correct* list will be empty, or it will show the SSF files that were created the last time you downloaded rover files. To remove any SSF files that are listed, select them and then click ×. To select the SSF files you want to differentially correct click +.

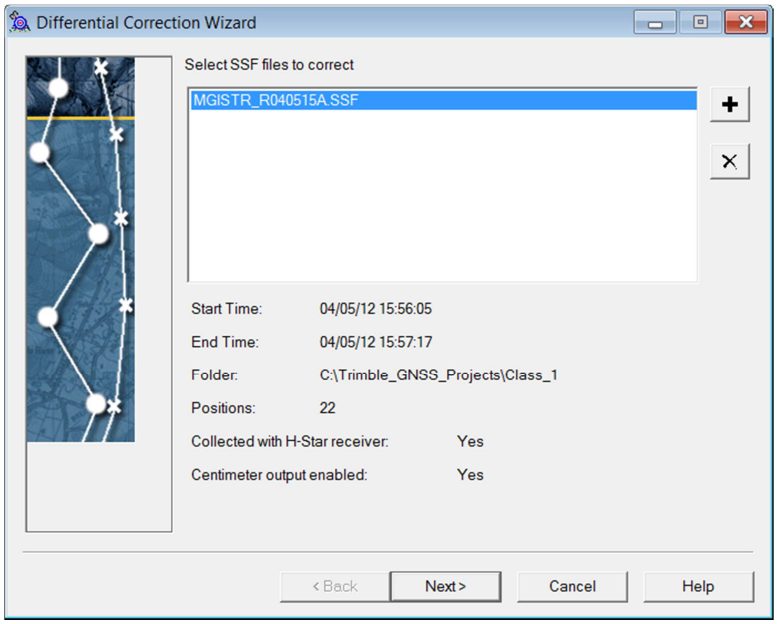
a. Click +. The *Select SSF Files* dialog appears:



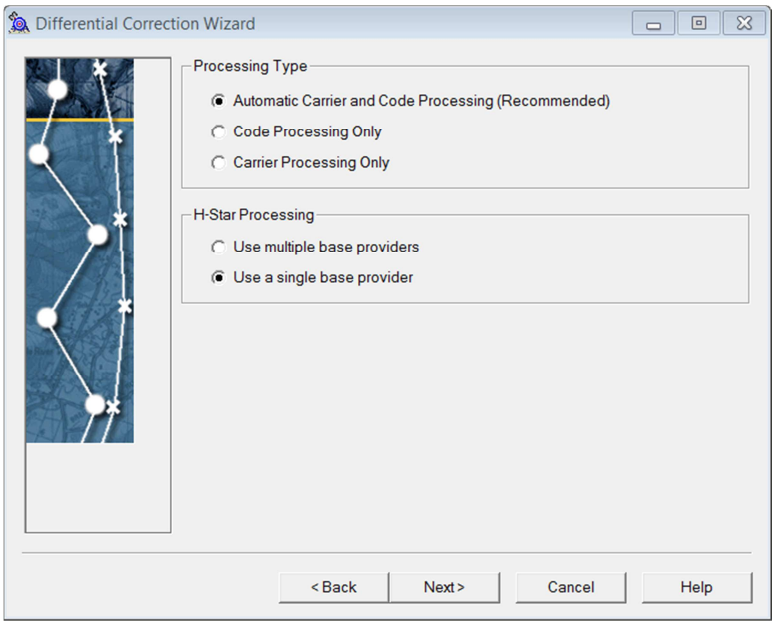
Select the rover file, or hold down the **Shift** key to select multiple files to be corrected. By default the uncorrected files (*.ssf) are shown.

b. Click **Open**.

The fields below the selection list display information about the selected file. The *Collected with H-Star receiver* field indicates whether the rover file contains data collected using a receiver with H-Star technology. The *Centimeter output enabled field* indicates whether the rover file was collected using a centimeter optioned GNSS receiver and TerraSync Centimeter Edition. The options displayed in the rest of the Differential Correction Wizard are dynamic: H-Star processing options are only displayed if the value for this field is Yes:



3. Click **Next**. The *Processing Type* page of the wizard appears:



This screen displays the processing options available for processing the GNSS data in the selected rover files. If the data was not collected with an H-Star receiver, the *H-Star Processing* options will not be available.

Select type of processing

Use the *Processing Type* step of the Differential Correction Wizard to specify the type of processing you want to use for the selected SSF files. There are three standard processing options. If the receiver that is used to collect the data uses H-Star technology, an additional two H-Star processing options are available.

Standard processing types

Standard processing corrects the GNSS data in the selected SSF files using data from a single base station. The standard processing options are always available whether the selected files were collected using an H-Star receiver or not. The options are:

- *Automatic Carrier and Code Processing* - The GNSS data is both carrier-processed and code-processed using data from a single base station. The position with the best precision estimate is used as the corrected position.
- *Code Processing Only* - The GNSS data is code-processed using data from a single base station.
- *Carrier Processing Only* - The GNSS data in the session is carrier-processed using data from a single base station to produce a carrier float solution.

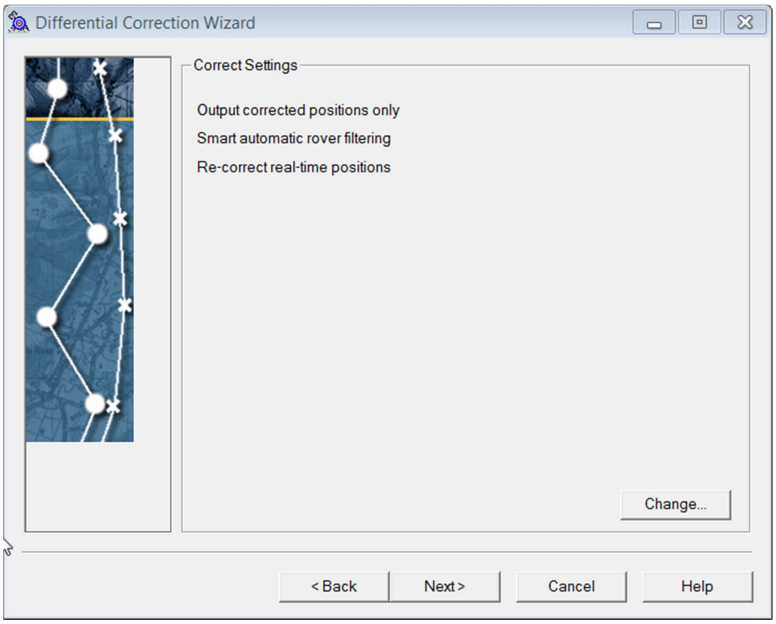
H-Star processing types

H-Star processing enables GNSS data in the selected SSF files to be corrected using data from a group of base stations. The files are corrected using data from each base station in the group, and then the results are averaged to produce a single corrected position for each original position. The averaging calculation gives more weight to base stations that are closer to where the original GNSS positions were collected, and can result in a better solution than a correction from a single base station. The options are:

- Use multiple base providers, if a network of base stations is available and within 200 km.
- Use a single base provider if a base station is within 80 km, and there is not a suitable network of base stations within 200 km.

To select the type of processing:

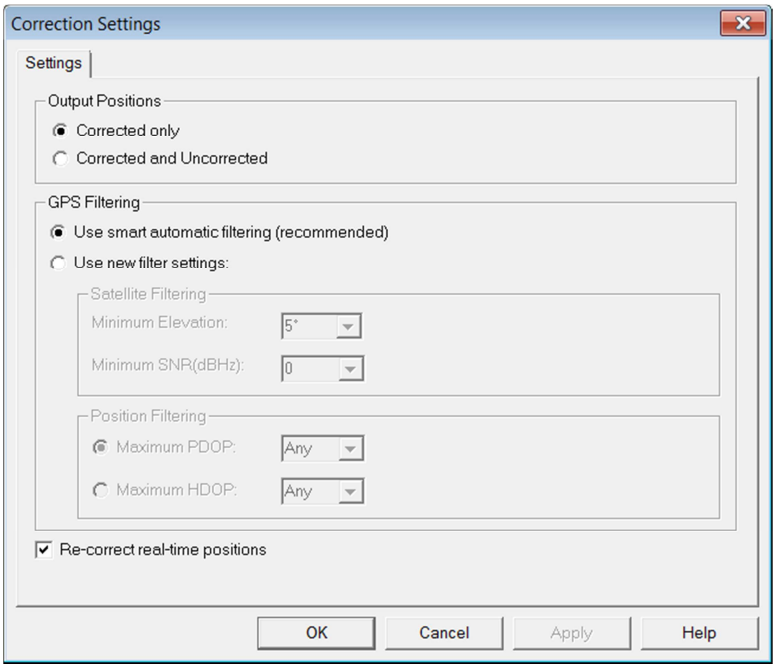
1. Select one of the processing types for differential correction. The options are explained above.
2. Click **Next.** The *Correction Settings* page of the 'Wizard appears:



Select appropriate settings

Use the options in the *Correction Settings* dialog to customize differential corrections.

1. Click **Change** to open the *Correction Settings* dialog:



2. Select an option from the *Output Positions* group, which determines the data to be stored in the corrected file:
   - *Corrected only* – stores only corrected positions and velocity records.
   - *Corrected and uncorrected* – stores corrected and uncorrected positions and velocity records.
3. Select the *Re-correct realtime code positions* check box to improve the accuracy of real-time corrected positions. Clear this check box to leave real-time corrected positions unprocessed.
4. Select which filters to apply to the data as it is differentially corrected. You can let the postprocessing smart filtering work out the best results for your GNSS measurements (recommended), or you can apply your own elevation, SNR, and DOP settings.
   - Select the *Use smart automatic filtering* option and process files with the processing engine having access to all the GNSS measurements (this is the recommended option).
   - Select the *Use new filter settings* option to process files using the settings specified in this tab.

The system uses files containing carrier or pseudorange data to increase the accuracy of positional calculations. Data collected using real-time correction sources such as SBAS can be postprocessed, as can data from rover positions using satellites not seen by the base station. (Rover data is recomputed using the satellites common to both rover and base station.)

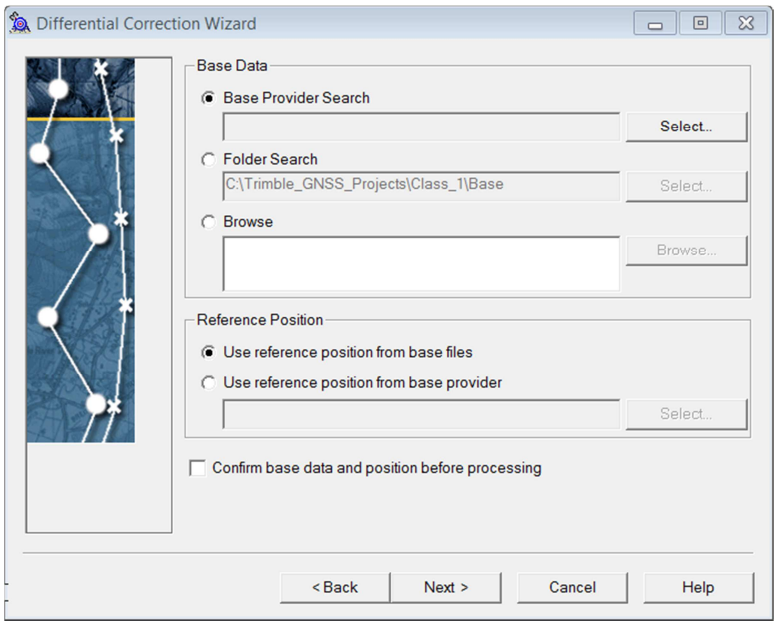
5. Click **OK** to save differential correction settings.
6. Click **Next.** The *Select Base Data* page of the wizard appears.

Select base files

The interface that appears will depend on whether your rover files contain H-star data.

Rover files without H-star data

If your rover files do not contain H-star data, the following page appears:

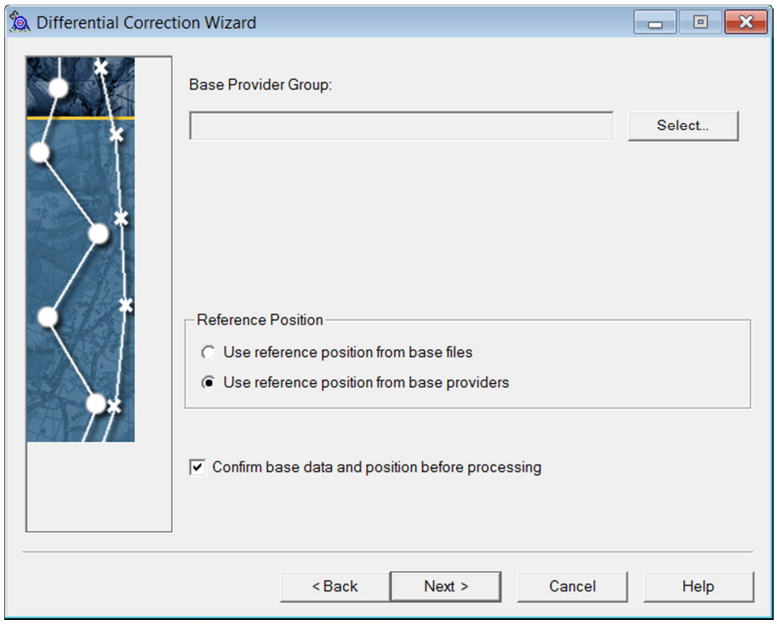


1. Select base files:
   - If you are going to download files from the Internet select the *Base Provider Search* option, and click **Select**.
   - If the base files are in the base folder for the current project select the *Folder Search* option. If the wrong folder is displayed, click Select and choose the correct folder.

– If you want to manually select the base files, select the *Browse* option and then click **Browse**. In the *Open* dialog, navigate to the folder where the base files are stored, select the files you want to use and click **OK** to return to the Differential Correction Wizard.

Rover files with H-star data

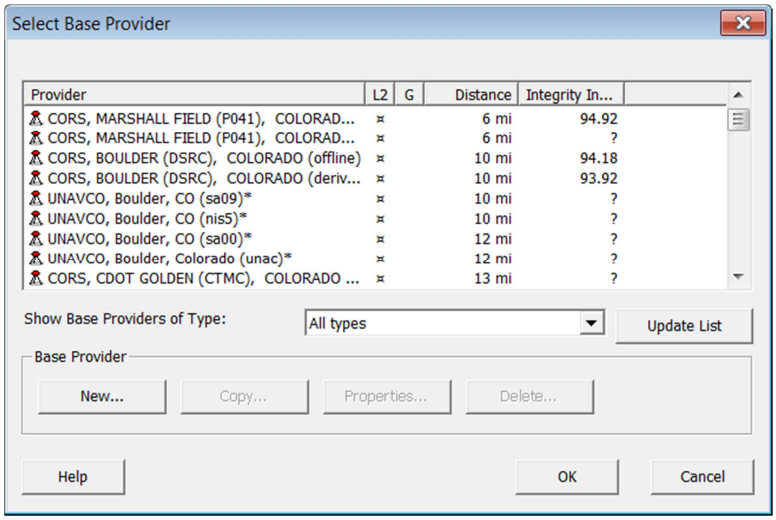
If your rover files contain H-star data the following page appears:



With H-star processing you can select more than one base station to correct your data with. It is important to make sure that all the base stations in a H-Star group use the same coordinate system and datum to represent their coordinates in.

To do this, select a number of base stations and save them as a group:

1. Click the **Select** button next to the *Base Provider Group* field. The *Base Provider Group* dialog appears:



   The *Base Provider Group* dialog displays information about the selected base provider group. Each member of the group is displayed in the group provider list, which displays the presence of L2 and GLONASS data, distance, and integrity index records for the base provider. These details are the same as those in the parent *Base Provider* list displayed in the *Select Base Provider* dialog. The type of integrity index shown in the group member list depends on the type of data contained in the GNSS sessions currently selected for differential correction. To display integrity index values of a different type, select a different type from the drop-down list.

Note – The Integrity Index value is an indicator of the quality of the data provided by the base station. A poor Integrity Index value can indicate that the base provider is unreliable or often off line. Good stations may be displayed with "?" as the Index value. For example, password protected stations and private stations may not be able to have a value calculated, so treat the value as an indication.

2. Click **New** to open the *New Base Provider Group* dialog and create a new base provider group.

3. Click  to open the *Select Base Provider* dialog and select a base provider to add to the group. Repeat this process until you have added all the required base stations to your group.

   Next to the list of base provider group members, a map displays the approximate positions of the base providers, in relation to the rover.

4. Click **OK** to return to the Differential Correction Wizard.

Reference Position settings

1. Select what you want to use as the source of the base station reference position.
   From the *Reference Position* option select one of the following:

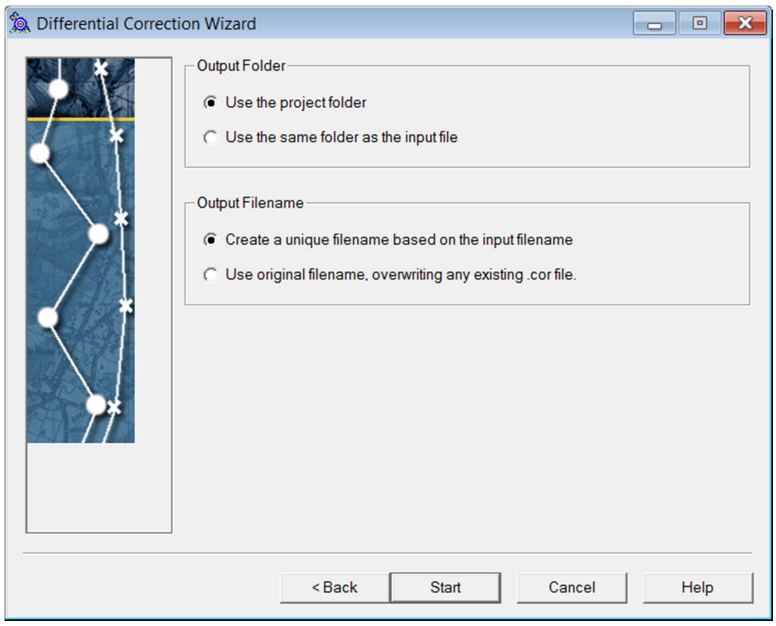
   – *Use reference position from base files* - If you know the reference position for the base provider is incorrect select this option to use the reference position specified in the selected base files. By default, these coordinates are taken from the first selected base file.

   – *Use reference position from base provider* - Select this option to use the recorded reference position of a selected base provider. This option is recommended, as the reference position recorded for a base provider is generally more accurate than the reference position provided in base files.

Note – If there is no H-star data in the selected rover files, or a single base provider was selected for H-Star processing, the name of the base provider selected to provide the reference position is displayed in the text box below this option. Click ***Select*** *to select a different base provider.*

2. Confirm base data and position before postprocessing. Select the check box to confirm the co-ordinates of the reference position and the availability of the base files to be used. This information appears in the *Differential Correction Processing* window on the last page of the wizard before you start the correction process. If the check box is not selected, clicking **Start** on the last page of the Differential Correction Wizard will automatically start the correction process without first checking that base data is available.

3. Click **Next.** The *Output* page of the wizard appears:



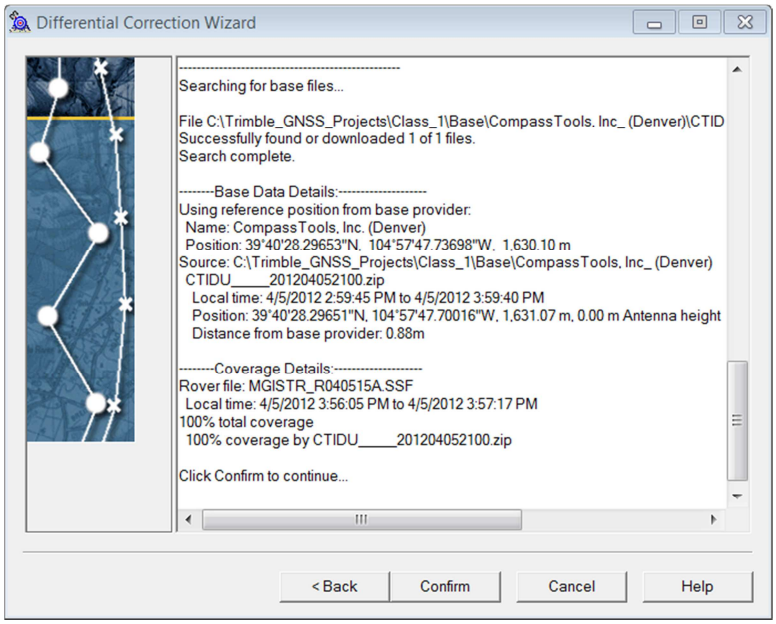
Select output options

1. Select the folder that you want to store the output files in from the following options:
   - Use the same folder as the input file - Output files will be stored in the same folder as the input folder. This allows you to select rover files from different folders, process them, and to store the corrected files with their corresponding input files.
   - Use this folder - All output files will be stored in the same folder. By default, this is the current project folder.
2. Select how you want the output files named from the following options:
   - Create a unique filename based on the input filename - Automatically creates a unique filename, based on the input filename. The format for automatically created names is <input rover file>_<n>.cor, where n denotes the number of subsequent processing of the same rover file.
   - Use original filename, overwriting any existing .cor file - The output file has the same name as the input rover file, with a .cor extension. Subsequent processing of the same input file results in previous output files being overwritten.

Differentially correct your data

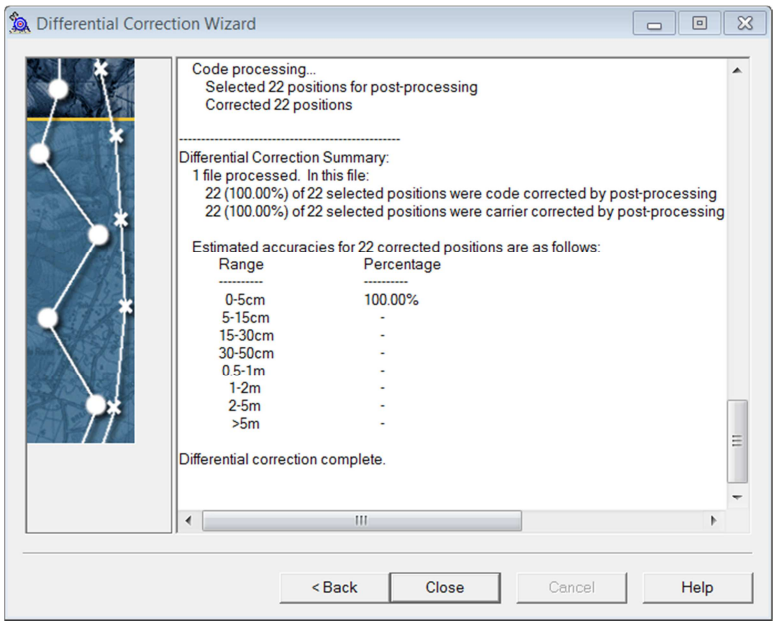
1. Select **Start**. The differential correction process starts.

   If you have chosen to *Confirm base data and position before processing* a dialog similar to the following will appear:



2. If the base data coverage and reference positions are correct, click **Confirm**. The data is processed.

As the GPS Pathfinder Office software begins differentially correcting the selected SSF files, the *Correct processing* page of the wizard appears:



It displays details about the status of the differential correction process. The SSF files are processed sequentially. The Correct Processing page displays the number of corrected positions for each SSF file.

When the last SSF has been processed, the message Differential correction complete and a summary of the estimated accuracy values gained for the corrected GNSS positions appears at the bottom of the Correct Processing page.

This summary provides immediate feedback as to the quality of the corrected GNSS positions. For example, if too few base providers have been selected for multi-base processing, the results will indicate this by showing large estimated accuracy values.

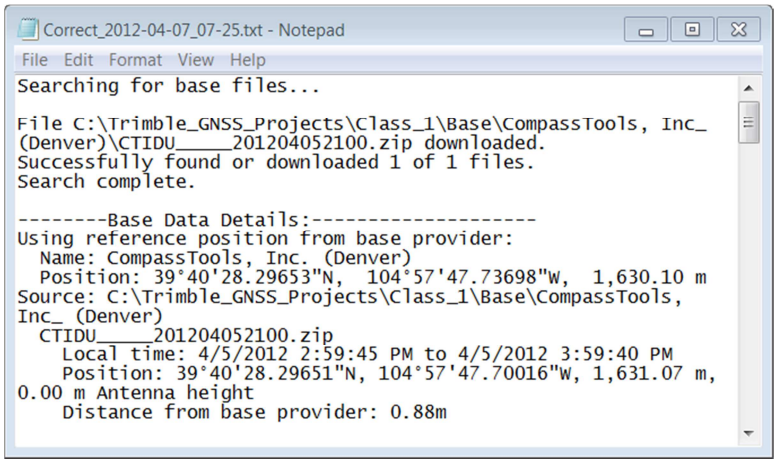
3. Click **Close**.

Note – The most common reason for differential correction failure is choosing the wrong base files.

View differential correction reports

The Summary - Correct_DATE_TIME.txt reports are created upon conclusion of processing. These reports detail processing settings, files used, files created, and include a processing summary.

You can view generated reports in a text editor, such as Microsoft Notepad:



Creating GIS export setups

Many types of GNSS data can be exported to a GIS, including features, attributes, not in feature positions, notes, velocity records, and external sensor records. This exercise defines options to convert this information to a format that matches an existing GIS or CAD database.

Exercise 5.3: Create your own GIS export setup

In this exercise, you will create a customized export setup, configure the format setup options, and export your corrected data file. Make sure you clearly understand the options offered to perform a GIS export. After completing this exercise, create an export setup that meets the requirements of your company's GIS.

This exercise shows you how to use the Export utility to match GNSS data to your GIS database.

To create an export setup:

1. Select *Utilities* / *Export*.
2. In the *Export* dialog, click **New** to open the *New Setup* dialog.
3. Rename the New Setup to match your project name and/or export specifics – for example Class 1 ESRI Shapefile Setup. Select OK to exit the New Setup dialog.
4. In the *Create* group, select the *New setup* option and then select ESRI Shapefile from the list.
5. Click **OK**.

Configure the format

To configure the format of an export setup:

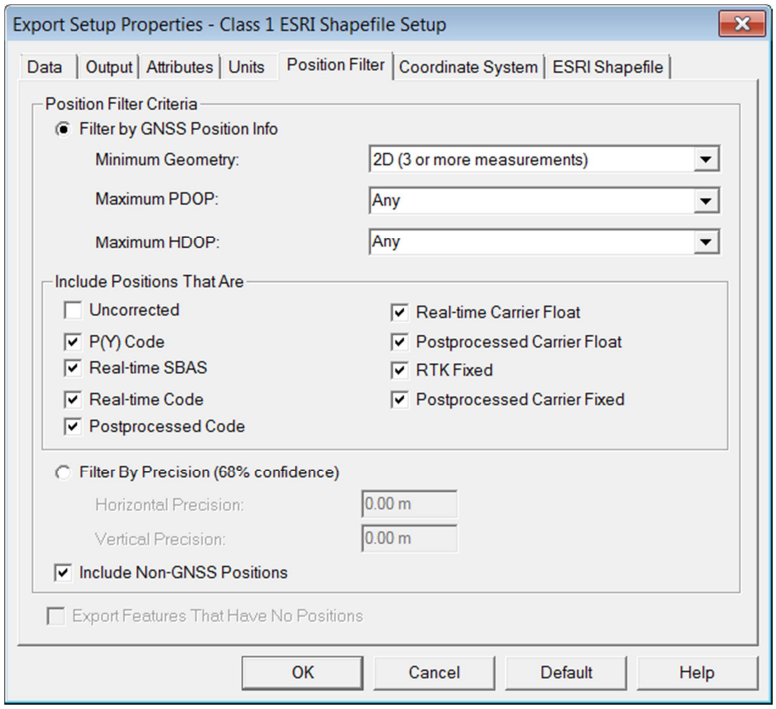
1. In the *Type of Data to Export* group in the *Data* tab, select the *Features / Positions and Attributes* option:
   - *Features / Positions and Attributes* – exports features and attribute information.
   - *Include Not in Feature Positions* – exports not in feature positions as either *one point per Not in Feature position* or as *one line per group of Not in Feature positions*.
   - *Positions Only* – exports positions as either one point per GNSS position, one point per file (mean position), one line per input file, or one area per input file.
2. In the *Create Point Features From* group, you can export the following as point features:
   - Notes
   - Velocity records
   - Sensor records

   A position for each note, velocity record, or sensor record is interpolated from GNSS positions within the input file.
3. The *Starting Feature ID* group is only available for export formats that require a unique ID. The *Value* field specifies the starting feature ID for the session:
   - *Start Each Session with this Value* – specifies that the starting feature ID always starts at the value shown.
   - *Continue Increment from Previous Session* – the value field defaults to 1 plus the last feature ID exported in the previous session.

Include certain filters

To include position filters:

1. Select the *Position Filter* tab:



2. Select the *Filter by GNSS Position Info* option.
   a. From the *Minimum Satellites* list, select 3D (4 or more SVs). This option only exports positions collected with a specified number of satellites. It does not filter out positions created manually (without GNSS).
   b. From the *Maximum PDOP* list, select 6. This option filters out positions above a particular PDOP. Only positions with a PDOP less than or equal to this value are exported.
   c. From the *Maximum HDOP* list, select 12. This option filters out positions above a particular HDOP. Only positions with an HDOP less than or equal to this value are exported.

d. In the *Include Positions That Are* group, select any of the following:

- *Uncorrected* – the uncorrected positions are exported.

CAUTION – If you have uncorrected data in your GIS you may be compromising the accuracy standards of your existing GIS database.

- *P(Y) Code* – positions collected using P- or Y-code are exported. Only military receivers can log positions using these codes.
- *Real-time SBAS* – positions collected using SBAS real-time DGPS are exported.
- *Real-time Code* – positions collected using real-time differential GPS and computed using a code phase solution are exported.
- *Postprocessed Code* – positions corrected in the Differential Correction utility using the code-processing options are exported.
- *Real-time Carrier Float* – (for RTK systems only.) Positions collected using real-time differential GPS and computed using a carrier float solution are exported.
- *Postprocessed Carrier Float* – positions that have a carrier float position. These positions were corrected using either the *H-Star processing* option in the Differential Correction Wizard, or using the *Smart Code and Carried Phase Processing* option or the *Carrier Phase Processing* option in the Differential Correction utility.
- *RTK Fixed* – (for RTK systems only.) Positions collected using real- time kinematic techniques and computed using a carrier fixed solution are exported.
- *Postprocessed Carrier Fixed* – positions corrected in the Differential Correction utility using the Centimeter Processing option, and having a carrier fixed solution, are exported.

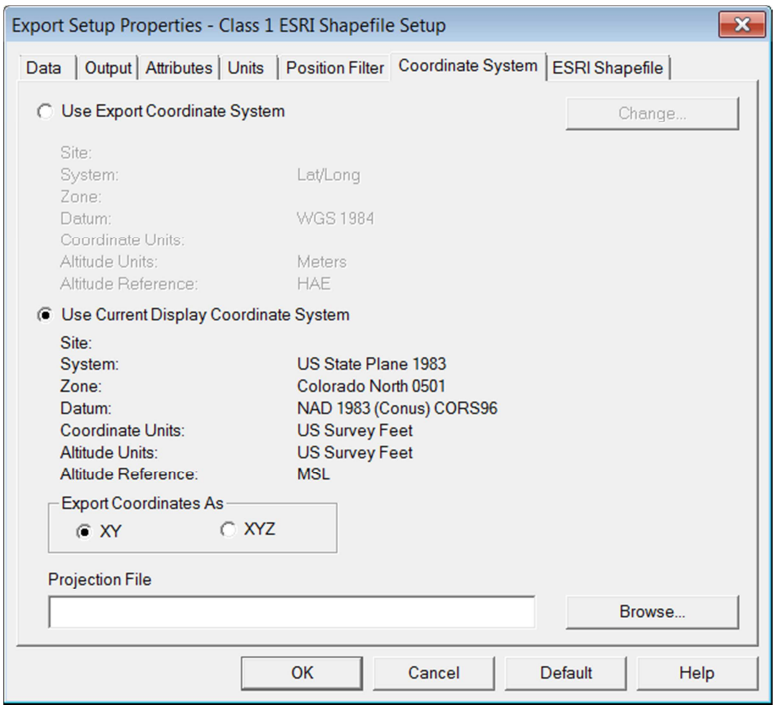
e. Select the *Include Non-GNSS Positions* check box to export positions that were collected manually, were originally imported from a GIS or CAD system using the *Import* utility, or were created with the *Create Feature* tool in the GPS Pathfinder Office software.

3. Select the *Filter by Precision (68% confidence)* option to filter a data set based on horizontal and vertical precision tolerances.
4. Select the *Export Features That Have No Positions* check box to include features that have no positions in the GIS or CAD output. This is useful when attribute information about a feature is gathered but GNSS positions were unavailable.

Reference graphic data

To reference graphic data:

1. Select the *Coordinate System* tab:



2. Select the *Use Export Coordinate System* option to export data in the coordinate system and zone configured in this tab.

   The *Use Current Display Coordinate System* option exports data as specified under *Options* / *Coordinate System* in the main GPS Pathfinder Office program.

3. Click **Change** to set the appropriate datum, coordinate system, and altitude reference.

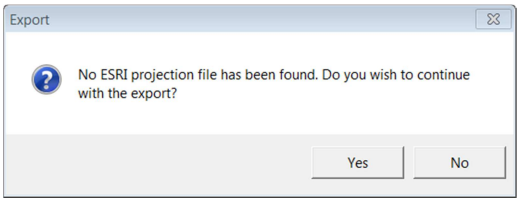
4. Click **OK**.

5. The options in the *Export Coordinates As* group are available for formats that accept either two-dimensional or three-dimensional coordinates.

   – *XY* – exports two-dimensional coordinates.

   – *XYZ* – exports three-dimensional coordinates.

6. Browse to an existing ESRI projection (*.prj) file, if available, to establish the final spatial reference for your project data. This setting is an optional setting and will not prohibit the final export. However, if a file is not selected you will be notified by the following message:

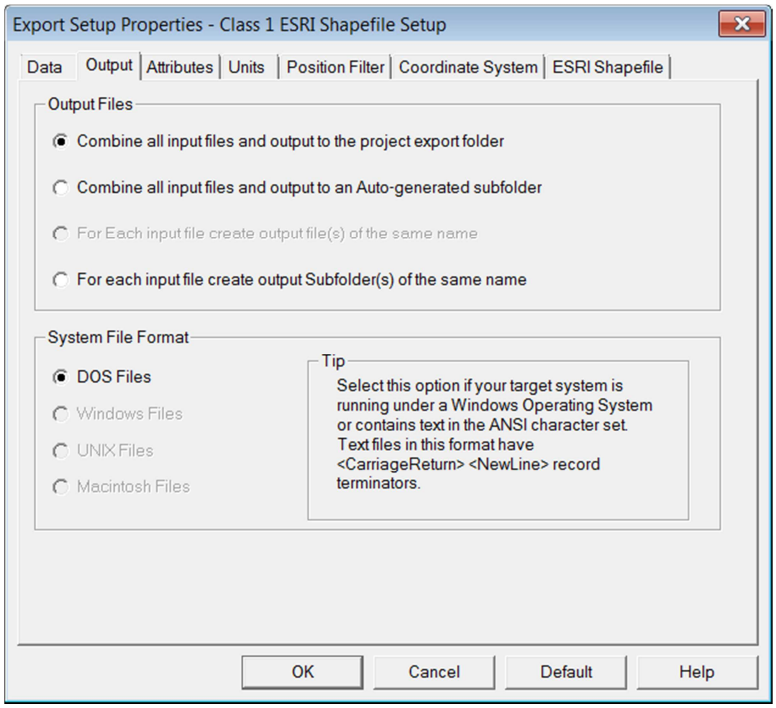


   Select *Yes* to proceed or *No* to return to the Export set up.

Choose the output options

To set output options:

1. Select the *Output* tab:

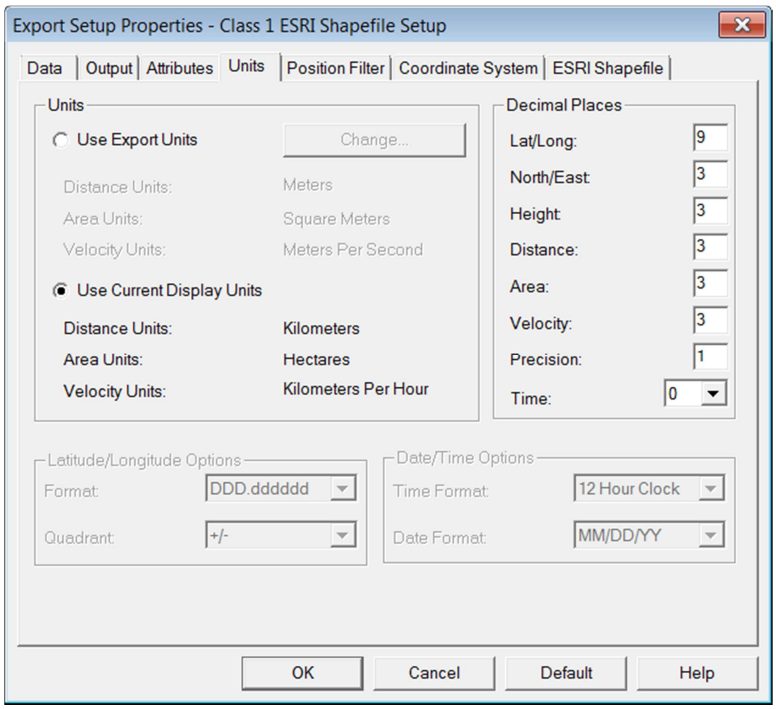


2. From the *Output Files* group, select one of the following:
   - *Combine all input files and output to the project export folder* – a single output file (or set of output files) is created in the export folder.
   - *Combine all input files and output to an auto-generated subfolder* – a single output file (or set of output files) is created in a subfolder of the export folder.
   - *For each input file create output file(s) of the same name* – for each input file, an output file (or set of output files) with the same filename as the input file is created in the export folder.
   - *For each input file create output subfolder(s) of the same name* – for each input file, an output file (or set of output files) is created in a subfolder of the export folder.
3. From the *System File Format* group, select the operating system of the computer for your GIS or CAD program.

Configure the units

To configure the units:

1. Select the *Units* tab:

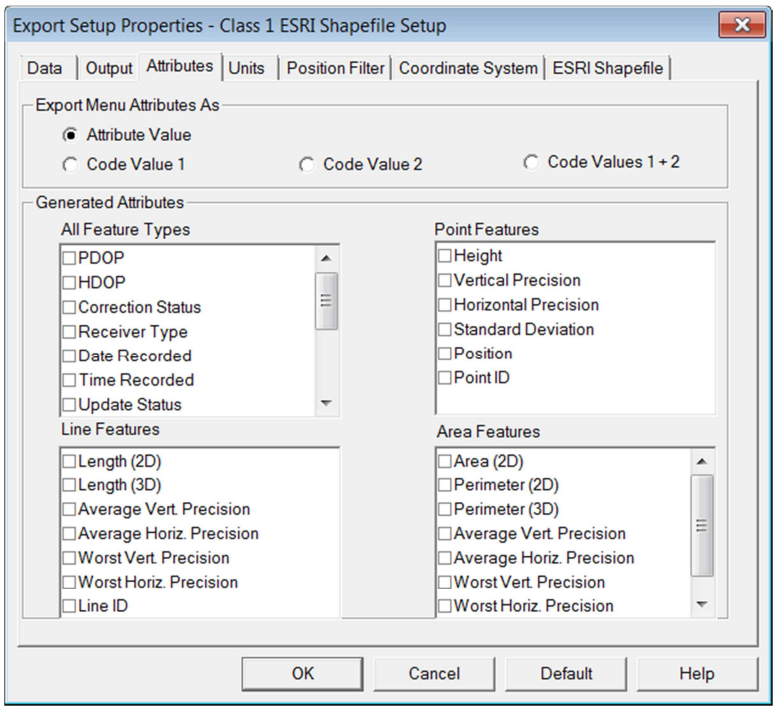


2. In the *Units* group, select *Use Export Units*. Data is exported in the units set in this tab. Click **Change** to reset the export units.
3. Choose the *Distance*, *Area*, and *Velocity Units*, and click **OK**.
4. Decimal Places – these fields control the number of decimal places exported. The decimal places fields apply only to data exported in ASCII formats.
5. Select the *Latitude/Longitude Options*, if they are available:
   - *Format* – controls the style of exported Latitude and Longitude coordinates.
   - *Quadrant* – determines how the quadrant or hemisphere component of a Latitude/Longitude coordinate is exported. Select +/– to export Northern hemisphere latitudes and Eastern hemisphere longitudes as positive numbers, and Southern hemisphere latitudes and Western hemisphere longitudes as negative numbers. Select NS/EW to export hemisphere letters.
6. Choose from the following *Date/Time Options*, if available:
   - Time Format
   - Date Format

Include attributes

To include attributes:

1. Select the *Attributes* tab:



2. In the *Export Menu Attributes As* group, select the *Attribute Value* option.
   - *Attribute Value* – exports the attribute value that was entered while collecting data.
   - *Code Value 1* – exports the first predefined code in the data dictionary.
   - *Code Value 2* – exports the second predefined code in the data dictionary.
   - *Code Values 1 + 2* – exports both predefined codes.

3. The *Generated Attributes* group includes additional attributes for documentation. Select any for your output file.

   For all feature types and their exported attribute names, include:

   - PDOP – MAX_PDOP
   - Correction Status – CORR TYPE
   - Receiver Type – RCVR_TYPE
   - Date Recorded – GPS_DATE
   - Time Recorded – GPS_TIME
   - Feature Name – FEAT_NAME
   - Data File Name – DATAFILE
   - Total Positions – UNFIL_POS. Total number of positions of the feature in the SSF file.

- Filtered Positions – FILT_POS. Total number of positions of the feature after position editing.

4. For *Point Features*, and their exported attribute name, include:
   - Height – GPS_CALC_HEIGHT. Elevation of the point features.

     Use this attribute if your GIS or CAD system does *not* accept three-dimensional coordinates. Do not select this if your GIS or CAD system stores three-dimensional positions.
   - Standard Deviation – STD_DEV. The spread of positions averaged for the point feature.

     Standard deviation is not a measure of accuracy of a point feature's position. It indicates the spread of positions from the mean.
   - Horizontal Precision – HORZ_PREC
   - Vertical Precision – VERT_PREC
5. For *Line Features*, include:
   - Length – GPS_LENGTH

     If your GIS or CAD system computes lengths internally, results may vary due to algorithmic processing.
   - Average Horizontal Precision – AVG_HORZ_P
   - Average Vertical Precision – AVG_VERT_P
   - Worst Horizontal Precision – WORST_HORZ
   - Worst Vertical Precision – WORST_VERT
6. For *Area Features*, and their exported attribute names, include:
   - Area – GPS_AREA
   - Perimeter – GPS_PERIMETER

     If your GIS or CAD system computes area and perimeter internally, results may vary due to algorithmic processing.
   - Average Horizontal Precision – AVG_HORZ_P
   - Average Vertical Precision – AVG_VERT_P
   - Worst Horizontal Precision – WORST_HORZ
   - Worst Vertical Precision – WORST_VERT
7. Click **OK** to save settings and return to the main *Export* dialog.

Export data

1. In the *Input Files* group, click **Browse**.
2. Select the corrected file to be exported (if it does not appear in the *Select Data Files* dialog), and click **Open**.

   You can export multiple files that use the same data dictionary.
3. In the *Choose an Export Setup* group, verify that the newly created export setup is selected, and click **OK**.

   Processing begins.

   An *Export Completed* dialog informs you of the number of positions and features exported.
4. Click **More Details** to view the text file created from the export.
5. Click **Close** to exit the Export utility.

When you return to the office, create an export setup to match your company's GIS. If you are unsure of the settings that your GIS requires, write down the settings here and speak to your GIS specialist.

Glossary

This section explains some of the terms used in this manual.

almanac - An almanac is data transmitted by a GPS satellite, which includes orbit information on all the satellites, clock corrections, and atmospheric delay parameters. The almanac is stored on the field computer. It is used to facilitate rapid acquisition of GPS signals when you turn on the TerraSync software, or when you have lost track of satellites and are trying to regain GPS signals.

attribute - An attribute is information about a geographic feature in a GIS or database, usually stored in a table and linked to the feature by a unique identifier. Every identifiable feature has attributes. One common attribute of all mapped features is geographic position. Other attributes depend on the type of feature. For example, attributes of a road might include its name, surface type, and number of lanes. Each attribute has a range of possible values, called a domain. The value selected is called the attribute value.

attribute value - An attribute is the particular value for a feature, chosen from the domain of an attribute. For example, for a road feature, surface type is an attribute; bitumen, gravel, and concrete are domains; and gravel is an attribute value.

base station - Also called a reference station. A base station is a GPS antenna and receiver positioned on a known location specifically to collect data for differential correction. Base data needs to be collected at the same time as you collect data on a rover unit. A base station can be a permanent station that collects base data for provision to multiple users, or a rover unit that you locate on known coordinates for the duration of the datalogging session.

baud rate - A baud is a unit used to measure the speed of electronic code transmissions, generally one bit per second. The higher the baud rate, the faster the transfer of data. However, both the input and output device must be configured to the same baud rate for data to be successfully transferred.

bearing - A bearing is the direction from one point to another, usually measured clockwise from north. In the TerraSync software, the bearing indicates the direction from your current position to the target.

broadcast server - A broadcast server is an Internet server that manages authentication and password control for differential correction sources such as virtual reference station (VRS network) networks, and relays corrections from the source that you select. An NTRIP server is an example of a broadcast server.

C/A code - See code phase.

carrier phase - Carrier phase is the time taken for the L1 or L2 carrier signal generated by the satellite to reach the GPS receiver. Measuring the number of carrier waves between the satellite and receiver is a very accurate method of calculating the distance between them.

Cartesian coordinates - The Cartesian coordinate system is a system of coordinates that defines the location of a point in space in terms of its perpendicular distance from each of a set of mutually perpendicular axes. The X direction is 0° latitude (the Greenwich meridian) and the Y direction is 90°east longitude.

centroid - The calculated center of an area feature.

CMR - (Compact Measurement Record) A real-time message format developed by Trimble for broadcasting corrections to other Trimble receivers. CMR is a more efficient alternative to RTCM correction messages, but is not supported by all non-Trimble receivers.

Coarse Acquisition code - See code phase.

code phase - (also known as Coarse Acquisition code, or C/A code) The difference between the pseudo-random number code generated by the TerraSync software and the pseudorandom number code coming in from the satellite. The code phase data is used to quickly compute the distance to a satellite and therefore calculate your position.

coordinate system - A set of transformations that allow GPS positions (in the WGS-84 ellipsoid) to be transformed to projection coordinates with elevations above the geoid. Essentially, a coordinate system consists of a datum transformation, a geoid model allocation, and a projection definition.

cross-track error - The amount and direction by which your current heading differs from the cross-track line.

cross-track line - The shortest direct path from the navigation start to the navigation target.

data dictionary - A data dictionary is a description of the objects to be collected for a particular project or job. It is used in the field to control the collection of the spatial and attribute information about these objects. The elements of a data dictionary could include point, line, and area features.

datum - A datum is a mathematical model of the earth's surface. World geodetic datums are typically defined by the size and shape of an ellipsoid and the relationship between the center of the ellipsoid and the center of the earth. Because the earth is not a perfect ellipsoid, any single datum will provide a better model in some locations than others. Therefore, various datums have been established to suit particular regions. For example, maps in Europe are often based on the European datum of 1950 (ED-50). Maps in the United States are often based on the North American datum of 1927 (NAD-27) or 1983 (NAD-83). All GPS coordinates are based on the WGS-84 datum and GRS80 ellipsoid.

datum transformation - A datum transformation defines the method and parameters that are used to transform the coordinates of a point defined in one datum to coordinates in a different datum. Trimble software supports several methods of datum transformation including Seven-Parameter, Three-Parameter (also referred to as Molodensky), and grid-based transformations. Typically, you use datum transformations to convert data collected in terms of the WGS-84 datum using GPS methods onto datums used for mapping purposes in individual regions and countries.

declination - See magnetic declination.

DGPS - See real-time differential GPS.

differential correction - Differential correction is the process of correcting GPS data collected on a rover with data collected simultaneously at a base station. Because it is on a known location, any errors in data collected at the base station can be measured, and the necessary corrections applied to the rover data. Differential correction can be done in real time, or after the data has been collected by postprocessing.

differential GPS - See real-time differential GPS.

digitizing - The process of creating positions manually by selecting a point on a map.

Dilution of Precision - (DOP) A measure of the quality of GPS positions, based on the geometry of the satellites used to compute the positions. When satellites are widely spaced relative to each other, the DOP value is lower, and position accuracy is greater. When satellites are close together in the sky, the DOP is higher and GPS positions may contain a greater level of error. PDOP (Position DOP) indicates the three-dimensional geometry of the satellites. Other DOP values include HDOP (Horizontal DOP) and VDOP (Vertical DOP), which indicate the accuracy of horizontal measurements (latitude and longitude) and vertical measurements respectively. PDOP is related to HDOP and VDOP as follows: PDOP2 = HDOP2 + VDOP2

DOP - See Dilution of Precision.

EGNOS - (European Geostationary Navigation Overlay Service) A satellite-based augmentation system (SBAS) that provides a free-to-air differential correction service for GPS. EGNOS is the European equivalent of WAAS, which is available in the United States.

ellipsoid - An ellipsoid is the three-dimensional shape that is used as the basis for mathematically modeling the earth's surface. The ellipsoid is defined by the lengths of the minor and major axes. The earth's minor axis is the polar axis and the major axis is the equatorial axis.

feature - A feature is a physical object or event that has a location in the real world, which you want to collect position and/or descriptive information (attributes) about. Features can be classified as points, lines, or areas. For example, a road sign is a point feature, a road is a line feature, and a park is an area feature. Features are defined in a data dictionary.

field computer - In the TerraSync software documentation, a field computer is any portable computer such as a handheld device, a laptop, or a Tablet PC running the TerraSync software. See also Windows Mobile powered device.

geoid - A geoid is an imaginary three-dimensional surface representing Mean Sea Level (MSL) if it was projected to extend through the continents. Unlike an ellipsoid or datum, which have a symmetrical surface, the geoid undulates perpendicular to the force of gravity.

geoid height - (Also known as geoid separation and geoidal undulation.) The geoid height is the distance of the geoid (MSL) above or below the reference ellipsoid.

geoid model - A geoid model is a mathematical representation of the geoid for a specific area, or for the whole earth.

great-circle distance - The great-circle distance is the shortest distance between two points on the

surface of a sphere.

guest - A guest connection lets a Windows Mobile powered device exchange and share information with a desktop computer. You need a guest connection or a partnership to transfer data between the TerraSync software on the device and the GPS Pathfinder Office software on the desktop computer. When you connect as a guest, you can:

- move or copy files between the two computers
- back up files on the Windows Mobile powered device
- install or uninstall programs on the Windows Mobile powered device

However, you cannot synchronize data between the two computers when you connect as a guest. To synchronize data you must set up a partnership. A guest connection is temporary. When the guest Windows Mobile powered device is disconnected from the desktop computer, any settings for the guest connection are lost. The next time you connect the device to the desktop computer, you must set the guest connection again. For more information, refer to the ActiveSync Help.

HAE - See Height Above Ellipsoid.

HDOP - See Horizontal Dilution of Precision.

heading - The heading is the direction you are facing or traveling, usually measured clockwise from north.

Height Above Ellipsoid - (HAE) HAE is a method for referencing altitude. Altitudes expressed in HAE are actually giving the height above the datum, not the ellipsoid. GPS uses the WGS-84 datum and GRS80 ellipsoid and all heights are collected in relation to this surface. It is important to use the same datum when comparing altitudes in HAE.

horizon - The line at which the earth and sky seem to meet.

Horizontal Dilution of Precision - (HDOP) Dilution of Precision (DOP) is a measure of the quality of GPS positions, based on the geometry of the satellites used to compute the positions. When satellites are widely spaced relative to each other, the DOP value is lower, and position accuracy is greater. When satellites are close together in the sky, the DOP is higher and GPS positions may contain a greater level of error. HDOP is a DOP value that indicates the accuracy of horizontal measurements. Other DOP values include VDOP (vertical DOP) and PDOP (Position DOP). The TerraSync software lets you specify either a maximum HDOP value or a maximum PDOP. It uses this maximum value as an upper bound on DOP values. You can configure the desired level of accuracy, and make sure that the positions logged are of a certain quality. When the DOP exceeds this maximum, the TerraSync software stops computing GPS positions. Using a maximum HDOP is ideal for situations where vertical precision is not particularly important, and your position yield would be decreased by the vertical component of the PDOP (for example, if you are collecting data under canopy).

H-Star technology - H-Star technology is a Trimble-patented technology allowing the collection of high accuracy GPS data. A GPS receiver that has H-Star technology logs L1 data or, if used with an external dual-frequency antenna, logs L1 and L2 data. Real-time H-Star technology uses corrections from an external source to provide decimeter accuracy in the field. Postprocessed H-Star technology uses base data from multiple base stations to obtain better postprocessed accuracy for the collected data once back in the office.

IMS - See Web map server.

International Terrestrial Reference Frame - (ITRF) A reference frame defined by the International Earth Rotation Service (IERS), with its origin at the Earth's center of mass. The WGS-84 datum is aligned with the current realization of ITRF, ITRF 2000 (also called ITRF00).

Internet Map Server - (IMS) See Web map server.

ionospheric noise - Ionospheric noise is the effect that the ionosphere has on GPS signals. The ionosphere is the band of charged particles 100 to 200 kilometers (60 to 125 miles approximately) above the surface of the earth.

ITRF - See International Terrestrial Reference Frame.

L1 - The primary L-band carrier used by GPS satellites to transmit satellite data. The frequency is 1575.42 MHz. It is modulated by C/A code, P-code, or Y-code, and a 50bps navigation message.

L2 - The secondary L-band carrier used by GPS satellites to transmit satellite data. The frequency is 1227.6 MHz. It is modulated by P-code or Y-code, and a 50bps navigation message.

laser rangefinder - An instrument that uses a laser beam to accurately measure the distance to a target. Some rangefinders also measure the bearing to the target. Use a laser rangefinder to measure offsets when you are unable to record positions at the exact location of the feature.

latitude - Latitude is an angular measurement made from the center of the earth to north or south of the equator. It comprises the north/south component of the latitude/longitude coordinate system, which is used in GPS data collection. Traditionally, north is considered positive, and south is considered negative.

local datum - The datum chosen for use in a particular region. Positions on a local datum are commonly called local geodetic coordinates. Coordinates are traditionally given in terms of the local datum. When you survey using the satellite-based Global Positioning System (GPS), however, the coordinates you collect are based on the World Geodetic System 1984. These coordinates are given in terms of the WGS-84 datum. Before you can use WGS-84 coordinates with coordinates measured in terms of the local datum, you must perform a datum transformation.

local ellipsoid - The ellipsoid specified by a coordinate system. The WGS-84 coordinates are first transformed onto this ellipsoid, then converted to grid coordinates.

lock - To track sufficient satellites for logging carrier phase or H-Star data. 'Loss of lock' occurs when the number of available satellites drops below four when logging a static GPS position, or below five when logging a streaming GPS position. Loss of lock can also occur during H-Star data collection if the PDOP rises above 6.

longitude - Longitude is an angular measurement made from the center of the earth to the east or west of the Greenwich meridian (London, England). It comprises the east/west component of the latitude/longitude coordinate system, which is used in GPS data collection. Traditionally, east is considered positive, and west is considered negative.

magnetic declination - Magnetic declination is the difference between magnetic north and true north. Declination is expressed as an angle and differs between locations.

magnetic north - A bearing that is relative to magnetic north uses the north magnetic pole as its north reference.

Mean Sea Level - (MSL) Mean Sea Level is a method of altitude reference. Altitudes expressed in relation to MSL actually give a height above the geoid. It is important to use the same geoid when comparing altitudes in MSL.

MSAS - (MTSAT Satellite-Based Augmentation System) MSAS is a satellite-based augmentation system (SBAS) that provides a free-to-air differential correction service for GPS. MSAS is the Japanese equivalent of WAAS, which is available in the United States.

MSL - See Mean Sea Level.

MTSAT Satellite-Based Augmentation System - See MSAS.

Multipath - Multipath is interference that occurs when GPS signals arrive at the receiver having traveled different paths. For example, this may happen if some signals are reflected off a building before reaching the receiver. If a signal takes a longer path it will show a larger distance to the satellite and therefore decrease position accuracy.

NAD-27 - (North American Datum of 1927) A horizontal datum employing the Clarke 1866 ellipsoid. Height values of this era are expressed in NGVD (National Geodetic Vertical Datum) of 1929.

NAD-83 - (North American Datum of 1983) A horizontal datum employing the GRS-80 ellipsoid. The original realization of NAD-83 was almost identical to WGS-84. The current realization NAD-83 (CORS96) differs from WGS-84 by up to a meter.

NMEA – (National Marine Electronics Association) NMEA 0183 defines the standard for interfacing marine electronic navigational devices. This standard defines a number of strings referred to as NMEA sentences that contain navigational details such as positions. Most Trimble GPS receivers can output positions as NMEA sentences.

NTRIP - (Networked Transport of RTCM via Internet Protocol) NTRIP enables the streaming of DGPS or RTK correction data via the Internet. Data is usually received using a modem and/or a cellphone. An NTRIP server is an Internet server that manages authentication and password control for differential correction sources including base stations and VRS networks, and relays corrections from the source that you select. An NTRIP server can be accessed by a number of users at the same time.

office computer - An office computer is any computer running Trimble postprocessing software. Usually the office computer is a desktop computer located in the office, but if you are running your data collection software on a laptop or Tablet PC then the office computer may actually be the same computer as the field computer.

parity - A digital message is composed of 0's and 1's. Parity is a form of error checking that sums the 0's and 1's of the digital message. A parity error results when one of the bits is changed so that the parity calculated at message reception is not the same as it was at message transmission. Options for parity checking include even, odd, and none. Typically you should have the same parity setting on the Windows Mobile powered device as on the external device you are communicating with.

partnership - A partnership lets a Windows Mobile powered device exchange and share information with a desktop computer. You need a partnership or a guest connection to transfer data between the TerraSync software on the device and the GPS Pathfinder Office software on the desktop computer. A partnership stores information about:

- how to connect to the device
- what types of files you can send and receive
- what files you can synchronize, and how to manage synchronization
- how to convert files for transfer

Unlike a guest connection, a partnership is stored on the desktop computer and remains when the device is disconnected from the desktop computer. For more information, refer to the ActiveSync Help.

PC - In TerraSync software documentation, a field computer that is running a supported Windows desktop operating system.

PDOP - See Position Dilution of Precision.

Position Dilution of Precision - (PDOP) Dilution of Precision (DOP) is a measure of the quality of GPS positions, based on the geometry of the satellites used to compute the positions. When satellites are widely spaced relative to each other, the DOP value is lower, and position accuracy is greater. When satellites are close together in the sky, the DOP is higher and GPS positions may contain a greater level of error. PDOP is a DOP value that indicates the accuracy of three-dimensional measurements. Other DOP values include VDOP (vertical DOP) and HDOP (Horizontal DOP). The TerraSync software lets you specify either a maximum HDOP value or a maximum PDOP. It uses this maximum value as an upper bound on DOP values. You can configure the desired level of accuracy, and make sure that the positions logged are of a certain quality. When the DOP exceeds this maximum, the TerraSync software stops computing GPS positions. Using a maximum PDOP value is ideal for situations where both vertical and horizontal precision are important.

postprocessing - Postprocessing is the processing of satellite data after it has been collected in order to eliminate error. This involves using PC software to compare data from the rover to data collected at the base station. Because the base station is on a known location, any errors can be determined and removed from the rover data.

predicted postprocessed accuracy - The predicted postprocessed accuracy is a prediction of the accuracy that will be achieved after postprocessing. When logging H-Star or carrier data, the predicted postprocessed accuracy value applies to all the positions collected since you achieved lock on the required minimum number of satellites. For all other receivers, this value applies only to the current position. The predicted postprocessed accuracy has a 68% confidence level, which means that 68% of the time the postprocessed position will be within the predicted postprocessed accuracy value shown when the position was collected.

PRN - See pseudo-random number.

projection - A mapping of a set of coordinates from a datum to a plane; or a set of mathematical rules for performing such a translation. Projections are used to create flat maps that represent the surface of the earth or parts of it.

Pseudo-Random Number - (PRN) The pseudo-random number is the code of 0s and 1s transmitted by GPS satellites, which appears to be random “noise”, but is actually a complex pattern that can be exactly reproduced. Each satellite has its own unique PRN code, which together are used by the GPS receiver to calculate code phase positions.

raster - A raster graphic is a graphical image consisting of rows and columns of dots. The color of each dot is represented by the value of one or more data bits in the image file. A bitmap (.bmp file) is a type of raster image.

Real-Time Differential GPS - (also known as real-time differential correction, DGPS) Real-time differential GPS is the process of correcting GPS data as you collect it. This is achieved by having corrections calculated at a base station sent to the receiver via a radio link. As the rover receives the position it applies the corrections to give you a very accurate position in the field. Most real-time differential correction methods apply corrections to code phase positions. RTK uses carrier phase measurements.

Real-Time Kinematic - See RTK.

rover - A rover is any mobile GPS datalogger collecting or updating data in the field, typically at an unknown location. Data collected on a rover can be differentially corrected relative to base station data.

roving mode - During RTK data collection, TerraSync logs line and area features, and between feature positions, in roving mode. Point features and vertices are logged in static mode. In roving mode, the TerraSync software records all RTK-corrected positions that meet the precision tolerances you have specified. All other positions are discarded.

RTCM correction messages - (Radio Technical Commission for Maritime Services) This is a commission established to define a differential data link for the real-time differential correction of roving GPS receivers. There are two types of RTCM differential correction message. All Trimble GPS receivers use the version 2.1 or later RTCM protocol.

RTK - (real-time kinematic) A real-time differential GPS method that uses carrier phase measurements for greater accuracy.

SBAS - (Satellite-Based Augmentation System) SBAS is based on differential GPS, but applied to wide area (WAAS, EGNOS, MSAS). Networks of reference stations are used and corrections and additional information are broadcast via geostationary satellites.

Signal-to-Noise Ratio - (SNR) The signal strength of a satellite is a measure of the information content of the signal, relative to the noise of the signal. The typical SNR of a satellite at 30° elevation is between 47 and 50 dB Hz. The quality of a GPS position is degraded if the SNR of one or more satellites in the constellation falls below 39 dB Hz. The TerraSync software lets you set a minimum SNR value. This value is used to determine whether the signal strength of a satellite is sufficient for that satellite to be used by the GPS receiver. If the SNR of a satellite is below the configured minimum SNR, that satellite is not used to compute positions.

site - A site consists of an existing coordinate system plus an extra set of parameters for horizontal and vertical adjustments. Together these provide the best fit of GPS data to a specific area or site. Because the additional corrections are only valid for a limited area, that area is called a site, or local site. A coordinate system is designed to apply over a large area and does not provide for variations that occur in local coordinates. When you create a site, you shift coordinates obtained using GPS so that they better fit coordinates in the existing map grid that were obtained using traditional surveying methods.

SNR - See signal-to-noise ratio.

SSF - (Standard Storage Format) A Trimble file format. SSF files store GPS data from a Trimble GPS receiver. Usually these files have the filename extension .ssf. A corrected SSF file has a .cor or .phs extension; an SSF file created by importing data has the extension .imp.

static GPS position - A static GPS position is a GPS position logged when the GPS receiver is stationary, as when logging a point feature or an averaged vertex in a line or area feature.

static mode - During RTK data collection, TerraSync logs point features and vertices in static mode. Line features, area features, and between feature positions are logged in roving mode. In static mode, the TerraSync software records only the RTK-corrected position with the best precision. All other positions are discarded.

streaming GPS position - (Also known as dynamic GPS positions) Streaming GPS positions are GPS positions logged when the GPS receiver is moving. When you are moving along a line feature, or around the perimeter of a polygon feature, you log streaming GPS positions. Your application logs a new vertex for every GPS position received from the GPS receiver.

synchronize - Synchronization is the process where ActiveSync technology compares information on a Windows Mobile powered device with the corresponding information on the desktop computer, and then updates either computer with the latest information. The data stored by the TerraSync software is not synchronized by ActiveSync technology. Use the Trimble Data Transfer utility to transfer data to and from the TerraSync software. For more information, refer to the ActiveSync Help and the Data Transfer Utility Help.

tracking - The process of receiving and recognizing signals from a satellite.

true north - A bearing that is relative to true north uses the north celestial pole as its north reference.

UTC – (Universal Time Coordinated) UTC is a time standard based closely on local solar meantime at the Greenwich meridian (GMT). GPS time is directly related to UTC.

UTM – (Universal Transverse Mercator) A special case of the Transverse Mercator map projection. Abbreviated as UTM, it consists of 60 north/south zones, each 6 degrees wide in longitude.

vector - A vector graphic is a graphical image consisting of mathematical descriptions of lines, points, and areas. When you transfer an SSF data file to the TerraSync software as a background file, its attribute information is removed, leaving only the vector information. You can view the features in the map, but you cannot select them, view their attributes, or edit them.

velocity - Velocity is essentially a measure of speed that takes into account direction of travel as well as the distance traveled over a period of time.

Vertex - A point on a line or area feature where two adjacent segments of the feature join. Each position that you collect for a line or area feature is a vertex of that feature.

VRS network - A VRS network consists of GPS hardware, software, and communication links. It uses data from several base stations to provide corrections to roving receivers that are more accurate than corrections from a single base station. Unlike other real-time correction sources, using corrections from a VRS network requires two-way communication between the VRS network and the roving receiver. The roving receiver must send its position to the server, so that the server can calculate corrections for that position, and select the closest base station if necessary. The server generates a unique virtual reference station for each roving receiver that connects to it.

WAAS - (Wide Area Augmentation System) WAAS is a satellite based augmentation system (SBAS) that provides a free-to-air differential correction service for GPS. WAAS was established by the Federal Aviation Administration (FAA). Its coverage area includes the continental United States and outlying parts of Canada and Mexico.

waypoint - A waypoint is a geographical point that, unlike a feature, holds no attribute information beyond a name and location. Typically, waypoints are used to denote objects whose locations are of primary interest, such as a survey mark. Waypoints are most often used for navigation.

web map server - An Internet site that lets users download GIS data, background, and other files for a specified geographical area. The TerraSync software can download raster background files from a web map server.

WGS-84 – (World Geodetic System 1984) WGS-84 has superseded WGS-72 as the datum used by GPS since January 1987. The WGS-84 datum is based on the ellipsoid of the same name.

Windows Mobile powered device - A small handheld device powered by the Windows Mobile operating system. A Windows Mobile powered device usually has a small screen, and limited memory and storage space.

SOP-08: Low Void Aggregate (LVA) Manufacturing

1.0 Purpose

The CMI WP outlines the remedy to construct a permeable barrier cover over the exposed soil/fill surface of the Redevelopment Area of the Site to preclude exposures to sitewide contaminants. The contaminants representing the greatest potential risk for direct contact exposure for both human and ecological receptors due to their elevated concentrations in soil/fill at the Site are the inorganic contaminants of arsenic, lead, antimony, thallium and cadmium. Other, inorganic contaminants or lesser potential risk due to concentration, include barium, chromium, cobalt, copper, manganese, selenium, silver, vanadium and zinc. The presence of these contaminants in the soil/fill represents an exposure pathway for Site occupants down to a depth of approximately seven feet below ground surface. The Final Decision response to Comments document issued by the USEPA establishes the need to construct an earthen permeable barrier cover to prevent exposure of Site occupants to these contaminants. This barrier cover is considered an engineering control and will require the importation of soil materials and masonry media materials to construct.

The materials generated from screening and crushing masonry media can be used or blended to manufacture a uniform product with low void-space ratios that can be gauged for quality control. This product is considered a Low Void Aggregate (LVA).

2.0 Scope

This SOP applies to all Impact personnel and subcontractors engaged in permeable barrier cover activities at the Former DuPont East Chicago Facility, Indiana (DuPont EC) site. This SOP focuses on the most commonly used site redevelopment surveying and environmental surveying and sampling tasks and applications anticipated at DuPont EC and should be used in conjunction with other applicable project SOPs, including the following:

- *SOP- Field Documentation*
- *SOP- Geographic Land Surveying*

3.0 Procedures

3.1 Masonry Media Sourcing

The soil and masonry media used for the construction of the permeable earthen barrier cover will be sourced from off-site borrow from construction projects within the region. Soil and masonry media include virgin soil, fill, foundry waste and mixed masonry (brick, block, asphalt and terracotta tile) and mixtures of these media that are borrow from construction and demolition activities performed at regional construction projects, herein referred to as Donor Sources. To ensure that no new pollution exposures are introduced onto the Site, the Donor Source will be thoroughly screened and the borrow inspected and tested for quality assurance and quality control.

Chemical Quality of Soil and Masonry Media

All of the soil and masonry media or qualified wastes approved for beneficial use will be tested and demonstrated to meet the IDEM Adjusted Legitimate Use Modified Residential Criteria based on the Project Conceptual Site Model. No material impacted by point source contamination will be accepted. There will be a limit of total PCBs set at the more conservative concentration of 2.0 parts per million per USEPA TSCA Policy Decision (pending changes to the PCB manual). The top foot of the barrier will be comprised of materials that meet the IDEM Regional Screening Levels for Residential Direct Contact Exposure Standard as presented in IDEM IAC, 2018 Screening Level Table A-6. There will be restriction on any detectable concentrations of PCBs set for this surface of the barrier cover.

Physical Quality

In that the soil fraction of materials used to construct the barrier cover will be coming from regional Donor Sources, variability can be expected in gradation, plasticity, organic content, angularity, porosity and color. For uniformity, Donor Source media will be collected at the Facility and processed with diesel-powered hydraulic sorting and sizing equipment within the designated processing area. This equipment will manufacture the necessary products from the soil and masonry media needed to construct the permeable barrier cover. Quality control testing is performed on the soil and masonry media after sorting and sizing to ensure that the physical and chemical quality of the media meets the specifications for the remedy and is suitable for the selected redevelopment method of building construction. The remedy requires the construction of the physical impediment to prevent direct and indirect exposure to contaminants. On-site sorting and sizing will also provide a greater population of potential Donor Sources (i.e. certain sources will not be considered unsuitable because of one or more physical deficits).

3.2 Soil and Masonry Media Processing (LVA Production)

Imported Donor Source material will be tipped from trucks in the tipping area for inspection prior to being placed into the Raw Feed Stockpile. The Raw Feed Stockpile will be limited in size to 100,000 cubic yards. The pile can be measured for management through use of a drone fitted with a GPS-enabled camera. The camera returns measurements that are very precise and that can output detailed GIS derived maps.

Materials from the Raw Feed Stockpile will be fed into a scalping screen configured to “scalp” fragments greater than 3 inches from the material using a vibratory screen deck equipped with 4 inch steel hexagonal punch plates. These fragments are inert brick, block, concrete, stone, etc. The 4 inch minus material is conveyed into a working pile that can be used to blend with other processed materials into LVA product. Materials retained on the screen deck range in diameter from 4 inch to 24 inches. Miscellaneous steel and wood debris are handpicked out of the material prior to crushing. A jaw crusher is utilized to primary crush on oversized material down to a workable size for finer crushing. The jaw crusher is equipped with hydraulically adjustable jaw settings, reverse crushing action to relieve blockages, hydraulic drive enabling the crusher to start under load, and jaw level sensors to control feed rate with minimal intervention. A jaw crusher is designed to create a 6:1 reduction in material size. It crushes material using the compressive force of a high strength steel hinged jaw plate reciprocating back and forth relative to a high strength steel fixed jaw plate. The jaw plates are mounted above a 6-inch slot. Material ranging from sand sized particles to 6 inch in diameter drops through a secondary scalping screen and onto a conveyor belt for a finishing crush. The finishing crush reduces the material at a 6:1 ratio until it is small enough to fit through a 2inch opening at the bottom of the machine. The material will be recirculated until all materials measure less than 2 inch and pass.

The configuration at the Facility will have two primary feeders feeding one finishing screen. The recirculation allows for the product to be created without the need to double handle the material. This process converts the imported fill to a 4 inch minus product that can be easily handled for filling and grading purposes while also producing a valuable product that can be used as an alternative to quarry mined stone and soil aggregate natural resources.

The materials generated from screening and crushing can be used or blended to manufacture a uniform product with low void-space ratios that can be gauged for quality control. This product is considered a Low Void Aggregate (LVA). The LVA will reduce soil gas airspace and promote equilibrium in the permeable barrier cover after the permeable barriers are subsequently constructed above. Simply stated, the LVA will have lower pore space and very high density due to the angularity of the crushed media and the great distribution of the particle sizes.

The scalper screen can operate at 585 tons per hour for 5 hours a day, for 4 days per week (1-day maintenance). Calculated for 108 days of work, this will generate approximately 270,000 tons of screen process material per year. The crushers will operate at 300 tons/hour for 5 hours a day for 4 days per week (1 day per week is for maintenance). Calculated for 108 days of work, this will generate approximately 324,000 tons of crush process material per year.

3.3 LVA Manufacturing and Stockpile

The manufactured LVA will be generated and stored in individual conical piles that will be piled to approximate a volume of 5,000 cubic yards as estimated by Field Staff or through use of a drone. These piles, termed "Charge Stockpiles", will be indexed as the volume is satisfied. At the point where one Charge Stockpile is completed to final volume, a new Charge Stockpile will be created. The number of Charge Stockpiles that can be in the processing area will not exceed 12 (60,000 cubic yards). Charge Stockpiles will be subject to testing prior to use in supplying LVA to construct cells of the barrier cover.

Charge Stockpiles that pass the testing specifications for LVA will be approved for use in barrier cover cell construction. Approved piles will be fitted with signs indicating "Approved LVA" that will include the pile index, sampling date and sample identification. If a representative sample is tested and found to be out of compliance with the gradation specifications, the pile will be failed. Failed piles will be fitted with signs indicating "Failed LVA" and the pile index. Such piles will be fed back into the Primary Process Stockpile for re-blending as deemed necessary by the Field Staff.

Charge Stockpile Testing

A representative composite sample of the charge stockpile will be taken for laboratory analysis. The composite sample will be comprised of 5 grab samples obtained from equidistant points of the charge pile that are taken from a depth within the pile that is a minimum of 2 feet from the pile surface. Each charge stockpile sample will be tested using ASTM methods by a competent soil laboratory and compared against the following threshold limits.

TEST Method	DESCRIPTION	THRESHOLD LIMITS FOR PASSING
AASHTO T194-87	Organic Content	0.6%
ASTM 422-63	Fines Content Passing 200 sieve Oversized (>3/4")	>15% 20% (volume)
ASTM G51-18	Soil pH	≥6
ASTM 698	Modified Proctor (for high-fines soils) – samples should contain <10% oversize.	Optimum Moisture for use in barrier compaction testing (no threshold)

4.0 Production Specifications

LVA will be manufactured to consist of crushed concrete, block and brick with varying percentages of soil fractions of sand, trace silt and clay. It will be produced from the proposed soil and masonry media borrow using a multi-step manufacturing process to produce a uniform fill with the following specifications:

- Gradation of 10-20% of fines passing No. 200 sieve.
- Gradation of 80-90% of aggregate that's up to 2 to 4 inches in diameter.
- Porosity- void ratio measured after compaction 0.2 (+/- 0.075).
- Compaction rate measured in place as a dry density to be greater than 95%.
- Thickness of lifts after compaction measured at 1 foot (+/- 0.1 foot)

Gradation

Gradation testing will be performed on samples representative of finished LVA charge piles in the soil and masonry media processing area. Each of the finished charge piles will have a volume of approximately 5,000 cubic yards. There will be 1 sample secured from each finished LVA charge pile. Analysis of the samples for gradation will be in accordance with ASTM D422 Standard Test Method For Particle-Size Analysis Of Soils.

Modified Proctor

Modified proctor compaction testing will be performed on samples representative of finished LVA charge piles in the soil and masonry media processing area. Each of the charge piles will have a finished volume of approximately 5,000 cubic yards. There will be 1 sample secured from each finished LVA charge pile. Analysis of the samples for modified proctor compaction will be in accordance with ASTM D1557 Standard Test Methods For Laboratory Compaction Characteristics Of Soil Using Modified Effort. The test is a laboratory method of experimentally determining the optimal moisture content at which the LVA will become most dense and achieve its maximum dry density. It is expressed as a graphical relationship of the dry density to moisture content is then plotted to establish the compaction curve and maximum density. The proctor compaction has a no pass or fail value; it will be used for other calculations. This data will be included with a running accounting in CMI Reports.

Specific Gravity

Specific gravity measurements will be taken from samples representative of finished LVA charge piles in the soil and masonry media processing area. Each of the charge piles will have a finished volume of approximately 5,000 cubic yards. There will be 1 sample secured from each finished LVA charge pile. Specific gravity is a unitless property equal to the density of the solid matter in the product normalized by the density of water. It is equivalent to the theoretical density of the product if there were no voids. The Specific Gravity of the product will show little variance since it is an intrinsic property. Therefore, there is no pass or fail value for specific gravity; it will be used for other calculations. This data will be included with a running accounting in Quarterly Progress Reports and in the Corrective Measures Implementation Report (Remedial Completion Report).

Soil Density - Percent Dry Density

Soil density measurements of LVA will be taken in the field after it has been placed and compacted to 1-foot thickness within a finished cell. The measurements will be taken using ASTM Method D6938 Standard Test Method for In-place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods. The density measurement of the LVA will show variance with any changes in moisture content or compaction methods.

The Nuclear Moisture Density device (or Nuclear Gauge) is specifically designed to measure the moisture and density of soils, aggregates, cement, and mixtures thereof. It provides a method of obtaining fast, accurate and in-place measurement of densities and moisture. The device provides results for both dry and wet density in Kg/m3 and a dry density in percentage. The device uses a small radioactive source which sends radiation through the material being tested, giving data which can be correlated to density and/or moisture (see Health and Safety Plan). This data will be included with a running accounting in CMI Reports.

Lift Thickness

Cell lift thickness will be determined through performance of elevations surveys. Cell thickness will be determined by taking the final GPS elevation profiles and subtracting this elevation from the corresponding starting GPS elevation profiles. Such measurement will only be made where a cell has passed compaction ($\geq$95%). This data will be included with a running accounting in CMI Reports.

Porosity - Void Ratio

Void ratio measurements of LVA will be taken in the field after it has been placed and compacted in a cell. This data will be used with data obtained from Charge Stockpile testing to calculate void ratio. Field measurements will be taken at a frequency of 1 test per 5,000 cubic yard LVA Charge Stockpile using ASTM D854 (*Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer*) and ASTM D6938 (*Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods*).

Calculation of void ratio, expressed as a percentage, uses data acquired from the in-place density measurements taken in the field. Normalizing this density by the density of water makes the in place compacted density and the specific gravity measurement compatible.

Where, the Gravel Corrected Maximum Dry Density/Density of Water = Specific Gravity of the compacted product (SG_c).

The difference between the Specific Gravity (SG) and the Specific Gravity of the compacted product (SG_c) is caused by the voids in the compacted product. The mass of the air voids is negligible. Therefore, the Void Ratio of the in place LVA = (SG/SG_c) -1

The Contractor will ensure that both the void ratio and the compaction rate (the ratio of the in-place LVA to the maximum dry density of the LVA measured in the Modified Proctor analysis) fall within the permissible range. This data will be included with a running accounting in CMI Reports.

5.0 General

Once LVA is stockpiled as an approved product it will be implemented within the following product uses:

- Source Area Pile Berming
- Roadway Stabilization
- Permeable Soil Cap

7.0 Air Emission Compliance and Permitting

All diesel-powered equipment will be in compliance with USEPA Tier 4 Final, Nonroad Compression Ignition Exhaust Emission Standards. Compliance with be documented using USEPA VERIFY for equipment model years with A-D engine technology categories.

Annual throughput of sorting and sizing equipment utilized on-site shall be submitted as a running total in CMI Reports. Each source or process will be described by subdivision and maintained for the 12-month period on a monthly rolling total basis.

The emissions of particulate generated from the operation of this crushing and screening plant will not require permitting with IDEM, Office of Air Quality due to the type of activities and potential emissions for air contaminants Attachment 1 - Air Emission Inventory). The emissions rate potential from an air inventory of sources has identified that the operations are exempt. State rules found in Title 326, Article 2-1.1-3 of the Indiana Administrative Code list exempt units, processes and operations and thresholds. Units or operations that are not exempt require an approval for construction and operation. There are three primary types of approvals in Indiana: registrations; State operating permits (general and source-specific); permit-by-rule operating permit; and Title V permits, which are issued for pollution control at large sources under Title V of the Federal Clean Air Act.

7.0 Records

Documented volumes of imported materials, product generation and other material parameters will be recorded and submitted within Quarterly progress reports. Furthermore, total volumes, manifests, and other LVA specific parameters will be included in the Corrective Measures Implementation Report (Remedial Completion Report).

8.0 References

ASTM D1557 *Standard Test Methods For Laboratory Compaction Characteristics Of Soil Using Modified Effort*

ASTM D422 *Standard Test Method For Particle-Size Analysis Of Soils*

ASTM Method *D6938 Standard Test Method for In-place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods*

ASTM D854 *Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer*

ASTM D6938 Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods

9.0 Definitions

Charge Stockpiles: Manufactured LVA Product stored in individual conical piles approximately 5,000 cubic yards in volume.

Donor Source: Mixed media (ranging from virgin soil, clean fill, foundry waste, brick, block, asphalt and terracotta tile) that are borrow from construction and demolition activities performed at regional construction project.

Gradation: Size distribution and classification of particulates.

Modified Proctor: Data transmitted by a GPS satellite, which includes orbit information on all the satellites, clock correction, and atmospheric delay parameters. The almanac is used to facilitate rapid SV acquisition. The orbit information is a subset of the ephemeris data with reduced precision.

Nuclear Moisture Density: Unit of measure for civil engineering and construction that measures soil density or soil water content for compactability.

Porosity - Void Ratio: The ratio of the volume of interstices of a material to the volume of its mass.

Raw Feed Stockpile: Imported Donor Source material collected in a conical stockpile limited in size to 100,000 cubic yards.

Scalping: Mechanical means of separating particles by size. Fragments greater than 3 inches will be screened out from the material using a vibratory screen deck equipped with 4inch steel hexagonal punch plates.

Specific Gravity: Also called *relative density*, ratio of the density of a substance to that of a standard substance.

10.0 Attachments

Attachment 1 - Air Emission Inventory

SOP-9: WELL DECOMMISSIONING AND ABANDONMENT

1.0 Purpose

This standard operating procedure (SOP) provides guidance in the decommissioning and abandonment of monitoring wells, temporary micro monitoring wells, and boreholes that are no longer in use, or that have fulfilled their intended purposes. Groundwater monitoring wells must be installed, developed, and decommissioned in accordance with applicable Agency methods, protocols and procedures, or another approved method that is protective of human health, safety, and welfare, and of the environment. The American Society for Testing and Materials (ASTM) D5299-99 *Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities* is also referenced as a guidance for the abandonment of other intrusive activities. Well decommissioning requires the prior approval of Agency, and wells should be decommissioned within 60 days if they are abandoned or no longer used, unless an alternative schedule is approved by Agency.

The practices described in this SOP are not applicable to all circumstances; regional, climatic, and geographic variables can influence monitoring well design and construction which will influence decommissioning methodology. While decommissioning methodologies may differ, site-specific application should be technically sound. This SOP offers an organized collection of information or a series of options and does not recommend a specific course of action. This SOP cannot replace education or experience and should be used in conjunction with professional judgment.

Well abandonment is conducted to prevent surface water from infiltrating into the subsurface, so that the well does not become a potential conduit for contaminant dispersion. The goal in decommissioning monitoring wells is to remove the well casing and screen in a manner that ensures that the abandoned borehole is sealed to a lesser permeability than the native soils surrounding the borehole. Casing removal is important because the outside of the casing can act as a conduit through horizontal formation changes even if the inside of the casing is grouted. The well casing and screen should be removed when wells are decommissioned unless permafrost, remoteness of the well, or other unique conditions make it impracticable. If the casing cannot be completely removed, unscrew the top section and grout from there. Otherwise, excavate the surface soil surrounding the well and cut the casing below the ground surface. Agency approval must be obtained for all monitoring well decommissioning methods.

Decommission wells that are damaged beyond repair, abandoned, or not intended for future use. A well that is no longer maintained and secured is susceptible to damage that can prevent proper future decommissioning and is a potential conduit for direct surface contamination to the aquifer.

Most monitoring wells are constructed of polyvinyl chloride (PVC) casing and screen with flush-threaded joints. Well casing and screen should typically never be removed unless sealing grout is concurrently placed in the vacated borehole during removal.

Before initiating decommissioning procedures, determine historical records concerning the well condition, details of construction, total depth, current water level, and the existence of any obstructions that could interfere with the process of filling and sealing the well, and obtain any well construction diagrams. For larger wells, downhole videos or photographs may be required to ascertain the current well condition and well construction details.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in the decommissioning of wells and boreholes during environmental investigations and monitoring programs for Project Sites. The procedures presented in this SOP describe the minimum acceptable practices for the abandonment of monitoring wells.

3.0 Procedures

The following procedures must be followed to ensure the proper decommissioning of wells and boreholes.

3.1 General

There are six elements that generally need to be addressed before conducting well abandonment activities. These include addressing regulatory requirements, well construction design, the hydrogeological environment, the chemical environment around the well or borehole, disposal of investigation derived wastes, and determining the types of equipment and quantities of materials that will be required to complete well abandonment.

In addition, the following key principals, specifications, and precautions should be considered during monitoring well decommissioning:

1. Decommission wells that are out of use within 60 days
2. Remove the well casing/screen
3. Apply pipe sealing materials directly to the point of application
4. Ensure that sealing grouts are properly mixed and prepared in accordance with manufacturer recommendations before placement.
5. Grout/slurry sealant should be used rather than bentonite/sealant pellets in order to achieve a complete and competent seal.
6. Pellets can bridge during placement, resulting in voids and an incomplete seal.
7. If using cement grout, neat cement, or puddled clay as sealing materials below the static water level in the well, introduce from the bottom up.
8. When using a tremie tube to place grout, submerge the discharge end in the grout to avoid breaking the seal while filling the annular space.
9. For artesian wells, place a cement grout or concrete plug in the confining stratum overlying the artesian zone to prevent upward seepage from the artesian zone.
10. Fill the remainder of the well with cement grout or bentonite.
11. Record decommissioning procedures and report to the Agency.

For wells with a diameter exceeding 12 inches, revised procedures (than those described in the following sections) should be submitted to the Agency for approval. A geologist or engineer should plan, supervise, and document well abandonment.

3.1.1 Well Decommissioning Materials

Materials that may be used for sealing wells and boreholes include concrete, cement grout, neat cement, bentonite, or combinations of these materials. The selection of the proper decommissioning materials must be based on the

construction of the well, depth of the borehole, the nature of the formation(s) penetrated, the type and concentration of chemicals present, and the location of the well or boring with respect to possible outside sources of contamination.

Concrete is generally used for filling the upper portions of a well, sealing water-bearing formations, plugging short sections of casings, or filling large-diameter wells. It is less expensive than neat cement or grout and it makes a stronger plug or seal. However, concrete will not penetrate seams, crevices, or interstices in the screen, casing, filter pack or formation. Furthermore, if not properly placed, the aggregate is likely to separate from the cement, weaken the mixture, and more easily cause bridging within the annular space.

Cement grout, a mixture of neat cement and water, is far superior for sealing small openings in the screen and casing, penetrating any annular space outside of the screen and casing, and filling voids in the surrounding formation. Special care must be taken to ensure that upper groundwater zones are securely cased off during sealing of lower zones.

Combinations of materials are frequently required to increase the effectiveness of the seal and the workability of its placement. Plans to use combinations of materials must be addressed with the regulatory agencies. Regardless of the type of material or combination of materials used for decommissioning, the sealant must be free of contaminants and must minimize potential chemical alteration of the quality of the groundwater and adjacent soil.

3.1.2 Grouting Requirements

Grouting must proceed from the bottom of the well up to the top of the well using a tremie pipe or dump bailer. Grout must be added to the borehole/well under pressure to ensure adequate penetration of the annular space and surrounding formation. In addition, the tremie pipe should be placed into the grout by two feet or more to prevent bridging. Free-fall placement of grout into the borehole is generally not acceptable.

When the grout has reached 5 feet below ground surface, or to a level above the water table (whichever is shallower) let it settle and cure. After 24 hours, check the grout for settling and add additional grout if necessary. Grouting is complete when the neat cement has set and no settlement has occurred.

If using cement grout, neat cement, or puddled clay as sealing materials below the static water level in the well, introduce from the bottom up using methods that avoid segregation or dilution of the material. A cement-bentonite grout should be used in the water bearing zone(s). A cement grout without bentonite should be used in the vadose zone to prevent shrinkage. Shrinkage may lead to cracks in the grout, which can provide a migration pathway for groundwater or surface water. For artesian wells, place a cement grout or concrete plug in the confining stratum overlying the artesian zone to prevent upward seepage from the artesian zone. Fill the remainder of the well with cement grout or bentonite.

3.2 Boring and Well Decommissioning Procedures

The following sections present the procedures that should typically be used for boring and well decommissioning, and the methods to be used for placement of the sealing material. Before beginning the decommissioning operations, ADEC must have approved the decommissioning procedures. The procedures and materials used must be properly documented to ensure defensibility.

The following three well decommissioning alternatives will be employed dependent on site conditions:

- Well casing removal

- Well casing remaining in place
- Re-drilling the well

Procedures for well abandonment with each of these options, and the likely rationale for selecting each option are described in the following sections.

3.2.1 Decommissioning—Well Casing Removal

Removal of well materials (casing and screen) is the preferred method for any well decommissioning. If it is believed that attempts to remove the well casing by pulling it out with jacks or a drill rig could fail and result in complications to properly decommission the well, the casing may be left in the well and abandoned by leaving the well casing in place of re-drilling the well. The decommissioning method is to remove the well casing; however the casing should not be withdrawn without being first completely filled to near the ground surface, from the bottom up, with sealing grout. Removing the well casing and screen without the concurrent placement of grout sealant will lead to a collapsed and lost borehole that may never be properly sealed. The well casing and screen serve as the conduit allowing placement of a hose or other tremie tube to the bottom of the well for purposes of grout placement. The procedural outline is as follows:

- Obtain approval from the Agency for the well decommissioning methodology
- Puncture or separate the bottom well cap by driving a steel drill rod or steel pipe against/through the end cap. The well casing/screen/end cap assembly can be lifted from the borehole slightly before driving off the end cap, in order to raise the end cap above the underlying compacted soil and assist in breaking it off the end of the well casing/screen.
- After the end cap has been ruptured or separated, sealing grout is pumped/placed to the bottom of the well, using a hose or tremie tube installed down the casing to the bottom of the well, until a column of grout fills the casing to the near ground surface.
- The well casing can now be withdrawn; however, the grout level within the casing will lower as the casing is withdrawn and grout will flow out the base of the well casing/screen to fill the borehole void space. Grout should be periodically added as the casing is removed to keep a column of grout near the ground surface. This will prevent the sloughing of the borehole, and fill any borehole void space, should the casing break while being pulled from the borehole.
- Grout the borehole to within 5-feet of ground surface or to above the groundwater table, whichever is shallower.
- Calculate the required volume of grout based on the depth and diameter of the borehole and record. Also record the volume actually used. Explain any discrepancy between the calculated and actual volume.
- Remove the surface seal and protective surface box.
- Backfill the top of the borehole with clean soil and match the surrounding surface completion (such as asphalt, concrete, soil, or other).
- Submit documentation of well abandonment to the Agency.

3.2.2 Well Casing In-Place

Competent Annular Grout Seal: If permafrost or other unique circumstances prevent the removal of the well casing and screen assembly and if the original construction of the well is known to have included a competent annular grout seal surrounding the well casing, the screen/casing should be completely grouted in-place up to the casing cutoff point located near the ground surface.

Perforate and Grout Well Casing: If it is not possible to remove the casing by pulling it out or over drilling around it and pulling it out, then perforation of the casing and well screen in place is the next option. This requires a drill rig with a knife or other device that can thoroughly perforate the entire casing such that grout may be pressurized into the annular space surrounding the well casing.

The following procedures should be followed for well abandonment with the casing in-place:

- Obtain approval from the Agency for the well decommissioning methodology.
- For wells with competent annular seals, grout the well to within 5-feet of site grade.
- For wells with unknown annular seals, use a drill rig to perforate the entire well casing.
- Grout the borehole to within 5-feet of ground surface.
- Calculate and record the required volume of grout based on the depth and diameter of the borehole.
- Record the volume of grout installed. Explain any discrepancy between the calculated and actual volume.
- Remove the well head including the surface seal and the uppermost 3 to 5 feet of casing.
- Backfill the top of the borehole with clean soil and match the surrounding surface completion (such as asphalt, concrete, soil, or other).
- Submit documentation of well abandonment to the Agency.

3.2.3 Well Re-Drilling

Re-drilling of the well with hollow stem augers in order to seal the borehole by placing grout down the hollow augers during auger removal can be an effective alternative option in circumstances where the well has been damaged, broken, filled, or plugged with soil or other extraneous media, preventing successful decommissioning using either of the prior two described methods. The concern with re-drilling a monitoring well borehole is there is no way to ensure that the augers will follow the original borehole to the completed well depth. For this reason, re-drilling should only be used when neither decommissioning method described above can be successfully employed. This alternative option consists of re-drilling the borehole to the full depth of the well. The PVC casing and well screen will be destroyed and broken into multiple pieces while re-drilling the borehole. After the auger string has been drilled to the total depth of the well, place grout sealant by hose or tremie tube to the bottom of the augers until a grout column is established within the augers to near the ground surface and the top of the drill string. Then methodically withdraw the augers while adding grout to maintain the grout column within the augers to near the ground surface until all of the augers have been removed.

The following re-drilling procedures should be followed for decommissioning:

- Obtain approval from the Agency for the well decommissioning methodology.
- Remove the well head re-drill the well attempting to keep the well casing inside the auger if possible and drill to the bottom of casing.

- Place grout sealant by hose or tremie tube to the bottom of the augers until a grout column is established within the augers to near the ground surface and the top of the drill string
- Withdraw the augers and keep the grout column within the augers to near the ground surface. Backfill the borehole to within 5-feet of ground surface.
- Calculate and record the required volume of grout based on the depth and diameter of the borehole.
- Record the actual volume installed. Explain any discrepancy between the calculated and actual volume.
    - Backfill the top of the borehole with clean soil and match the surrounding surface completion (such as asphalt, concrete, soil, or other).
    - Submit documentation of well abandonment to the Agency.

3.3 Micro Well Decommissioning Procedures

The following procedures are proposed for the permanent abandonment of Micro Wells:

- Obtain approval from the Agency for the well decommissioning methodology.
- Pull the entire casing and well screen from the borehole using a drill rig or hydraulic jacks.
- Backfill the borehole to within 5 feet of ground surface adding bentonite pellets via a tremie pipe or similar to prevent bridging.
- Regularly hydrate the bentonite pellets during emplacement once above the water table.
- Calculate and record the required volume of backfill and bentonite based on the depth and diameter of the well annulus.
- Record the volume actually used. Explain any discrepancy between the calculated and actual volume.
- Fill remainder of borehole with clean fill and return surface conditions to site grade.
- Submit documentation of well abandonment to the Agency.

3.4 Test Boring Abandonment Procedures

Test borings that are no longer of use must be properly abandoned and permanently sealed. Test borings are typically less than 30 feet deep and are defined as being for the immediate determination of subsurface stratigraphy, hydrologic conditions, or contamination conditions in the unsaturated or saturated zone. Test borings should be sealed properly and abandoned as soon as possible after the boring has been completed. Test borings will typically be 2-inch diameter and advanced with a vibratory drill rig which does not produce cuttings at the surface. Abandonment of test borings will be by filling the open hole with bentonite pellets. Water should be poured down the hole on a regular basis to hydrated the chips. The test boring should be sealed to 5 feet below the ground surface and the ground surface should be restored to match the pre-drilling conditions.

If the test boring is greater than 2 inches in diameter, these revised procedures cannot be followed, and alternative procedures will be proposed. All information regarding well decommissioning must be recorded and documented in the field log book.

3.5 Investigation-Derived Waste

Documentation of investigation derived waste (IDW) should be conducted throughout well decommissioning activities. Establish plans for disposal of IDW before beginning field activities, see *the SOP for Investigative and Remedial Derived Waste Management*. Potentially contaminated IDW may include soil or rock material, pumps, samplers, well casings and screens.

3.6 Reporting

Report well abandonment to the Agency, including the following information:

1. A copy of the original boring log
2. The well construction log
3. An abandonment log
4. A site map showing the location of the abandoned monitoring well
5. Disposal documentation for wastes generated during the abandonment process

4.0 Records

All decommissioning procedures will be documented at a minimum per field notes taken according to technical procedures for Field Log books.

5.0 References

American Society of Testing Materials (ASTM) D5299-99 (Reapproved 2005). *Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.*

6.0 Definitions

Annular seal: an impermeable material, such as cement grout or bentonite, placed in the annular space between the borehole wall and the permanent casing to prevent downhole movement of surface water or the vertical mixing of water-bearing zones.

Annulus: the space between the borehole wall and the well casing.

Bentonite: a hydrous aluminum silicate which increases volume (swells) upon contact with water and provides a tight seal between the well casing and the borehole. Available in powder, granular, or pellet form.

Bridging: the development of gaps or obstructions in either grout or filter pack materials during emplacement. Bridging of particles in a naturally developed or artificially gravel- packed well can occur during development.

Cement grout: a fluid mixture of cement and water, possibly with bentonite added. Consistency of the mixture is such that it can be forced through a pipe and emplaced in the annular space between the borehole and the well casing to form an impermeable seal.

Decommissioning: the complete sealing of a well or borehole with grout or other impermeable materials when the well or borehole is determined to no longer be of use. Decommissioning eliminates the potential for improper access to the subsurface.

Filter pack: a chemically inert, uniform, well-rounded material (sand, gravel, or glass beads) that is placed in the annulus of the well between the well screen and the surrounding formation to (1) prevent formation material from entering the well, (2) ensure continuous fluid flow from the formation into the well, and (3) stabilize the adjacent formation.

Monitoring well: a well that is installed for the purpose of extracting representative groundwater samples for physical, chemical, or biological analyses and can be utilized for groundwater head measurements.

Neat cement: a mixture of Portland cement (ASTM C-150) and water in the proportion of 5 to 6 gallons of clean water per bag of cement (94 pounds or 1 cubic foot).

Packer: a compressible cylinder of rubber and metal that is placed in or outside a well to plug or seal the well or borehole at a specific point.

Plugging: the complete filling of a borehole or well with an impermeable material which prevents flow into and through the borehole or well.

Pressure grouting: a process by which grout is confined within the borehole or casing by the use of retaining plugs or packers and by which sufficient pressure is applied to drive the grout slurry into the annular space or zone to be grouted.

Soil boring: a hole drilled or bored into the earth for the collection of soil samples for analysis.

Well casing: an impervious durable tubular product that is a permanent feature of a well and designed to (1) prevent caving in of the boring walls, (2) provide access from the ground surface to some point in the subsurface, and (3) serve as a passage for groundwater level measurement and sample collection devices.

Well Perforation: drill, puncture or otherwise put holes in the well casing to allow grout to infiltrate the filter pack and/or porous material surrounding the well.

7.0 Attachments

None

SOP-10: MONITORING WELL/PIEZOMETER INSTALLATION

1.0 Purpose

This standard operating procedure (SOP) provides the methodology for installing and constructing groundwater monitoring wells and piezometers.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in installation and construction of groundwater monitoring wells and piezometers at former Dupont East Chicago Facility, Indiana (Dupont EC) site projects and tasks. This SOP was developed in accordance with the following guidance documents:

- *American Society for Testing and Materials (ASTM) Standard D5092: Standard Practice for Design and Installation of Ground Water Monitoring Wells* (American Society for Testing and Materials [ASTM], 2004).

This SOP focuses on the most common monitoring well installation tasks anticipated at the Site and should be used in conjunction with other applicable project SOPs, including the following:

- *SOP- Note Taking and Field Log Books*
- *SOP- Organic Vapor Monitoring and Air Monitoring*
- *SOP- Hollow Stem Auger and Direct Push Drilling Methods*
- *SOP- Monitoring Well Development*
- *SOP- Equipment Decontamination Procedures*
- *SOP- Field Procedure Change Management*

3.0 General

Data collected from monitoring wells and piezometers at investigation sites support various site characterization objectives, including delineation of the nature and extent of a contaminant plumes, development of a conceptual model of the subsurface lithology, assessment of aquifer properties, and development of a long-term monitoring network to detect trends in site groundwater elevations and contaminant concentrations. Wells installed for each of these purposes must satisfy different requirements and may require different strategies for well design and installation. Representative groundwater samples and groundwater level measurements depend upon proper monitoring well design and construction, which should reflect anticipated contaminant types and concentrations, project objectives, and site conditions. Selection of monitoring well type, construction materials, and drilling method is commonly a site-specific determination and often site logistics and economics influence well design and installation choices.

Well design and installation must prevent the introduction of surface contaminants into the groundwater and prevent the transfer of groundwater or contaminants between stratigraphic intervals within the well borehole or along the well annulus. Do not install monitoring wells in locations where they are subject to periodic or seasonal inundation by floodwaters, unless the well has special watertight construction. Protect monitoring wells integrity from soil erosion, soil settlement, shrink-swell soil conditions, frost heaving of soils, damage by vehicles or heavy equipment, or other site-specific hazards. Monitoring wells should not be completed at-grade or below-grade.

Drilling techniques anticipated for use at Site projects and tasks include hollow-stem auger (HSA) and direct push systems (DPS):

- HSA drilling will be used to install 2- to 4-inch diameter (or greater) permanent groundwater monitoring wells or when consolidated geologic conditions are expected. The drill rig will be mounted on a heavy-duty truck, or it will be self-propelled by an all- terrain mechanized track system.
- DPS drilling will be used for soil sampling in unconsolidated lithology and to install 0.75- to 1.0-inch-diameter microwells or piezometers. The drill rig will be mounted on a heavy- duty truck, or it will be self-propelled by an all-terrain mechanized track system.

Microwells and piezometers will have a 0.75- to 1-inch-diameter casing with an attached screen; they are used primarily to temporarily monitor the static water level or obtain a finite number of water samples for water quality or contaminant screening purposes. Microwells use pre-packed screens for installations in small-diameter DPS boreholes.

Successful installation of a well requires that the procedures for installing each component of the well are followed and well documented. There are nine essential components of a well installation:

- Well casing
- Well screen
- Filter pack
- Annular seals (lower and upper surface seals)
- Surface completion
- Well protection
- Field notebooks
- Well completion report
- Records Management

References and definitions are provided in Sections 8.0 and 9.0, respectively. Figure 1 illustrates the design of a typical groundwater monitoring well.

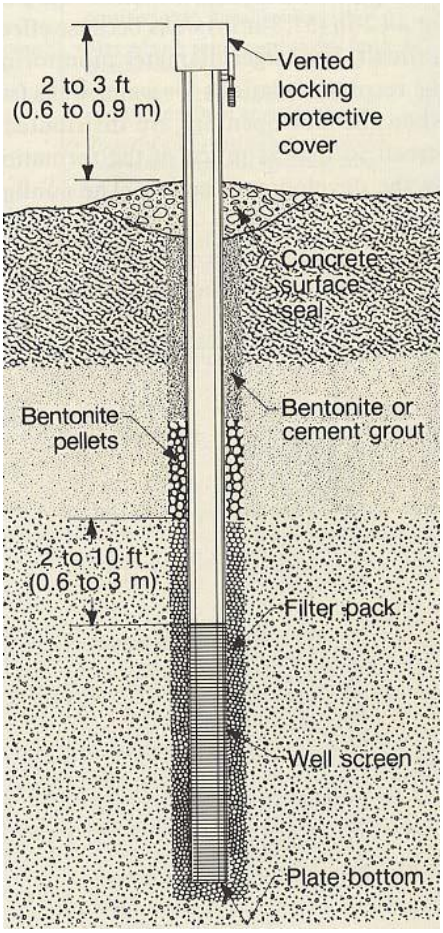


Figure 1. Typical Monitoring Well (Driscoll, 1986)

5.0 Procedure

Installation of monitoring wells will be performed under the direct supervision of a qualified geologist, engineer, or other professional. Permanent monitoring wells should be constructed in accordance with ASTM Standard D5092 (see Attachment 1).

A monitoring well is generally composed of a well casing, well screen, filter pack, and sanitary or grout seal. Permanent monitoring wells will be installed in open boreholes advanced by an HSA drill rig. Soil borings should be advanced until the desired depth is obtained and the subsurface soil demonstrates saturated soil conditions. Once the desired borehole depth is obtained, all drill tooling will be removed from the borehole and the monitoring well will be installed. The diameter of the HSA boreholes will be at least 4 inches larger than the outside diameter of the blank casing and screen. This allows for proper installation of materials within the annular space to create an adequate annular seal.

The following general guidelines will be followed to properly complete each monitoring well to the desired depth:

1. Properly decontaminate well construction materials before installation.
2. Prevent contamination when joining casings and attaching the screen.
3. Pour the filter pack into the annulus to a minimum of 2 feet above the top of the screen and 1 foot beneath the well end cap.
4. Use bottom caps or end plugs.

5. Use permanent or temporary surface casing if contamination or sloughing is a potential issue.
6. Apply filter packs with a tremie pipe or similar method (unless using a pre-packed filter).
7. After installation, “sound” the filter pack for proper placement.
8. Place a fine-grain sand filter 0.5 to 2 feet thick at the top of the filter pack and below the annular seal to help prevent infiltration of bentonite into the filter pack.
9. Apply bentonite pellets or granules to seal the annular space by pouring them freely or through a tremie pipe.
10. If the well is 40 feet or greater in depth, pump grout or slurry into the annular space by using a tremie pipe.
11. For wells less than 40 feet deep, pour grout or slurry freely into the annular space, with or without the use of a tremie pipe.
12. If more than 10 feet of standing water is present, use a tremie pipe to install neat cement and bentonite-cement grouts.
13. Submerge the end of the tremie pipe in the sealing material when installing a slurry or grout.
14. When using a slurry or grout, allow 24 hours between installation of the annular space seal and installation of the protective pipe cover. Fill any settlement in the annular space seal before installing the protective cover.
15. Install a cement surface seal at the ground surface.

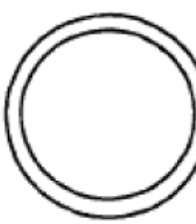
5.1 Well Casing and Well Screen

5.1.1 Well Casing

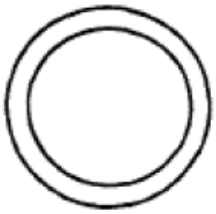
The well casing allows access to groundwater from the ground surface. To eliminate the introduction of contaminants when sampling, join casing sections together with threaded couplings rather than glues, in order to eliminate the introduction of adhesive contaminants into the groundwater. Threaded couplings should have O-rings to complete the seal, and the well casing should be flush, on the inside.

The inside diameter of the well casing should be at least 1.9 inches, with the exception of microwells and piezometer installations. Monitoring wells in Alaska commonly use Schedule 40 polyvinyl chloride (PVC), nominal 2-inch-diameter casing. Deeper wells, or wells that need large, dedicated pumps or tubing, may require 4-, 6-, or 8-inch-diameter casing. However, most monitoring wells will use a smaller casing (2 or 4-inch-diameter) to minimize the amount of water generated during sampling events. Table 1 lists the inside diameters of various well casings.

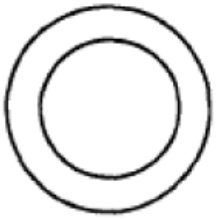
Table 1. Casing Thickness and Diameter for Monitoring Well Materials (EPA, 1991b)



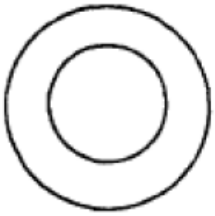
Schedule 5
(Stainless Steel)



Schedule 10
(Stainless Steel)



Schedule 40
(Stainless Steel, PVC, Fluorooplymer)



Schedule 60
(PVC, Fluoropolymer)

Wall Thickness (Inches)	Sch 5	Sch 10	Sch 40	Sch 80	Outside Diameter (Standard)
Nominal 2	0.066	0.109	0.164	0.218	2.375
Nominal 3	0.063	0.120	0.216	0.300	3.500
Nominal 4	0.083	0.120	0.237	0.337	4,500
Nominal 5	0.109	0.134	0.258	0.375	5.563
Nominal 6	0.109	0.134	0.280	0.432	6.625
Inside Diameter	Sch 5	Sch 10	Sch 40	Sch 80	
Nominal 2	2.245	2.157	2.067	1.939	
Nominal 3	3.334	3.260	3.068	2.900	
Nominal 4	4.334	4.260	4.026	3.826	
Nominal 5	5.345	5.285	5.047	4.813	
Nominal 6	6.407	6.357	6.065	5.761	

5.1.2 Well Screen

The well screen is the part of the well that allows groundwater to enter into the monitoring well and allows access to the aquifer. Determining the slot size and well screen length characteristics of a well screen depends on the purpose of the monitoring well and aquifer characteristics. The proper slot size of the well screen should be determined based upon the filter pack selected for the monitoring well and the formation material. Monitoring wells typically installed within unconsolidated soil use a 20-slot (0.020-inch) well screen with a No.10-20 silica sand pack, or 10-slot (0.010-inch) well screen with a No.20-40 silica sand pack. Screen slots will be sized to prevent 90% of the filter pack from entering the well. The standard screen slot size anticipated for newly installed wells at the Site is 10-slot (0.010-inch), unless field conditions indicate otherwise and approval of the PM has been obtained. Monitoring wells must use commercially manufactured, machine-slotted well screens. Table 2 lists the recommended screen slot size and filter pack characteristics.

Table 2. Recommended Filter Pack Characteristics for Common Screen Slot Sizes (ASTM D5092)

Size of Screen Opening, mm (in.)	Slot No.	Sand Pack Mesh Size Name(s)	1 % Passing Size (D-1), mm	Effective Size, (D-10), mm	30 % Passing Size (D-30), mm	Range of Uniformity Coefficient	Roundness (Powers Scale)
0.125 (0.005)	5[A]	100	0.09 to 0.12	0.14 to 0.17	0.17 to 0.21	1.3 to 2.0	2 to 5
0.25 (0.010)	10	20 to 40	0.25 to 0.35	0.4 to 0.5	0.5 to 0.6	1.1 to 1.6	3 to 5
0.50 (0.020)	20	10 to 20	0.7 to 0.9	1.0 to 1.2	1.2 to 1.5	1.1 to 1.6	3 to 6
0.75 (0.030)	30	10 to 20	0.7 to 0.9	1.0 to 1.2	1.2 to 1.5	1.1 to 1.6	3 to 6
1.0 (0.040)	40	8 to 12	1.2 to 1.4	1.6 to 1.8	1.7 to 2.0	1.1 to 1.6	4 to 6
1.5 (0.060)	60	6 to 9	1.5 to 1.8	2.3 to 2.8	2.5 to 3.0	1.1 to 1.7	4 to 6
2.0 (0.080)	80	4 to 8	2.0 to 2.4	2.4 to 3.0	2.6 to 3.1	1.1 to 1.7	4 to 6

[A] A 5-slot (0.152-mm) opening is not currently available in slotted PVC but is available in Vee wire PVC and Stainless; 6-slot opening may be substituted in these cases.

The type of well screen and slot size controls the amount of open area in a well intake (EPA, 1991b). In addition, the depth of the screened interval and the well screen length can affect the water quality and hydraulic characteristic results. Minimize the length of the well screen to avoid dilution during sampling. Increased open area in the monitoring well screen allows effective development and easy flow of water from the formation into the well. The well screen depth and length are determined on a site-specific basis in consideration of water table variations, site stratigraphy, expected contaminant behavior, and groundwater flow.

Clustered monitoring wells are often installed to determine vertical hydraulic or contaminant concentration gradients. Clustered wells should consist of individual wells installed in separate boreholes in close proximity to each other and screened at varying depth intervals. Nested wells that consist of multiple aquifer completions in a single borehole should not be installed. Figure 2 illustrates both clustered and nested well designs. When installing clustered wells, drill the deepest well first. Refer to borehole sampling information to determine what formation interval to screen or where to place seals to prevent communication between the aquifers.

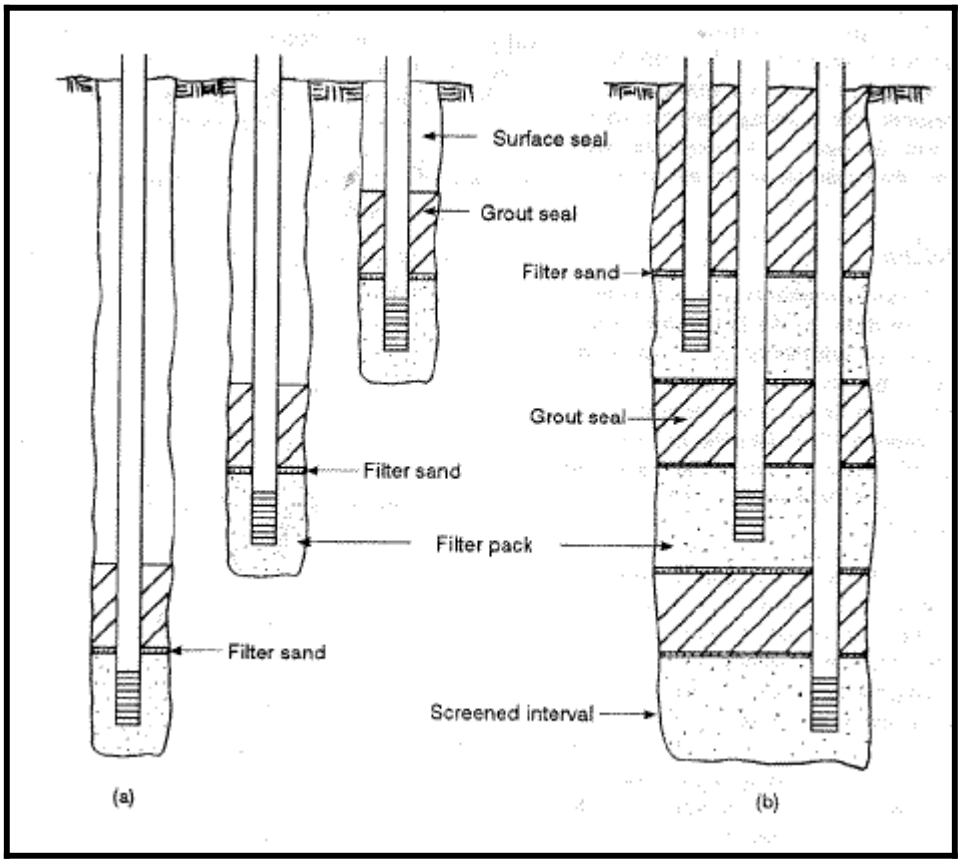


Figure 2. Piezometers Installed as (a) Clusters, or (b) Nested (EPA, 1991b).

5.1.3 Materials

A variety of construction materials are used for the well casings and well screens. The material used for well screens is generally selected based on the same guidelines used for selecting well casing. There are many different casing materials used in design of a monitoring well; thermoplastic materials (such as PVC) and stainless steel are the most widely used. PVC well screens are used because they provide a strong monitoring well with good chemical resistance (EPA, 1991). The type of well casing and well screen material to be used, screening intervals, screen slot sizes, and specific material decontamination procedures are provided in the site-specific field sampling plan in Appendix D.

5.1.4 Installation Procedures

The following general procedures should be followed when installing well casings and well screens:

- Keep the well casing sealed in plastic until it is ready to be installed into the borehole.
- Carefully assemble and install well casings and screens to prevent damage to the sections and joints.
- Sections of well casing and screen must be mechanically connected, such as flush threading. Use of glue or solvents to connect or seal casing is prohibited.

- Secure an end cap at the bottom of the well screen before installing section(s) of well screen into the well boring.
- If using pre-pack well screens, take care to not tear or damage the outer fabric or screen holding the pre-pack filter sand to the well screen.
- Install the well casing and well screen straight and plumb and centered within the middle of the borehole.
- Install the filter pack from the bottom of the borehole to at least 2 feet (up to 5 feet) above the top of the well screen. At locations that have shallow groundwater, the filter pack can be placed to extend to at least 1 foot above the top of the screen.
- During installation, place a cap on top of the casing to prevent well materials from entering the well casing.
- A completed monitoring well should be sufficiently straight to allow passage of pumps or sampling devices.
- Document the calculated and actual quantities of materials used in the well installation and the condition of well materials in the Field Notebook in accordance with *SOP-XX, Note Taking and Field Log Books*.

5.2 Filter Pack

The well screen of each monitoring well should be surrounded by a permeable, course- grained sand known as the filter pack. Fill the annular space surrounding the well screen with a filter pack of uniform-grain-size sand that is coarser and has a higher permeability than the natural, surrounding formation. The filter pack should allow groundwater to flow freely into the well from adjacent formation material and minimize or eliminate fine-grain material from entering the well. The use of natural formation material as the only filter pack is not acceptable.

Montoring wells within unconsolidated soils are installed with either a No.10-20 or 20-40 silica sand filter pack. The filter pack should extend above the well screen to a length of 20 percent of the well screen length, but no less than 2 feet (ASTM D5092). The thickness of the filter pack between the borehole and the well screen should be at least 2 inches but no greater than 8 inches (EPA, 1991).

5.2.1 Materials

Filter pack materials must be poorly graded (well sorted) to provide good permeability and hydraulic conductivity of the materials near the screen. The filter pack material should be clean, chemically inert, and well-rounded siliceous material and should be slightly coarser than the surrounding formation. Using coarser material increases the effective well diameter. The sand or gravel used for filter packs should be of uniform size, be hard and durable, and have an average specific gravity of 2.50 or greater. The filter pack material should be obtained from known clean sources and should be well washed and free of clay, dust, and organic matter. No more than 5 percent of the sand or gravel should be soluble in hydrochloric acid.

Filter pack material should meet the National Sanitary Foundation (NSF) standards and be packaged in properly sealed and marked packages. Record the NSF label information and any associated lot or identification numbers in the Field Notebook.

The filter pack is designed for the anticipated and tested grain size distribution in the screened formation and the size of well-screen openings (see Table 2). The filter pack should have a grain size distribution and uniformity coefficient compatible with the formation materials and the screen (Driscoll, 1986). The filter pack must not extend

across more than one water-bearing unit (or aquifer). Install the filter pack in all wells (deep or shallow) in a manner that minimizes bridging and void spaces in the filter pack.

Any open annular space outside of a pre-pack filter should be filled to the maximum extent practical with additional filter pack material, as previously described. Natural collapse can also be allowed to fill annular space around a pre-pack filter.

5.2.2 Installation Procedures

The following procedures should be followed to optimize the installation of the filter pack and the quality of the well:

- Calculate the volume of the well annulus (that is, the filter pack required), and document in the Field Notebook the type and volume of the filter pack material installed.
- Record in the Field Notebook the NSF label information and any associated lot or identification numbers from the filter pack material.
- Periodically measure the filter pack during installation by using a sounder or weighted measuring tape to confirm uniform placement and prevent bridging.
- Measure the depth of the top of the filter pack to verify the thickness of the pack and to confirm proper depth placement above the well screen (at least 2 feet above the screen.
- Under no circumstances should the filter pack extend into any aquifer other than the aquifer to be monitored.

5.3 Annular (Bentonite) Seal

Annular seals prevent vertical movement of water or contaminants between the filter pack, the adjacent soil formation, and the natural backfill material above the screen.

There should be two annular seals in standard monitoring wells, one above the filter pack (lower seal) and one at the ground surface (upper seal). All permanent monitoring wells should be constructed with a lower annular seal at the top of the filter pack to confine the well screen within the desired sampling interval. The lower annular seal should be installed at least 2 feet thick on the top of the filter pack to prevent seal material from leaching into the filter pack. Pelletized bentonite is preferred for this application; however, a bentonite slurry or similar material may also be used, if appropriate.

Install the upper annular seal near the ground surface to protect the well from infiltration of surface runoff and potential aboveground contaminants. The upper annular seal should be installed at least 2 feet thick and extend from approximately 1 to 2 feet below ground surface (bgs) to 3 to 4 feet bgs. This annular seal should be bentonite pellets, bentonite slurry, or similar material.

For shallow wells constructed with approximately only 5 to 6 feet between the top of the filter pack and the ground surface, it is acceptable to combine the upper and lower annular seals into a single annular bentonite seal approximately 3 to 4 feet thick from the top of the filter pack to approximately 1 to 2 feet bgs. For deeper wells, the annular space between the two seals should be filled with a bentonite slurry or coarse bentonite chips.

When using bentonite pellets to seal the filter pack, install the pellets in sequential, 1-foot- thick layers. Hydrate each layer by pouring an approximately equal volume of clean, potable water into the borehole before placing the next layer of pellets. Continue this process until the required minimum 2-foot seal thickness is installed. Use a

weighted tape measure, measuring rod, or similar measurement device to check that the filter pack seal is installed in the proper depth interval. Bentonite grout is suggested when freeze–thaw processes may affect the well.

5.3.1 Materials

Pelletized bentonite is preferred for this application; however, the following may also be used:

- Neat cement grout (not recommended for use with schedule 40 PVC well casing or where there might be shrinkage that would allow leakage along the casing)
- Sodium-based bentonite slurry with a mud weight of at least 10 pounds per gallon
- Sodium-based bentonite granules
- Sodium-based bentonite pellets
- Bentonite-cement grout.

Measure the thickness of the bentonite before hydration. The permeability of the seal must be one to two orders of magnitude less than that of the surrounding formation. The seal must be chemically compatible with the anticipated contaminants and chemically inert so that it does not affect the quality of ground-water samples.

Use fine-grain bentonite, such as granules and powder, for seals placed above the existing water level. A bentonite slurry should be used for the bentonite seal below the existing water level. Coarse bentonite, such as pellets and chips, can also be used for bentonite seals located just below the groundwater water level.

5.3.2 Installation Procedures

The following procedures should be followed for placement of the annular seals:

- When installing an annular seal, determine the type and volume of annular seal material needed by referring to the information in the well borehole log. Record the type, calculated volume, and actual volume of annular seal material used in the Field Notebook.
- Install at least 2 feet of lower annular seal material above the filter pack.
- Install at least 2 feet of upper annular seal material at least 1 to 2 feet bgs.
- At locations where there is shallow groundwater, the upper and lower annular seal may be combined so that there is 2 feet of filter pack above the well screen and 3 to 4 feet of annular seal. Document alternative procedures like this in the Field Notebook.
- Install the annular seal in 1-foot layers or less and hydrated with clean, potable water between layers.
- Water used for bentonite hydration or for mixing bentonite slurry should be from an approved potable source, of suitable quality, and free of pollutants and contaminants. Document the volume of water used in the Field Notebook.
- Measure the depth to the seal by using a weighted tape measure, measuring rod, or similar measurement device to confirm that the thickness and depth of the seal meets the design requirements.

- Allow the bentonite to completely hydrate in accordance with the manufacturer's instructions before filling the remainder of the annular space with bentonite/cement grout (described below).
- For deep wells, install the seal material by using a tremie pipe to prevent bridging. When using cased borehole drilling methods (such as HSA), the annulus between the monitoring well casing and drill stem may serve as the tremie pipe.
- Record the actual volumes of bentonite and grout used during well construction in the Field Notebook and explain any discrepancy between the calculated and actual volume.
- Record the details of the well construction including annular seal depth, thickness, seal material type, and installation methods in the Field Notebook.

5.4 Surface Completion and Well Protection

Two types of surface completions are typical to monitoring well installations:

- aboveground completion and
- flush-mounted completion.

Surface completion and well protection prevent surface runoff from infiltrating the well annulus and protect the well from accidental damage or vandalism. Properly survey the well installation after completion and document the survey measurements.

5.4.1 Surface Seals

There must be a surface seal of concrete around the protective well casing at each well that fills the upper annular space. A surface seal is a separate upper annular seal installed above, but not connected to, the bentonite seal (except in very shallow monitoring wells).

Because of the temporary nature of microwells, surface seals other than hydrated bentonite are not necessary. For further information regarding surface seals (upper annular seals) refer to Section 5.3.

5.4.2 Surface Completion and Monuments

Construct each monitoring well with a surface monument to protect the well casing from damage. Depending on site conditions, concrete may be used to create a secure monument foundation and provide an additional surface seal. Constructed concrete monument foundations (slabs) should be sloped away from the well so that it sheds rain and surface water. On a site-specific basis, alternative well construction designs may be used if approved by the PM (for example, in areas of permafrost, frequent frostjacking, or shallow groundwater).

If an aboveground monitoring well monument is installed, construct the well monument with a protective casing, preferably made of steel. Extend the protective casing at least 6 inches above the top of the well casing, and at least 2 feet into the ground. In areas that experience frost heaving, extend the protective casing from below the depth of frost penetration (3 to 5 feet below grade, depending on local conditions) to approximately 6 inches above the top of the well casing. Install the protective casing before the upper annular seal sets. Seal and immobilized the protective casing within the concrete monument foundation. To accommodate sampling equipment, make sure there is sufficient clearance, usually 6 inches, between the lid of the protective casing and the top of the riser. Drill an approximately ¼-inch-diameter weep hole in the protective casing approximately 6 inches above ground surface

to permit water to drain out of the annular space between the protective casing and the riser. In winter, this hole will also prevent water freezing between the protective casing and the well casing. Place dry bentonite pellets, granules, or chips in the annular space from 3 to 4 inches below the weep hole within the protective casing.

Place coarse sand or pea gravel (or both) in the annular space above the dry bentonite pellets and within 6 to 12 inches below the top of the well casing to allow water to drain from within the protective casing and prevent insect habitation.

If a flush-mount monitoring well monument is installed, construct the well monument with a steel protective cap with a subsurface casing that extends approximately 2 feet bgs. The top of the steel protective cap and protective casing must be flush with the ground. Drill an approximately ¼-inch-diameter weep hole in the protective casing approximately 18 to

24 inches from the top of the protective casing to permit water to drain out of the annular space between the protective casing and the well casing. Install the protective casing before the upper annular seal sets, making sure that the weep hole is above the top of the upper annular seal. Seal and immobilized the protective casing in a concrete, flush-mount foundation, if possible. To accommodate sampling equipment, make sure there is sufficient clearance, usually 6 inches, between the steel protective cap and the top of the well casing. Place coarse sand or pea gravel (or both) in the annular space within the protective casing to within 2 to 3 inches below the top of the well casing to allow water to drain from within flush-mount monument and prevent insect habitation.

Regardless of the type of monument, each well will be fitted with a locking well casing cap that easily fits below the protective well monument cap. Install a leak-proof, locking well casing cap on the top of each well casing to prevent vandalism and to prevent water from entering the well casing. The protective well monument cap should be leak-proof and secured with multiple bolts for additional protection.

Document all construction details and materials used in the Field Notebook. Clearly mark monitoring wells with a unique well identifier on the inside and outside of the protective casing.

Aboveground Completions

The following basic procedures will be followed for aboveground completions:

- Extend the well casing approximately 2 to 3 feet above the ground surface.
- Install a protective casing around the aboveground well casing. Install the protective casing in a plumb, vertical position. Place concrete (surface seal) above and around the base of the protective casing up to and becoming part of the surface concrete pad. The concrete seal should not extend below the base of the protective casing; this will allow trapped water during installation and sampling events to drain.
- The protective casing may be painted if requested by the client.
- Install a weatherproof, locking well monument cap on the top of the protective casing so there is adequate clearance between the top of the well casing cap and the bottom of the well monument cap.
- A concrete surface pad may be placed around the well protective casing. The pad should be approximately 3 feet square by 4 inches thick and sloped away from the protective casing.
- Install bollards around wells where traffic might threaten the integrity of the well (see Section 5.5.3 for detailed instructions).
- When possible, attach a stainless steel, well identification tag to the outside of the protective casing.

Flush-mounted Completions

The following procedures will be followed for flush-mounted completions:

- Cut off the well casing below grade, leaving enough space to install an leak-proof, locking well casing cap.
- Install a subgrade, protective casing with a steel protective cap around the top of the well casing. Install the protective casing to approximately 2 feet bgs. The top of the steel protective cap and protective casing must be flush with the ground.
- Drill an approximately ¼-inch-diameter weep hole in the protective casing approximately 18 to 24 inches from the top of the protective casing to permit water to drain.
- To accommodate sampling equipment, make sure there is sufficient clearance (typically 6 inches) between the steel protective cap and the top of the well casing.
- Place coarse sand or pea gravel (or both) in the annular space within the protective casing to prevent water infiltration and insect habitation.
- A concrete flush-mount foundation may be placed around the well protective casing. The concrete foundation must slope away from the protective casing.
- For flush-mounted completions located in high-traffic areas, follow the procedures outlined above except that traffic-rated cement or a steel vault should be used and cemented flush with the traffic surface.
- For flush-mounted completions, be careful to construct watertight bonds between the protective structure and the cement surface seal.
- Install a weatherproof, locking well monument cap on the top of the protective casing and weatherproof, locking well casing cap on top of the well casing.
- Where significant amounts of runoff occur, additional protection measures may be required.
- When possible, attach a stainless steel, well identification tag to the inside of the protective casing.

5.4.1 Well Protection

Monitoring wells can have either aboveground or flush-mount completions. If the well casing is composed of metal and completed above the ground surface, attach a lockable cap to the top of the protective well casing and lock the cap with a padlock. If the well is not cased with metal and is completed above the ground surface, install a metal protective casing around the well. For flush-mount wells, install a protective well monument vault (or equivalent) around the well with a lockable or bolt-on cover that has a waterproof seal. Install the cover level with the ground surface to help prevent the inflow of surface water.

Construct flush-mount well covers to withstand the maximum expected loadings (such as vehicular traffic or material staging). Install bollards around aboveground wells where traffic might threaten the integrity of the well. Install three or four bollards in a triangular or rectangular array at least 2 feet from the casing. Use 3-inch-diameter steel or wooden bollards that extend at least 4 feet above and 3 feet below the ground surface; the bollards must be tall enough to be easily visible to traffic. Bollards should not be placed in the concrete surface pads around the wells.

Paint the aboveground portion of the bollards with bright paint (such as yellow or orange), and place photo-reflective tape on the bollards if they are potentially hazardous during low- light conditions. In areas where there is a high probability of damage to the well (such as where there is high traffic, heavy equipment, or poor visibility), it may be

necessary to also install posts, markers, signs, or other safety features, as described in ASTM D5787. The level of protection should adequately mitigate the potential risk of damage to the well.

5.5 Installation of Microwells

Microwells are small-diameter monitoring wells. Microwells are generally installed in boreholes driven by DPS and are typically less than 2 inches in diameter. Microwells installed by the DPS method use pre-packed well screens. Microwells have the same installation requirements as conventional wells except that a sand barrier is installed directly above the pre-packed well screen to prevent grout from entering the screens. Other than the following modification, installation of a microwell is the same as a monitoring well:

- Place a sand barrier directly above the pre-packed well screen in the annulus between the well casing (riser pipe) and the borehole wall as the probe rods are retracted.
- The sand barrier must not extend more than 2 feet above the top of the pre-packed well screen.
- Install an annular seal from the filter pack to the top of the well in general conformance with Section 5.3.
- The annular seal must prevent vertical migration of liquids into the borehole annular space.

5.6 Supply Well Installation Specifications

For onsite pilot testing and treatment systems, makeup water or supply water may be pumped from the onsite aquifer, these wells are defined as supply wells. Typically supply wells have a larger diameter and longer screen length to accommodate an increase in uptake volume.

Supply wells will be installed by hollow-stem auger drilling machinery and techniques to a terminal depth approximately 35 feet BSG. The supply wells will be constructed utilizing six-inch I.D, Sch. 40 PVC well riser and 20-slot well screen, with the screen interval between 15 and 35 feet BSG. A filter pack consisting of inert silica (sand (US Mesh size between 20 to 30 mesh) will be installed from the terminal depth of the well to three feet above the well screen, followed by a bentonite seal installed between the sand pack and three feet above the sand pack. High-solids bentonite grout or equivalent will be installed within the remainder of the boring surrounding the well casing to approximately one foot below Site grade. The well will be finished approximately three to five feet above grade and protected within an iron stick-up box secured with a concrete pad installed at site grade. Development and drawdown testing will be completed as per *SOP – Well Development*.

5.7 Monitoring Wells in Frozen Ground

Monitoring wells are designed and constructed to minimize the effects on subsurface thermal behaviors and to withstand freeze-thaw forces creating frost heaving or frost jacking. Frost heaving or frost jacking is the upward movement of a well, caused by freezing and upward expansion of the soil. Frost heaving can change the height of the well casing, and, in some cases, separate casing sections. Monitoring wells installed into seasonally frozen ground (for example, screened in the seasonal active layer) must be designed and constructed so that representative groundwater samples can be collected throughout the year, including during periods of thaw. Screen wells in seasonally frozen soil deeper than the greatest expected depth of thaw to prevent them from going dry in the thawing season. Wells installed in a permafrost layer require special attention. Use caution when installing a well through permafrost that may act as a confining unit because flowing artesian conditions may occur. Firmly seal the thawed annulus between the pipe and the permafrost to prevent upward seepage from the confined aquifer. Minimize well damage by installing a surface outer casing to a depth of 5 to 10 feet bgs and a steeply inclined cement

cap around the surface protective casing (Driscoll, 1986). When frost heaving occurs and pressure is exerted on the cement cap, the surface protective casing must be able to rise without affecting the monitoring well casing (Driscoll, 1986). More information about frost heave and frost-heave-susceptible soils is available in ASTM D5918

6.0 Records

All materials and procedures used during installation of wells should be documented in the Field Notebook, the Well Construction Datasheets, or both, in accordance with *SOP-01, Field Note taking and Field Logbooks*. Submit well completion reports to regulatory agencies as required and maintain all copies of field notes and well completion reports in the project files.

7.0 References

Aller, L., et al. 1989. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.* National Water Well Association, U.S. Environmental Protection Agency (EPA). EPA 600/4-89/034.

American Society for Testing and Materials (ASTM). 2008. *Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling*. ASTM Standard D 6151, ASTM International, West Conshohocken, PA.

American Society for Testing and Materials (ASTM). November 1, 2006. *Standard Test Methods for Frost Heave and Thaw Weakening Susceptibility of Soils*. ASTM Standard D5918, ASTM International, West Conshohocken, PA.

American Society for Testing and Materials (ASTM). 2005. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations*. ASTM Standard D 6282-98, ASTM International, West Conshohocken, PA.

American Society for Testing and Materials (ASTM). 2004a. *Standard Guide for Installation of Direct Push Ground Water Monitoring Wells*. ASTM Standard D6724, ASTM International, West Conshohocken, PA. July 1.

American Society for Testing and Materials (ASTM). 2004b. *Standard Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices*. ASTM Standard D 5784, ASTM International, West Conshohocken, PA.

American Society for Testing and Materials (ASTM). 2004c. *Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers*. ASTM Standard D6725, ASTM International, West Conshohocken, PA. July 1.

American Society for Testing and Materials (ASTM). 2004d. *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. ASTM Standard D5092, ASTM International, West Conshohocken, PA. January 1.

American Society for Testing and Materials (ASTM). September 10, 1995. *Standard Practice for Monitoring Well Protection*. ASTM Standard D5787, ASTM International, West Conshohocken, PA.

Barcelona, M.J., J.P. Gibb, J.A. Helfrich, and E.E. Garske. 1985. *Practical Guide for Ground-Water Sampling.* EPA/600/2-85/104.

Driscoll, F.G. 1986. *Groundwater and Wells.* 2nd Edition. Johnson Division, St. Paul, MN.

National Water Well Association and Plastic Pipe Institute (NWWAPPI). 1981. *Manual on the Selection and Installation of Thermoplastic Water Well Casing*. National Water Well Association, Worthington, Ohio.

Nielsen, D.M. 1991. *Practical Handbook of Ground-Water Monitoring.* Lewis Publishers. Todd, D.K. 1980. *Ground-Water Hydrology.* 2nd ed.

United States Environmental Protection Agency (EPA). 1991a. *Groundwater Volume II: Methodology.* EPA/625/6-90/016b.

United States Environmental Protection Agency (EPA). 1991b. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells*. Office of Research and Development.

United States Environmental Protection Agency (EPA). 1986. *RCRA (Resource Conservation and Recovery Act) Ground-Water Monitoring Technical Enforcement Guidance Document.* OSWER-9950.1.

8.0 Definitions

Annular space or annulus: the space between the borehole wall and the well casing, or the space between the casing pipe and well casing.

Bentonite seal: a seal with expansion potential that is placed above the filter pack to provide a positive seal above the filter pack.

Filter pack: a chemically inert, uniform, well-rounded material (sand or gravel) that is placed in the annulus between the well screen and the surrounding formation to prevent formation material from entering the screen.

Monitoring well: a well constructed to extract groundwater for physical, chemical, or biological testing, or for measuring water levels.

Piezometer: a small diameter (typically well 0.75 to 1 inch) well installed to measure hydraulic head.

Surge block: a plunger-like tool consisting of rubber or Teflon® discs sandwiched between steel discs that may be solid or valved; used to alternate flow from the well casing into the surrounding formation.

Tremie pipe: a pipe (usually small diameter) that carries materials to the bottom of the borehole and allows placement of materials upward from the bottom without introducing appreciable air pockets or caved material formations.

Well casing: an impervious durable tubular product that is a permanent feature of a well that is designed to provide access from the ground surface to some point in the subsurface and to serve as a passage for groundwater level measurements and sample collection devices.

Well screen: a section of casing that has been slotted to allow the free movement of water into the well.

Well sorted: clastic sediment or rock that consists of particles having approximately the same size.

Annular seal: the material placed between the borehole wall and the well casing.

Surface seal: the material placed above the annular seal from 2 feet bgs to the ground surface.

9.0 Attachments

Attachment 1: *ASTM Standard D5092*

Attachment 2: *Well Construction Datasheet*

Designation: D 5092 – 04ε1

Standard Practice for Design and Installation of Ground Water Monitoring Wells[1]

This standard is issued under the fixed designation D 5092; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Editorial changes were made throughout in June 2004.

1. Scope

1.1 This practice describes a methodology for designing and installing conventional (screened and filter-packed) ground-water monitoring wells suitable for formations ranging from unconsolidated aquifers (i.e., sands and gravels) to granular materials having grain-size distributions with up to 50 % passing a #200 sieve and as much as 20 % clay-sized material (i.e., silty fine sands with some clay). Formations finer than this (i.e., silts, clays, silty clays, clayey silts) should not be monitored using conventional monitoring wells, as representative ground-water samples, free of artifactual turbidity, cannot be assured using currently available technology. Alternative monitoring technologies (not described in this practice) should be used in these formations

1.2 The recommended monitoring well design and installation procedures presented in this practice are based on the assumption that the objectives of the program are to obtain representative ground-water samples and other representative ground-water data from a targeted zone of interest in the subsurface defined by site characterization.

1.3 This practice, in combination with proper well development (D 5521), proper ground-water sampling procedures (D 4448), and proper well maintenance and rehabilitation (D 5978), will permit acquisition of ground-water samples free of artifactual turbidity, eliminate siltation of wells between sampling events, and permit acquisition of accurate ground-water levels and hydraulic conductivity test data from the zone screened by the well. For wells installed in fine-grained formation materials (up to 50 % passing a #200 sieve), it is generally necessary to use low-flow purging and sampling techniques (D 6771) in combination with proper well design to collect turbidity-free samples.

1.4 This practice applies primarily to well design and installation methods used in drilled boreholes. Other Standards, including Guide D 6724 and Practice D 6725, cover installation of monitoring wells using direct-push methods.

1.5 The values stated in inch-pound units are to be regarded as standard. The values in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Nat all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 150 Specification for Portland Cement

C 294 Descriptive Nomenclature of Constituents of Natural Mineral Aggregates

D 421 Practice for Dry Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants

D 422 Test Method for Particle Size Analysis of Soils

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 1452 Practice for Soil Investigation and Sampling by Auger Borings

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils

D 1587 Practice for Thin-Walled Tube Sampling of Soils

D 2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation

D 2217 Practice for Wet Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21.05 on Design and Installation of Ground-Water Monitoring Wells.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D 3282 Practice for Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes
D 3441 Test Method for Deep, Quasi-Static, Cone and Friction Cone Penetration Tests of Soil
D 3550 Practice for Ring Lined Barrel Sampling of Soils
D 4220 Practice for Preserving and Transporting Soil Samples
D 4700 Guide for Soil Sampling from the Vadose Zone
D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
D 5079 Practices for Preserving and Transporting Rock Core Samples
D 5088 Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites
D 5254 Practice for Minimum Set of Data Elements to Identify a Ground-Water Site
D 5299 Guide for Decommissioning of Ground-Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D 5518 Guide for Acquisition of File Aerial Photography and Imagery for Establishing Historic Site Use and Surficial Conditions
D 5521 Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers
D 5608 Practice for Decontamination of Field Equipment Used at Low-Level Radioactive Waste Sites
D 5730 Guide to Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone, and Ground Water
D 5753 Guide for Planning and Conducting Borehole Geophysical Logging
D 5777 Guide for Using the Seismic Refraction Method for Subsurface Investigation
D 5781 Guide for Use of Dual-Wall Reverse-Circulation Drilling for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5782 Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5784 Guide for Use of Hollow Stem Augers for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5787 Practice for Monitoring Well Protection
D 5872 Guide for the Use of Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5875 Guide for the Use of Cable Tool Drilling and Sampling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5876 Guide for the Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D 5978 Guide for Maintenance and Rehabilitation of Ground-Water Monitoring Wells
D 5979 Guide for Conceptualization and Characterization of Ground-Water Systems
D 6001 Guide for Direct-Push Water Sampling for Geoenvironmental Investigations
D 6067 Guide for Using the Electronic Cone Penetrometer for Environmental Site Characterization
D 6167 Guide for Conducting Borehole Geophysical Logging
D 6169 Guide to the Selection of Soil and Rock Sampling Devices Used With Drilling Rigs for Environmental Investigations
D 6235 Practice for Expedited Site Characterization of Vadose Zone and Ground-Water Contamination at Hazardous Waste Contaminated Sites
D 6274 Guide for Conducting Borehole Geophysical Logging—Gamma
D 6282 Guide for Direct-Push Soil Sampling for Environmental Site Characterization
D 6286 Guide to the Selection of Drilling Methods for Environmental Site Characterization
D 6429 Guide for Selecting Surface Geophysical Methods
D 6430 Guide for Using the Gravity Method for Subsurface Investigation
D 6431 Guide for Using the Direct Current Resistivity Method for Subsurface Investigation
D 6432 Guide for Using the Surface Ground Penetrating Radar Method for Subsurface Investigation
D 6519 Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler
D 6639 Guide for Using the Frequency Domain Electromagnetic Method for Subsurface Investigations
D 6640 Guide for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigations
D 6724 Guide for the Installation of Direct-Push Ground-Water Monitoring Wells
D 6725 Practice for the Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers
D 6771 Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations
F 480 Specification for Thermoplastic Well Casing and Couplings Made in Standard Dimension Ratios (SDR), Schedule 40 and Schedule 80

3. Terminology

3.1 *Definitions:*

3.1.1 *annular space; annulus*—the space between two concentric strings of casing, or between the casing and the

borehole wall. This includes the space(s) between multiple strings of casing in a borehole installed either concentrically or adjacent to one another.

3.1.2 *artifactual turbidity*—particulate matter that is not naturally mobile in the ground-water system and that is produced in some way by the ground-water sampling process. May consist of particles introduced to the subsurface during drilling or well construction, sheared from the target monitoring zone during pumping or bailing the well, or produced by exposure of ground water to atmospheric conditions.

3.1.3 *assessment monitoring*—an investigative monitoring program that is initiated after the presence of a contaminant in ground water has been detected. The objective of this program is to determine the concentration of constituents that have contaminated the ground water and to quantify the rate and extent of migration of these constituents.

3.1.4 *ballast*—materials used to provide stability to a buoyant object (such as casing within a water-filled borehole).

3.1.5 *borehole*—an open or uncased subsurface hole, generally circular in plan view, created by drilling.

3.1.6 *borehole log*—the record of geologic units penetrated, drilling progress, depth, water level, sample recovery, volumes, and types of materials used, and other significant facts regarding the drilling and/or installation of an exploratory borehole or well.

3.1.7 *bridge*—an obstruction within the annulus that may prevent circulation or proper placement of annular fill materials.

3.1.8 *casing*—pipe, finished in sections with either threaded connections or beveled edges to be field welded, which is installed temporarily or permanently either to counteract caving, to advance the borehole, or to isolate the zone being monitored, or any combination of these.

3.1.9 *casing, protective*—a section of larger diameter pipe that is placed over the upper end of a smaller diameter monitoring well riser or casing to provide structural protection to the well, to prevent damage to the well, and to restrict unauthorized access into the well.

3.1.10 *casing, surface*—pipe used to stabilize a borehole near the surface during the drilling of a borehole that may be left in place or removed once drilling is completed.

3.1.11 *caving; sloughing*—the inflow of unconsolidated material into a borehole that occurs when the borehole walls lose their cohesiveness.

3.1.12 *cement*—commonly known as Portland cement. A mixture that consists of calcareous, argillaceous, or other silica-, alumina-, and iron-oxide-bearing materials that is manufactured and formulated to produce various types which are defined in Specification C 150. Portland cement is considered a hydraulic cement because it must be mixed with water to form a cement-water paste that has the ability to harden and develop strength even if cured under water.

3.1.13 *centralizer*—a device that assists in the centering of a casing or riser within a borehole or another casing.

3.1.14 *confining unit*—a body of relatively low hydraulic conductivity formation material stratigraphically adjacent to one or more aquifers. Synonymous with “aquiclude,”“ aquitard,” and “aquifuge.”

3.1.15 *detection monitoring*—a program of monitoring for the express purpose of determining whether or not there has been a contaminant release to ground water.

3.1.16 *d-10*—the diameter of a soil particle (preferably in mm) at which 10 % by weight (dry) of the particles of a particular sample are finer. Synonymous with the effective size or effective grain size.

3.1.17 *d-60*—the diameter of a soil particle (preferably in mm) at which 60 % by weight (dry) of the particles of a particular sample are finer.

3.1.18 *flush joint or flush coupled*—casing or riser with ends threaded such that a consistent inside and outside diameter is maintained across the threaded joints or couplings.

3.1.19 *gravel pack*—common term used to refer to the primary filter pack of a well (see *primary filter pack*).

3.1.20 *grout (monitoring wells)*—a low-permeability material placed in the annulus between the well casing or riser and the borehole wall (in a single-cased monitoring well), or between the riser and casing (in a multi-cased monitoring well), to prevent movement of ground water or surface water within the annular space.

3.1.21 *hydrologic unit*—geologic strata that can be distinguished on the basis of capacity to yield and transmit fluids. Aquifers and confining units are types of hydrologic units. Boundaries of a hydrologic unit may not necessarily correspond either laterally or vertically to lithostratigraphic formations.

3.1.22 *multi-cased well*—a well constructed by using successively smaller diameter casings with depth.

3.1.23 *neat cement*—a mixture of Portland cement (Specification C 150) and water.

3.1.24 *packer (monitoring wells)*—a transient or dedicated device placed in a well that isolates or seals a portion of the well, annulus, or borehole at a specific level.

3.1.25 *piezometer*—a small-diameter well with a very short screen that is used to measure changes in hydraulic head, usually in response to pumping a nearby well. Synonymous with observation well.

3.1.26 *primary filter pack*—a clean silica sand or sand and gravel mixture of selected grain size and gradation that is installed in the annular space between the borehole wall and the well screen, extending an appropriate distance above the screen, for the purpose of retaining and stabilizing the particles from the adjacent formation(s). The term is used in place of *gravel pack.*

3.1.27 *PTFE tape*—joint sealing tape composed of polytetrafluoroethylene.

3.1.28 *riser*—the pipe or well casing extending from the well screen to just above or below the ground surface.

3.1.29 *secondary filter pack*—a clean, uniformly graded sand that is placed in the annulus between the primary filter pack and the overlying seal, or between the seal and overlying grout backfill, or both, to prevent intrusion of the seal or grout, or both, into the primary filter pack.

3.1.30 *sediment sump*—a blank extension of pipe or well casing, closed at the bottom, beneath the well screen used to collect fine-grained material from the filter pack and adjacent

formation materials during the process of well development. Synonymous with rat trap or tail pipe.

3.1.31 *single-cased well*—a monitoring well constructed with a riser but without an exterior casing.

3.1.32 *static water level*—the elevation of the top of a column of water in a monitoring well or piezometer that is not influenced by pumping or conditions related to well installation, or hydraulic testing.

3.1.33 *tamper*—a heavy cylindrical metal section of tubing that is operated on a wire rope or cable. It either slips over the riser and fits inside the casing or borehole annulus, or fits between the riser and annulus. It is generally used to tamp annular sealants or filter pack materials into place and to prevent bridging or break bridges that form in the annular space.

3.1.34 *target monitoring zone*—the ground-water flow path from a particular area or facility in which monitoring wells will be screened. The target monitoring zone should be an interval in subsurface materials in which there is a reasonable expectation that a monitoring well will intercept ground water moving beneath an area or facility and any migrating contaminants that may be present.

3.1.35 *tremie pipe*—a small-diameter pipe or tube that is used to transport filter pack materials and annular seal materials from the ground surface into an annular space.

3.1.36 *uniformity coefficient*—the ratio of d-60/d-10, where d-60 and d-10 are particle diameters corresponding to 60 % and 10 % finer on the cumulative particle size curve, respectively.

3.1.37 *uniformly graded*—a quantitative definition of the particle size distribution of a soil that consists of a majority of particles being of approximately the same diameter. A granular material is considered uniformly graded when the uniformity coefficient is less than about five (Test Method D 2487). Comparable to the geologic term *well sorted*.

3.1.38 *vented cap*—a cap with a small hole that is installed on top of the riser.

3.1.39 *weep hole*—a small-diameter hole (usually ¼ in.) drilled into the protective casing above the ground surface that serves to drain out water that may enter the annulus between the riser and the protective casing.

3.1.40 *well completion diagram*—a record that illustrates the details of a well installation.

3.1.41 *well screen*—a device used to retain the primary or natural filter pack; usually a cylindrical pipe with openings of a uniform width, orientation, and spacing.

4. Significance and Use

4.1 This practice for the design and installation of ground-water monitoring wells will promote *(1)* efficient and effective site hydrogeological characterization; *(2)* durable and reliable well construction; and *(3)* acquisition of representative ground-water quality samples, ground-water levels, and hydraulic conductivity testing data from monitoring wells. The practices established herein are affected by governmental regulations and by site-specific geological, hydrogeological, climatological, topographical, and subsurface geochemical conditions. To meet these geoenvironmental challenges, this practice promotes the development of a conceptual hydrogeologic model prior to monitoring well design and installation.

4.2 A properly designed and installed ground water monitoring well provides essential information on one or more of the following subjects:

4.2.1 Formation geologic and hydraulic properties;

4.2.2 Potentiometric surface of a particular hydrologic unit(s);

4.2.3 Water quality with respect to various indicator parameters; and

4.2.4 Water chemistry with respect to a contaminant release.

5. Site Characterization

5.1 *General*—A thorough knowledge of site-specific geologic, hydrologic and geochemical conditions is necessary to properly apply the monitoring well design and installation procedures contained within this practice. Development of a conceptual site model, that identifies potential flow paths and the target monitoring zone(s), and generates a 3-D picture of contaminant distribution and contaminant movement pathways, is recommended prior to monitoring well design and installation. Development of the conceptual site model is accomplished in two phases -- an initial reconnaissance, after which a preliminary conceptual model is created, and a field investigation, after which a revised conceptual model is formulated. When the hydrogeology of a project area is relatively uncomplicated and well documented in the literature, the initial reconnaissance may provide sufficient information to identify flow paths and the target monitoring zone(s). However, where limited or no background data are available or where the geology is complex, a field investigation will be required to develop the necessary conceptual site model.

5.2 *Initial Reconnaissance of Project Area*—The goal of the initial reconnaissance of the project area is to identify and locate those zones or preferential flow pathways with the greatest potential to transmit fluids from the project area. Identifying these flow pathways is the first step in selecting the target ground-water monitoring zone(s).

5.2.1 *Literature Search*—Every effort should be made to collect and review all applicable field and laboratory data from previous investigations of the project area. Information such as, but not limited to, topographic maps, aerial imagery (see Guide D 5518), site ownership and utilization records, geologic and hydrogeologic maps and reports, mineral resource surveys, water well logs, information from local well drillers, agricultural soil reports, geotechnical engineering reports, and other engineering maps and reports related to the project area should be reviewed to locate relevant site information.

5.2.2 *Field Reconnaissance*—Early in the investigation, the soil and rocks in open cut areas (e.g., roadcuts, streamcuts) in the vicinity of the project should be studied, and various soil and rock profiles noted. Special consideration should be given to soil color and textural changes, landslides, seeps, and springs within or near the project area.

5.2.3 *Preliminary Conceptual Model*—The distribution of the predominant soil and rock units likely to be found during subsurface exploration may be hypothesized at this time in a preliminary conceptual site model using information obtained in the literature search and field reconnaissance. In areas where

the geology is relatively uniform, well documented in the literature, and substantiated by the field reconnaissance, further refinement of the conceptual model may not be necessary unless anomalies are discovered in the well drilling stage.

5.3 *Field Investigation*—The goal of the field investigation is to refine the preliminary conceptual site model so that the target monitoring zone(s) is (are) identified prior to monitoring well installation.

5.3.1 *Exploratory Borings and Direct-Push Methods*—Characterization of the flow paths conceptualized in the initial reconnaissance involves defining the porosity (type and amount), hydraulic conductivity, stratigraphy, lithology, gradation and structure of each hydrologic unit encountered beneath the site. These characteristics are defined by conducting an exploratory program which may include drilled soil borings (see Guide D 6286 for selection of drilling methods) and direct-push methods (e.g., cone penetrometers [see Test Method D 3441 or Guide D 6067] or direct-push machines using soil sampling, ground-water sampling and/or electrical conductivity measurement tools [see Guides D 6282 and D 6001]). Exploratory soil borings and direct-push holes should be deep enough to develop the required engineering and hydrogeologic data for determining the preferential flow pathway(s), target monitoring zone(s), or both.

5.3.1.1 *Sampling*—Soil and rock properties should not be predicted wholly on field description or classification, but should be confirmed by laboratory and/or field tests made on samples or in boreholes or wells. Representative soil or rock samples of each material that is significant to the design of the monitoring well system should be obtained and evaluated by a geologist, hydrogeologist, soil scientist or engineer trained and experienced in soil and rock analysis. Soil sample collection should be conducted according to Practice D 1452, Test Method D 1586, Practice D 3550, Practice D 6519 or Practice D 1587, whichever is appropriate given the anticipated characteristics of the soil samples (see Guide D 6169 for selection of soil sampling methods). Rock samples should be collected according to Practice D 2113. Soil samples obtained for evaluation of hydraulic properties should be containerized and identified for shipment to a laboratory. Special measures to preserve either the continuity of the sample or the natural moisture are not usually required. However, soil and rock samples obtained for evaluation of chemical properties often require special field preparation and preservation to prevent significant alteration of the chemical constituents during transportation to a laboratory (see Practice D 6640). Rock samples for evaluation of hydraulic properties are usually obtained using a split-inner-tube core barrel. Evaluation and logging of the core samples is usually done in the field before the core is removed from the core barrel.

5.3.1.2 *Boring Logs*—Care should be taken to prepare and retain a complete boring log and sampling record for each exploratory soil boring or direct-push hole (see Guide D 5434).

NOTE 1—Site investigations conducted for the purpose of generating data for the installation of ground-water monitoring wells can vary greatly due to the availability of reliable site data or the lack thereof. The general procedure would be as follows: *(1)* gather factual data regarding the surficial and subsurface conditions, *(2)* analyze the data, *(3)* develop a conceptual model of the site conditions, *(4)* locate the monitoring wells based on the first three steps. Monitoring wells should only be installed with sufficient understanding of the geologic, and hydrologic and geochemical conditions present at the site. Monitoring wells often serve as part of an overall site investigation for a specific purpose, such as determining the extent of contamination present, or for predicting the effectiveness of aquifer remediation. In these cases, extensive additional geotechnical and hydrogeologic information may be required that would go beyond the Section 5 Site Characterization description.

Boring logs should include the location, geotechnical data (that is, penetration rates or blow counts), and sample description information for each material identified in the borehole either by symbol or word description, or both. Description and identification of soils should be in accordance with Practice D 2488; classification of soils should be in accordance with either Practice D 2487 or Practice D 3282. Identification of rock material should be based on Nomenclature C 294 or by an appropriate geologic classification system. Observations of seepage, free water, and water levels should also be noted. The boring logs should be accompanied by a report that includes a description of the area investigated; a map illustrating the vertical and horizontal location (with reference to either North American Vertical Datum of 1988 [NAVD 88] or to a standardized survey grid) of each exploratory soil boring or test pit, or both; and color photographs of rock cores, soil samples, and exposed strata labeled with a date and identification.

5.3.2 *Geophysical Exploration*—Geophysical surveys may be used to supplement soil boring and outcrop observation data and to aid in interpretation between soil borings. Appropriate surface and borehole geophysical methods for meeting site-specific project objectives can be selected by consulting Guides D 6429 and D 5753 respectively. Surface geophysical methods such as seismic (Guide D 5777), electrical-resistivity (Guide D 6431), ground-penetrating radar (Guide D 6432), gravity (Guide D 6430) and electromagnetic conductance surveys (Guide D 6639) can be particularly valuable when distinct differences in the properties of contiguous subsurface materials are indicated. Borehole methods such as resistivity, gamma, gamma-gamma, neutron, and caliper logs (see Guide D 6167) can be useful to confirm specific subsurface geologic conditions. Gamma logs (Guide D 6274) are particularly useful in existing cased wells.

5.3.3 *Ground-Water Flow Direction*—Ground-water flow direction is generally determined by measuring the vertical and horizontal hydraulic gradient within each conceptualized flow pathway. However, because water will flow along the pathways of least resistance (within the highest hydraulic conductivity formation materials at the site), actual flow direction may be oblique to the hydraulic gradient (within buried stream channels or glacial valleys, for example). Flow direction is determined by first installing piezometers in the exploratory soil borings that penetrate the zone(s) of interest at the site. The depth and location of the piezometers will depend upon anticipated hydraulic connections between conceptualized flow pathways and their respective lateral direction of flow. Following careful evaluation, it may be possible to utilize existing private or public wells to obtain water-level data. The construction integrity of such wells should be verified to ensure that the water levels obtained from the wells are representative only of the zone(s) of interest. Following water-level data acquisition,

a potentiometric surface map should be prepared. Flow pathways are ordinarily determined to be at right angles, or nearly so, to the equipotential lines, though consideration of complex geology can result in more complex interpretations of flow

5.4 *Completing the Conceptual Model*—A series of geologic and hydrogeologic cross sections should be developed to refine the conceptual model. This is accomplished by first plotting logs of soil and rock observed in the exploratory soil borings or test pits, and interpreting between these logs using the geologic and engineering interrelationships between other soil and rock data observed in the initial reconnaissance or with geophysical techniques. Extrapolation of data into adjacent areas should be done only where geologically uniform subsurface conditions are known to exist. The next step is to integrate the geologic profile data with the potentiometric data for both vertical and horizontal hydraulic gradients. Plan view and cross-sectional flow nets should be constructed. Following the analysis of these data, conclusions can be made as to which flow pathway(s) is (are) the appropriate target monitoring zone(s).

NOTE 2—UUse of ground-water monitoring wells is difficult and may not be a reliable technology in fine-grained, low hydraulic conductivity formation materials with primary porosity because of *(1)* the disproportionate influence that microstratigraphy has on ground-water flow in fine-grained strata; *(2)* the proportionally higher vertical flow component in low hydraulic conductivity strata; and *(3)* the presence of indigenous metallic and inorganic constituents in the matrix that make water-quality data evaluation difficult.

6. Monitoring Well Construction Materials

6.1 *General*—The materials that are used in the construction of a monitoring well that come in contact with water samples should not alter the chemical quality of the sample for the constituents being examined. The riser, well screen, and annular seal installation equipment should be cleaned immediately prior to well installation (see either Practice D 5088 or D 5608) or certified clean from the manufacturer and delivered to the site in a protective wrapping. Samples of the riser and screen material, cleaning water, filter pack, annular seal, bentonite, and mixed grout should be retained to serve as quality control until the completion of at least one round of ground- water quality sampling and analysis has been completed.

6.2 *Water*—Water used in the drilling process, to prepare grout mixtures and to decontaminate the well screen, riser, and annular sealant injection equipment, should be obtained from a source of known chemistry that does not contain constituents that could compromise the integrity of the well installation.

6.3 *Primary Filter Pack*:

6.3.1 *General*—The purposes of the primary filter pack are to act as a filter that retains formation material while allowing ground water to enter the well, and to stabilize the formation to keep it from collapsing on the well. The design of the primary filter pack is based on the grain-size distribution of the formation material (as determined by sieve analysis—see Test Method D 422) to be retained. The grain size distribution of the primary filter pack must be fine enough to retain the formation, but coarse enough to allow for unrestricted movement of ground water into and through the monitoring well. The design of the well screen (see 6.4.3) must be done in concert with the design of the filter pack. After development, a monitoring well with a correctly designed and installed filter pack and screen combination should produce samples free of artifactual turbidity.

6.3.2 *Materials*—The primary filter pack should consist of an inert granular material (generally ranging from gravel to very fine sand, depending on formation grain size distribution) of selected grain size and gradation that is installed in the annulus between the well screen and the borehole wall. Washed and screened silica sands and gravels, with less than 5 % non-siliceous materials, should be specified.

6.3.3 *Design*—The design theory of filter pack gradation is based on mechanical retention of formation materials.

6.3.3.1 1 For formation materials that are relatively coarse-grained (i.e., fine, medium and coarse sands and gravels), the grain size distribution of the primary filter pack is determined by calculating the d-30 (30 % finer) size, the d-60 (60 % finer) size, and the d-10 (10 % finer) size of the filter pack. The first point on the filter pack grain-size distribution curve is the d-30 size. The primary filter pack is usually selected to have a d-30 grain size that is about 4 to 6 times greater than the d-30 grain size of the formation material being retained (see Fig. 1). A multiplication factor of 4 is used if the formation material is relatively fine-grained and well sorted or uniform (small range in grain sizes); a multiplication factor of 6 is used if the formation is relatively coarse grained and poorly sorted or non-uniform (large range in grain sizes). Thus, 70 % of the filter pack will have a grain size that is 4 to 6 times larger than the d-30 size of the formation materials. This ensures that the filter pack is coarser (with a higher hydraulic conductivity) than the formation material, and allows for unrestricted ground-water flow from the formation into the monitoring well.

The next 2 points on the filter pack grain-size distribution curve are the d-60 and d-10 grain sizes. These are chosen so that the ratio between the two grain sizes (the uniformity coefficient) is less than 2.5. This ensures that the filter pack has a small range in grain sizes and is uniform (see technical Note 5). The d-60 and d-10 grain sizes of the filter pack are calculated by a trial and error method using grain sizes that are close to the d-30 size of the filter pack. After the d-30, d-60 and d-10 sizes of the filter pack are determined, a smooth curve is drawn through these points. The final step in filter pack design is to specify the limits of the grain size envelope, which defines the permissible range in grain sizes for the filter pack. The permissible range on either side of the grain size curve is 8 %. The boundaries of the grain size envelope are drawn on either side of the filter pack grain-size distribution curve, and filter pack design is complete. A filter medium having a grain-size distribution as close as possible to this curve is then obtained from a local sand supplier.

6.3.3.2 In formation materials that are predominantly fine-grained (finer than fine to very fine sands), soil piping can occur when a hydraulic gradient exists between the formation and the well (as would be the case during well development and sampling). To prevent soil piping in these materials, the following criteria are used for designing granular filter packs:

$$\frac{\text{d-15 of filter}}{\text{d-85 of formation}} \leq 4 \text{ to } 5 \quad \text{and} \quad \frac{\text{d-15 of filter}}{\text{d-15 of formation}} \geq 4 \text{ to } 5$$

The left half of this equation is the fundamental criterion for the prevention of soil piping through a granular filter, while the right half of the equation is the hydraulic conductivity criterion. This latter criterion serves the same purpose as multiplying the d-30 grain size of the formation by a factor of between 4 and 6 for coarser formation materials. Filter pack materials suitable for retaining formation materials in formations that are predominantly fine-grained are themselves, by necessity, relatively fine-grained (e.g., fine to very fine sands), presenting several problems for well designers and installers. First, well screen slot sizes suitable for retaining such fine-grained filter pack materials are not widely available (the smallest commercially available slotted well casing is 0.006 in. [6 slot]; the smallest commercially available continuous-slot wire-wound screen is 0.004 in. [4 slot]). Second, the finest filter pack material practical for conventional (tremie tube) installation is a 40 by 70 (0.008 by 0.018 in.) sand, which can be used with a well screen slot as small as 0.008-in. (8 slot). Finer grained filter pack materials cannot be placed practically by either tremie tubes or pouring down the annular space or down augers. Thus, the best method for ensuring proper installation of filter packs in predominantly fine-grained formation materials is to use pre-packed or sleeved screens, which are described in detail in Practice D 6725. A 50 by 100 (0.011 by 0.006 in.) filter-pack sand can be used with a 0.006-in. slot size pre-packed or sleeved screen, and a 60 by 120 (0.0097 by 0.0045 in.) filter-pack sand can be used with a 0.004-in. (4 slot) slot size pre-packed or sleeved screen. Filter packs that are finer than these (e.g., sands as fine as 100 by 120 [0.006 by 0.0045 in.], or silica flour as fine as 200 mesh [0.003 in.]) can only be installed within stainless steel mesh sleeves that can be placed over pipe-based screens. While these sleeves, or the space between internal and external screens in a pre-packed well screen may be as thin as 1/2-in. (1.27 cm), the basis for mechanical retention dictates that a filter-pack thickness of only two or three grain diameters is needed to contain and control formation materials. Laboratory tests have demonstrated that a properly sized filter pack material with a thickness of less than 1/2-in. (1.27 cm) successfully retains formation particles regardless of the velocity of water passing through the filter pack [3].

[3] (1) Driscoll, F.G., 1986, Groundwater and Wells, Johnson Division, St. Paul, MN, pg.443

6.3.3.3 The limit of mechanical filtration for monitoring wells is defined by the finest filter pack material that can be practically installed via a pre-packed or sleeved screen—silica flour with a grain size of 0.003 in. (200 mesh), encased within a very fine mesh screen of stainless steel or other suitable material. This fine a filter pack material will retain formation material as fine as silt, but not clay. Formations with a small fraction of clay (up to about 20 %) can be successfully monitored, as long as the wells installed in these formations are properly developed (see Guide D 5521). For mechanical filtration to be effective in formations with more than 50 % fines, the filter pack design would have to include silt-sized particles in the filter pack in order to meet the design criteria, which is impractical, as placement would be impossible and screen mesh fine enough to retain the material is not commercially available. Therefore, formations with more than 50 % passing a #200 sieve, and having more than 20 % clay-sized material, should not be monitored using conventional well designs. Alternative monitoring technologies should be used in these formations..

NOTE 3—When installing a monitoring well in solution-channeled limestone or highly fractured bedrock, the borehole configuration of void spaces within the formation surrounding the borehole is often unknown. Therefore, the installation of a filter pack becomes difficult and may not be possible.

NOTE 4—This practice presents a design for monitoring wells that will be effective in the majority of formations. Applicable state guidance may differ from the designs contained in this practice.

NOTE 5—Because the well screen slots have uniform openings, the filter pack should be composed of particles that are as uniform in size as is practical. Ideally, the uniformity coefficient (the quotient of the 60 % passing, D-60 size divided by the 10 % passing D-10 size [effective size]) of the filter pack should be 1.0 (that is, the D-60 % and the D-10 % sizes should be identical). However, a more practical and consistently achievable uniformity coefficient for all ranges of filter pack sizes is 2.5. This value of 2.5 should represent a maximum value, not an ideal.

NOTE 6—Although not recommended as standard practice, often a project requires drilling and installing the well in one phase of work. Therefore, the filter pack materials must be ordered and delivered to the drill site before soil samples can be collected. In these cases, the suggested well screen slot size and filter pack material combinations are presented in Table 1.

NOTE 7—Silica flour can alter water chemistry, particularly for transuranics, and its use should be evaluated against the monitoring program analytes

6.4 *Well Screen*:

6.4.1 *General*—The purposes of the well screen are to provide designed openings for ground-water flow through the well, and to prevent migration of filter pack and formation

TABLE 1 Recommended (Achievable) Filter Pack Characteristics for Common Screen Slot Sizes

Size of Screen Opening, mm (in.)	Slot No.	Sand Pack Mesh Size Name(s)	1 % Passing Size (D-1), mm	Effective Size, (D-10), mm	30 % Passing Size (D-30), mm	Range of Uniformity Coefficient	Roundness (Powers Scale)
0.125 (0.005)	5[A]	100	0.09 to 0.12	0.14 to 0.17	0.17 to 0.21	1.3 to 2.0	2 to 5
0.25 (0.010)	10	20 to 40	0.25 to 0.35	0.4 to 0.5	0.5 to 0.6	1.1 to 1.6	3 to 5
0.50 (0.020)	20	10 to 20	0.7 to 0.9	1.0 to 1.2	1.2 to 1.5	1.1 to 1.6	3 to 6
0.75 (0.030)	30	10 to 20	0.7 to 0.9	1.0 to 1.2	1.2 to 1.5	1.1 to 1.6	3 to 6
1.0 (0.040)	40	8 to 12	1.2 to 1.4	1.6 to 1.8	1.7 to 2.0	1.1 to 1.6	4 to 6
1.5 (0.060)	60	6 to 9	1.5 to 1.8	2.3 to 2.8	2.5 to 3.0	1.1 to 1.7	4 to 6
2.0 (0.080)	80	4 to 8	2.0 to 2.4	2.4 to 3.0	2.6 to 3.1	1.1 to 1.7	4 to 6

[A] A 5-slot (0.152-mm) opening is not currently available in slotted PVC but is available in Vee wire PVC and Stainless; 6-slot opening may be substituted in these cases.

material into the well. The well screen design is based on either the grain-size distribution of the formation (in the case of a well with a naturally developed filter pack), or the grain-size distribution of the primary filter pack material (in the case of a filter-packed well). The screen openings must be small enough to retain most if not all of the formation or filter-pack materials, yet large enough to maintain ground-water flow velocities, from the well screen/filter pack interface back to the natural formation materials, of less than 0.10 ft/s (0.03 m/s). If well screen entrance velocities exceed 0.10 ft/s (0.03 m/s), turbulent flow conditions can occur, resulting in mobilization of sediment from the formation and reductions in well efficiency.

6.4.2 *Materials*—TThe well screen should be new, machine-slotted casing or continuous wrapped wire-wound screen composed of materials compatible with the monitoring environment, as determined by the site characterization program. The screen should be plugged at the bottom (unless a sediment sump is used), and the plug should generally be of the same material as the well screen. This assembly must have the capability to withstand well installation and development stresses without becoming dislodged or damaged. The length of the well screen open area should reflect the thickness of the target monitoring zone. Immediately prior to installation, the well screen should be cleaned (see either Practice D 5088 or Practice D 5608) with water from a source of known chemistry, if it is not certified clean by the manufacturer, and delivered, and maintained in a clean environment at the site.

NOTE 8—Well screens are most commonly composed of PVC or stainless steel. Stainless steel may be specified based on knowledge of the occurrence of microbially influenced corrosion in formations (specifically reducing or acid-producing conditions).

6.4.3 *Diameter*—TThe minimum nominal internal diameter of the well screen should be chosen based on factors specific to the particular application (such as the outside diameter of the purging and sampling device(s) to be used in the well). Well screens as small as 1/2-in. (1.27 cm) nominal diameter are available for use in monitoring well applications.

6.4.4 *Design*—The design of the well screen should be determined based on the grain size analysis (per Test Method D 422) of the interval to be monitored and the gradation of the primary filter pack material. In granular, non-cohesive formation materials that will fall in easily around the screen, filter packs can be developed from the native formation materials—filter pack materials foreign to the formation are not necessary. In these cases of naturally developed filter packs, the slot size of the well screen is determined using the grain size of the materials in the surrounding formation. The well screen slot size selected for this type of well completion should retain at least 70 % of formation materials—the finest 30 % of formation materials will be brought into the well during development, and the objectives of filter packing (to increase hydraulic conductivity immediately surrounding the well screen, and to promote easy flow of ground water into and through the screen) will be met. In wells in which a filter pack material of a selected grain size distribution is introduced from the surface, the screen slot size selected should retain at least 90 %, and preferably 99 %, of the primary filter pack materials. The method for determining the primary filter pack design is described in 6.3.3.

6.4.5 *Prepacked or Sleeved Well Screens*—An alternative to designing and installing filter pack and well screens separately is to use a pre-packed or sleeved screen assembly. A pre-packed well screen consists of an internal well screen, an external screen or filter medium support structure, and the filter medium contained between the screens, which together comprise an integrated structure. The internal and external screens are constructed of materials compatible with the monitored environment, and are usually of a common slot size specified by the well designer to retain the filter pack material. The filter pack is normally an inert (e.g., siliceous) granular material that has a grain-size distribution chosen to retain formation materials. A sleeved screen consists of a slotted pipe base over which a sleeve of stainless steel mesh filled with selected filter media is installed. Pre-packed or sleeved screens may be used for any formation conditions, but they are most often used where heaving, running or blowing sands make accurate placement of conventional well screens and filter packs difficult, or where predominantly fine-grained formation materials are encountered. In the latter case, using pre-packed or sleeved screens is the only practical means of ensuring that filter pack materials of the selected grain-size distribution (generally fine to very fine sands) are installed to completely surround the screen.

NOTE 9—The practice of using a single well screen/filter pack combination (e.g., 0.010 in. [0.254 mm]) well screen slot size with a 20/40 sand) for all wells, regardless of formation grain-size distribution, will result in siltation of the well and significant turbidity in samples when applied to formations finer than the recommended design. It will also result in the loss of filter pack, possible collapse of the screen, and invasion of overlying well construction materials (e.g., secondary filter pack, annular seal materials, grout) when applied to formations coarser than the recommended design. For these reasons, the universal application of a single well screen/filter pack combination to all formations is not recommended, and should be avoided.

6.5 *Riser*:

6.5.1 *Materials*—TThe riser should be new pipe composed of materials that will not alter the quality of water samples for the constituents of concern and that will stand up to long-term exposure to the monitoring environment, including potential contaminants. The riser should have adequate wall thickness and coupling strength to withstand the stresses imposed on it during well installation and development. Each section of riser should be cleaned (see either Practice D 5088 or Practice D 5608) using water from a source of known chemistry immediately prior to installation.

NOTE 10—Risers are generally constructed of PVC, galvanized steel or stainless steel.

6.5.2 *Diameter*—The minimum nominal internal diameter of the riser should be chosen based on the particular application. Risers as small as ½-in. (1.25-cm) in diameter are available for applications in monitoring wells.

6.5.3 *Joints (Couplings)*—Threaded joints are recommended. Glued or solvent-welded joints of any type are not recommended because glues and solvents may alter the chemistry of water samples. Because square profile flush joint

threads (Specification F 480) are designed to be accompanied by O-ring seals at the joints, they do not require PTFE taping. However, tapered threaded joints should be PTFE taped to prevent leakage of water into the riser.

6.6 *Casing*—Where conditions warrant, the use of permanent casing installed to prevent communication between water-bearing zones is encouraged. The following subsections address both temporary and permanent casings.

6.6.1 *Materials*—The material type and minimum wall thickness of the casing should be adequate to withstand the forces of installation. All casing that is to remain as a permanent part of the installation (that is, in multi-cased wells) should be new and cleaned to be free of interior and exterior protective coatings.

NOTE 11—The exterior casing (temporary or permanent multi-cased) is generally composed of steel, although other appropriate materials may be used.

6.6.2 *Diameter*—Several different casing sizes may be required depending on the geologic formations penetrated. The diameter of the borehole and the well casing for conventionally filter packed wells should be selected so that a minimum annular space of 2 in. (5 cm) is maintained between the inside diameter of the casing and outside diameter of the riser to provide working space for a tremie pipe. For naturally developed wells and pre-packed or sleeved screen completions, this annular space requirement need not be met. In addition, the diameter of the casings in multi-cased wells should be selected so that a minimum annular space of 2 in. (5 cm) is maintained between the casing and the borehole (that is, a 2-in. [5 cm] diameter screen will require first setting a 6-in. [15.2 cm] diameter casing in a 10-in. [25.4 cm] diameter boring).

NOTE 12—Under difficult drilling conditions (collapsing soils, rock, or cobbles), it may be necessary to advance temporary casing. Under these conditions, a smaller annular space may be maintained.

6.6.3 *Joints (Couplings)*—The ends of each casing section should be either flush-threaded or beveled for welding.

6.7 *Sediment Sump*—A sediment sump, a length of blank pipe, generally of the same diameter and made of the same material as the riser and well screen -- may be affixed to the bottom of the screen, and capped with a bottom plug, to collect fine-grained material brought into the well by the process of well development. A drainage hole may be drilled in the bottom of the sump to prevent the sump from retaining water in the event that the water level outside the well falls below the bottom of the well screen. Because the sediment that collects in the sump may harbor geochemistry-altering microflora and reactive metal oxides, this sediment must be removed periodically to minimize the potential for sample chemical alteration.

6.8 *Protective Casing*:

6.8.1 *Materials*—Protective casings may be made of aluminum, mild steel, galvanized steel, stainless steel, cast iron, or structural plastic pipe. The protective casing should have a lid capable of being locked shut by a locking device or mechanism.

6.8.2 *Diameter*—The inside dimensions of the protective casing should be a minimum of 2 in. (5 cm) and preferably 4 in. (10 cm) larger than the nominal diameter of the riser to facilitate the installation and operation of sampling equipment.

6.9 *Annular Sealants*—TThe materials used to seal the annulus may be prepared as a slurry or used un-mixed in a dry pellet, granular, or chip form. Sealants should be selected to be compatible with ambient geologic, hydrogeologic, geochemical and climatic conditions and any man-induced conditions (e.g., subsurface contamination) anticipated during the life of the well.

6.9.1 *Bentonite*—Bentonite should be powdered, granular, pelletized, or chipped sodium montmorillonite from a commercial source, free of impurities that may adversely impact the water quality in the well. Pellets consist of roughly spherical units of moistened, compressed bentonite powder. Chips are large, irregularly shaped, and coarse granular units of bentonite free of additives. The diameter of pellets or chips selected for monitoring well construction should be less than one fifth the width of the annular space into which they are placed to reduce the potential for bridging. Granules consist of coarse to fine particles of unaltered bentonite, typically smaller than 0.2 in. (5.0 mm). It is recommended that the water chemistry of the formation in which the bentonite is intended for installation be evaluated to ensure that it is suitable to hydrate the bentonite. Some water-quality conditions (e.g., high chloride content, high concentrations of certain organic solvents or petroleum hydrocarbons) may inhibit the hydration of bentonite and result in an ineffective seal.

6.9.2 *Cement*—Each type of cement has slightly different characteristics that may be appropriate under various physical and chemical conditions. Cement should be one of the five Portland cement types that are specified in Specification C 150. The use of quick-setting cements containing additives is not recommended for use in monitoring well installation. Additives may leach from the cement and influence the chemistry of water samples collected from the monitoring well.

6.9.3 *Grout*—The grout backfill that is placed above the bentonite annular seal and secondary filters (see Fig. 1) is ordinarily a thick liquid slurry consisting of either a bentonite (powder or granules, or both) base and water, or a Portland cement base and water. Often, bentonite-based grouts are used when it is desired that the grout remain workable for extended periods of time during well construction or flexible (that is, to accommodate freeze-thaw cycles) during the life of the well. Cement-based grouts are often used when filling cracks in the surrounding geologic material, adherence to rock units, or a rigid setting is desired.

6.9.3.1 *Mixing*—The mixing (and placing) of a grout backfill should be performed with precisely recorded weights and volumes of materials, and according to procedures stipulated by the manufacturer that often include the order of component mixing. The grout should be thoroughly mixed with a paddle-type mechanical mixer or by recirculating the mix through a pump until all lumps are disintegrated. Lumpy grout should not be used in the construction of a monitoring well to prevent bridging within the tremie pipe.

NOTE 13—Lumps do not include lost circulation materials that may be added to the grout if excessive grout losses occur.

6.9.3.2 *Typical Bentonite-Based Grout*—When a bentonite-based grout is used, bentonite, usually unaltered, should be placed in the water through a venturi device. A typical

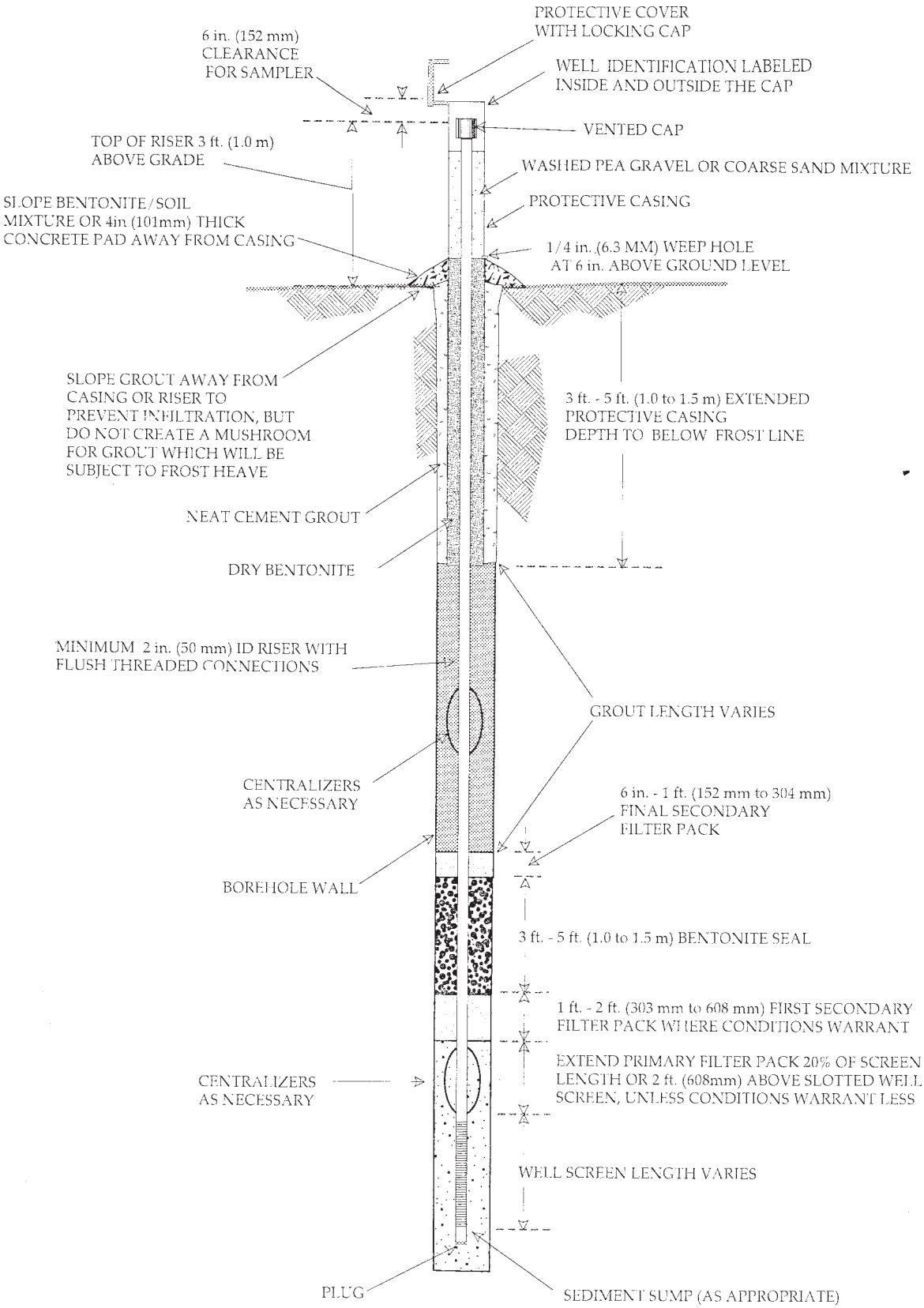

FIG. 1 Monitoring Well Design—Single–Cased Well

unbeneficiated bentonite-based grout consists of about 1 to 1.25 lb (0.57 kg) of unaltered bentonite to each 1 gal (3.8 L) of

water. 100 % bentonite grouts should not be used for monitoring well annular sealants in the vadose zone of arid regions because of the possibility that they may desiccate. This could result in migration of water into the screened portion of the well from zones above the target monitoring zone.

NOTE 14—High solids bentonite grouts (minimum 20 % by weight with water) and other bentonite-based grouts may contain granular bentonite to increase the solids content and other components added under manufacturer's directions to either stiffen or retard stiffening of the mix. All additives to grouts should be evaluated for their effects on subsequent water samples.

6.9.3.3 *Typical Cement-Based Grout*—A typical cement-based grout consists of about 6 gal. (23 L) of water per 94-lb. (43-kg) bag of Type I Portland cement. Though not recommended because of the chemical incompatability of bentonite with cement (2, 3), from 3 to 8 % (by dry weight) of unaltered bentonite powder is often added after the initial mixing of cement and water to retard shrinkage and provide plasticity..

6.10 *Secondary Filter Packs*:

6.10.1 *Materials*—A secondary filter pack is a layer of material placed in the annulus between the primary filter pack and the bentonite seal, and/or between the bentonite seal and the grout backfill (see Fig. 1 and Fig. 2).

6.10.2 *Gradation*—The secondary filter pack should be uniformly graded fine sand with 100 % by weight passing the #30 U.S. Standard sieve, and less than 2 % by weight passing the #200 U.S. Standard sieve.

6.11 *Annular Seal and Filter Pack Installation Equipment*—The equipment used to install the annular seals and filter pack materials should be cleaned (if appropriate for the selected material) using water from a source of known quality prior to use. This procedure is performed to prevent the introduction of materials that may ultimately alter water quality samples.

7. Drilling Methods

7.1 The type of equipment required to create a stable, open, vertical borehole for installation of a monitoring well depends upon the site geology, hydrology, and the intended use of the data. Engineering and geological judgment and some knowledge of subsurface geological conditions at the site is required for the selection of the appropriate drilling method(s) utilized for drilling the exploratory soil borings and monitoring wells (see Guide D 6286). Appropriate drilling methods for investigating and installing monitoring wells at a site may include any one or a combination of several of the following methods: hollow-stem auger (Guide D 5784); direct (mud) rotary (Guide D 5783); direct air-rotary (Guide D 5782); direct rotary wireline casing advancement (Guide D 5876); dual-wall reverse-circulation rotary (Guide D 5781); cable-tool (Guide D 5875); or various casing advancement methods (Guide D 5872). Whenever feasible, it is advisable to utilize drilling procedures that do not require the introduction of water or drilling fluids into the borehole, and that optimize cuttings control at ground surface. Where the use of water or drilling fluid is unavoidable, the selected fluid should have as little impact as possible on the water samples for the constituents of interest. The chemistry of the fluid to be used should be evaluated to determine the potential for water quality sample alteration. In addition, care should be taken to remove as much drilling fluid as possible from the well and the surrounding formation during the well development process. It is recommended that if an air compressor is used, it should be equipped with an oil air filter or oil trap to minimize the potential for chemical alteration of ground-water samples collected after the well is installed. 8. Monitoring Well Installation

8. Monitoring Well Installation

8.1 *Stable Borehole*—A stable borehole must be constructed prior to attempting the installation of monitoring well screen and riser. Steps must be taken to stabilize the borehole before attempting installation if the borehole tends to cave or blow in, or both. Boreholes that are not straight or are partially obstructed should be corrected prior to attempting the installation procedures described herein.

8.2 *Assembly of Well Screen and Riser*:

8.2.1 *Handling*—TThe well screen, sediment sump, bottom plug and riser should be either certified clean from the manufacturer or steam-cleaned or high-pressure hot-water washed (whichever is appropriate for the selected material) using water from a source of known chemistry immediately prior to assembly. Personnel should take precautions to assure that grease, oil, or other contaminants that may ultimately alter the water sample do not contact any portion of the well screen and riser assembly. As one precaution, for example, personnel should wear a clean pair of cotton, nitrile or powder-free PVC (or equivalent) gloves while handling the assembly..

8.2.2 *Riser Joints (Couplings)*—Flush joint risers with square profile (Specification F 480) threads do not require PTFE taping to achieve a water tight seal; these joints should not be taped. O-rings made of a material of known chemistry, selected on the basis of compatibility with contaminants of concern and prevailing environmental conditions, should be used to assure a tight seal of flush-joint couplings. Couplings are often tightened by hand; however, if necessary, steam-cleaned or high-pressure water-cleaned wrenches may be utilized. Precautions should be taken to prevent damage to the threaded joints during installation, as such damage may promote leakage past the threads.

8.3 *Setting the Well Screen and Riser Assembly*—When the well screen and riser assembly is lowered to the predetermined level in the borehole and held in position, the assembly may require ballast to counteract the tendency to float in the borehole. Ballasting may be accomplished by filling the riser with water from a source of known and acceptable chemistry or, preferably, using water that was previously removed from the borehole. Alternatively, the riser may be slowly pushed into the fluid in the borehole with the aid of hydraulic rams on the drill rig and held in place as additional sections of riser are added to the column. Care must be taken to secure the riser assembly so that personnel safety is assured during the installation. The assembly must be installed straight and plumb, with centralizers installed at appropriate locations (typically every 20 to 30 ft [6 to 9 m]). Difficulty in maintaining a straight installation may be encountered where the weight of the well screen and riser assembly is significantly less than the buoyant force of the fluid in the borehole. The riser should extend above grade and be capped temporarily to deter entrance of foreign materials during final completion.

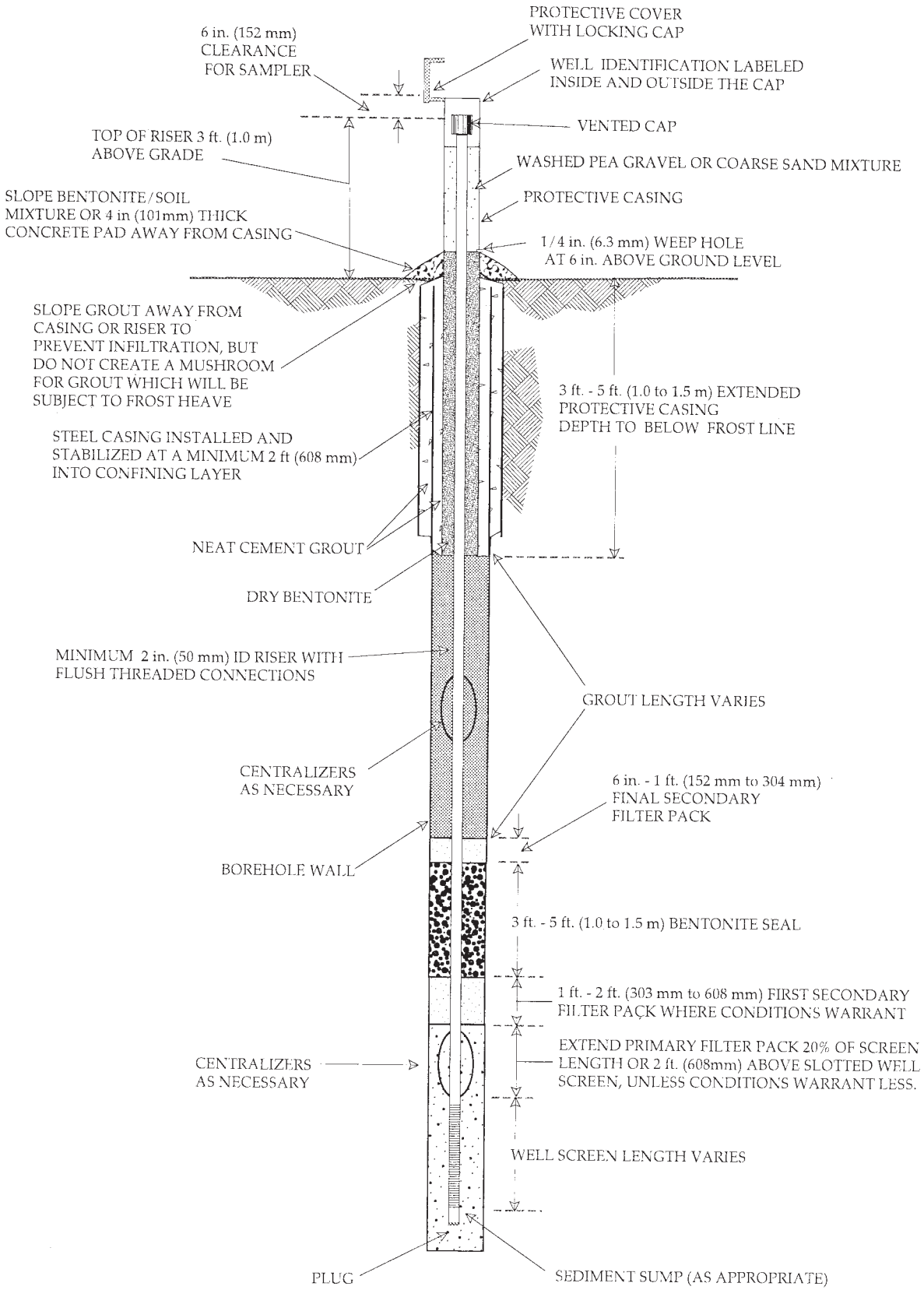

FIG. 2 Monitoring Well Design—Multi–Cased Well

8.4 *Installation of the Primary Filter Pack*:

8.4.1 *Volume of Filter Pack*—TThe volume of filter pack required to fill the annular space between the well screen and borehole should be calculated, measured, and recorded on the well completion diagram during installation. To be effective, the filter pack should extend above the screen for a distance of about 20 % of the length of the well screen but not less than 2 ft. (0.6 m) (see Figs. 1 and 2). Where there is hydraulic connection between the zone to be monitored and the overlying strata, this upward extension should be gauged to prevent seepage from overlying hydrologic units into the filter pack. Seepage from other units may alter hydraulic head measurements or the chemistry of water samples collected from the well.

8.4.2 *Placement of Primary Filter Pack*—Placement of the well screen is preceded by placing no less than 2 % and no more than 10 % of the primary filter pack into the bottom of the borehole using a decontaminated, flush threaded, 1-in. (25-mm) minimum internal diameter tremie pipe. Alternatively, the filter pack may be added directly between the riser pipe and the auger or drive/temporary casing and the top of the filter pack located using a tamper or a weighted line. The well screen and riser assembly is then centered in the borehole. This can be done using one or more centralizer(s) or alternative centering devices located not more than 10 ft (3 m) above the bottom of the well screen (see Figs. 1 and 2). Centralizers should not be located in the well screen. The remaining primary filter pack is then placed in increments as the tremie is gradually raised or as the auger or drive/temporary casing is removed from the borehole. As primary filter pack material is poured into the tremie pipe, water from a source of known and acceptable chemistry may be added to help deliver the filter pack to the intended interval in the borehole. The tremie pipe or a weighed line can be used to measure the top of the primary filter pack as work progresses. If bridging of the primary filter pack material occurs, the bridged material should be broken mechanically prior to proceeding with the addition of more filter pack material. The elevation (or depth below ground surface), volume, and gradation of primary filter pack should be recorded on the well completion diagram (see Fig. 2 for an example).

8.4.3 *Withdrawal of the Temporary Casing/Augers*—If used, the drive/temporary casing or hollow stem auger is withdrawn, usually in stipulated increments. Care should be taken to avoid lifting the riser with the withdrawal of the temporary casing/augers. To limit borehole collapse in stable formations, the temporary casing or hollow stem auger is usually withdrawn until the lower-most point on the temporary casing or hollow stem auger is at least 2 ft (0.6 m), but no more than 5 ft (1.5 m) above the filter pack for unconsolidated materials; or at least 5 ft (1.5 m), but no more than 10 ft (3.0 m), for consolidated materials. In highly unstable formations, withdrawal intervals may be much less. After each increment, it should be ascertained that the primary filter pack has not been displaced during the withdrawal operation (using a weighed measuring device).

8.5 *Placement of First Secondary Filter*—A secondary filter pack may be installed above the primary filter pack to prevent the intrusion of the bentonite grout seal into the primary filter pack (see Figs. 1 and 2). To be effective, a measured and recorded volume of secondary filter material should be added to extend 1 to 2 ft (0.3 to 0.6 m) above the primary filter pack. As with the primary filter, a secondary filter must not extend into an overlying hydrologic unit (see 8.4.1). The well designer should evaluate the need for this filter pack by considering the gradation of the primary filter pack, the hydraulic heads between adjacent units, and the potential for grout intrusion into the primary filter pack. The secondary filter material is poured into the annular space through a decontaminated, flush threaded, 1-in. (25-mm) minimum internal diameter tremie pipe lowered to within 3 ft (1.0 m) of the placement interval. Water from a source of known and acceptable chemistry may be added to help deliver the filter pack to its intended location. The tremie pipe or a weighed line can be used to measure the top of the secondary filter pack as work progresses. The elevation (or depth below ground surface), volume, and gradation of the secondary filter pack should be recorded on the well completion diagram.

8.6 *Installation of the Bentonite Seal*—A bentonite pellet or a slurry seal is placed in the annulus between the borehole and the riser pipe on top of the secondary or primary filter pack (see Figs. 1 and 2). This seal retards the movement of cement-based grout backfill into the primary or secondary filter packs. To be effective, the bentonite seal should extend above the filter packs approximately 3 to 5 ft (1.0 to 1.5 m), depending on local conditions. The bentonite slurry seal should be installed using a positive displacement pump and a side-discharge tremie pipe lowered to the top of the filter pack. The tremie pipe should be raised slowly as the bentonite slurry fills the annular space. Bentonite pellets or chips may be poured from the surface and allowed to free-fall into the borehole. As a bentonite pellet or chip seal is poured into the borehole, a tamper may be necessary to tamp pellets or chips into place or to break bridges formed as the pellets or chips stick to the riser or the walls of the water-filled portion of the borehole. If the bentonite seal is installed above the water level in the borehole, granular bentonite should be used as the seal material – *bentonite pellets or chips should not be used in the unsaturated zone.* Granular bentonite should be poured into the borehole and installed in lifts of 2 in., then hydrated with water from a source of known chemistry. The tremie pipe or a weighed line can be used to measure the top of the bentonite seal as the work progresses. Sufficient time should be allowed for the bentonite pellet seal to hydrate or the slurry annular seal to expand prior to grouting the remaining annulus. The volume and elevation (or depth below ground surface) of the bentonite seal material should be measured and recorded on the well completion diagram.

8.7 *Final Secondary Filter Pack*—A 6-in. to 1-ft (0.15 to 0.3-m) secondary filter may be placed above the bentonite seal in the same manner described in 8.5 (see Figs. 1 and 2). This secondary filter pack will provide a layer over the bentonite seal to limit the downward movement of cement-based grout backfill into the bentonite seal. The volume, elevation (or depth

below ground surface), and gradation of this final secondary filter pack should be documented on the well completion diagram.

8.8 *Grouting the Annular Space*:

8.8.1 *General*—Grouting procedures vary with the type of well design. The following procedures will apply to both single- and multi-cased monitoring wells. Paragraphs 8.8.2 and 8.8.3 detail those procedures unique to single- and multi-cased installations, respectively.

8.8.1.1 *Volume of Grout*—An ample volume of grout should be mixed on site to compensate for unexpected losses to the formation. The use of alternate grout materials, including grout containing gravel, may be necessary to control zones of high grout loss. The volume and location of grout used to backfill the remaining annular space is recorded on the well completion diagram.

8.8.1.2 *Grout Installation Procedures*—The grout should be pumped down hole through a side-discharge tremie pipe using a positive displacement pump (e.g., a diaphragm pump, moyno pump, or similar pump) to reduce the chance of leaving voids in the grout, and to displace any liquids and drill cuttings that may remain in the annulus. In very shallow wells, grouting may be accomplished by gravity feeding grout through a tremie pipe. With either method, grout should be introduced in one continuous operation until full-strength grout flows out of the borehole at the ground surface without evidence of drill cuttings, drilling fluid, or water.

8.8.1.3 *Grout Setting and Curing*—The riser should not be disturbed until the grout sets and cures for the amount of time necessary to prevent a break in the seal between the grout and riser. The amount of time required for the grout to set or cure will vary with the grout mix and ambient temperature and should be documented on the well completion diagram.

8.8.2 *Specific Procedures for Single-Cased Wells*—Grouting should begin at a level directly above the final secondary filter pack (see Fig. 1) if used, or above the bentonite pellet, chip or slurry seal. Grout should be pumped using a side-discharge tremie pipe to dissipate the fluid-pumping energy against the borehole wall and riser, reducing the potential for infiltration of grout into the primary filter pack. The tremie pipe should be kept full of grout from start to finish, with the discharge end of the pipe completely submerged as it is slowly and continuously lifted. Approximately 5 to 10 ft (1.5 to 3.0 m) of tremie pipe should remain submerged until grouting is complete. For deep installations or where the joints or couplings of the selected riser cannot withstand the collapse stress exerted by a full column of grout as it is installed, a staged grouting procedure may be used. If used, the drive/temporary casing or hollow-stem auger should be removed in increments immediately following each increment of grout installation and before the grout begins to set. If casing removal does not commence until grout pumping is completed, then, after the casing is removed, additional grout may be periodically pumped into the annular space to maintain a continuous column of grout up to the ground surface.

8.8.3 *Specific Procedures for Multi-Cased Wells*—If the outer casing of a multi-cased well cannot be driven to form a tight seal between the surrounding stratum (strata) and the casing, it should be installed in a pre-drilled borehole. After the borehole has penetrated not less than 2 ft. (0.6 m) of the first targeted confining stratum, the outer casing should be lowered to the bottom of the boring and the annular space pressure grouted. Pressure grouting requires the use of a grout shoe or packer installed at the end of the outer casing to prevent grout from moving up into the casing. The grout must be allowed to cure and form a seal between the casing and the borehole prior to advancing the hole to the next hydrologic unit. This procedure is repeated as necessary to advance the borehole to the desired depth. Upon reaching the final depth, the riser and screen should be set through the inner casing. After placement of the filter packs and bentonite seal, the remaining annular space is grouted as described in 8.8.2 (see Fig. 2).

NOTE 15—When using a packer, pressure may build up during grout injection and force grout up the sides of the packer and into the casing.

8.9 *Well Protection*—Well protection refers specifically to installations made at the ground surface to deter unauthorized entry to the monitoring well, to prevent damage to or destruction of the well, and to prevent surface water from entering the annulus. The methods described in Practice D 5787 should be used for well protection.

8.9.1 *Protective Casing*—Protective casing should be used for all monitoring well installations. In areas that experience frost heaving, the protective casing should extend from below the depth of frost penetration (3 to 5 ft [1.0 to 1.5 m] below grade, depending on local conditions), to slightly above the top of the well casing. The protective casing should be initially placed before final set of the grout. The protective casing should be sealed and immobilized in concrete placed around the outside of the protective casing above the set grout. The protective casing should be stabilized in a position concentric with the riser (see Figs. 3 and 1). Sufficient clearance, usually 6 in. (0.15 m) should be maintained between the lid of the protective casing and the top of the riser to accommodate sampling equipment. A ¼-in. (6.3-mm) ddiameter weep hole should be drilled in the protective casing approximately 6 in. (15 cm) above ground surface to permit water to drain out of the annular space between the protective casing and the riser. In cold climates, this hole will also prevent water freezing between the protective casing and the well casing. Dry bentonite pellets, granules, or chips should then be placed in the

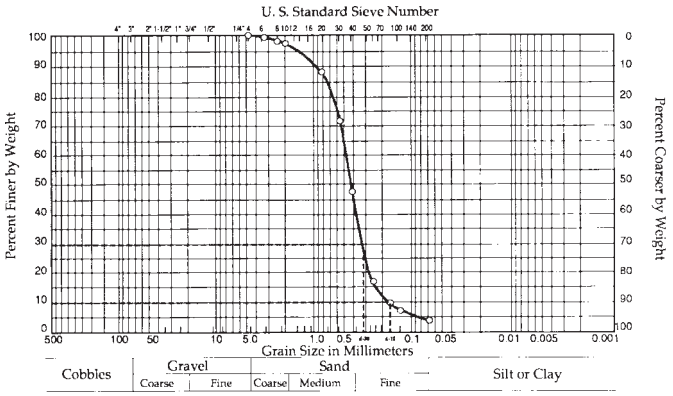

FIG. 3 Example Grading Curve for Design of Monitoring Well Screens

annular space below ground level within the protective casing. Coarse sand or pea gravel or both should be placed in the annular space above the dry bentonite pellets and to just above the weep hole to prevent entry of insects. All materials chosen should be documented on the well completion diagram. The monitoring well identification number should be clearly visible on the inside and outside of the protective casing.

8.9.2 *Completion of Surface Installation*—The well protection installation may be completed in one of three ways:

8.9.2.1 In areas subject to frost heave, place a soil or bentonite/sand layer adjacent to the protective casing sloped to direct water drainage away from the well.

8.9.2.2 In regions not subject to frost heave, a concrete pad, sloped slightly to provide water drainage away from the well, should be placed around the installation.

8.9.2.3 Where monitoring well protection must be installed flush with the ground, an internal cap should be fitted on top of the riser within the manhole or vault. This cap should be leak-proof so that if the vault or manhole should fill with water, the water will not enter the well casing. Ideally, the manhole cover cap should also be leak-proof..

8.9.3 *Additional Protection*—In areas where there is a high probability of damaging the well (high traffic, heavy equipment, poor visibility), it may be necessary to enhance the normal protection of the monitoring well through the use of posts, markers, signs, or other means, as described in Practice D 5787. The level of protection should meet the damage threat posed by the location of the well.

9. Well Development

9.1 *General*—Well development serves to remove fine-grained material from the well screen and filter pack that may otherwise interfere with water quality analyses, to restore the formation properties disturbed during the drilling process, and to improve the hydraulic characteristics of the filter pack and hydraulic communication between the well and the hydrologic unit adjacent to the well screen. Methods of well development vary with the physical characteristics of hydrologic units in which the monitoring well is screened and with the drilling method used.

9.2 *Development Methods and Procedures*—The methods and procedures for well development described in Guide D 5521 should be followed to ensure a proper well completion.

9.3 *Timing and Duration of Well Development*—Well development should begin either after the riser, well screen and filter pack are installed and before the bentonite seal and grout are installed (the preferred time), or after the monitoring well is completely installed and the grout has cured or set. In the former case, the installer may add filter pack material to the borehole before the bentonite seal is installed to compensate for settlement that typically occurs during the development process. This allows the installer to maintain the desired separation between the top of the screen and the bentonite seal. In the latter case, the possibility exists that settlement of the filter pack may result in the bentonite seal settling into the top of the screen. Development should be continued until representative water, free of the drilling fluids, cuttings, or other materials introduced or produced during well construction, is obtained. Representative water is assumed to have been obtained when turbidity readings stabilize and the water is visually clear of suspended solids. The minimum duration of well development will vary with the method used to develop the well. The timing and duration of well development and the turbidity measurements should be recorded on the well completion diagram.

9.4 *Well Recovery Test*—A well recovery test should be performed immediately after and in conjunction with well development. The well recovery test provides an indication of well performance and provides data for estimating the hydraulic conductivity of the screened hydrologic unit. Readings should be taken at intervals suggested in Table 2 until the well has recovered to 90 % of its static water level.

NOTE 16—If a monitoring well does not recover sufficiently for sampling within a 24-hr period and the well has been properly developed, the installation should not generally be used as a monitoring well for detecting or assessing low level organic constituents or trace metals. The installation may, however, be used for long-term water-level monitoring if measurements of short-frequency water-level changes are not required.

10. Installation Survey

10.1 *General*—The vertical and horizontal position of each monitoring well in the monitoring system should be surveyed and subsequently mapped by a licensed surveyor. The well location map should include the location of all monitoring wells in the system and their respective identification numbers, elevations of the top of riser position to be used as the reference point for water-level measurements, and the elevations of the ground surface protective installations. The locations and elevations of all permanent benchmark(s) and pertinent boundary marker(s) located on-site or used in the survey should also be noted on the map.

10.2 *Water-Level Measurement Reference*—The water-level measurement reference point should be permanently marked, for example, by cutting a V-notch into the top edge of the riser pipe. This reference point should be surveyed in reference to the nearest NAVD reference point.

10.3 *Location Coordinates*—The horizontal location of all monitoring wells (active or decommissioned) should be surveyed by reference to a standardized survey grid or by metes and bounds.

10.4 *Borehole Deviation Survey*—A borehole deviation survey, to determine the direction and distance of the bottom of the well relative to the top of the well and points in between, should be completed in wells deeper than 100 feet and in wells installed in dipping formations.

11. Monitoring Well Network Report

11.1 TTo demonstrate that the goals set forth in the Scope have been met, a monitoring well network report should be prepared. This report should:

TABLE 2 Suggested Recording Intervals for Well Recovery Tests

Time Since Starting Test	Time Interval
0 to 15 min	1 min
15 to 50 min	5 min
50 to 100 min	10 min
100 to 300 min (5 h)	30 min
300 to 1440 min (24 h)	60 min

11.1.1 Locate the area investigated in terms pertinent to the project. This should include sketch maps or aerial photos on which the exploratory borings, piezometers, sample areas, and monitoring wells are located, as well as topographic items relevant to the determination of the various soil and rock types, such as contours, streambeds, etc. Where feasible, include a geologic map and geologic cross sections of the area being investigated.

11.1.2 Include copies of all well boring test pits and exploratory borehole logs, initial and post-completion water levels, all laboratory test results, and all well completion diagrams.

11.1.3 Include the well installation survey.

11.1.4 Describe and relate the findings obtained in the initial reconnaissance and field investigation (Section 5) to the design and installation procedures selected (Sections 7-9) and the surveyed locations (Section 10).

11.1.5 This report should include a recommended decommissioning procedure that is consistent with those described in Guide D 5299 and/or with applicable regulatory requirements.

12. Keywords

12.1 aquifer; borehole drilling; geophysical exploration; ground water; monitoring well; site investigation

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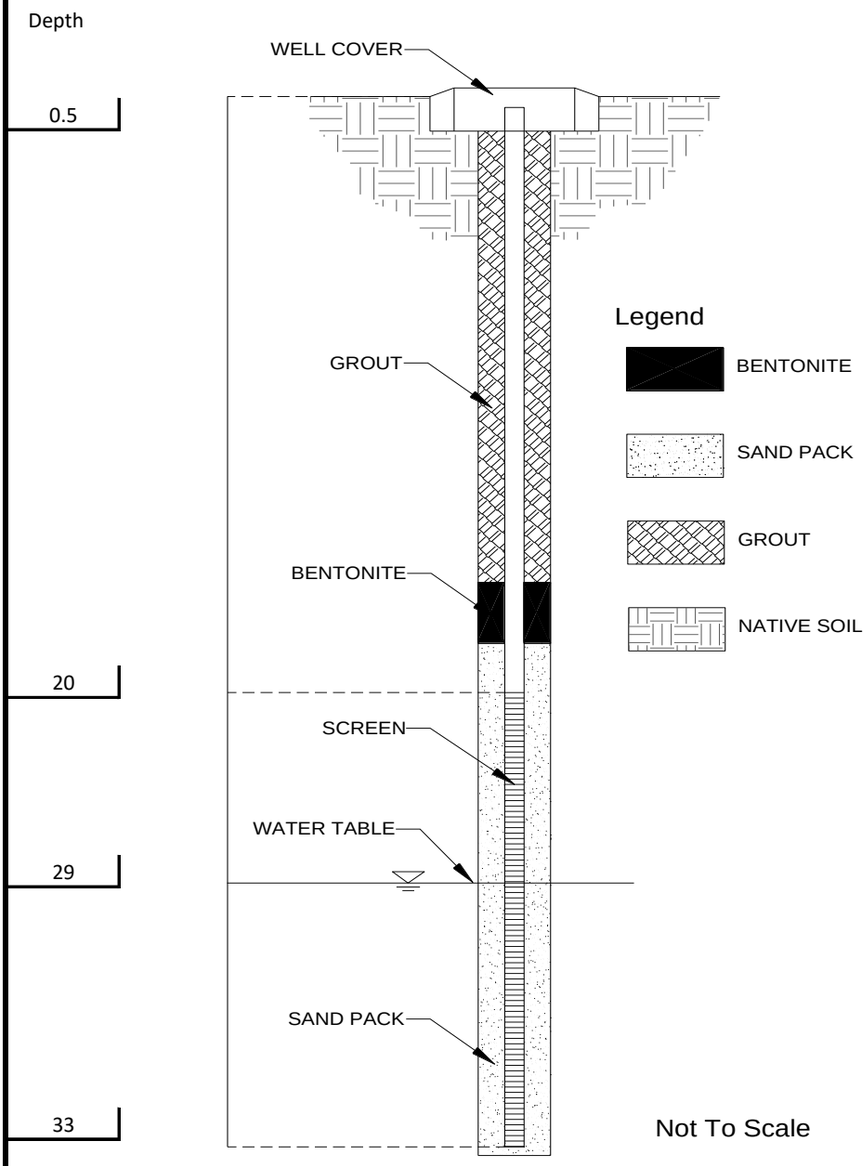
Well Code:	

Site Location:		**Installer:**	
Job Number:		**Installation Method:**	
Client:		**Installation Date:**	



Surface Pad
- Type: Concrete

Well Cap
- Type: J-Plug

Surface Casing
- Type: 8" Steel Manhole

Riser Pipe
- Type: Schedule 40 PVC
- Diameter: 2"
- Length: 19.5'
- Interval (BEG): 0.5-20'

Annular Seal
- Type: Sand #2 + concrete
- Length: 2.5'
- Interval (BEG): 0.5-3'

Bentonite Seal
- Type: Granular 3/8"
- Length: 4'
- Interval (BEG): 3-17'

Filter Pack
- Type: Sand #2
- Length: 16'
- Interval (BEG): 17-33'

Screen
- Type: Schedule 40 PVC
- Diameter: 2"
- Length: 15'
- Slot Size: 0.010"
- Interval (BEG): 20-33'

SOP-11: MONITORING WELL DEVELOPMENT

1.0 Purpose

This standard operating procedure (SOP) provides guidance for developing temporary and permanent monitoring wells after their installation and before their designated use.

The primary function of a monitoring well is to provide a representative sample of groundwater as it exists in the formation. The overall objectives of monitoring well development are as follows:

- Restoring the aquifer properties near the well boring disturbed during drilling or direct push emplacement
- Removing the finer-grained materials from the surrounding filter pack that may otherwise interfere with water quality analyses
- Improving the hydraulic characteristics of the filter pack and hydraulic communication between the well and the hydrologic unit adjacent to the well screen
- Removing all water introduced into the borehole while drilling

Formation characteristics change during drilling and well installation, and usually include the compaction of unconsolidated particles surrounding the annulus. In fine-grained soils, this can result in a mudwall around the boring annulus, which can impede free flow of formation water into the well. Monitoring well development physically agitates the formation around the well boring by pushing and pulling water through the filter pack and surrounding formation; thereby flushes fine-grained soils into the well, where they either settle within the filter pack or are removed from the well during development and purging.

Common well development methods include combinations of surging, pumping, and bailing. The most effective well development method is alternating between using a surge block and pumping or bailing, so that multidirectional flow occurs through the filter pack and native formation around the well.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in well development procedures in monitoring wells at site projects.

This SOP focuses on the most commonly used monitoring well development tasks and applications anticipated at DuPont EC and should be used in conjunction with other applicable projects, including the following:

- *SOP- Field Documentation*
- *SOP- Organic Vapor Monitoring and Air Monitoring*
- *SOP- Hollow Stem Auger and Direct Push Drilling Methods*
- *SOP- Field Water Quality Measurements and Calibration*
- *SOP- Groundwater Sampling Procedures*

- *SOP- Equipment Decontamination Procedures*
- *SOP- Field Procedure Change Management*
- *SOP- Well Decommissioning and Abandonment*
- *SOP- Groundwater Sampling Procedures*

3.0 Procedures

3.1 Equipment

Well development commonly involves using equipment to surge, pump, and/or bail a monitoring well. Typical equipment includes the following:

- Surge block on a cable or line
- Peristaltic sampling pump or similar pump (bladder and gear pumps are not recommended because of pump damage from fine sediments)
- Water quality monitoring instrument(s) capable of measuring dissolved oxygen (DO), oxidation-reduction potential (ORP), conductivity, pH, turbidity, and temperature
- Water level indicator
- Groundwater purge container, tank, or drum
- Field notebook and Well Development Datasheet
- PPE

3.2 Conventional Monitoring Well Development

Newly installed conventional monitoring wells will be developed no sooner than 48 hours after well installation, according to the *SOP for Monitoring Well, Piezometer Installation.* Use a surge and purge method to develop conventional monitoring wells whenever feasible. The entire vertical screened interval should be developed using surge blocks, bailers, pumps, or other equipment, which frequently reverse the flow of water through the well screen and prevent bridging of formation or filter pack particles. Use the following instructions to develop monitoring wells:

1. Measure and record the water level and total depth of the well using a water level indicator. Note any accumulated sediment thickness and record all information in a field notebook and on the Well Development Datasheet provided as Attachment 1.
2. Remove approximately 1 to 2 pints of water from the well using a decontaminated groundwater sampling pump or disposable bailer. Measure pH, temperature, conductivity, DO, ORP, and turbidity.
3. Begin well development by surging the bottom of the monitoring well and removing any sediment from the bottom of the well. To do this, slowly lower a decontaminated surge block into the well so that the surge block is within approximately 0.5 to 1 foot from the bottom of the well or measured sediment accumulation. Slowly raise and lower the surge block approximately 1 to 2 feet to create a mild surging effect at the bottom of the well; this will suspend any sediment that has settled at the bottom. Do not

agitate the water violently. A general rule for well development is to start slowly and gently, and gradually increase agitation as the well is developed. After several surge strokes, remove the surge block and immediately begin to pump or bail the sediment-laden water. Repeat this process until accumulated sediment has been removed from the bottom of the monitoring well.

Next, develop the well from the bottom of the screened interval upward by alternately using the surge block and the bailer or pump. This will account for settlement that occurs as the filter pack is reworked through surging. Lower the surge block to the base of the well screen interval and rapidly raise and lower the surge block across a 2- to 3-foot interval above the base of the well screen for approximately 2 to 3 minutes. However, do not overdevelop the well with overly aggressive surging. Record the surge interval and duration of surging.

4. Remove the surge block and lower the pump or bailer so that the intake is at the bottom of the surged screen interval. Turn the pump on or bail the well at the development interval until the purge water begins to clear up. Measure and record the water quality parameters every 3 to 5 minutes during pumping or bailing for each developed 2- to 3-foot screen interval, according to *SOP for Field Water Quality Measurements and Calibration*. Record the purge intake depth and the duration of pumping.

5. Once the water is clear, repeat Steps 4 and 5, continuing to alternate between surging and purging, until measurements stabilize for at least three consecutive water quality parameter readings, according to the following criteria:

- ± 1.0 degrees Celsius (°C) temperature
- ± 0.1 pH
- ± 3 percent conductivity
- ± 10 millivolts (mV) ORP
- ± 10 percent DO or 0.2 milligram per liter (mg/L)
- ± 10 percent turbidity or ≤ 10 nephelometric turbidity units (NTUs)

6. After the parameters stabilize and the water clarity improves, move the surge block up in 2- to 3-foot intervals, and repeat Steps 4 through 6 until the entire screened interval has been developed. Afterward, continue purging at a rate intended to avoid dewatering the screened interval and record water quality parameters at regular 3- to 5-minute intervals. In total, the entire well screen interval should be developed and surging should be conducted for a minimum of 10 minutes.

If the well is purged dry at any point during development, approximately one well casing of clean, potable water can be introduced into the well and surging can continue (ADEC, 2009). Add water only as a last resort and only add non-formation water as necessary. After surging, purge the well dry again to complete the development process by removing at least the amount of potable water added to the well. If the well will recover naturally, continue development with formation water only.

7. The well will be considered adequately developed and development can stop after the water quality parameters have stabilized according to the criteria in Step 6 or a minimum of 10 well casing volumes (see Attachment 1) have been removed from the well (ADEC, 1992). If none of these conditions have been achieved after 4 hours of well development, the FM will decide whether to continue development.

8. Measure and record a final depth to water and total well depth measurement after well development.

9. Record all well development data on a Well Development Datasheet and/or in a field notebook.

3.3 Direct Push Groundwater Sampler and Well Point Development

Like conventionally installed wells, direct push system (DPS) groundwater samplers and well points (see *SOP for Groundwater Sampling Procedures*) may be developed if necessary, depending on project-specific goals. Because of the way some DPS samplers and well points are constructed and used, they may not accommodate surging, and only pumping or bailing may be feasible (U.S. Environmental Protection Agency [EPA], 2005). DPS samplers and well points that require development should be developed similarly to the methods described in Section 5.2 for conventional wells; however, because of the generally smaller diameters of DPS samplers and well points, smaller-diameter pumps, bailers, and, occasionally, surge blocks will be needed. Because most DPS groundwater samplers and DPS well points do not have filter packs to prevent fine-grained formation materials from entering the well casing, obtaining low-turbidity purge water during and after development may be difficult. In addition, in fine-grained formations, attempting to develop direct push wells may not improve well yield, and may result in increases in suspended sediment, well screen clogging, and/or screen damage. Purging the DPS groundwater sampler or well point at a low flow rate (≤0.1 gallon per minute), to the point at which pump discharge is free of suspended sediment (using a peristaltic pump, bladder pump, or gas-displacement pump), is often effective for developing wells installed in fine-grained formations. If DPS samplers and well points will be developed beyond usual purging during groundwater sampling, use the development techniques described in American Society for Testing and Materials (ASTM) D5521, ASTM D6724, and ASTM D5092.

3.4 Supply Well Development and Draw-down Testing

Remedial supply wells will be developed concurrent with the proposed additional monitoring wells; related purge water will be handled in a manner similar to the monitoring wells in conformance with IDW containerization, characterization and disposal protocols and procedures specified within this work plan and related *SOP- Equipment Decontamination Procedures* and *SOP – IDW Handling and Disposal.* Immediately after development is completed, a groundwater sample will be collected from each well and analyzed for arsenic content, to confirm the arsenic concentrations are below USEPA requirements (< 5 mg/l) for utilization as remedial makeup water for stock solutions. The analytical results will be immediately reported to USEPA for Agency approval.

After the development work is completed and analytical results from resultant groundwater samples are reported (and approved for remedial use), a step/drawdown test will be performed on each proposed remedial supply well. The purpose of said test is to investigate the performance of a pumping well under controlled variable discharge conditions. In a step-drawdown test, the discharge rate in the pumping well is increased from an initially low constant rate through a sequence of pumping intervals (steps) of progressively higher constant rates. The tests will be conducted in incremental stages based on the ideal well yield of 25 GPM and each step will be conducted over a two-hour period:

- Step One: 60% of Ideal Pumping Yield – Approximately 15 GPM
- Step Two: 80% of Ideal Pumping Yield – Approximately 20 GPM
- Step Three: 100% of Ideal Pumping Yield – Approximately 25 GPM
- Step Four: 120% of Ideal Pumping Yield – Approximately 30 GPM

A stainless-steel submersible pump with an at-grade flow controller will be utilized for the tests. Said pump will be installed within the center of each remedial supply well screen and engaged once water table aquifer measurements are made within the pumping well and within neighboring wells (monitoring/PRB/injection/etc.) Electronic data loggers will be deployed within the test well and surrounding wells to track the change in water table elevation in response to each pumping step. An inline flow meter will be installed within the effluent discharge piping to track the actual groundwater purge rate for each step. Field personnel will measure and record field measurements during each step, in dedicated field notebooks, in conformance with the protocols and procedure cited within the *SOP-Field Documentation.*

Generated purge water will be handled in a manner similar to the monitoring wells in conformance with IDW containerization, characterization and disposal protocols and procedures specified within this work plan and related *SOP – IDW Handling and Disposal*. Pumping and field measurement equipment will be decontaminated in accordance with the protocols and procedures cited within the *SOP- Field Documentation* and dedicated effluent tubing will be disposed of in accordance with site IDW protocols and procedures.

Data obtained from field measurement and downloaded level logger data will be compiled and evaluated utilizing industry standard modeling programs (Aqtesolv, etc.) to identify well yield and related pumping rates to be employed during the supplementary remedial event. The Step/Drawdown results will be immediately provided to the Agency in a technical memorandum for review and commentary.

3.5 Development Water Management

Manage development water generated during well development as investigation-derived waste (IDW), according to the *SOP for Investigative/ Remedial Derived Waste Management.*

4.0 Records

Record all data collected during well development activities in a Field Notebook and/or on a Well Development Datasheet (Attachment 1), according to *SOP for Field Documentation.*

5.0 References

American Society for Testing and Materials (ASTM). 2006. *Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers - Reinstated*. ASTM Standard D5521, ASTM International, West Conshohocken, PA. November 1.

American Society for Testing and Materials (ASTM). 2004a. *Standard Guide for Installation of Direct Push Ground Water Monitoring Wells*. ASTM Standard D6724, ASTM International, West Conshohocken, PA. July 1.

American Society for Testing and Materials (ASTM). 2004b. *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. ASTM Standard D5092, ASTM International, West Conshohocken, PA. January 1.

Driscoll, F.G. 1986. *Groundwater and Wells*. Johnson Division. St. Paul, MN.

Nielsen, D.M. 1991. *Practical Handbook of Ground-Water Monitoring*. Lewis Publishers. Oregon Department of Environmental Quality (ODEQ). 1992. *Groundwater Monitoring Well*

Drilling, Construction, and Decommissioning Guidance. August 24.

U.S. Department of the Interior (USDI). 1981. *Groundwater Manual, A Water Resource Technical Publication*. Water and Power Resources Services. Denver, CO: U.S. Government Printing Office.

U.S. Environmental Protection Agency (EPA). 2005. *Groundwater Sampling and Monitoring with Direct Push Technologies*. Office of Solid Waste and Emergency Response, Washington, DC. EPA 540/R-04/005. August.

6.0 Definitions

Bailer: a long, narrow tubular device with an open top and a check valve at the bottom that is used to remove water and sediment from a borehole or well.

Bailing: a well development technique using a bailer that is raised and lowered in the well to create a strong inward and outward movement of water from the formation, to break sand bridges and to remove water and fine-grained materials from the well.

Surging: a well development technique in which a surge block is alternately raised and lowered within the well casing or screen, or both, to create a strong inward and outward movement of water through the well screen.

Surge block: a weighted tool that is slightly smaller than the inside diameter of the well casing. Most surge blocks are 6 to 12 inches in length, as are some in-well pumps (Grundfos pumps) commonly used as surge blocks.

Mechanical surging: a process that uses a plunging motion (surge block) to force water to flow through a well screen. A pump or bailer is then used to remove dislodged sediment.

Mudwall: a layer of fine-grained soils formed around the boring annulus during drilling that can impede free flow of the formation water into the well.

Turbidity: cloudiness in water resulting from suspended and colloidal material.

Well casing: a durable pipe placed in a borehole to prevent the walls of the borehole from caving in, and to seal off surface drainage or undesirable water, gas, or other fluids and prevent their entrance into the well.

Well development: the act of repairing damage to the borehole caused by the drilling process and removing fine-grained materials or drilling fluids, or both, from formation materials so that natural hydraulic conditions are restored and well yields are enhanced.

Well screen: a filtering device that allows groundwater to flow freely into a well from the adjacent formation, while minimizing or eliminating the entrance of fine-grained material into the well.

7.0 Attachments

Attachment 1: *Well Development Datasheet*

WELL DEVELOPMENT RECORD

Project Name:	**Project Number:**	**Well Number:**

Project Information	**Elevation of Monitoring Well**
Facility Name:	Ground Surface Elevation (GS):
Location:	Top of Casing Elevation (TOC):
Well Information	**Borehole Volume Calculation**
Date Well Installed:	Water Column =
Total Depth of Well:	1 Borehole Volume =
Depth to Top of Screen:	5 Borehole Volumes =
Length of Casing Screened:	1 borehole volume (gallons) = water level thickness (ft) x .163 + (0.748 x saturated filter pack thickness); for 2-inch well initial height of water column (ft) = total depth (ft) - initial depth to water (ft)
Type of Formation Screened:	

Development Method

Equipment:				Method Description: Well surged with pump. Well purged dry during development.
Surge		Bail		
Airlift		Pump		

Observations During Development

Date	Time	Depth to Water* (ft)	Total Depth* (ft)	Fluid Removed		Temp. (ºC)	pH (units)	S.C. (µS/cm)		Fluid Appearance and Remarks (turbidity, color, odor, etc.)
				Gallons	Total					

*from TOC unless otherwise noted in Remarks

SOP-12: GROUNDWATER LEVEL MEASUREMENT

1.0 Purpose

This standard operating procedure (SOP) provides guidance on the methods and equipment used to determine water table aquifer levels or total depth in a groundwater monitoring well or piezometer.

Groundwater level data can be used for several purposes during site investigations, including the following:

- To determine the magnitude of horizontal and vertical hydraulic gradients in an aquifer system
- To measure changes in groundwater levels over time
- To estimate the magnitude of surface water/groundwater interaction that occurs during various flow conditions
- To estimate aquifer properties after aquifer testing
- To calculate the purge volume of standing water in the well
- To establish whether wells have fully recharged after purging and aquifer testing

A water level meter will typically be used to measure the groundwater level and total depth in wells. Water level meters use a battery-powered probe assembly attached to a cable marked in 0.01-foot increments. When the probe contacts the water surface, a circuit is closed and electricity is transmitted through the cable to sound an audible and/or visual alarm. The equipment has a sensitivity adjustment switch that enables the operator to distinguish between actual and false readings caused by the presence of conductive, immiscible components (such as LNAPL floating on the groundwater) or condensation inside the well casing. Consult the manufacturer's operating manual for instructions on adjusting sensitivity.

Static groundwater level (depth to water [DTW) and total depth (TD) are measured relative to an established measurement reference point. The measurement reference point is generally the top of the casing (TOC) and may be marked with a surveyor's reference mark. The reference mark should be permanent, such as a small notch cut into the TOC or a permanent ink mark at the TOC. If a reference mark is not present at the time of water level measurement, use and mark the north side of the casing. Decontaminate all equipment before and after introducing it to the well, following procedures in *SOP for Equipment Decontamination Procedures*.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in measuring water levels, floating product, and total depths in wells at Project Sites and tasks.

This SOP is applicable to the sampling of monitoring wells and must be performed before any activities that may disturb the groundwater table level, such as pumping, purging, or aquifer testing. This SOP should be used in conjunction with other project SOPs, including the following:

- *SOP-Monitoring Well/Piezometer Installation*
- *SOP-Monitoring Well Development*
- *SOP-Continuous Water Level Monitoring*
- *SOP-Groundwater Sampling Procedures*

3.0 Procedure

3.1 General

Decontaminate all measurement devices according to *SOP for Equipment Decontamination Procedures* before and between measurements. In addition, employ air monitoring procedures according to *SOP for Organic Vapor Monitoring and Air Monitoring,* while opening groundwater monitoring wells and measuring groundwater levels.

3.1.1 Equipment

The following equipment is required for groundwater level measurement:

- Water level meter with audible alarm and a cable marked in 0.01-foot increments. The point on the probe that triggers the alarm corresponds to the zero point. Calibrate the water level meter according to the manufacturer's instructions.
- Oil-water interface probe and a cable marked in 0.01-foot increments, if a floating LNAPL layer is suspected in the well.
- Decontamination equipment (see *SOP*) (one spray bottle containing Alconox or Liquinox solution, one spray bottle containing deionized water, paper towels, 5-gallon poly bucket, and absorbent pads).

3.1.2 Depth to Water Measurement

If the well is sealed with an airtight cap, allow time for pressure to equilibrate after the cap is removed before measuring water levels. Take measurements until consecutive readings are within 0.01 foot.

Measure DTW as follows:

1. With the water level indicator switched on, wet the tip of the probe in potable water to test whether the meter is working properly. If no audible alarm is observed, the meter is not working properly.
2. Slowly lower the water level meter or oil-water indicator probe down the monitoring well until the probe contacts the groundwater, as indicated by the audible alarm. Do not let the probe tip and tape free-fall down the well. Always hold onto the meter's reel handle.
3. Raise the probe out of the water until the audible alarm stops. Continue raising and lowering the probe until a precise level is determined within 0.01 foot.
4. Continue to lower the probe until the meter indicates the presence of groundwater. The alarm will typically emit a beep when water is detected.
5. Record the measurements in the field log book or Groundwater Sampling Datasheet according to *SOP for Field Documentation*.

3.1.3 Total Depth Measurement

Use the following procedures to measure the total depth (DTW) of a groundwater monitoring well:

1. Slowly lower the water level meter until the cable goes slack. Do not let the probe tip and tape free-fall down the well. Always hold onto the meter's reel handle.

2. Gently raise and lower the water level meter probe to tap the bottom of the well.
3. Record the reading on the cable at the established reference point to the nearest

0.01 foot. If there is an offset between the bottom of the probe and the water level sensor, adjust the measurement accordingly. Record the TD measurement in the field log book or Groundwater Sampling Datasheet according to *SOP for Field Documentation*.

4.0 Records

Document all measurements in the field notebook and/or on a Groundwater Sampling Datasheet according to *the SOP for Field Documentation.*

5.0 References

American Society for Testing and Materials (ASTM). 1987. *Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)*. ASTM Standard D 4750, ASTM International, West Conshohocken, PA. November 27.

Driscoll, F.G. 1986. *Groundwater and Wells.* St. Paul, MN: Johnson Division. Thornhill, Jerry T. 1989. "Accuracy of Depth to Ground Water Measurements." *EPA Superfund Ground Water Issue*. EPA/540/4-89/002.

U.S. Department of the Interior. 1981. *Groundwater Manual, A Water Resource Technical Publication.* Water and Power Resources Services. Denver, CO: U.S. Government Printing Office.

6.0 Definitions

None.

7.0 Attachments

None.

SOP 13: FIELD WATER QUALITY MEASURMENT AND CALIBRATION

1.0 Purpose

The purpose of this standard operating procedure (SOP) is to describe general methods for calibrating, maintaining, and operating water quality meters and probes used for groundwater sampling. This technical procedure provides general guidelines; however, the manufacturer's manual describing calibration and standard operating procedures for each field instrument should be referred to for complete calibration and operating instructions.

Water quality meters are typically used in the field to measure the following parameters:

- Dissolved oxygen (DO)
- Oxidation-reduction potential (ORP)
- Conductivity
- pH
- Turbidity
- Temperature

Instructions for maintenance and operation of all these field instruments are described in the operation manuals provided by the manufacturer.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors responsible for collecting water quality parameters during well development, sampling, or for other purposes at Project Sites.

This SOP focuses on the most commonly used field water quality measurement tasks and applications anticipated at the Project Site and should be used in conjunction with other applicable project SOPs including the following:

- *SOP- Field Documentation*
- *SOP- Organic Vapor Monitoring and Air Monitoring*
- *SOP- Groundwater Sampling Procedures*
- *SOP- Equipment Decontamination Procedures*
- *SOP- Field Procedure Change Management*
- *SOP- Groundwater Sampling Procedures*

3.0 Procedures

3.1 Instruments and Supplies

Water quality meters and instruments vary in their manufacturer and model number. Below is a list of commonly used meters and instruments, and other related supplies that can be used for field water quality measurements:

- Horiba U-50 Series Multi Water Quality Checker Instrument
    - Horiba U-52 Flow Cell or similar flow-thru cell
    - Data transfer connector cables
    - Discharge hoses (two)
    - Fittings to attach sample tubing to flow through cell (barbs and master flex pump tubing)
    - Distilled water
    - Calibration solutions and buffers (ORP, conductance, pH, and turbidity)

3.2 Calibration

Calibrate all instruments for all field parameters daily before collecting water quality data, according to the manufacturer calibration specifications developed for the instrument being calibrated. In addition, if there are anomalous readings during sample collection, stop sample collection and re-calibrate, if possible. Document field calibration in the Field Notebook or on the Field Calibration Sheet provided as *Attachment 1*.

If a field instrument will not calibrate, perform troubleshooting as described in the manufacturer's manual. Check that the calibration standards have not expired. If the issue cannot be resolved, use a backup instrument. If one is not available, consult with the PM on whether data collection should continue and on any other corrective actions to be taken.

Flag any data recorded from a meter with calibration problems on the Groundwater Purge and Sampling Field Datasheet as discussed and provided in the *SOP for Groundwater Sampling Procedures.*

3.2.1 pH Calibration (2-point or 3-point calibration)

Calibrate all instruments recording pH daily, using at minimum a 2-point calibration method. A 2-point calibration uses only two pH buffer calibration solutions (for example, pH 4 and pH 7 or pH 7 and pH 10) and is valuable only if the water being monitored is known to be either basic or acidic. For example, if the pH is known to vary between 5.5 and 7, a 2-point calibration with a pH 7 and pH 4 buffer solutions is sufficient.

If the pH of water being measured is unknown, a 3-point calibration method is preferred. Using this calibration, the pH sensor is calibrated with a pH 7 buffer and two additional buffers (such as pH 4 and pH 10). The 3-point calibration method accounts for the full pH range and assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. Typically, the procedure for a 3-point calibration is the same as for a 2-point calibration, but the instrument may prompt you to select a third pH buffer. Follow the recommended manufacturer pH calibration instructions for additional detailed instruction for the instrument being used. Enter all pH calibration values based on the appropriate temperature as labeled on the pH calibration solutions used or according to Table 1 below. Record the final pH calibration reading, with the corresponding temperature, on the *Field Calibration Sheet.*

Table 1. pH Buffer Solution Values Based on Temperature.

Temp	pH Buffers			Temp	pH Buffers		
°C	4.01	7	10.01	°C	4.01	7	10.01
0	4	7.11	10.32	26	4.01	6.99	10
1	4	7.11	10.31	27	4.01	6.99	9.99
2	4	7.1	10.29	28	4.01	6.99	9.98
3	4	7.09	10.28	29	4.01	6.99	9.98
4	4	7.09	10.26	30	4.02	6.98	9.97
5	4	7.08	10.25	31	4.02	6.98	9.96
6	4	7.08	10.23	32	4.02	6.98	9.95
7	4	7.07	10.22	33	4.02	6.98	9.94
8	4	7.07	10.21	34	4.02	6.98	9.93
9	4	7.06	10.2	35	4.02	6.97	9.93
10	4	7.06	10.18	36	4.03	6.97	9.92
11	4	7.05	10.17	37	4.03	6.97	9.91
12	4	7.05	10.16	38	4.03	6.97	9.9
13	4	7.04	10.14	39	4.03	6.97	9.9
14	4	7.04	10.13	40	4.03	6.97	9.89
15	4	7.03	10.12	41	4.04	6.97	9.88
16	4	7.03	10.11	42	4.04	6.97	9.88
17	4	7.02	10.1	43	4.04	6.96	9.87
18	4	7.02	10.09	44	4.04	6.96	9.86
19	4	7.02	10.08	45	4.04	6.96	9.86
20	4	7.01	10.06	46	4.05	6.96	9.85
21	4.01	7.01	10.05	47	4.05	6.96	9.85
22	4.01	7.01	10.04	48	4.05	6.96	9.84
23	4.01	7	10.03	49	4.05	6.96	9.84
24	4.01	7	10.02	50	4.06	6.96	9.83
25	4.01	7	10.01	51	4.06	6.96	--

3.2.2 Conductivity Calibration

Perform daily calibration for conductivity according to the recommended manufacturer's calibration instructions. Conductivity should be calibrated for Specific Conductance and is typically entered as milliSiemens per centimeter (mS/cm) at 25 degrees Celsius (ºC). Typical conductivity standard solution has a specific conductance value of 1.413 mS/cm; which is equivalent to 1413 microSiemens per centimeter (µS/cm) or 1413 µmho/cm. Table 2 below summarizes the value relationship of a 1413 µS/cm (1.413 mS/cm) standard solution to temperature and should be referenced following calibration to verify an accurate final conductivity calibration at the appropriate temperature of the calibration solution used.

Record the final conductivity calibration reading, with the corresponding temperature, on the Field Calibration Sheet.

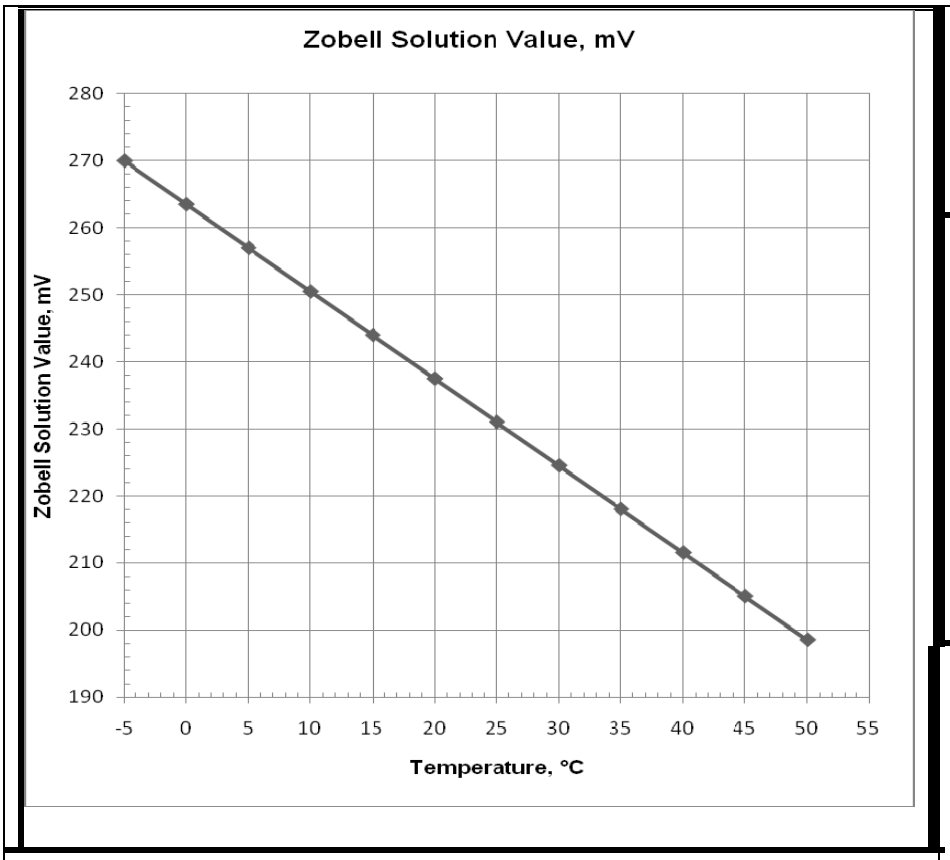
Table 2. Conductivity Standard Solution Values Based on Temperature.

Temperature	**1413 µS/cm Conductivity Standard**	**Temperature**	**1413 µS/cm Conductivity Standard**
°C	(µS/cm)	°C	(µS/cm)
0	776	26	1441
1	799	27	1468
2	822	28	1496
3	846	29	1524
4	870	30	1552
5	894	31	1580
6	918	32	1608
7	943	33	1636
8	968	34	1665
9	992	35	1693
10	1017	36	1722
11	1043	37	1751
12	1068	38	1780
13	1094	39	1808
14	1119	40	1837
15	1145	41	1866

16	1171	42	1896
17	1198	43	1925
18	1224	44	1954
19	1251	45	1983
20	1277	46	2013
21	1304	47	2042
22	1331	48	2071
23	1358	49	2101
24	1386	50	2130
25	1413		

3.2.3 Calibration Check of the Oxidation Reduction Potential (ORP) Probe

A calibration check of the ORP probe can be performed by placing it into a Zobell™ solution that is within approximately 10°C of the expected groundwater temperature, or as close to groundwater temperature as practical. Groundwater temperatures ranging from approximately X°C to X°C can generally be expected in Alaska. This is not a calibration solution, but a check that the probe is working properly. Zobell™ solution has a short shelf life, typically lasting only 3 months. If expired, make or obtain new solution before measurement. The Zobell™ reading is dependent upon temperature and should fall within 20% of the value shown in Figure 1 below, before taking measurements. If readings are out of this range, then take a second reading with a backup electrode. If both instruments fail, replace the Zobell solution, and repeat the measurements. Record the Zobell™ solution ORP reading, with the corresponding temperature, on the *Field Calibration Sheet.*



Temperature °C	Zobell Solution Value, mV
-5	270
0	263.5
5	257
10	250.5
15	244
20	237.5
25	231
30	224.5
35	218
40	211.5
45	205
50	198.5

Figure 1. Zobell Solution ORP Dependence on Temperature for a Silver Chloride (Ag:AgCl) Electrode.

3.2.4 Turbidity Calibration (4-point calibration)

Perform routine calibration of the turbidity instrument according to the recommended manufacturer's calibration instructions. Turbidity instruments should be calibrated using a 4-point calibration method; typical calibration standards used are <0.1 NTU, 20 NTU, 100 NTU, and 800 NTU StablCal standard or formazin standard. This 4-point calibration

method accounts for turbidity over a wide range from 0 to 1000 NTU. Record the calibration standard value and the calibrated turbidity value of each calibration point (< 0.1, 20,

100, and 800 NTU) on the Field Calibration Sheet.

3.3 Water Quality Instrument Field Measurement and Usage

The general procedures for measuring groundwater quality parameters and flow-through cell setup are as follows:

1. Before taking any field measurements, calibrate instruments according to the manufacturer's procedures and record the calibration on the Field Calibration Sheet.
2. Perform a saturated air check of the DO probe by placing a wet piece of cloth or paper towel in the cap that covers the probe. Check the dissolved oxygen reading against the theoretical value of saturated oxygen at

different elevations using *SOP-XX, Attachment 2: Solubility of Oxygen in Water and Pressure/Altitude Chart.* If the instrument is not reading in the proper range, it should be recalibrated, or the dissolved oxygen probe membrane should be replaced.

3. Secure the multi-meter sonde (or analyte specific probes) to the flow-through cell. Connect a short discharge tube to the effluent connector at the top of the flow-through cell and run the other end of the discharge tube into a 5-gallon purge water capture bucket.

4. Place the tube from the pump directly into the 5-gallon purge water bucket and start to purge (pump) for approximately 1 to 2 minutes or until the purge water begins to visually clear up. The intent is to limit any initially high turbidity water from filling and settling in the flow-through cell.

5. Once the turbidity has stabilized, briefly turn off the pump and secure the tube from the pump to the influent connector at the bottom of the flow-through cell. Turn on the pump again and then allow the flow-through cell to completely fill with water. Effort should be made to keep air bubbles from collecting in the flow-through cell. To remove any collected air from the cell, disconnect the probes from the cell while pumping until all the air escapes and then reconnect the probes.

6. Continue pumping and begin low-flow purging of the monitoring well at a flow rate of approximately 1 liter (0.25 gallons) every 3 minutes or 0.1 gallon per minute (gal/min).

7. Routinely measure and record the DO, ORP, conductivity, pH, turbidity, temperature, and current groundwater level throughout the purge at approximately every 3- to 5-minute interval. A minimum of three of these parameters should be monitored and recorded. Record the purge groundwater parameters on a *SOP-XX, Attachment 3: Groundwater Purge and Sampling Field Datasheet*.

8. Continue to measure and record the groundwater parameters and current groundwater level until the parameters stabilize according to the following stabilization criteria, or until 3 well casing volumes are purged. Groundwater parameters are considered stable after purging if three successive readings are within:

    - ± 1.0 °C temperature
    - ± 0.1 pH
    - ± 3% conductivity
    - ± 10 millivolt (mV) ORP
    - ± 10% parts per million (ppm) DO or 0.2 milligrams per liter (mg/L)
    - ± 10% turbidity or ≤ 10 nephelometric turbidity units (NTUs)

9. Note the following before and during water quality measurement and groundwater purging:

    - Obtain the typical ranges for the water quality parameters at a well (or site) prior to measurement and purging, if possible, and bring these values to the field for reference during sampling. Water quality parameter ranges can often be obtained from historical groundwater purging and sampling events. These previous values should be used as clues to determine if an instrument is reading correctly and/or is drifting during water quality measurement.

    - ORP and DO measurements should always correlate with each other. Generally ORP should be negative whenever DO is near or less than 1 milligram per liter(mg/L); likewise, DO should be greater than 1 mg/L if ORP is positive.

- DO measurement should always be positive and range between 0 and 14.62 mg/L.
- ORP measurements should range between -500 mV and 275 mV.
- The pH of environmental samples will typically range from 6 to 8 pH units.
- When measuring turbidity, be sure to clear any moisture or dust off of the turbidity sample cell and emplace the sample cell and light cover completely and securely. Also, be sure to put the turbidity instrument out of direct sunlight (it should be shadowed), or else light interference may provide false readings.

10. When parameters have stabilized, record final measurements and collect samples as specified in SOP-XX, Groundwater Sampling Procedures.

3.4 Storage

Perform the following tasks each day upon conclusion of using any water quality measurement instrument:

1. Decontaminate the instrument(s): rinsing with distilled water, a dilute solution of Alconox or Liquinox (or similar) and rinsing with distilled water as specified in the *SOP for Equipment Decontamination Procedures*.
2. Moisten protective caps that are made to protect the tips of probes or sensors with fresh water and replacing them back to their probes or sensors for storage while the instrument is not in use
3. Recharge or replace batteries on any instruments and meters to verify full battery charge for next use.
4. Store the instrument or meter in the protective case provided with the instrument or meter
5. Take any additional storage and maintenance steps recommended by the manufacturer as specified in the instrument operations and maintenance manual.

3.5 Service and Maintenance

Perform service and maintenance according to manufacturer's instructions.

4.0 Records

Record all instrument calibration information on a Field Calibration Datasheet, provided as *Attachment 1*. Calibration information that should be recorded into the field book for each instrument calibrated includes the brand and model number, unique identification number, type, lot number, expiration date of any calibration solutions, and results of the calibration. Record all field data collected during groundwater sampling on a Groundwater Purge and Sampling Field Datasheet as provided as *Attachment 3*.

5.0 References

Puls, R.W. and M.J. Barcelona. April 1996. *Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures*. EPA Ground Water Issue, EPA/540/S-95/504.

Horiba Process & Environmental. *Applications: Water Infrastructure/Wastewater*: http://www.horiba.com/us/en/process-environmental/application/sewage-treatment/details/u-50-multiparameter-water-quality-checker-368/

6.0 Definitions

Meter (instrument): A device that presents a digital display of instrument measurements.

Probe: A device that is submerged in the flow through cell (or sample container) designed to read a specific water quality parameter such as pH or DO.

Sonde: A device that houses six field-replaceable sensors designed to measure DO, conductivity, temperature, pH, ORP, and turbidity.

Terminal: The 650-MDS Terminal is a display terminal and data logger by which the sonde communicates readings.

Flow-through cell: The flow-through cell is an attachment for the water quality probe or sonde that allows air-tight water quality measurements of small streams of water (low flow), such as water pumped from a piezometer or monitoring well.

7.0 Attachments

Attachment 1: *Field Instrument Calibration Datasheet*

Attachment 2*: Solubility of Oxygen in Water and Pressure/Altitude Chart*

Attachment 3*: Groundwater Purge and Sampling Field Datasheet*

Attachment 4*: Water Quality Instrument Instruction Manuals*

TABLE 1

INSTRUMENT CALIBRATION LOG

Project Name_____ Date_____ Weather_____

Calibrated by_____ Instrument_____
Serial Number_____

Parameters	Morning Calibration	Morning Temperature	End of Day Calibration Check*	End of Day Temperature
Specific Conductance Standard #1				
Specific Conductance Standard #2				
pH (7)				
pH (4)				
pH (10)				
ORP Zobel solution				
Dissolved Oxygen 100% water saturated air mg/L				
Dissolved Oxygen Zero Dissolved Oxygen Solution mg/L				
Barometric Pressure mm Hg		NA		NA
Turbidity Standard #1				
Turbidity Standard #2				
Turbidity Standard #3				

* For each Parameter, chose one standard as your check standard. If possible, choose the one that is closest to the ambient measurement value.

Oxygen Solubility at Indicated Pressure

Temp.	Pressure (Hg)							
	760	755	750	745	740	735	730	mm
EC	29.92	29.72	29.53	29.33	29.13	28.94	28.74	in
0	14.57	14.47	14.38	14.28	14.18	14.09	13.99	mg/l
1	14.17	14.08	13.98	13.89	13.79	13.70	13.61	
2	13.79	13.70	13.61	13.52	13.42	13.33	13.24	
3	13.43	13.34	13.25	13.16	13.07	12-98	12.90	
4	13.08	12.99	12.91	12.82	12.73	12.65	12.56	
5	12.74	12.66	12.57	12.49	12.40	12.32	12.23	
6	12.42	12.34	12.26	12.17	12.09	12.01	11.93	
7	12.11	12.03	11.95	11.87	11.79	11.71	11.63	
8	11.81	11.73	11.65	11.57	11.50	11.42	11.34	
9	11.53	11.45	11.38	11.30	11.22	11.15	11.07	
10	11.28	11.19	11.11	11.04	10.96	10.89	10.81	
11	10.99	10.92	10.84	10.77	10.70	10.62	10.55	
12	10.74	10.67	10.60	10.53	10.45	10.38	10.31	
13	10.50	10.43	10.36	10.29	10.22	10.15	10.08	
14	10.27	10.20	10.13	10.06	10.00	9.93	9.86	
15	10.05	9.98	9.92	9.85	9.78	9.71	9.65	
16	9.83	9.76	9.70	9.63	9.57	9.50	9.43	
17	9.63	9.57	9.50	9.44	9.37	9.31	9.24	
18	9.43	9.37	9.30	9.24	9.18	9.11	9.05	
19	9.24	9.18	9.12	9.05	8.99	8.93	8.87	
20	9.06	9.00	8.94	8.88	8.82	8.75	8.69	
21	8.88	8.82	8.76	8.70	8.64	8.58	8.52	
22	8.71	8.65	8.59	8.53	8.47	8.42	8.36	
23	8.55	8.49	8.43	8.38	8.32	8.26	8.20	
24	8.39	8.33	8.28	8.22	8.16	8.11	8.05	
25	8.24	8.18	8.13	8.07	8.02	7.96	7.90	
26	8.09	8.03	7.98	7.92	7.87	7.81	7.76	
27	7.95	7.90	7.84	7.79	7.73	7.68	7.62	
28	7.81	7.76	7.70	7.65	7.60	7.54	7.49	
29	7.68	7.63	7.57	7.52	7.47	7.42	7.36	
30	7.55	7.50	7.45	7.39	7.34	7.29	7.24	
31	7.42	7.37	7.32	7.27	7.22	7.16	7.11	
32	7.30	7.25	7.20	7.15	7.10	7.05	7.00	
33	7.08	7.13	7.08	7.03	6.98	6.93	6.88	
34	7.07	7.02	6.97	6.92	6.87	6.82	6.78	
35	6.95	6.90	6.85	6.80	6.76	6.71	6.66	
36	6.84	6.79	6.76	6.70	6.65	6.60	6.55	
37	6.73	6.68	6.64	6.59	6.54	6.49	6.45	
38	6.63	6.58	6.54	6.49	6.44	6.40	6.35	
39	6.52	6.47	6.43	6.38	6.35	6.29	6.24	
40	6.42	6.37	6.33	6.28	6.24	6.19	6.15	
41	6.32	6.27	6.23	6.18	6.14	6.09	6.05	
42	6.22	6.18	6.13	6.09	6.04	6.00	5.95	
43	6.13	6.09	6.04	6.00	5.95	5.91	5.87	
44	6.03	5.99	5.94	5.90	5.86	5.81	5.77	
45	5.94	5.90	5.85	5.81	5.77	5.72	5.68	

(Continued)

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

Oxygen Solubility at Indicated Pressure (continued)

Temp.	Pressure (Hg)								
	725	720	715	710	705	700	695	690	mm
EC	28.54	28.35	28.15	27.95	27.76	27.56	27.36	27.17	in
0	13.89	13.80	13.70	13.61	13.51	13.41	13.32	13.22	mg/l
1	13.51	13.42	13.33	13.23	13.14	13.04	12.95	12.86	
2	13.15	13.06	12.07	12.88	12.79	12.69	12.60	12.51	
3	12.81	12.72	12.63	12.54	12.45	12.36	12.27	12.18	
4	12.47	12.39	12.30	12.21	12.13	12.04	11.95	11.87	
5	12.15	12.06	11.98	11.89	11.81	11.73	11.64	11.56	
6	11.84	11.73	11.68	11.60	11.51	11.43	11.35	11.27	
7	11.55	11.47	11.39	11.31	11.22	11.14	11.06	10.98	
8	11.26	11.18	11.10	11.02	10.95	10.87	10.79	10.71	
9	10.99	10.92	10.84	10.76	10.69	10.61	10.53	10.46	
10	10.74	10.66	10.59	10.51	10.44	10.36	10.29	10.21	
11	10.48	10.40	10.33	10.28	10.18	10.11	10.04	9.96	
12	10.24	10.17	10.10	10.02	9.95	9.88	9.81	9.46	
13	10.01	9.94	9.87	9.80	9.73	9.66	9.59	9.52	
14	9.79	9.72	9.65	9.68	9.51	9.45	9.38	9.31	
15	9.58	9.51	9.44	9.58	9.31	9.24	9.18	9.11	
16	9.37	9.30	9.24	9.17	9.11	9.04	8.97	8.91	
17	9.18	9.11	9.05	8.98	8.92	8.85	8.79	8.73	
18	8.99	8.92	8.86	8.80	8.73	8.67	8.61	8.54	
19	8.81	8.74	8.68	8.62	8.56	8.49	8.43	8.37	
20	8.63	8.57	8.51	8.45	8.39	8.33	8.27	8.21	
21	8.46	8.40	8.34	8.28	8.22	8.16	8.10	8.04	
22	8.30	8.24	8.18	8.12	8.06	8.00	7.95	7.89	
23	8.15	8.09	8.03	7.97	7.91	7.86	7.80	7.74	
24	7.99	7.94	7.88	7.82	7.76	7.71	7.65	7.59	
25	7.85	7.79	7.74	7.68	7.60	7.57	7.51	7.46	
26	7.70	7.65	7.59	7.54	7.48	7.43	7.37	7.32	
27	7.57	7.52	7.46	7.41	7.35	7.30	7.25	7.19	
28	7.44	7.38	7.33	7.28	7.22	7.17	7.12	7.06	
29	7.31	7.26	7.21	7.15	7.10	7.05	7.00	6.94	
30	7.19	7.14	7.08	7.03	6.98	6.93	6.88	6.82	
31	7.06	7.01	6.96	6.91	6.86	6.81	6.76	6.70	
32	6.95	6.90	6.85	6.80	6.70	6.70	6.64	6.59	
33	6.83	6.78	6.73	6.68	6.83	6.58	6.53	6.48	
34	6.73	6.68	6.63	6.58	6.53	6.48	6.43	6.38	
35	6.61	6.56	6.51	6.47	6.42	6.37	6.36	6.27	
36	6.51	6.46	6.41	6.36	6.31	6.27	6.22	6.17	
37	6.40	6.35	6.31	6.26	6.21	6.16	6.12	6.07	
38	6.30	6.26	6.21	6.16	6.12	6.07	6.02	5.98	
39	6.26	6.15	6.11	6.06	6.01	5.97	5.92	5.87	
40	6.10	6.06	6.01	5.96	5.92	5.86	5.83	5.78	
41	6.00	5.96	5.91	5.87	5.82	5.78	5.73	5.69	
42	5.91	5.86	5.82	5.77	5.73	5.69	5.64	5.60	
43	5.82	5.78	5.73	5.69	5.65	5.60	5.56	5.51	
44	5.72	5.68	5.64	5.59	5.55	5.51	5.46	5.42	
45	5.64	5.59	5.55	5.51	5.47	5.42	5.38	5.34	

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

OXYGEN SOLUBILITY TABLE

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Solubility of Oxygen (mg/L) in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure.

Temp °C	Chlorinity 0 Salinity: 0	5.0 ppt 9.0 ppt	10.0 ppt 18.1 ppt	15.0 ppt 27.1 ppt	20.0 ppt 36.1 ppt	25.0 ppt 45.2 ppt
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.72	6.39
26.0	8.11	7.71	7.33	6.96	6.62	6.28
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.96	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	3.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.98	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

CALIBRATION TABLE

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Calibration Values for Various Atmospheric Pressures and Altitudes

Pressure			Altitude		Calibration Value
Inches Hg	mm Hg	kPa	Feet	Meters	Percent Saturation
30.23	768	102.3	-276	-84	101
29.92	760	101.3	0	0	100
29.61	752	100.3	278	85	99
29.33	745	99.3	558	170	98
29.02	737	98.3	841	256	97
28.74	730	97.3	1126	343	96
28.43	722	96.3	1413	431	95
28.11	714	95.2	1703	519	94
27.83	707	94.2	1995	608	93
27.52	699	93.2	2290	698	92
27.24	692	92.2	2587	789	91
26.93	684	91.2	2887	880	90
26.61	676	90.2	3190	972	89
26.34	669	89.2	3496	1066	88
26.02	661	88.2	3804	1160	87
25.75	654	87.1	4115	1254	86
25.43	646	86.1	4430	1350	85
25.12	638	85.1	4747	1447	84
24.84	631	84.1	5067	1544	83
24.53	623	83.1	5391	1643	82
24.25	616	82.1	5717	1743	81
23.94	608	81.1	6047	1843	80
23.62	600	80.0	6381	1945	79
23.35	593	79.0	6717	2047	78
23.03	585	78.0	7058	2151	77
22.76	578	77.0	7401	2256	76
22.44	570	76.0	7749	2362	75
22.13	562	75.0	8100	2469	74
21.85	555	74.0	8455	2577	73
21.54	547	73.0	8815	2687	72
21.26	540	71.9	9178	2797	71
20.94	532	70.9	9545	2909	70
20.63	524	69.9	9917	3023	69
20.35	517	68.9	10293	3137	68
20.04	509	67.9	10673	3253	67
19.76	502	66.9	11058	3371	66

GROUND-WATER SAMPLING RECORD

Well ID:_____

Station #:_____

Facility Name:_____ Date:____/____/____

Well Depth:_____ Depth to Water:_____ Well Diameter:

Casing Material.:_____ Volume of Water per Well Volume:

Sampling Crew:_____,_____,_____,

Type of Pump:_____ Tubing Material:_____ Pump set at _____ ft.

Weather Conditions:_____ NOTES:

GROUND-WATER SAMPLING PARAMETERS

Time	Water Level	Volume Pumped	Pumping Rate	DO (mg/l)	Temp. (^{O}C)	SEC (µS/cm)	pH	ORP (mV)	Turbidity (NTU)

Other Parameters: _____

Sampled at:_____ Parameters taken with: _____

Sample delivered to _____ by _____ at_____.

Sample CRL #:_____ OTR #:_____ ITR #:_____ SAS #: _____

Multi Water Quality Checker
U-50 Series

Instruction Manual

CODE:GZ0000144342C

Preface

This manual describes the operation of the Multi Water Quality Checker, U-50 Series.
Be sure to read this manual before using the product to ensure proper and safe operation of the instrument. Also safely store the manual so it is readily available whenever necessary.

Product specifications and appearance, as well as the contents of this manual are subject to change without notice.

■ Warranty and Responsibility

HORIBA warrants that the Product shall be free from defects in material and workmanship and agrees to repair or replace free of charge, at HORIBA's option, any malfunctioned or damaged Product attributable to HORIBA's responsibility for a period of one (1) year from the delivery unless otherwise agreed with a written agreement. In any one of the following cases, none of the warranties set forth herein shall be extended;

- Any malfunction or damage attributable to improper operation
- Any malfunction attributable to repair or modification by any person not authorized by HORIBA
- Any malfunction or damage attributable to the use in an environment not specified in this manual
- Any malfunction or damage attributable to violation of the instructions in this manual or operations in the manner not specified in this manual
- Any malfunction or damage attributable to any cause or causes beyond the reasonable control of HORIBA such as natural disasters
- Any deterioration in appearance attributable to corrosion, rust, and so on
- Replacement of consumables

HORIBA SHALL NOT BE LIABLE FOR ANY DAMAGES RESULTING FROM ANY MALFUNCTIONS OF THE PRODUCT, ANY ERASURE OF DATA, OR ANY OTHER USES OF THE PRODUCT.

■ Trademarks

Generally, company names and brand names are either registered trademarks or trademarks of the respective companies.

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Conformable Directive

This equipment conforms to the following directives and standards:

CE

Directives: the EMC Directive 2004/108/EC

Standards: [the EMC Directive]
EN61326-1:2006 Class B, Portable test and measurement equipment

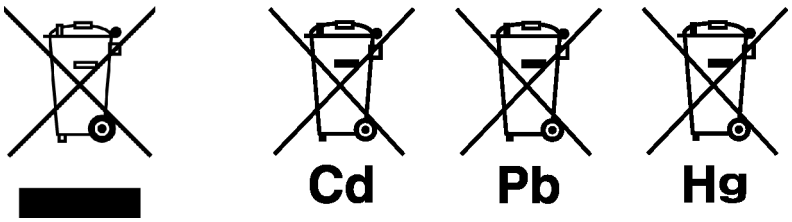
■ Information on Disposal of Electrical and Electronic Equipment and Disposal of Batteries and Accumulators

The crossed out wheeled bin symbol with underbar shown on the product or accompanying documents indicates the product requires appropriate treatment, collection and recycle for waste electrical and electronic equipment (WEEE) under the Directive 2002/96/EC, and/or waste batteries and accumulators under the Directive 2006/66/EC in the European Union.

The symbol might be put with one of the chemical symbols below. In this case, it satisfies the requirements of the Directive 2006/66/EC for the object chemical.

This product should not be disposed of as unsorted household waste.
Your correct disposal of WEEE, waste batteries and accumulators will contribute to reducing wasteful consumption of natural resources, and protecting human health and the environment from potential negative effects caused by hazardous substance in products.

Contact your supplier for information on applicable disposal methods.



FCC Rules

Any changes or modifications not expressly approved by the party responsible for compliance shall void the user's authority to operate the equipment.

■ WARNING

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.
Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

For your safety

Warning messages are described in the following manner. Read the messages and follow the instructions carefully.

● Meaning of warning messages

⚠DANGER	This indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.
⚠WARNING	This indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠CAUTION	This indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices. Without safety alert indication of hazardous situation which, if not avoided, could result in property damage.

● Symbols

	Description of what should be done, or what should be followed
	Description of what should never be done, or what is prohibited

■ Safety Precautions

This section provides precautions to enable you to use the product safely and correctly and to prevent injury and damage. The terms of DANGER, WARNING, and CAUTION indicate the degree of imminency and hazardous situation. Read the precautions carefully as it contains important safety messages.

⚠ WARNING
Do not disassemble or modify the meter. May cause overheating or fire, resulting in accidents.

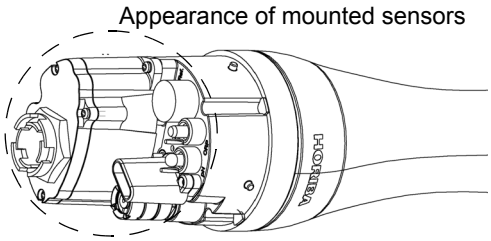
⚠ CAUTION
The pH and ORP sensors are made of glass. Handle them carefully to avoid breakage.
Do not ingest the DO, pH or ORP standard solutions. If it comes into contact with the eyes, rinse thoroughly with water. If swallowed, consult a physician.
Keep away from water when using USB communication. Improper use may result in fire or damage.

Points of concern

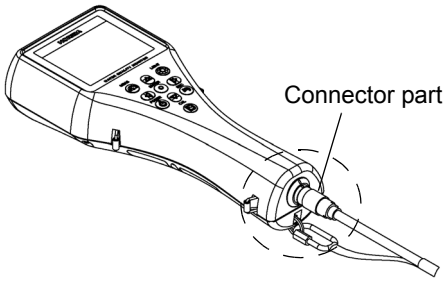
Use of the equipment in a manner not specified by the manufacturer may impair the protection provided by the equipment. It may also reduce equipment performance.

● Sensor probe

- Do not immerse the sensor probe in seawater or other samples with high salinity. Doing so may erode metallic parts. After use, promptly wash the sensor probe thoroughly in water.
- Do not immerse the sensor probe in alcohol, organic solvent, strong acid, strong alkaline, and other similar solutions.
- Do not subject to strong shocks.
- Do not perform measurement in environments of magnetic fields. Measurement errors may result.
- The sensor probe is no longer waterproof when the sensors are not mounted.

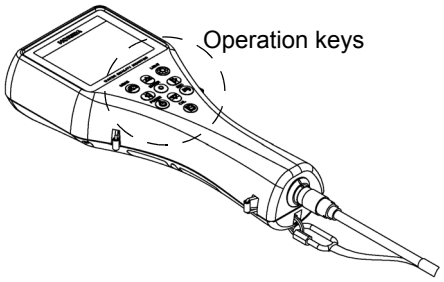


- Does not support measurement of samples containing fluorine.
- To disconnect the sensor cable or interface cable, pull them out with holding the connector part. Do not pull the cable part; it may cause breakage.



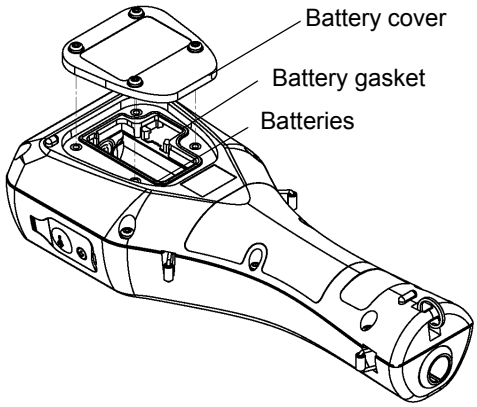
● Control unit

- Do not subject to strong shocks.
- The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.



- The control unit is no longer waterproof when the USB cable is connected.
- When operating the control unit only, protect the connector with the connector cap provided.

- Remove the batteries when not using the control unit for an extended period of time. Battery fluid leakage may cause equipment failure.
- Do not wipe the control unit with organic solvents or powder polish. The surface may deteriorate or its printing may disappear. If the display becomes dirty, wipe the dirt off with a soft cloth soaked in neutral detergent.
- Do not turn the power OFF or disconnect the cable during calibration or setting. Memory data may be erased.
- To perform measurement, connect the sensor probe cable before turning the power ON.
- Do not remove the battery gasket or twist it.
- When opening the battery case, make sure that no foreign matter is attached to the battery gasket.
- Do not use any unspecified batteries; it may cause breakage.



Measurement

- Do not pull the cable when lowering the sensor probe into the sample during measurement. Lower the sensor probe into the sample on a chain or string.
- Before lowering the sensor probe into the sample, do not connect the hook on the unit to a human body.
- The correct values are not displayed if the sensor is not mounted when the measurement display is activated.
- Perform DO measurement with no air bubbles in the internal solution.
- Do not reuse a membrane cap of DO sensor.
- Use the spanner for DO sensor provided to attach or remove the DO sensor.
- Avoid both U-53 and U-53G turbidity measurement in air, since the rubber wiper will quickly become damaged.
- Avoid turbidity measurement in direct sunlight, since the readout may be affected.

Calibration

During atmosphere calibration for the DO electrode with DO salinity compensation set to automatic, values are compensated based on electrical conductivity, but calibration is performed normally.

Location of use and storage

- Storage temperature: −10°C to 60°C
- Relative humidity: Under 80% and free from condensation

Store the meter in locations void of dust, strong vibrations, direct sunlight, corrosive gases, near air conditioners or windy areas.

Disposal of the product

When disposing of the product, follow the related laws and/or regulations of your country for disposal of the product.

Description in this manual

Note

This interprets the necessary points for correct operation and notifies the important points for handling the unit.

Reference

This indicates where to refer for information.

Tip

This indicates reference information.

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1 About this Unit

The U-50 Series Multi Water Quality Checker features an integrated control unit and sensors. It is capable of making a maximum of eleven simultaneous measurements for various parameters, and is perfect for use in the field. The U-50 Series is designed with on-site ease-of-use in mind, provides a wide variety of functions, and can be used for water quality measurements and inspections of river water, groundwater, and waste water.

2 Device Information

2.1 Measurement parameters

Parameters	Model				
	U-51	U-52	U-52G	U-53	U-53G
pH (pH)	✓	✓	✓	✓	✓
pH (mV)	✓	✓	✓	✓	✓
Oxidation reduction potential (ORP)	✓	✓	✓	✓	✓
Dissolved oxygen (DO)	✓	✓	✓	✓	✓
Electrical conductivity (COND)	✓	✓	✓	✓	✓
Salinity (SAL) [expressed as electrical conductivity]	✓	✓	✓	✓	✓
Total dissolved solids (TDS) [expressed as electrical conductivity]	✓	✓	✓	✓	✓
Seawater specific gravity (SG) [expressed as electrical conductivity]	✓	✓	✓	✓	✓
Water temperature (TEMP)	✓	✓	✓	✓	✓
Turbidity (TURB) [LED transmission/front 30° scattering method]	–	✓	✓	–	–
Turbidity (TURB) [tungsten lamp 90° transmission/scattering method] with wiper	–	–	–	✓	✓
Water depth (DEP)	–	–	✓	✓	✓
GPS	–	–	✓	–	✓

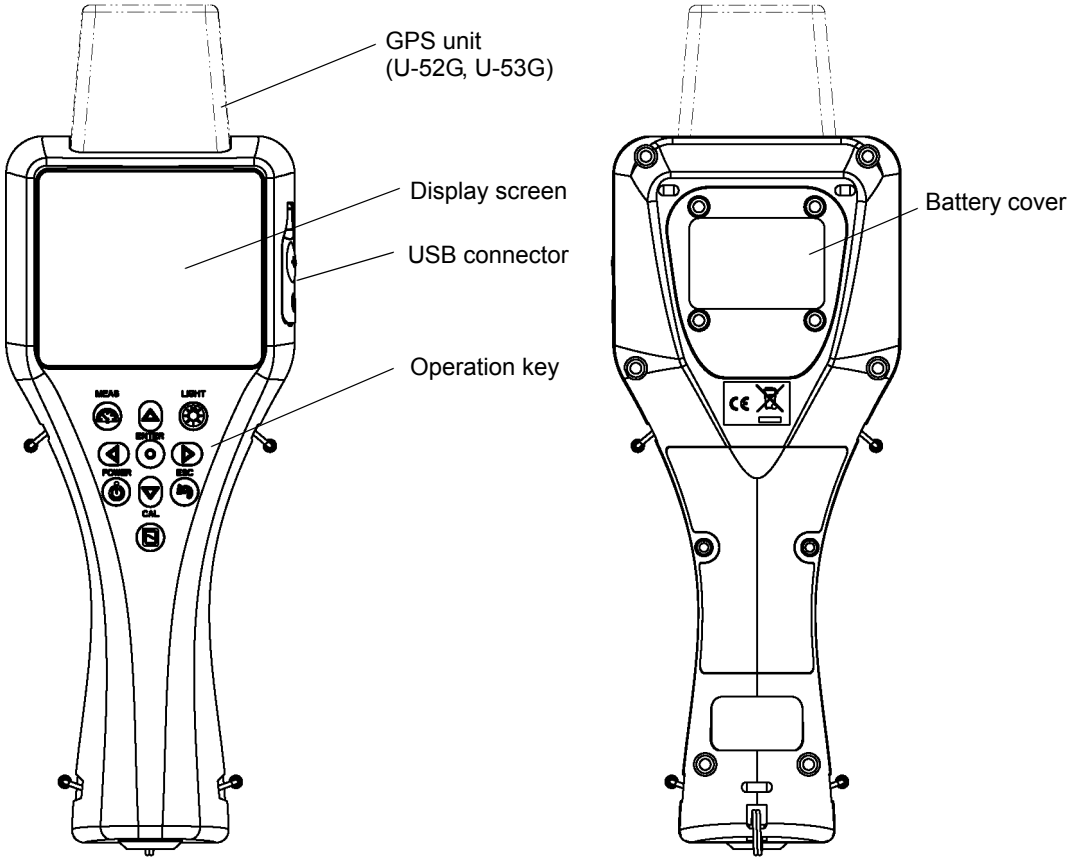
"✓" indicates a measurable parameter.

2.2 Packing list

Parts Name	Quantity	Note
Control unit	1	
Sensor probe	1	
pH sensor (#7112)	1	
ORP sensor (#7313)	1	
Reference electrode (#7210)	1	
DO sensor (#7543)	1	
Turbidity sensor (#7800)	1	With U-52/U-52G only. Attached to the sensor probe.
Turbidity sensor (#7801)	1	With U-53/U-53G only. Attached to the sensor probe.
pH 4 standard solution (#100-4)	1	500 mL
pH reference internal solution (#330)	1	250 mL
DO sensor internal solution set (#306)	1	Internal solution (50 mL), Sandpaper (#8000, #600), Syringe
DO Membrane spare parts set	1	
Spanner for DO sensor	1	
Cleaning brush	1	
calibration cup	1	transparent calibration cup, black calibration cup
Back pack	1	
Strap	1	
Alkaline batteries	4	LR14
Silicon grease	1	
Instruction manual	1	

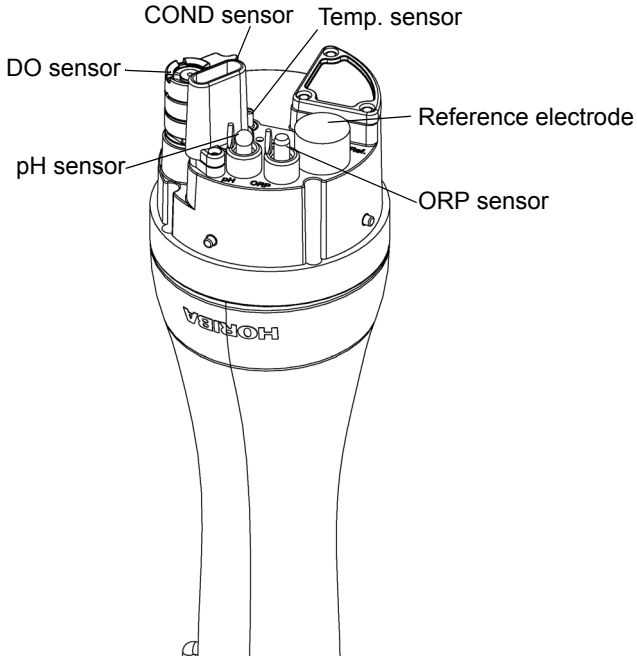
2.3 Parts name and functions

● Display

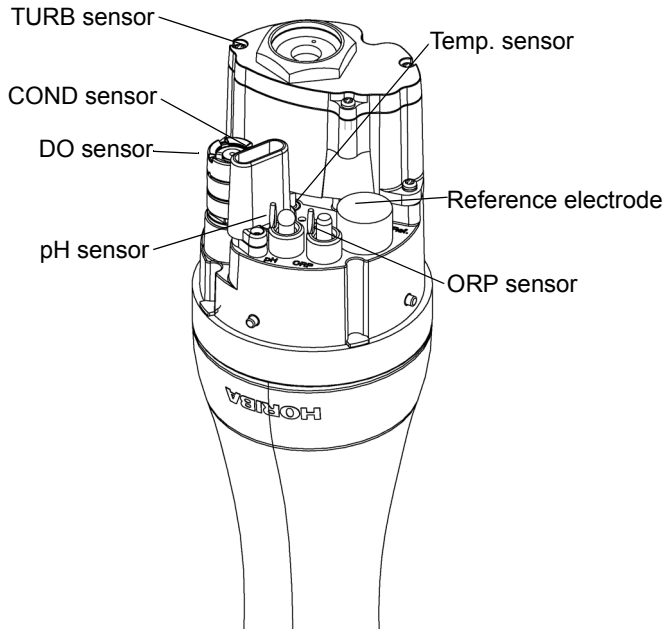


Front view　　Back view

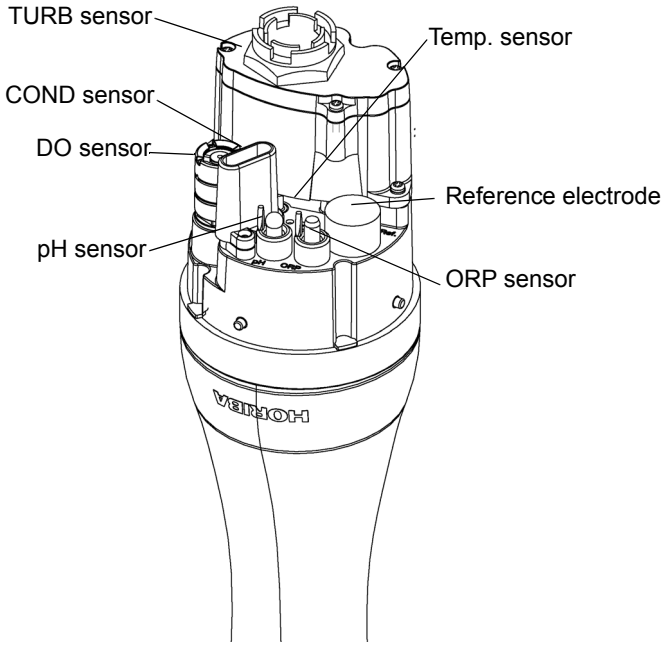
● Sensor probe (U-51)



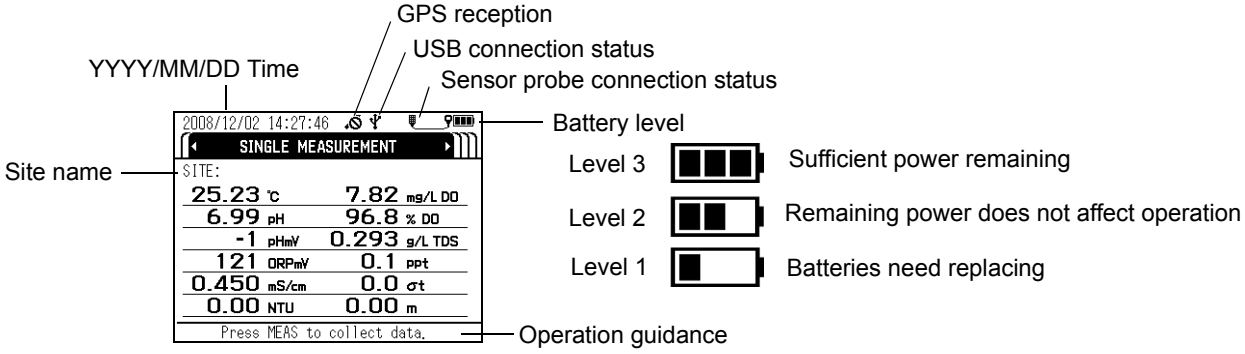
● Sensor probe (U-52)



● Sensor probe (U-53)



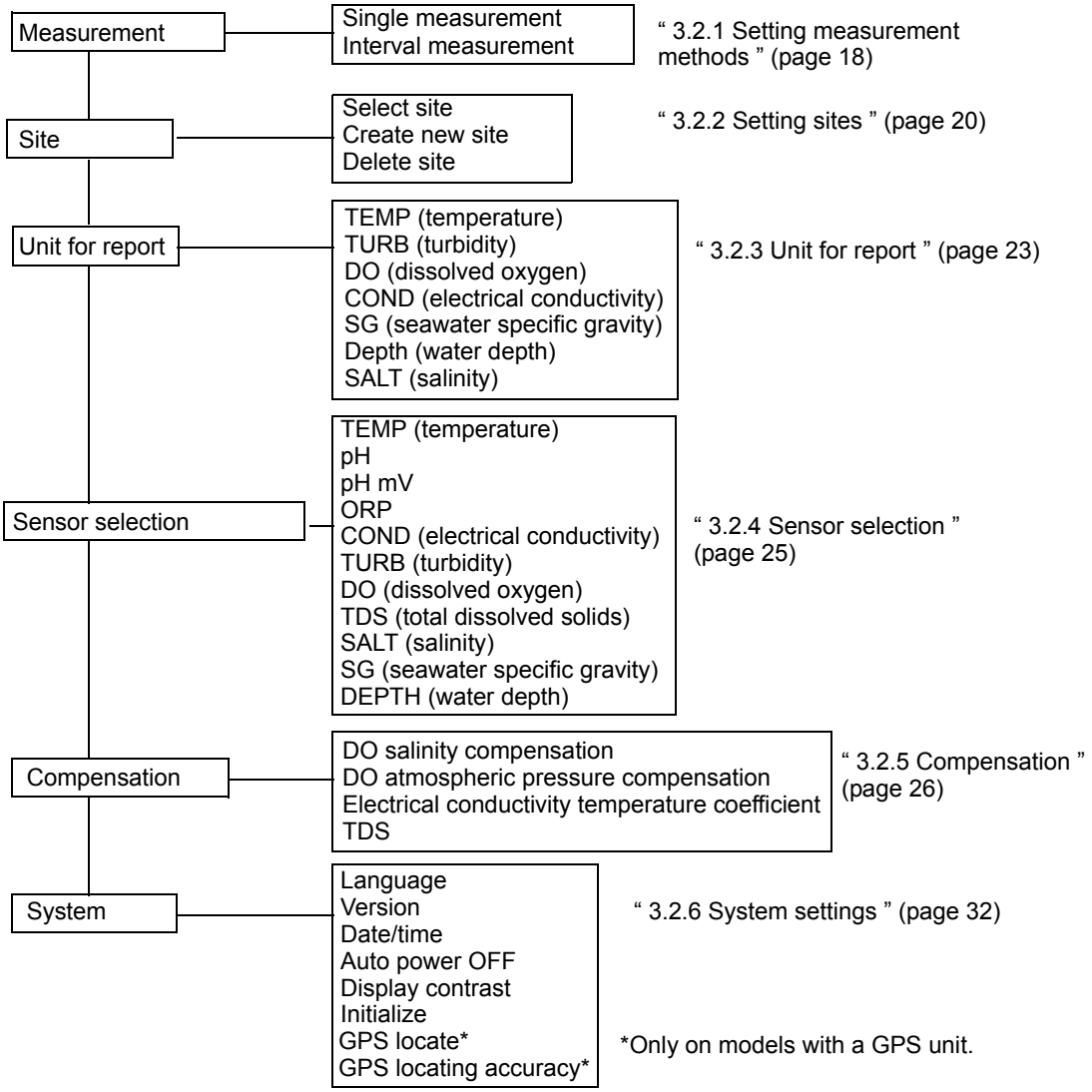
● Display screen



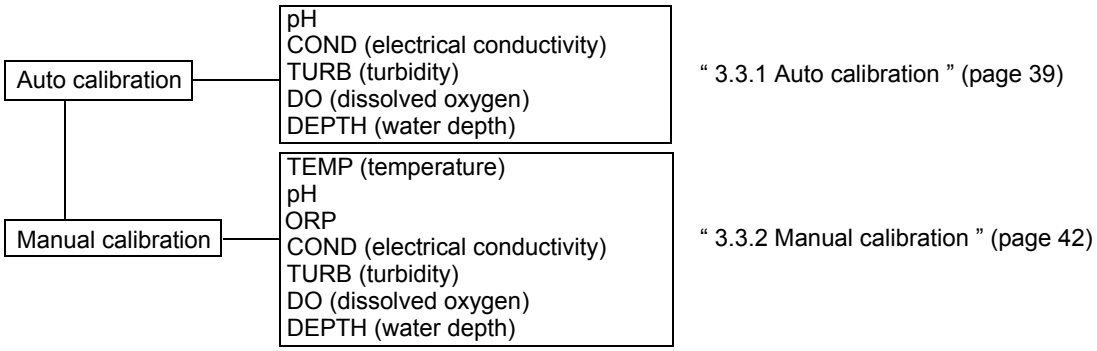
● Operation key

	Key name	description
	POWER key	Turns the system's power ON/OFF. The initial screen appears immediately after turning the power ON. Press and hold down the POWER key for about 3 seconds to turn the power ON and OFF.
	MEAS key	When pressed in the measurement screen, used to set the measurement values of all the measurement parameters. Measurement values flash until the data stabilizes.
		When pressed in the setting, calibration or data operation screen, returns to the measurement screen.
	ENTER key	Used to execute functions, set entered values or store data in memory.
	CAL key	Switches to the calibration screen.
	ESC key	Returns to the immediately preceding operation.
	LIGHT key	Turns the backlight ON/OFF. ● Using the backlight shortens battery life. ● The backlight does not light for about 3 seconds after power ON. ● When the sensor probe is connected while the display's backlight is lit, the backlight goes out for about 3 seconds.
	Left key	Moves the cursor to the left.
	Right key	Moves the cursor to the right.
	Up key	Moves the cursor up.
	Down key	Moves the cursor down.

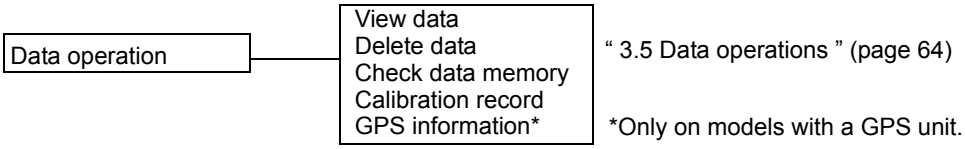
2.4 Setting menu items



2.5 Calibration menu items



2.6 Data operation menu items



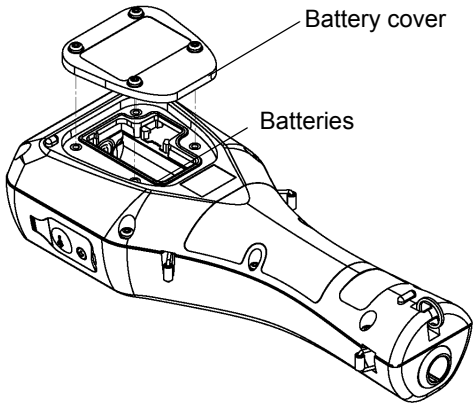
3 Basic Operation

3.1 System setup

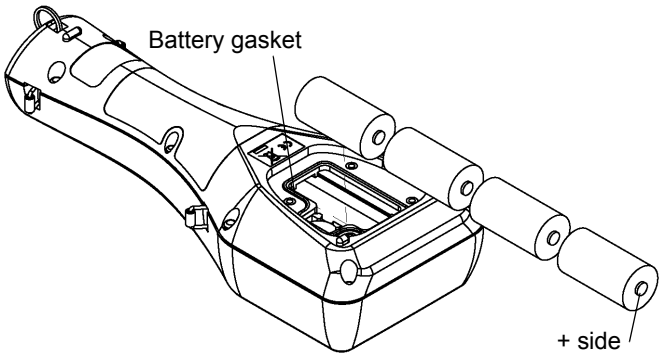
3.1.1 Inserting and replacing the batteries

The control unit is shipped without batteries. Follow the steps below to insert the batteries when using the system for the first time or replacing old batteries.

1. **Loosen the 4 screws on the battery cover by using No. 2 Phillips head screwdriver and remove the cover.**



2. **If replacing the batteries, discard the old batteries.**
3. **Insert new batteries in the control unit.**
   Check that the battery gasket is not dirty or twisted.



4. **Replace the battery cover and fasten it with the 4 screws.**
   Tighten the screws to less than 0.5 N·m.

Note

- **Data and settings will not be lost when the batteries are replaced.**
- **If dirty or twisted, the battery gasket will fail to keep the batteries dry. Check its condition before closing the cover.**
- **To ensure long service life, replacing the battery gasket periodically (once a year) is recommended.**

Precautions when using dry cell batteries

- **Batteries to use: LR14 alkaline dry cell batteries (C-size dry cell batteries) or rechargeable nickel-metal hydride dry cell batteries (C-size)**
  Do not use manganese batteries.
- **Dry cell batteries used incorrectly may leak or burst. Always observe the following**
  - Orient the batteries correctly (positive and negative ends in correct positions).
  - Do not combine new and used batteries, or batteries of different types.
  - Remove the batteries when not using the system for a prolonged period.
  - If batteries leak, have the system inspected at your nearest Horiba service station.

● Battery life

- The battery life for continuous operation when using C-size alkaline dry cell batteries is about 70 hours.
- Using the backlight consumes a proportionate amount of battery power, shortening battery life.
- Searching position information using the GPS unit consumes a proportionate amount of battery power, shortening battery life.
- Nickel-metal hydride secondary batteries can be used, but the battery life is not guaranteed since it will vary according to usage (number of times data is saved, number of charges and amount of each charge). In general, secondary batteries have one-half to one-third the life of C-size alkaline batteries.
- The 70-hour battery life figure applies to a control unit operating temperature of 20°C or more. The battery characteristics shorten the battery life at operating temperatures lower than 20°C, so check the remaining battery level, and replace the batteries before it reaches Level 1.
- The batteries packed with the system at the time of shipment are for checking operation. Their life is not guaranteed.
- The 70-hour battery life figure is the amount of operating time the batteries can provide until the system stops operating. The system may fail during operation if the remaining battery level is low, so it is a good idea to check the remaining battery level and replace the batteries with new ones well before the batteries run out completely.

U-51/52

Battery life: 70 hours (backlight off)

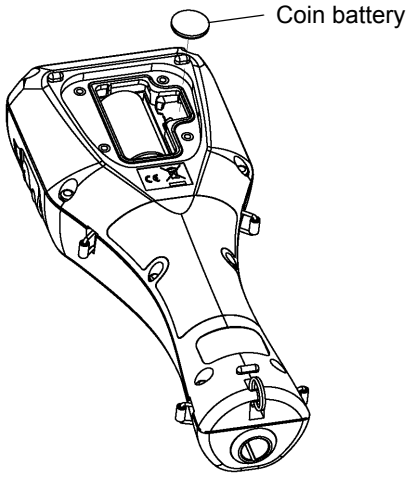
U-53

Battery life: 500 measurements (backlight off)

- Since U-53 is designed for turbidity measurement with wiper, its battery life is estimated in terms of the number of turbidity measurement sequences performed.
- Battery power is also consumed by measurement operations other than turbidity measurement.
- The battery life when turbidity measurement is not performed is about 70 hours.

3.1.2 Replacing the coin battery

- Coin battery to use: CR-2032
- The coin battery is only for the clock. It will provide problem-free operation for three years, but when using the clock continuously, it should be replaced every two years as a precaution.
- When replacing the coin battery for the clock, leave the control unit ON. If the coin battery is replaced when the control unit is turned OFF, the clock will be reset to the default settings.



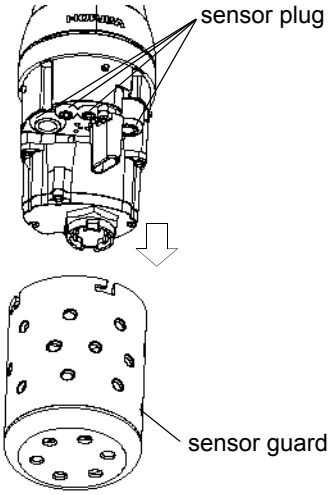
3.1.3 Attaching sensors

Note

- **When attaching or replacing a sensor, wipe any moisture off the sensor probe and sensor.**
- **Be sure to keep water out of sensor connectors. If moisture comes in contact with a sensor connector, blow-dry it with dry air.**
- **The sensor probe is not waterproof when the sensor is not mounted.**
- **Take care not to tighten the sensor too much.**

● Attaching the pH sensor

1. **Remove the sensor guard.**



2. **Remove the sensor plug.**

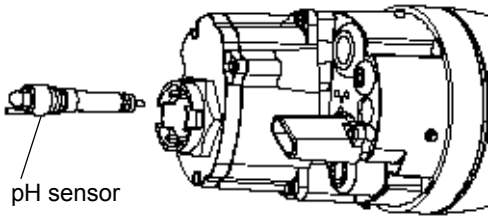
3. **Coat the pH sensor O-ring with a thin layer of silicon grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

4. **Make sure there is no moisture on the sensor probe's sensor connector (marked "pH").**

5. **Fasten the pH sensor securely by hand.**



6. **Clean the sensor with an alcohol-soaked cloth.**

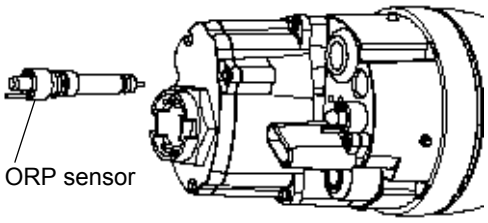
Attaching the ORP sensor

1. **Remove the sensor guard.**
2. **Remove the sensor plug.**
3. **Coat the ORP sensor O-ring with a thin layer of grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

4. **Make sure there is no moisture on the sensor probe's sensor connector (marked "ORP").**
5. **Fasten the ORP sensor securely by hand.**



6. **Clean the sensor with an alcohol-soaked cloth.**

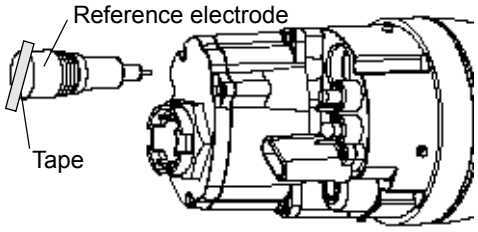
Attaching the reference electrode

1. **Remove the sensor guard.**
2. **Remove the sensor plug.**
3. **Coat the reference electrode O-ring with a thin layer of grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

4. **Make sure there is no moisture on the sensor probe's sensor connector (marked "REF").**
5. **Fasten the reference electrode securely by hand.**
6. **Remove the tape from the liquid junction part of the reference electrode.**



Attaching the dissolved oxygen (DO) sensor

1. **Remove the membrane cap mounted on the DO sensor beforehand, and replace it with the new membrane cap provided. Replace the internal solution with fresh solution. The main component of the internal solution is potassium chloride (KCl), so the old solution can be disposed of down a sink or other drain.**

Reference

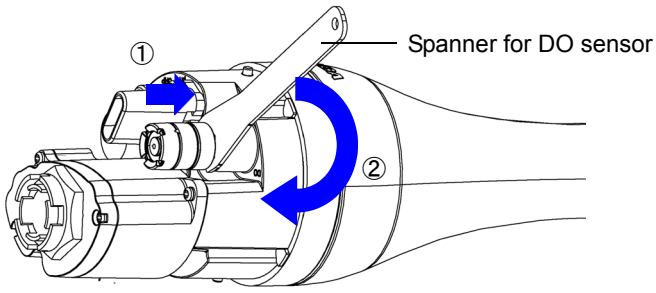
“ 4.5 Replacing the membrane cap ” (page 87)

2. **Screw in the DO sensor to attach it, allowing the internal solution to overflow slightly.**
3. **Use a soft cloth to wipe off the internal solution that overflowed onto the DO sensor.**
4. **Remove the sensor guard.**
5. **Remove the sensor plug.**
6. **Coat the DO sensor O-ring with a thin layer of grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

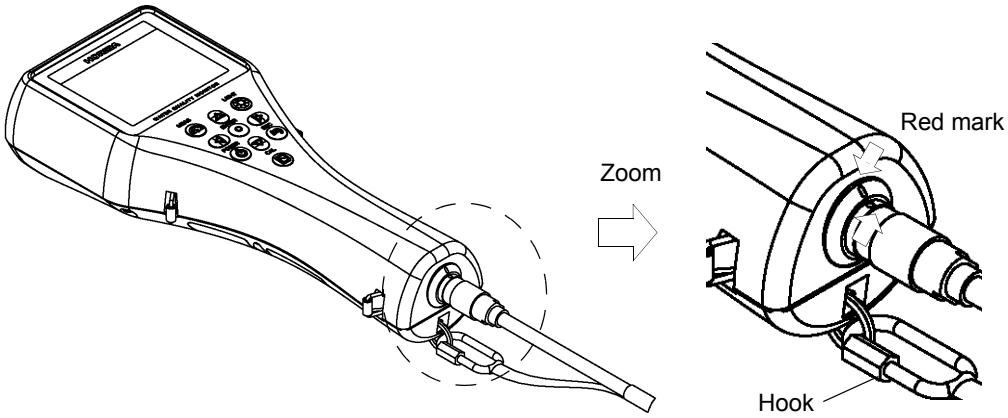
7. **Make sure there is no moisture on the sensor probe’s sensor connector (marked "DO").**
8. **Fasten the DO sensor securely using the spanner for DO sensor.**
   - Hold the DO sensor with the provided spanner for DO sensor and push the sensor down. (Step 1 in figure below)
   - Screw the DO sensor in place. (Step 2 in figure below)



3.1.4 Connecting the control unit and sensor probe

Note

Connect the control unit with its power OFF.

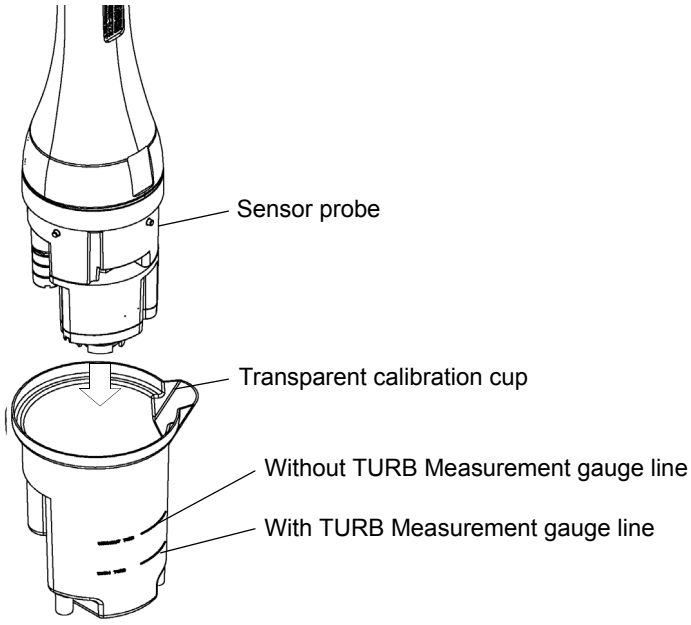


1. **Align the red mark on the connector, and press the connector in until you hear it click.**
2. **Connect the cable's hook to the display.**

3.1.5 Conditioning

Carry out the steps below when using the unit for the first time or when the system has not been used for 3 months or longer.

1. **Fill the transparent calibration cup to the line with pH 4 standard solution.**
   The transparent calibration cup has With TURB Measurement and Without TURB Measurement gauge lines.
2. **Insert the sensor probe in the transparent calibration cup.**



Note

Check that all sensors are attached.

3. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON. Leave the unit for at least 20 minutes to condition the sensors.**

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

Tip

- **The procedure for immersing the sensor probe in the pH standard solution is the same as that described in " 3.3.1 Auto calibration " (page 39).**
  Auto calibration can be performed using the same pH 4 standard solution that was used in the conditioning procedure.
- **Immersing the sensor in the standard solution is generally required for sensor conditioning, but a voltage supply is required for DO sensor conditioning. Turning ON the power of the control unit is necessary during sensor conditioning.**

3.1.6 GPS (U-52G, U-53G)

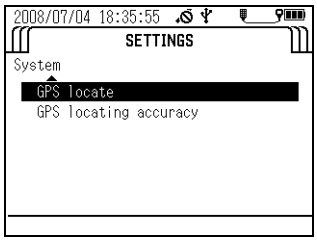
The GPS position measurement precision is proportional to the GPS position measurement time. When the position measurement precision increases, the position measurement time also increases. See " ● GPS locating accuracy" (page 17) for how to set the position measurement precision. See " ● GPS locate" (page 15) below for how to check acquired GPS data.

● GPS locate

1. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

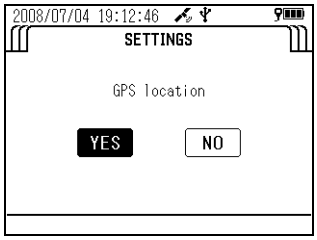
2. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**

3. **Press the down (▽) key to move the cursor to "GPS locate", then press the ENTER key.**



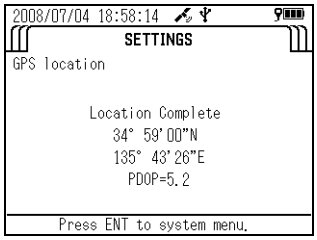
4. **The message "Press ENT key to start position measurement." appears. Press the ENTER key.**

5. **The message "Execute GPS position measurement?" appears. Move the cursor to "YES", then press the ENTER key.**

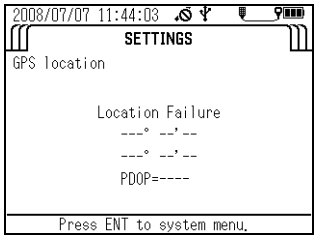


6. **The message "Warming up. Please wait." appears. Wait until the system has finished warming up (about 10 seconds).**

- Position measurement starts automatically when warmup has finished. Position measurement is performed up to 10 times.
- The GPS location complete screen appears after successful position measurement.

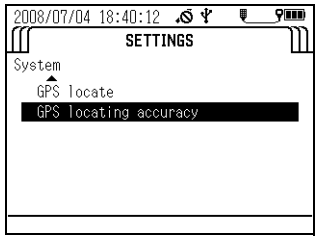


- The GPS location failure screen appears after position measurement has failed. Redo the measurement in a location free from obstacles, or wait for the meteorological conditions to improve before redoing the measurement.

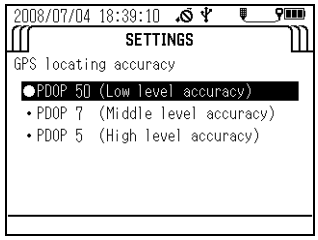


● GPS locating accuracy

1. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
2. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**
3. **Press the down (▽) key to move the cursor to "GPS locating accuracy", then press the ENTER key.**



4. **The screen below appears. Move the cursor to the locating accuracy, then press the ENTER key. The black circle (●) indicates the currently set precision.**



3.2 Settings

3.2.1 Setting measurement methods

This section describes how to set the measurement method.

● Measurement methods

● U-51/U-52

Single measurement	Pressing the MEAS key acquires the 5-second average for the selected measurement parameter.
Interval measurement	Pressing the MEAS key acquires and saves the 5-second average for the selected measurement parameter in the set interval. The measurement interval can be set to any value between 10 seconds and 24 hours.

● U-53

The U-53 turbidity sensor uses a tungsten lamp. The lamp lights for about 10 seconds, and the average measurement value acquired during this interval is displayed.

Single measurement	Pressing the MEAS key acquires the 5-second average for the selected measurement parameter after wiper operation. The 10-second average is acquired when measuring turbidity.
Interval measurement	Pressing the MEAS key acquires and saves the 5-second average for the selected measurement parameter in the set interval. The 10-second average is acquired when measuring turbidity. The measurement interval can be set to any value between 10 seconds (final check of this value required; 30 seconds may be better for U-52) and 24 hour.

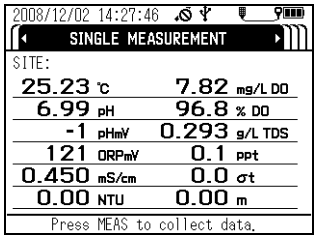
Reference

“ 3.4 Measurement ” (page 61)

● Operation method

1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**

The "MEASUREMENT" screen appears after about 10 seconds.

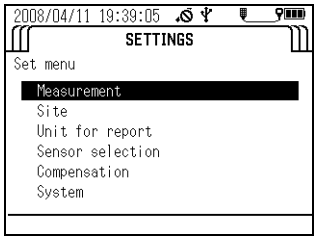


Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

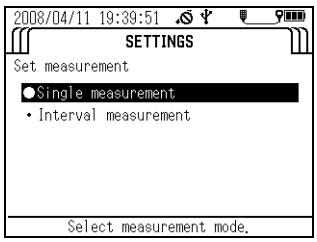
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "Measurement", then press the ENTER key.**



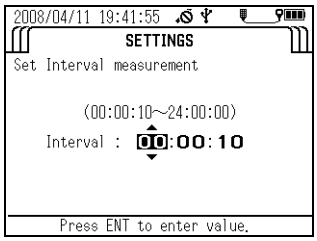
4. **Press the down (▽) key to move the cursor to the desired measurement mode. Press the ENTER key to save the setting.**

The black circle (●) indicates the currently selected measurement mode.



5. **If you selected "Interval measurement", the display switches to the screen used to set the measurement interval. Press the up (△) and down (▽) keys to set the measurement interval.**

The measurement interval can be set to any value between 10 seconds and 24 hours in the case of the U-51 and U-52, or between 30 seconds and 24 hours in the case of the U-53.



3.2.2 Setting sites

The site function allows position data to be connected to corresponding measurement data. Sites have the following specifications and features:

Site names: Text data consisting of up to 20 one-byte alphanumeric characters, spaces, etc.
Site names can be used for control unit searches and as labels for computer processing.
Site names allow measurement data to be saved with a name corresponding to the actual location where it was measured.

You can use site information as a search key when viewing data uploaded by a PC or data saved in the control unit (see " 3.5 Data operations " (page 64)).

- **Selecting sites**

  You can select previously created sites. The black circle (●) indicates the name of the currently selected site. No sites are created at new purchasing or after initialization. Select a site after first creating one from the "Create new site" menu.

- **Creating new sites**

  You can create and save new sites. Up to 20 site names can be registered.

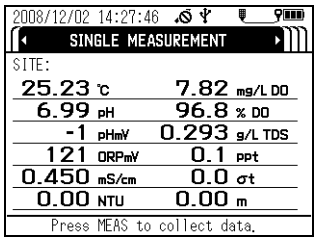
- **Deleting sites**

  You can select a previously created site and delete it.

● Operation methods

- **Selecting a site**

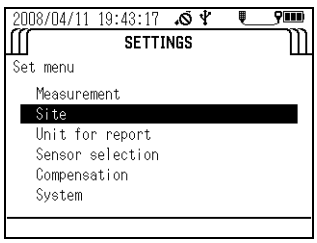
  1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
     The "MEASUREMENT" screen appears after about 10 seconds.



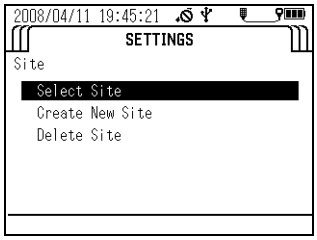
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

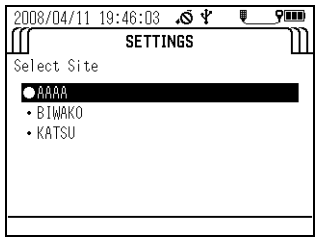
  2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
  3. **Press the down (▽) key to move the cursor to "Site", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Select Site", then press the ENTER key to display the names of the currently saved sites.**

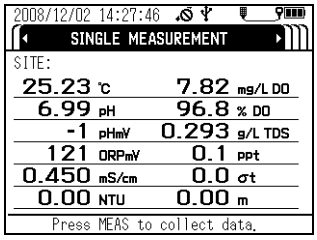


The black circle (●) indicates the currently selected site.



● **Creating a new site**

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

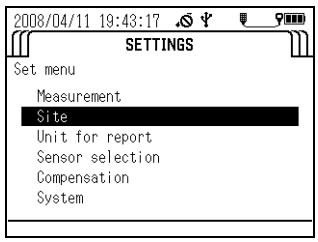


Note

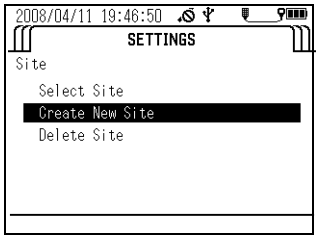
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

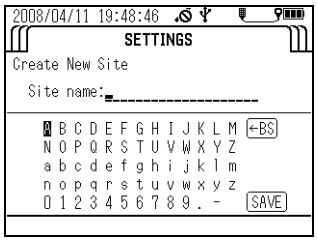
3. **Press the down (▽) key to move the cursor to "Site", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Create New Site", then press the ENTER key.**
Enter the desired site name (up to 20 alphanumeric non-Asian width characters).

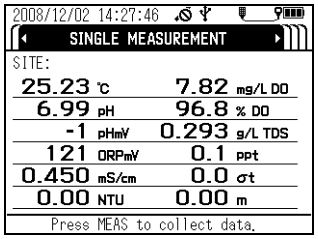


5. **Press the up (△), down (▽), right (▷), and left (◁) keys to move the cursor to each letter or number to use in the name, then press the ENTER key to confirm the entered characters. To delete incorrectly entered characters, move the cursor to "BS" and press the ENTER key to start deleting from the last character. When you have finished entering the name, save it by moving the cursor to "SAVE" and pressing the ENTER key.**



● **Deleting a site**

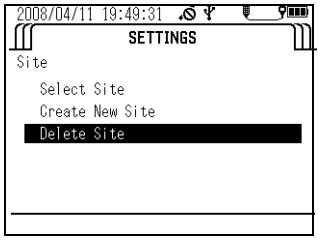
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.



Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

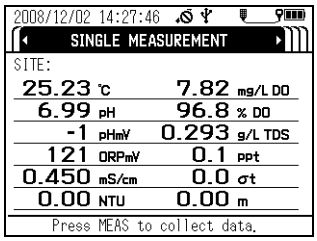
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**



3. **Press the down (▽) key to move the cursor to "Site", then press the ENTER key.**

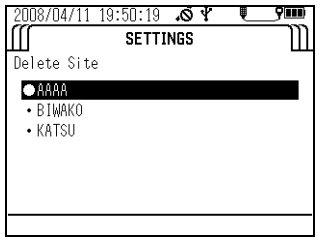
4. **Press the down (▽) key to move the cursor to "Delete Site", then press the ENTER key.**

A list of the currently saved sites appears. The black circle (●) indicates the currently selected site.



5. **Press the down (▽) key to move the cursor to the site to delete, then press the ENTER key to delete it.**

The currently selected site can be deleted after a different site has been selected from the site selection menu or after all unselected sites have been deleted. The same site name cannot be registered more than once.



3.2.3 Unit for report

Note

Units can only be selected when the sensor probe is connected.

Follow the steps below to set the measurement units of measurement parameters. No units are displayed if a measurement parameter has not been selected in the measurement parameter selection screen (see “ 3.2.4 Sensor selection ” (page 25)).

1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**

The "MEASUREMENT" screen appears after about 10 seconds.

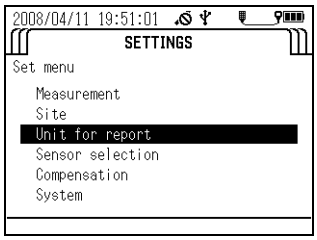
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

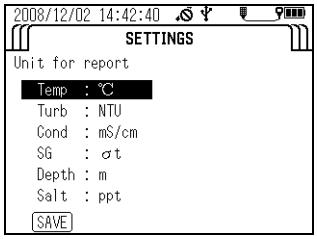
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "Unit for report", then press the ENTER key.**

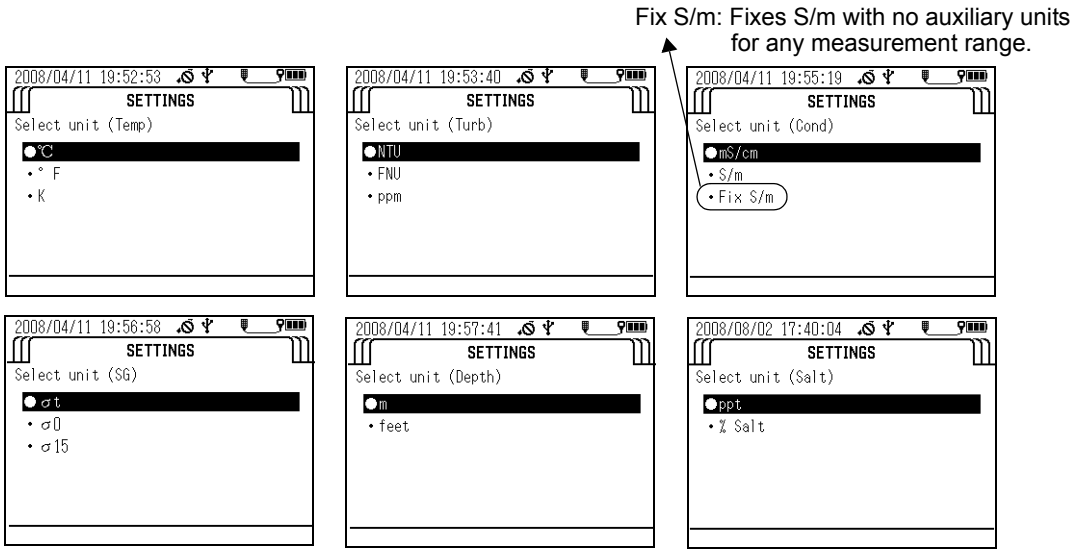
A list of the currently selected measurement parameters and their units appears. Note that measurement parameters not selected (in the measurement parameter selection screen) are not displayed.



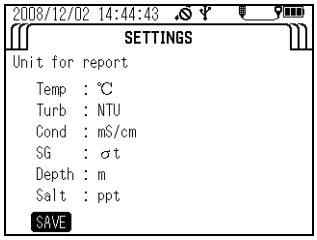
4. **Press the up (△) and down (▽) keys to move the cursor to the item to change, then press the ENTER key.**



5. **A list of the units that can be selected appears. The black circle (●) indicates the currently selected unit. Press the up (△) and down (▽) keys to move the cursor to the desired unit, then press the ENTER key.**



6. **To save the changes, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you do not want to save the changes, press the ESC key.**



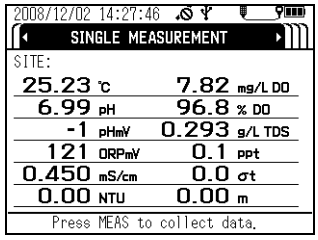
3.2.4 Sensor selection

Note

Measurement parameters can only be selected when the sensor probe is connected.

You can set between 1 and 11 measurement parameters to display in the control unit screen. Follow the steps below to select the desired measurement parameters.

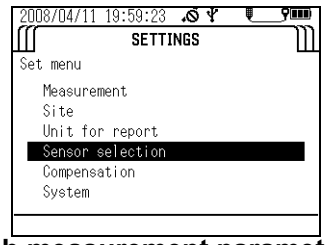
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



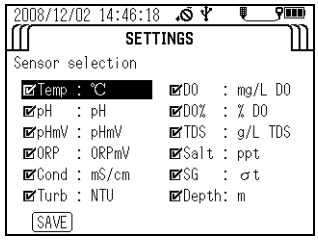
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Sensor selection", then press the ENTER key.**
   A list of the measurement parameters that can be set and the currently set units are displayed.



4. **Move the cursor to each measurement parameter to change, then press the ENTER key.**
   A check in the check box of a measurement parameter indicates it will be displayed.
5. **To save the changes, press the up (△), down (▽), left (◁) and right (▷) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the changes, press the ESC key.**



Note

Available measurement parameters differ according to product specifications.

3.2.5 Compensation

Note

Compensation settings can only be made when the sensor probe is connected.

U-50 series have following functions of compensation.

- Salinity compensation and atmospheric pressure compensation for dissolved oxygen (DO)
- Temperature compensation for conductivity (COND)
- Setting total dissolved solid (TDS) coefficient for TDS

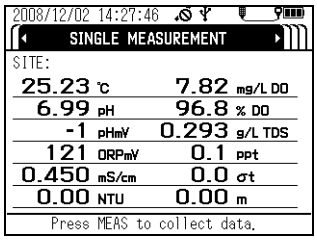
● Salinity compensation (DO)

The dissolved oxygen (DO) value is presented higher than actual value if salinity compensation is not added, because the increase of salinity gives higher DO value. To obtain correct value salinity compensation is needed. The following modes are available for calculation of salinity compensation.

AUTO: Salinity compensation is performed automatically with salinity converted from conductivity.

Value input: Press the up (△) and down (▽) keys to enter a setting value when the salinity is known.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

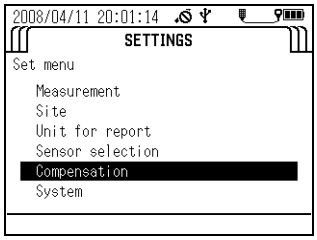


Note

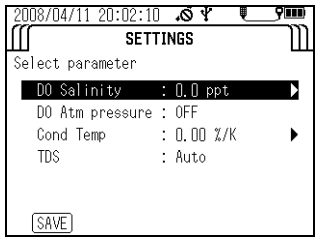
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

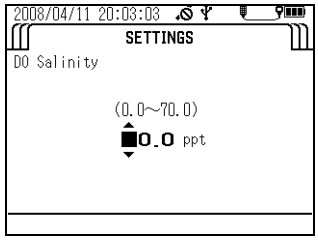
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**



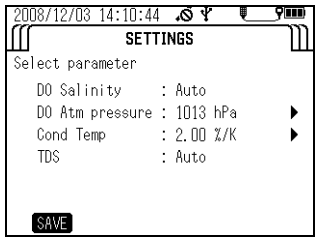
4. **Press the down (▽) key to move the cursor to "DO Salinity", then press the ENTER key to toggle the setting between "Auto" and "Input mode".**
Default: Auto



5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



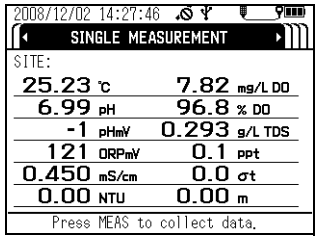
6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the change, press the ESC key.**



● **Atmospheric pressure compensation (DO)**

Differences in the atmospheric pressure of the measurement location influence the Dissolved Oxygen (DO) measurement. By setting (input) the actual atmospheric pressure of the measurement location into the control unit, it is possible to standardize the measured Dissolved Oxygen (DO) value to a value at the standard atmospheric pressure (1013 hPa).

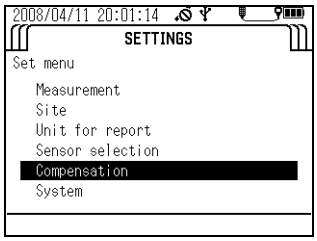
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.



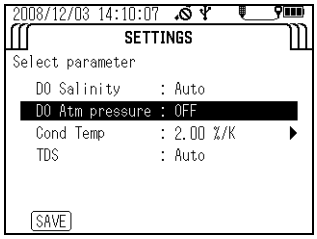
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

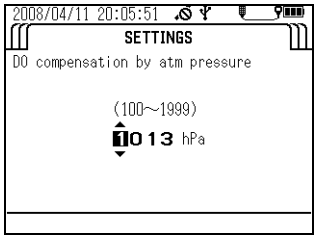
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**



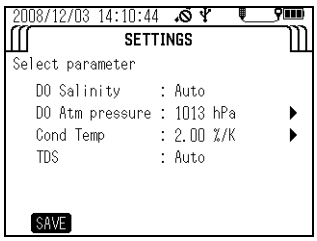
4. **Press the down (▽) key to move the cursor to "Cond Temp", then press the ENTER key to toggle the setting between "OFF" and "Input mode".**
   Default: OFF



5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the change, press the ESC key.**

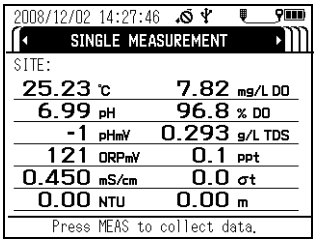


● Temperature compensation for conductivity (COND)

Sample conductivity (COND) varies with temperature, and this control unit uses a temperature compensation coefficient to automatically standardize the conductivity (COND) at 25°C. The initial setting coefficient is 2%/K, which is the generally used.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

The "MEASUREMENT" screen appears after about 10 seconds.

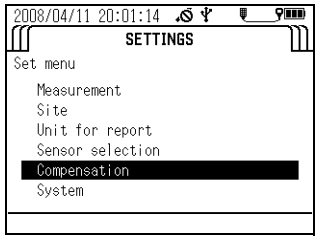


Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

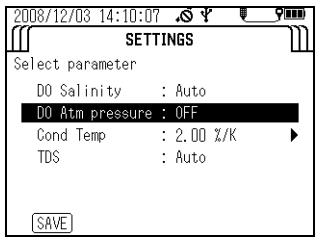
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**

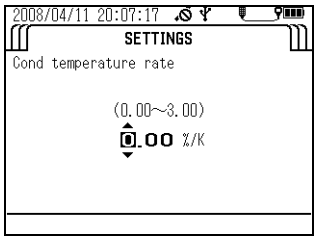


4. **Press the down (▽) key to move the cursor to "Cond Temp", then press the ENTER key to toggle the setting between "OFF" and "Input mode".**

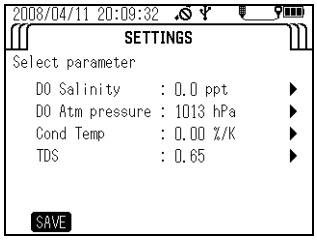
Default: 2.00%/K



5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key.**
If you don't want to save the change, press the ESC key.



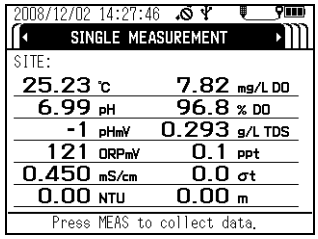
● Setting a total dissolved solid (TDS) coefficient

The total dissolved solid amount (TDS) is a converted value obtained by multiplying the conductivity (COND) by a known coefficient. The coefficient initially set for the control unit is based on a conversion for KCl and $CaCO_3$ solutions and it depends on the conductivity (COND) value as shown below.

Conductivity (COND) (S/m)	Conversion coefficient
< 0.05	0.65
0.05 to 0.5	0.64
0.5 to 1	0.63
1 to 3	0.62
3 to 5	0.61
> 5	0.60

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

The "MEASUREMENT" screen appears after about 10 seconds.

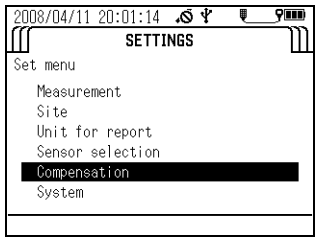


Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

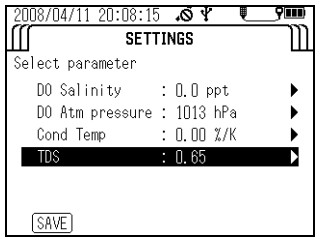
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**

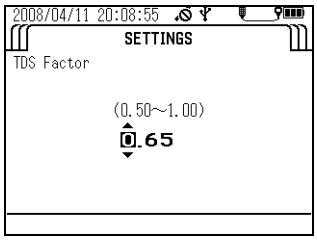


4. **Press the down (▽) key to move the cursor to "TDS", then press the ENTER key to toggle the setting between "AUTO" and "Input mode".**

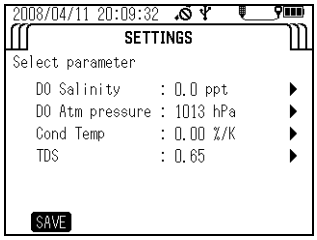
Default: Auto



5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the change, press the ESC key.**



3.2.6 System settings

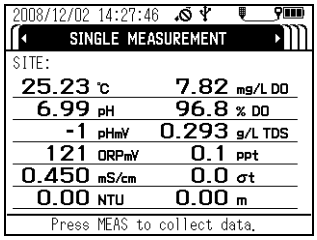
The system settings let you change the display language, check the system software version, set the date/time, set the auto power OFF time, set the display contrast, and initialize the settings.

● **Display language**

Follow the steps below to select either English or Japanese as the display language.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

The "MEASUREMENT" screen appears after about 10 seconds.

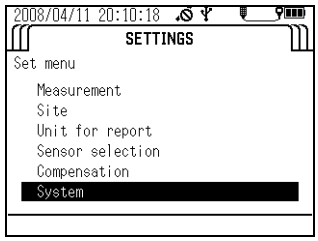


Note

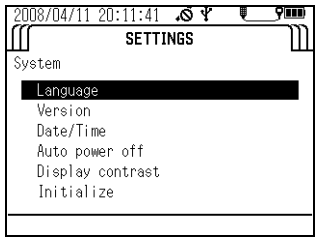
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

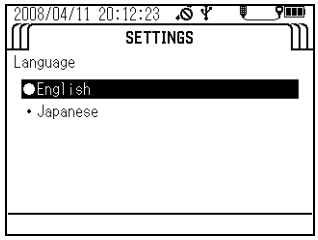
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Language", then press the ENTER key.**



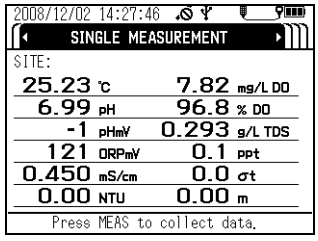
5. **A list of the supported display languages appears. Press the up (△) and down (▽) keys to move the cursor to the desired language, then press the ENTER key.**
The black circle (●) indicates the currently selected display language.



● Version

Follow the steps below to display the program No. and version of the control unit and sensor probe software.
The program No. and version of the sensor probe software will not be displayed if the sensor probe is not connected.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

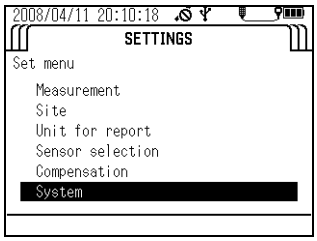


Note

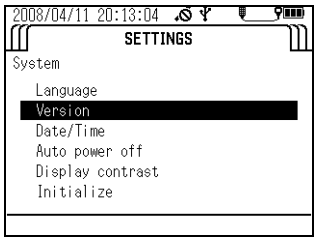
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



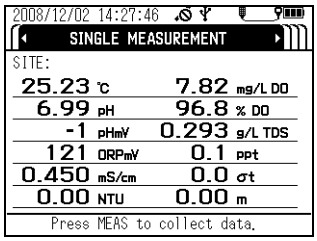
4. **Press the down (▽) key to move the cursor to "Version", then press the ENTER key.**
The program No. of the control unit and sensor probe software appears.



● **Setting the date/time**

Follow the steps below to set the date and time.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

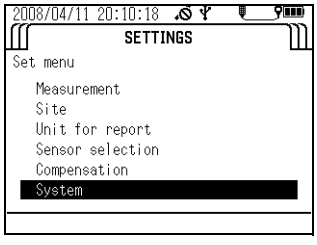


Note

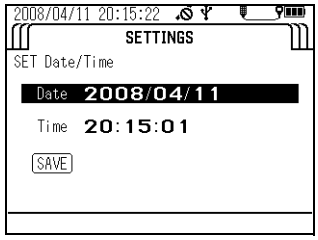
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**

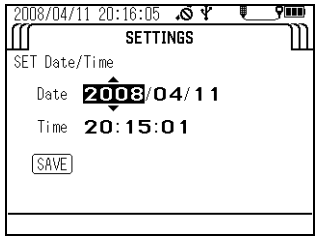


4. **Press the down (▽) key to move the cursor to "Date/time", then press the ENTER key.**

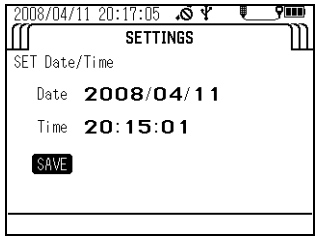


5. **Move the cursor to the date, then press the ENTER key.**

6. **Press the right (▷) key to move the cursor to the year, month, day, hour, minute and second, and press the up (△) and down (▽) keys to enter each value.**



7. **When finished entering settings, press the ENTER key to move the cursor to SAVE, then press the ENTER key again to save the settings.**

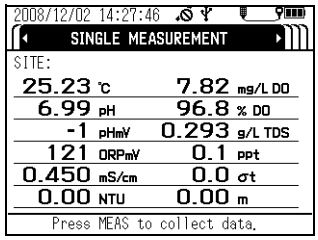


● Setting the auto power OFF time

Follow the steps below to set the time for the auto power OFF function (which turns the power OFF automatically when no operation is performed for the preset amount of time).

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

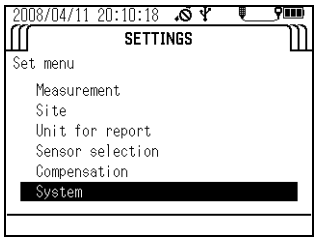
The "MEASUREMENT" screen appears after about 10 seconds.



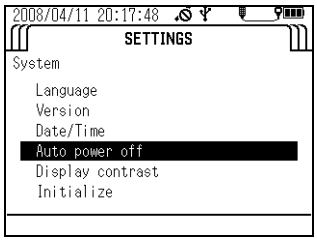
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

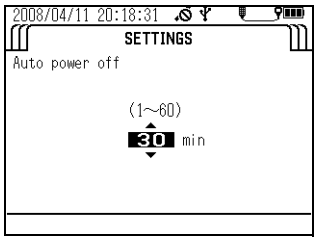
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Auto power off", then press the ENTER key.**



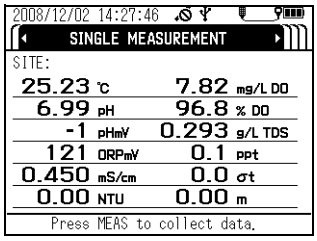
5. **Press the up (△) and down (▽) keys to select the desired time setting, then press the ENTER key.**
   You can select OFF, or settings of 1, 2, 5, 10, 20, 30 or 60 minutes.
   Default: 30 minutes



● Display contrast

Follow the steps below to adjust the display's contrast.

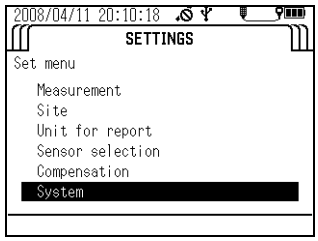
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



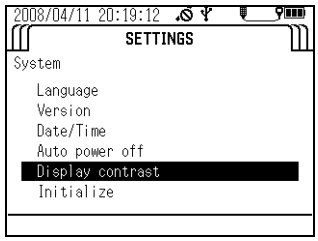
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

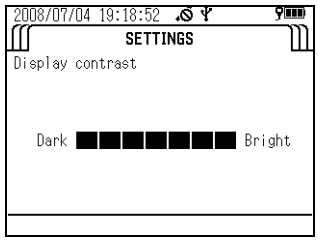
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Display contrast", then press the ENTER key.**



5. **Press the left (◁) and right (▷) keys to adjust the contrast.**
   Adjustment can be made in 26 steps.

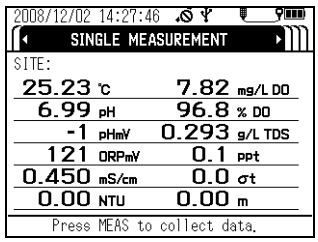


6. **Press the ENTER key.**

● Initialization

Follow the steps below to restore all the settings except date/time to their factory defaults. Factory default calibration data for the electrical conductivity and turbidity sensors will also be deleted at the same time.

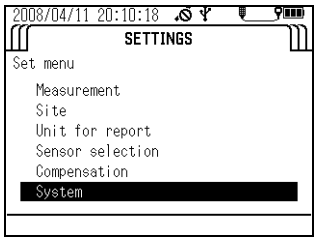
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



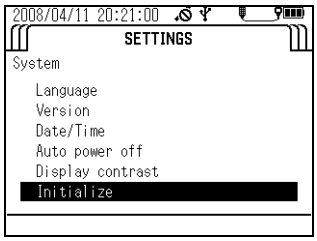
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

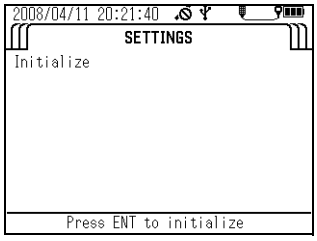
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



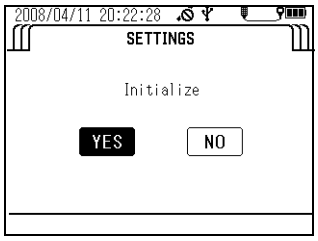
4. **Press the down (▽) key to move the cursor to "Initialize", then press the ENTER key.**



5. **Press the ENTER key again.**



6. **A confirmation message appears asking whether to execute initialization. Press the left (◁) key to move the cursor to YES, then press the ENTER key.**
   The message "Initialize Complete" appears to indicate the process has finished.



3.3 Calibration

To obtain correct measurement values, the sensors need to be calibrated using standard solution before measurement. You can select simultaneous auto calibration of the pH, COND and TURB sensors in pH4 standard solution and DO and DEP sensors simultaneously in air, or manual calibration of individual measurement parameters. You can check the result of the previous calibration using the procedure on " 3.5.4 Checking the calibration record " (page 70).

Note

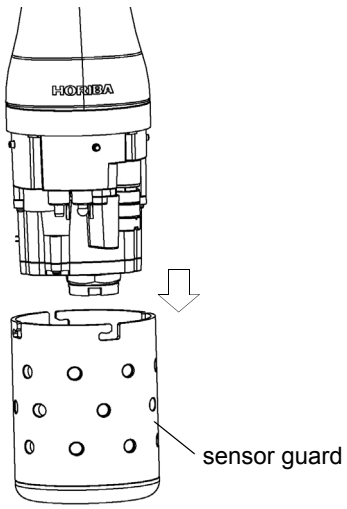
- **Wait at least 20 minutes after turning the system power ON before calibrating the DO sensor.**
- **Make the DO and COND compensation settings before calibration since these settings are applied during calibration.**
- **You can select only the desired parameters for calibration and calibrate just those parameters (see " 3.2.4 Sensor selection " (page 25)).**
- **Use about 200 mL of standard solution in the calibration cup.**
- **Calibration data is stored in the sensor probe.**

3.3.1 Auto calibration

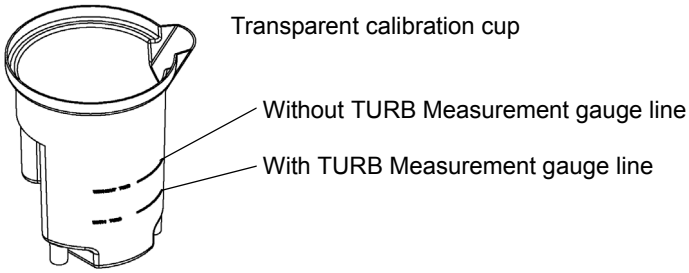
Tip

- **The following parameters are calibrated (at 25°C):**
  pH: Set to 4.01 (zero-point calibration); the span is adjusted to the factory default value.
  COND: 0.449 S/m (4.49 mS/cm, span calibration); the zero point is adjusted to the factory default value.
  TURB: 0 NTU (zero-point calibration); the span is adjusted to the factory default value.
  DO: 8.92 mg/L (span calibration); the zero point is adjusted to the factory default value.
  DEP: 0 m (zero-point calibration); the zero point is adjusted to the factory default value.
- **If the air temperature changes, the readout value may not be stable. Ensure that the ambient air temperature is the same temperature as the calibration solution, because the internal probe temperature sensor and external temperature sensor (in the calibration solution) are used for the auto calibration. Allow the probe and standard solution to equilibrate for 1 hour if a thermometer is not available to verify that these temperatures are the same.**
- **Do not hold the probe while performing the auto calibration. Body temperature may elevate the internal temperature sensor measurement creating DO calibration error.**

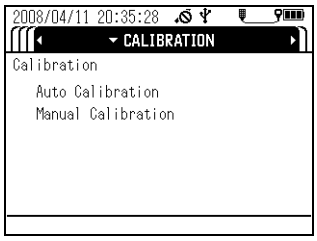
1. **Remove the sensor guard and wash the sensor probe 2 or 3 times with deionized water.**



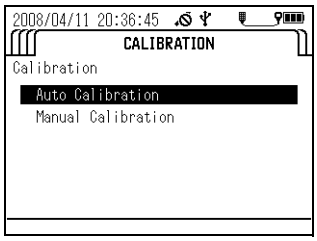
2. **Remove the transparent calibration cup.**
3. **Fill the transparent calibration cup to the line with pH 4 standard solution.**
   The transparent calibration cup has With TURB Measurement and Without TURB Measurement gauge lines.



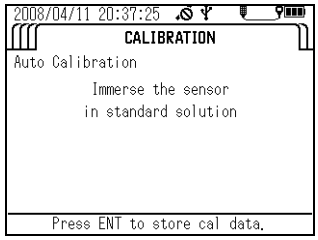
4. **Press the control unit's CAL key to set the calibration mode.**

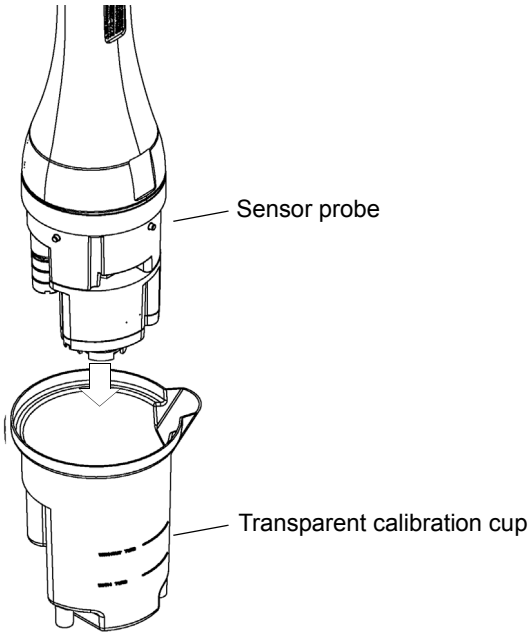


5. **Press the down (▽) key to move the cursor to "Auto Calibration", then press the ENTER key.**

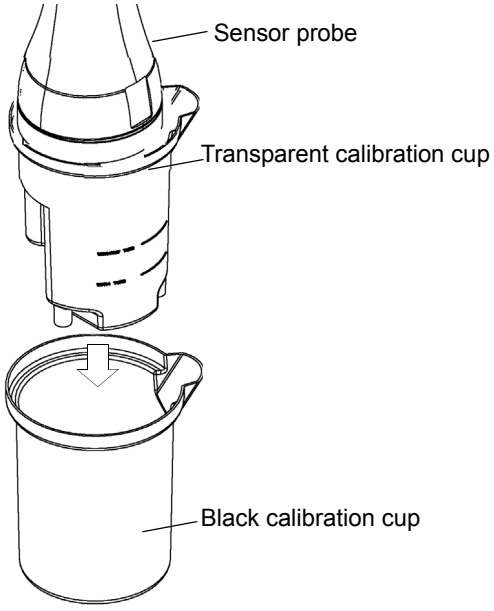


6. **Immerse the sensor probe in the transparent calibration cup.**
Check that the pH sensor, ORP sensor, reference electrode, COND sensor, TURB sensor and temperature sensor are submerged in the pH 4 standard solution and check that there are no air bubbles on the sensor.





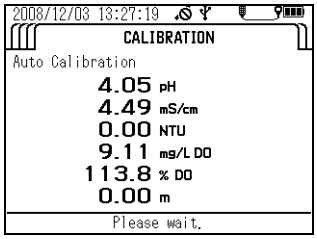
7. **With the sensor probe still in the transparent calibration cup, place the transparent calibration cup into the black calibration cup.**



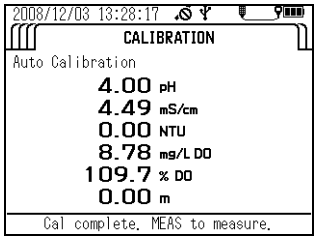
8. **When all the sensor values have stabilized, press the ENTER key to start calibration.**

Note

Do not remove the sensor probe from the calibration solution. U-53 turbidity data will display "----" until the calibration is completed.



Calibration is finished when the message "Cal complete. MEAS to measure." appears. Press the MEAS key to set the measurement screen, then start measurement.



If a calibration error occurs, start calibration after first resolving the issue according to the instructions in " 4.6 Troubleshooting " (page 89).

3.3.2 Manual calibration

The procedures below describe how to calibrate each sensor individually.

Note

The displayed units are the units set by selecting "Unit for report" in the "SETTINGS" screen.

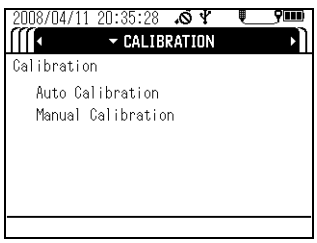
● **Temperature (TEMP) calibration**

1. **Fill a bucket or similar container with water of a known temperature, and insert the sensor probe in it.**

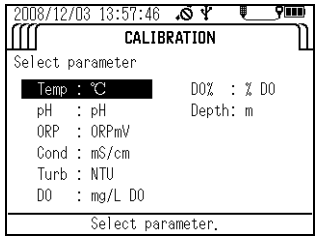
Wait 5 minutes before starting calibration to allow the sensor probe temperature to stabilize.

2. **Press the control unit's CAL key to set the calibration mode.**

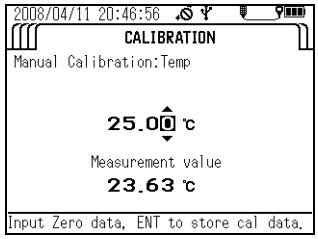
3. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



4. **In the parameter selection screen, move the cursor to “Temp”, then press the ENTER key.**



5. **Press the up (△) and down (▽) keys to set the calibration value - the temperature of the water containing the submerged sensor probe.**



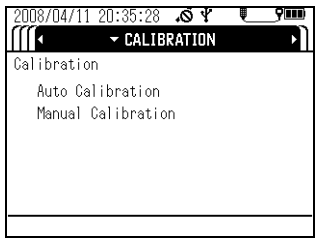
6. **Check that “Measurement value” has stabilized, then press the ENTER key to start calibration.**
   Calibration is finished when the message “Cal complete. CNT to measure.” appears.

● pH calibration

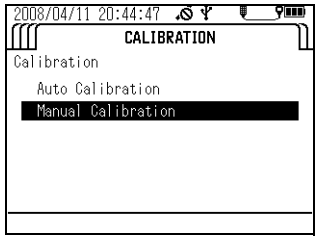
Note

You can select one calibration point (zero-point calibration) or two calibration points (zero-point calibration and span calibration). Carry out two calibration procedures to ensure good measurement precision throughout all measurement ranges.

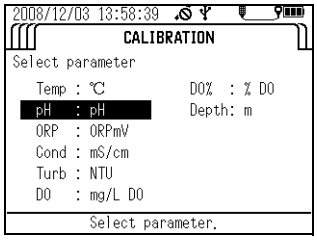
1. **Calibrate the zero point. Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with pH 7 standard solution.**
2. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
3. **Press the control unit’s CAL key to set the calibration mode.**



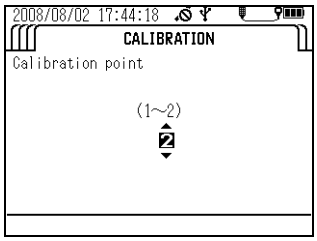
4. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



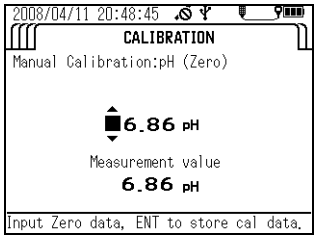
5. **In the parameter selection screen, move the cursor to "pH", then press the ENTER key.**



6. **Set the number of calibration points, then press the ENTER key.**



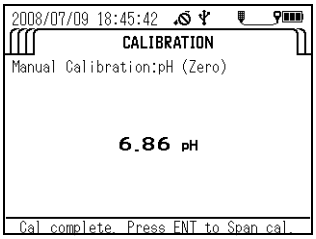
7. **Press the up (△) and down (▽) keys to set the pH value of the pH 7 standard solution containing the submerged sensor probe at the measurement temperature**



Temp. (°C)	pH 4 standard solution Phthalate	pH 7 standard solution Neutral phosphate	pH 9 standard solution Borate
0	4.01	6.98	9.46
5	4.01	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14
35	4.02	6.84	9.10
40	4.03	6.84	9.07
45	4.04	6.84	9.04

8. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

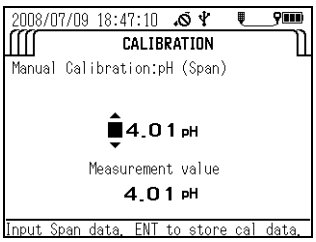
9. **Press the ENTER key to start the span calibration procedure when the message "Cal complete. Press ENT to Span cal." appears.**



10. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with pH 4 or pH 9 standard solution.**

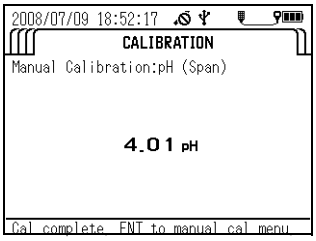
11. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

12. **Press the up (△) and down (▽) keys to set the pH value of the pH 4 or pH 9 standard solution containing the submerged sensor probe at the measurement temperature.**



13. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

14. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter**

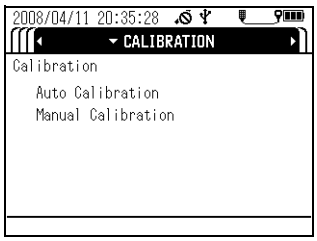


● ORP calibration

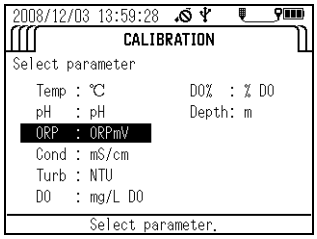
Note

- **If the prepared ORP standard solution is left in open air for one hour or more, the solution may be transformed. For this reason ORP standard solution cannot be stored.**
  Calibrate within one hour of preparing the solution.
- **When measuring sample with low concentrations of oxidants and reductants after conducting an operational check using a standard substance, the measured values may not stabilize or the results of measurement might not be repeatable. If this is the case, start the measurement after immersing the sensors in the sample water sufficiently.**
- **Note that when measuring the ORP of solution with extremely low concentrations of oxidants and reductants, such as tap water, well water, or water treated with purifying equipment, there may be less responsiveness, repeatability, and stability, in general.**
- **When alkaline ion water is left for 5 minutes, its ORP undergoes changes significantly. Always measure alkaline ion water promptly.**

1. **Fill a clean beaker with one bag of ORP standard powder No. 160-22 or No. 160-51. Add 250 mL of deionized water and agitate the solution thoroughly (there will be some excess quinhydrone (a black powder) that floats on the surface when agitating the solution). Fill the transparent calibration cup to the reference line with this standard solution.**
2. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
3. **Press the control unit's CAL key to set the calibration mode.**
4. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



5. **In the parameter selection screen, move the cursor to ORP, then press the ENTER key.**



6. **Press the up (△) and down (▽) keys to set the mV value of the ORP standard solution containing the submerged sensor probe at the measurement temperature.**

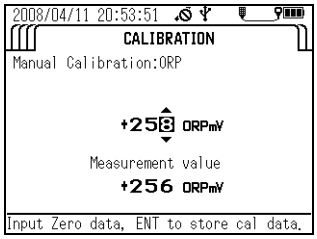


Table 1 Indicated value of ORP standard solution at various temperatures (mV)

Temperature	160-22	16051
5	+274	+112
10	+271	+107
15	+267	+101
20	+263	+95
25	+258	+89
30	+254	+83
35	+249	+76
40	+244	+69

7. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

8. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**

● Conductivity (COND) calibration

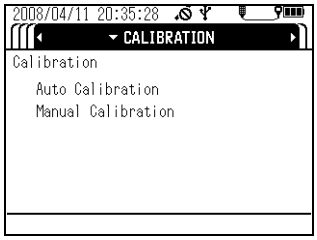
Note

- **To support a wide range of sample concentrations, electrical conductivity is divided into three measurement ranges: 0.0 mS/m to 99.9 mS/m, 0.090 S/m to 0.999 S/m, and 0.9 S/m to 9.99 S/m.**
- **When manually calibrating conductivity, you can select two calibration points (one zero-point calibration point and a span calibration point for one of the three measurement ranges) or four calibration points (one zero-point calibration point and span calibration points for all three measurement ranges). Carry out the four calibration points to ensure good measurement precision throughout all measurement ranges.**
- **Make the compensation setting before calibration since this setting is applied during calibration. (Refer to " 6.5.3 Temperature coefficient " (page 104)).**

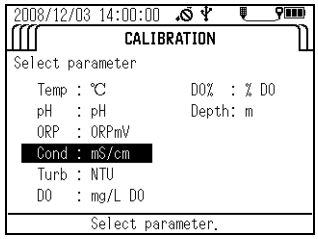
1. **Prepare the standard solution. Dry Potassium chloride (KCl) powder (high-grade commercially available) at 105°C for two hours, and leave it to cool in a desiccator.**
2. **Consult the following table and weigh potassium chloride (KCl), then prepare three standard potassium chloride (KCl) solutions following the procedure below.**

Potassium chloride (KCl) standard solution	Conductivity (COND) value	Potassium chloride (KCl) mass (g) at solution temperature of 25 °C	Calibration range
0.005 mol/L	71.8 mS/m (0.718 mS/cm)	0.373	0.0 mS/m to 99.9 mS/m (0.00 mS/cm to 0.999 mS/cm)
0.050 mol/L	0.667 S/m (6.67 mS/cm)	3.73	0.090 S/m to 0.999 S/m (1.00 mS/cm to 9.99 mS/cm)
0.500 mol/L	5.87 S/m (58.7 mS/cm)	37.2	0.9 S/m to 9.99 S/m (10.0 mS/cm to 99.9 mS/cm)

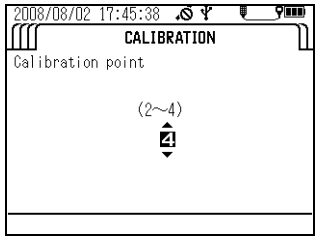
3. **Dissolve the weighed Potassium Chloride (KCl) in deionized water.**
4. **Put the dissolved Potassium Chloride (KCl) into a 1 L measuring flask, and fill to the 1 L mark with deionized water.**
5. **Calibrate the zero point. Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then remove all moisture from the sensor probe (it will be calibrated in air).**
6. **Press the control unit's CAL key to set the calibration mode.**
7. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



8. **In the parameter selection screen, move the cursor to “Cond”, then press the ENTER key.**



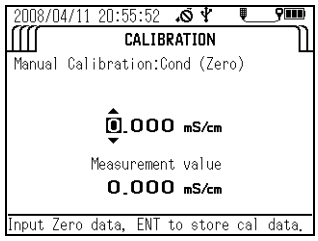
9. **Set the number of calibration points, then press the ENTER key.**



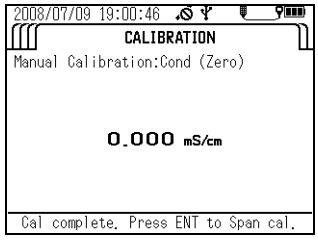
The instructions below assume that four calibration points have been set.

10. **Press the up (△) and down (▽) keys to set the "Cond" value to 0.0 mS/m (0.000 mS/cm).**

11. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**



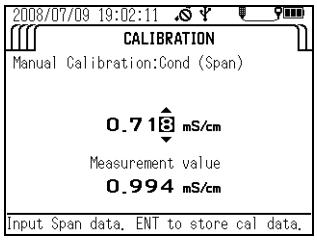
12. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the first span calibration procedure.**



13. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 71.8 mS/m (0.718 mS/cm) standard solution.**

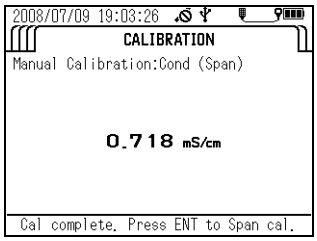
14. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

15. **Press the up (△) and down (▽) keys to set the "Cond" value to 71.8 mS/m (0.718 mS/cm).**
Calibration range = 0 mS/m to 99.9 mS/m (0 mS/cm to 0.999 mS/cm)



16. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

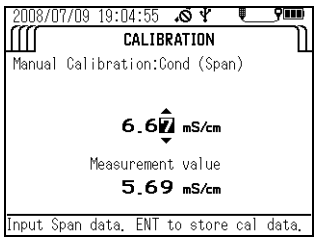
17. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



18. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 0.667 S/m (6.67 mS/cm) standard solution.**

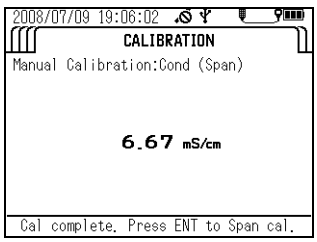
19. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

20. **Press the up (△) and down (▽) keys to set the "Cond" value to 0.667 S/m (6.67 mS/cm).**
Calibration range = 0.100 S/m to 0.999 S/m (1.00 mS/cm to 9.99 mS/cm)



21. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

22. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**

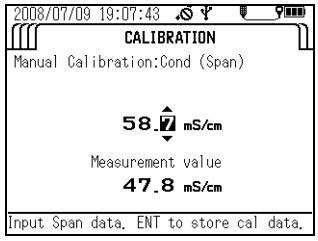


23. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 5.87 S/m (58.7 mS/cm) standard solution.**

24. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

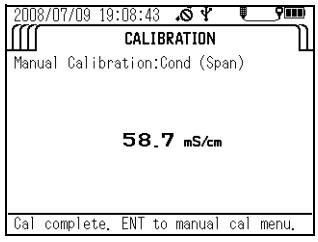
25. **Press the up (△) and down (▽) keys to set the "Cond" value to 5.87 S/m (58.7 mS/cm).**

Calibration range = 1.00 S/m to 10.00 S/m(10.0 mS/cm to 100.0 mS/cm)



26. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

27. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**



● Turbidity (TURB) calibration

Note

- **To support a wide range of sample concentrations, turbidity is divided into three measurement ranges: 0.0 to 9.9 NTU, 10 to 100 NTU, and over 100 NTU.**
- **When manually calibrating turbidity, you can select two calibration procedures (one zero-point calibration procedure and a span calibration procedure for one of the three measurement ranges), three calibration procedures (one zero-point calibration procedure and a span calibration procedure for two of the three measurement ranges) or four calibration procedures (one zero-point calibration procedure and span calibration procedures for all three measurement ranges). Carry out the four calibration procedures to ensure good measurement precision throughout all measurement ranges.**
- **Always use the calibration cup provided. Using other containers can create effects from ambient light that cause incorrect calibration.**

● Preparing the standard solutions

1. **Weigh out 5.0 g of hydrazine sulfate (commercial special grade or above), and dissolve it in 400 mL of deionized water. Dissolve 50 g of hexamethylene tetramine (commercial special grade or above) in 400 mL of deionized water in anther flask.**
2. **Mix the two solutions and add deionized water until the total solution volume is 1000 mL, and mix well. Store this solution at a temperature of 25°C ±3°C for 48 hours.**
   The turbidity value (TURB) of this solution is equivalent to 4000 NTU.
3. **Dilute 4000 NTU-solution 5 times (use a pipette to measure 50 mL of the 4000 NTU solution and pour it into a 250 mL measuring flask, and fill up to 250 mL meniscus)**
   The turbidity value (TURB) of this solution is equivalent to 800 NTU.
4. **Dilute 800 NTU solution 10 times (use a pipette to measure 25 mL of the 800 NTU solution and pour it into a 250 mL measuring flask, and fill up to 250 mL meniscus)**
   The turbidity value (TURB) of this solution is equivalent to 80 NTU.
5. **Dilute 80 NTU solution 10 times (use a pipette to measure 25 mL of the 80 NTU solution and pour it into a 250 mL measuring flask, and fill up to 250 mL meniscus)**
   The turbidity value (TURB) of this solution is equivalent to 8 NTU.

Note

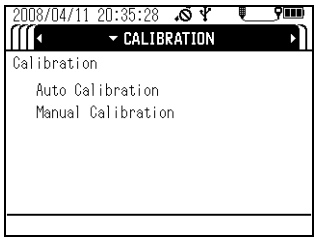
Instead of the standard solutions above, you can use other standard solutions of known concentration measured with other standard instruments.

● U-52, U-53 turbidity calibration

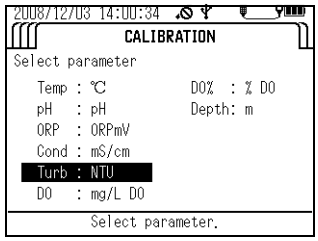
Set the number of calibration points.

You can set between 2 and 4 points.

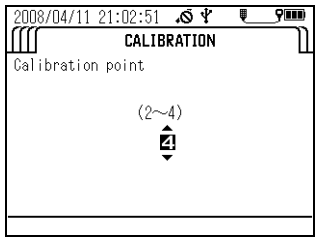
1. **Press the control unit's CAL key to set the calibration mode.**
2. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



3. **In the parameter selection screen, move the cursor to "Turb", then press the ENTER key.**



4. **Press the up (△) and down (▽) keys to set the number of calibration points, then press the ENTER key.**

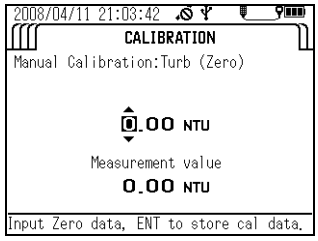


The instructions below assume that four calibration points have been set.

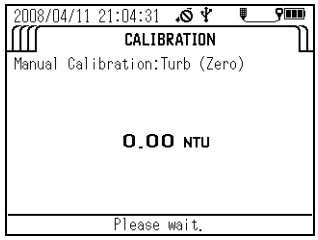
5. **Calibrate the zero point. Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with deionized water.**

6. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

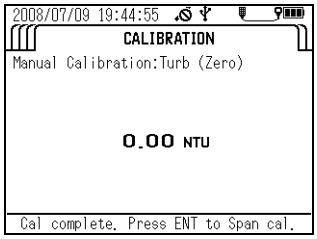
7. **Press the up (△) and down (▽) keys to set the "Turb" value to 0.0 NTU.**



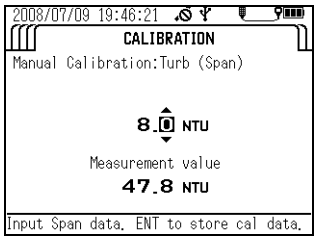
8. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**



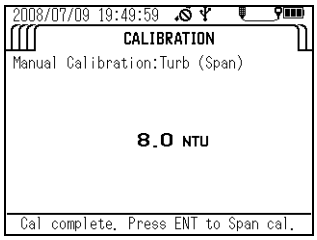
9. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the first span calibration procedure.**



10. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 8 NTU standard solution, or a standard solution of known concentration between 0.1 and 10 NTU.**
11. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
12. **Press the up (△) and down (▽) keys to set the "TURB" value to 8 NTU, or to the known concentration of the standard solution between 0.1 and 10 NTU. (Input range = 0 NTU to 9.9 NTU (U-51) or 0 NTU to 9.99 NTU (U-52))**

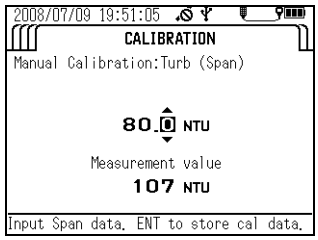


13. **Check that "Current measurement value" has stabilized, then press the ENTER key to start calibration.**
14. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



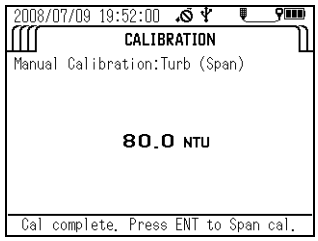
15. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 80 NTU standard solution, or a standard solution of known concentration between 10 and 100 NTU.**
16. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

17. **Press the up (△) and down (▽) keys to set the "Turb" value to 80 NTU, or to the known concentration of the standard solution between 10 and 100 NTU. (Input range = 10.0 NTU to 99.9 NTU)**



18. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

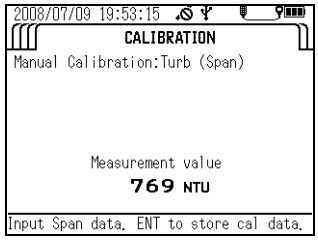
19. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



20. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 800 NTU standard solution, or a standard solution of known concentration 100 NTU above.**

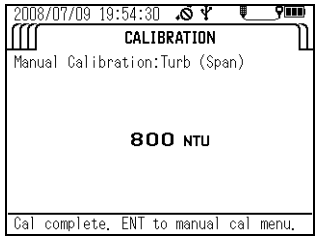
21. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

22. **Press the up (△) and down (▽) keys to set the "TURB" value to 800 NTU, or to the known concentration of the standard solution 100 NTU above.**
(Input range = 100 NTU to 800 NTU (U-51), 100 NTU to 1000 NTU (U-52))



23. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

24. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**



● Dissolved oxygen (DO) calibration

Note

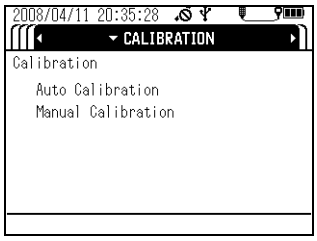
- **You can select one calibration procedure (span calibration) or two calibration procedures (zero-point calibration and span calibration). Carry out the two calibration procedures to ensure good measurement precision throughout all measurement ranges.**
- **It is necessary to prepare new solution before calibration of the Dissolved Oxygen (DO) sensor.**
- **The calibration cup (included) cannot be used to manually calibrate the DO sensor. Use a suitable bottle in which the DO sensor and the temperature sensor can be immersed.**
- **Wait at least 20 minutes after turning the system power ON before calibrating the DO sensor.**
- **Make the compensation setting before calibration since the setting is applied during calibration.**
- **The DO sensor is affected by flow. When performing span calibration with saturated dissolved oxygen water, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) or agitate the saturated dissolved oxygen water.**

1. **Prepare the standard solution.**

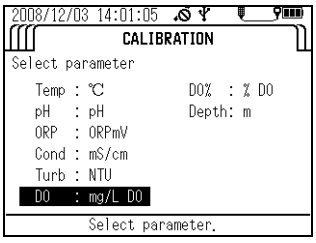
- Add about 50 g of sodium sulfite to 1000 mL of water (either deionized water or tap water) and stir the mixture to dissolve the sodium sulfite in it.
- Pour 1 to 2 liters of water into a suitable flask (either deionized water or tap water). Using a air pump, feed air into the water and aerate the solution until oxygen is saturated.

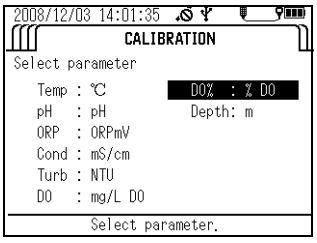
2. **First, calibrate the zero point. Press the control unit's CAL key to set the calibration mode.**

3. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**

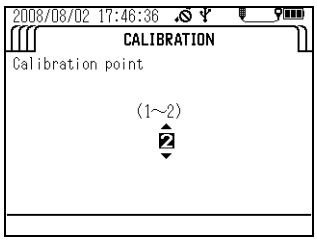


4. **In the parameter selection screen, move the cursor to DO or DO%, then press the ENTER key.**



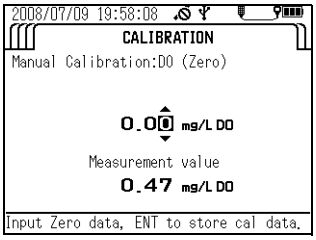


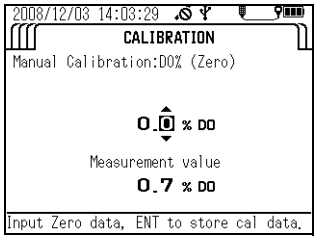
5. **Set the number of calibration procedures, then press the ENTER key.**



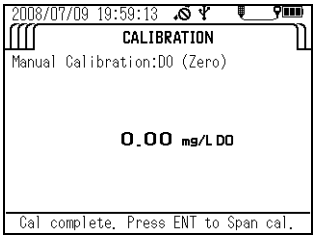
The instructions below assume that two calibration points have been set.

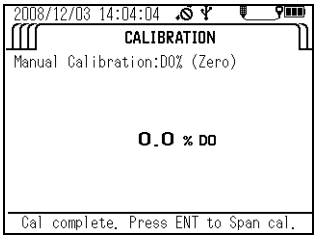
6. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the bottle.**
7. **Press the up (△) and down (▽) keys to set the DO value to 0.00 mg/L or 0.0%.**



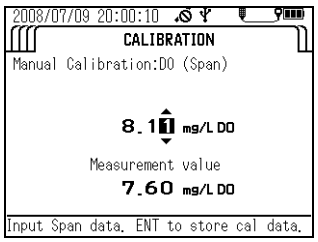


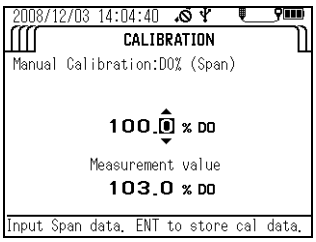
8. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
9. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the span calibration procedure.**



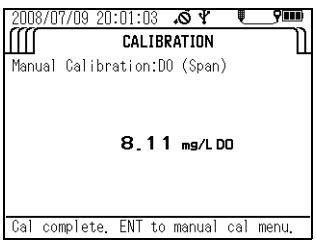


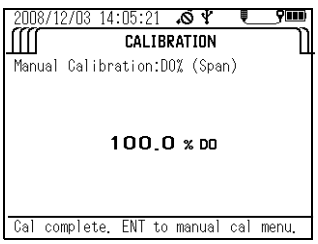
10. **Wash the sensor probe 2 or 3 times with deionized water to remove any dirt, then submerge the sensor probe in the container filled with the span solution.**
11. **Press the up (△) and down (▽) keys to set the DO value to the saturated dissolved oxygen value (mg/L) of the water at that temperature or the dissolved oxygen saturation ratio.**





12. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
13. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**





Amounts of saturated dissolved oxygen in water at various temperatures (salinity=0.0%)

JIS K0101

Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	14.16						
1	13.77	11	10.67	21	8.68	31	7.42
2	13.40	12	10.43	22	8.53	32	7.32
3	13.04	13	10.20	23	8.39	33	7.22
4	12.70	14	9.97	24	8.25	34	7.13
5	12.37	15	9.76	25	8.11	35	7.04
6	12.06	16	9.56	26	7.99	36	6.94
7	11.75	17	9.37	27	7.87	37	6.86
8	11.47	18	9.18	28	7.75	38	6.76
9	11.19	19	9.01	29	7.64	39	6.68
10	10.92	20	8.84	30	7.53	40	6.59

ISO5814

Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	14.62				
1	14.22	11	11.03	21	8.91
2	13.83	12	10.78	22	8.74
3	13.46	13	10.54	23	8.58
4	13.11	14	10.31	24	8.42
5	12.77	15	10.08	25	8.26
6	12.45	16	9.87	26	8.11
7	12.14	17	9.66	27	7.97
8	11.84	18	9.47	28	7.83
9	11.56	19	9.28	29	7.69
10	11.29	20	9.09	30	7.56

● **Span setting values for calibration in air**

The software should display these values when auto calibration is performed.
Use this table to input values for manual span calibrations in air.

Tip

The DO measurement value of "air-saturated water" and air are different.
Due to the pressure difference against the membrane in air versus the membrane in water, the measurement value in air is about 10% higher than the value of air-saturated water on average.

Amounts of saturated dissolved oxygen in air at various temperatures

Following tables are applicable only to the air calibration of the U-50 DO sensor. Do not use them for other purpose.

Air calibration value in adopting evaluation based on JIS K0101

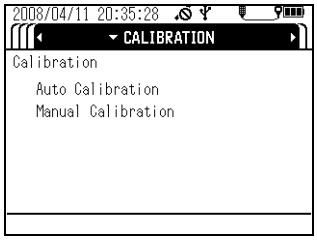
Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	15.58						
1	15.15	11	11.74	21	9.55	31	8.16
2	14.74	12	11.47	22	9.38	32	8.05
3	14.34	13	11.22	23	9.23	33	7.94
4	13.97	14	10.97	24	9.08	34	7.84
5	13.61	15	10.74	25	8.92	35	7.74
6	13.27	16	10.52	26	8.79	36	7.63
7	12.93	17	10.31	27	8.66	37	7.55
8	12.62	18	10.10	28	8.53	38	7.44
9	12.31	19	9.91	29	8.40	39	7.35
10	12.01	20	9.72	30	8.28	40	7.25

Air calibration value in adopting evaluation based on ISO5814

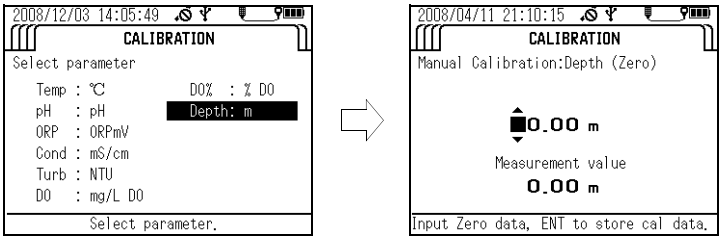
Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	16.08				
1	15.64	11	12.13	21	9.80
2	15.21	12	11.86	22	9.61
3	14.81	13	11.59	23	9.44
4	14.42	14	11.34	24	9.26
5	14.05	15	11.09	25	9.09
6	13.70	16	10.86	26	8.92
7	13.35	17	10.63	27	8.77
8	13.02	18	10.42	28	8.61
9	12.72	19	10.21	29	8.46
10	12.42	20	10.00	30	8.32

● **Water depth (DEPTH) calibration**

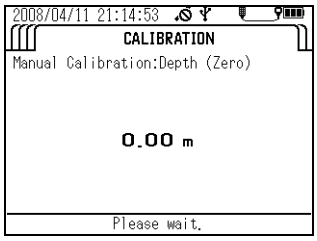
1. **Calibrate the zero point. Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then remove all moisture from the sensor probe (it will be calibrated in air).**
2. **Press the control unit's CAL key to set the calibration mode.**
3. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



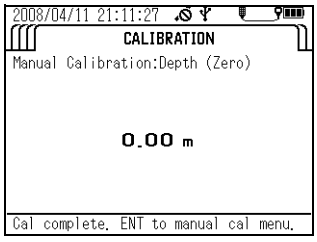
4. **In the parameter selection screen, move the cursor to "Depth", then press the ENTER key.**



5. **Press the up (△) and down (▽) keys to set the "Depth" value to 0.00 m.**
6. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**



7. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**



3.4 Measurement

You can perform measurement by either of the methods below.

- Storing data in memory manually with reference to the measurement value (single measurement)
- Having data stored in memory automatically and continuously
  U-51/U-52: Interval measurement (minimum memory interval of 10 seconds)
  U-53: Interval measurement (minimum memory interval of 30 seconds)

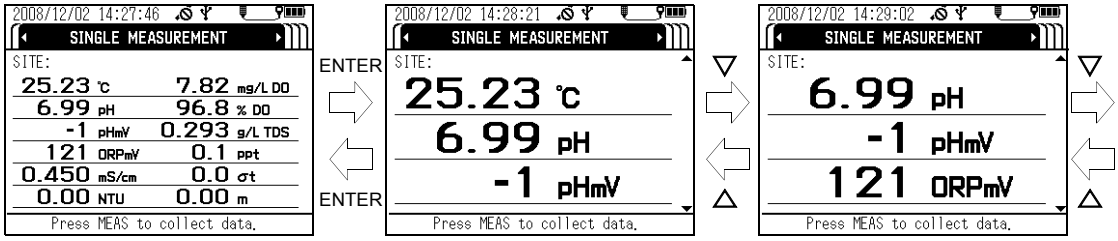
Select the measurement method that meets your requirements.

Note

- **Lower sensor probe slowly when submerging them in samples.**
- **Sensors may break if sensor probe are dropped from a height of 1 meter or more.**
- **Do not submerge sensor probe in water depths of over 30 meters. Sensor probe are only resistant to water pressure of up to 30 meters.**
- **After turning the power ON, check that the DO readout value has stabilized before starting measurement (takes around 20 minutes).**

Tip

- **When on the measurement screen, pressing the ENTER key enlarges the display and shows three measured values at a time.**
- **Pressing the up (△) and down (▽) keys scrolls through the measured values one item at a time.**
- **Pressing the ENTER key again reverts to the normal measurement screen display.**



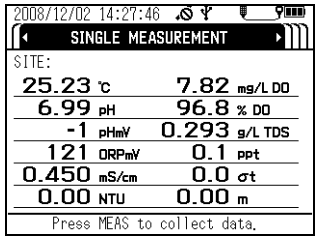
Measurement screen Normal Enlarged

3.4.1 Storing data in memory manually

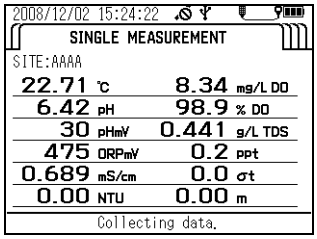
Follow the steps below to manually store data in memory while referring to the measurement value to check the readout value is stable.

● **U-51/U-52**

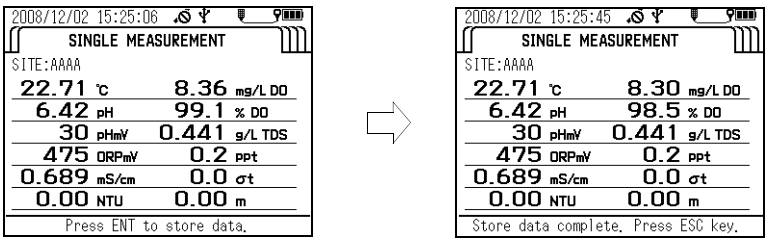
1. **Check that each sensor and sensor guard is mounted.**
2. **Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.**



3. **Submerge the sensor probe in the sample, gently shaking them in the sample to remove any air bubbles from the sensors.**
   If the sample is non-flowing, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) to ensure that fresh sample is continuously supplied to the DO sensor.
4. **When the measurement values are stable, press the MEAS key to acquire the 5-second average.**



5. **Press the ENTER key to save the held measurement values, or press the ESC key to cancel the operation.**

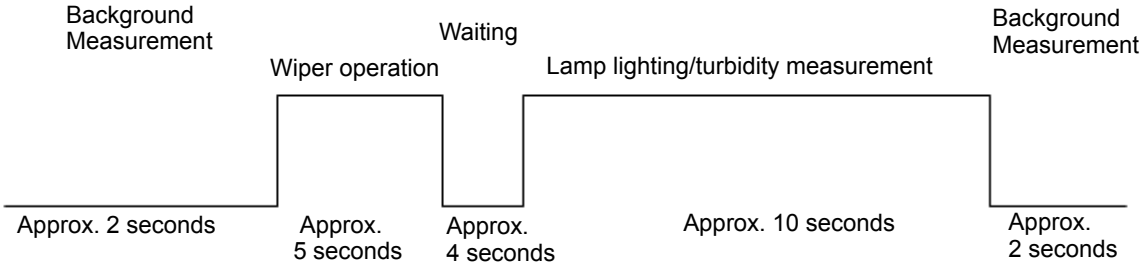


● U-53

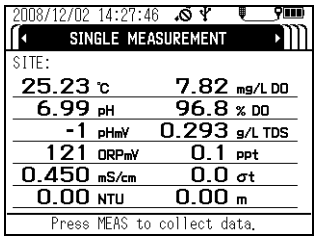
Note

Do not perform turbidity measurement in air as it may damage the wiper.

U-53 turbidity measurement follows the sequence below. The measurement values are held after each sequence.

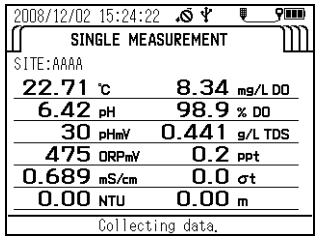


1. **Check that each sensor and sensor guard is mounted.**
2. **Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.**

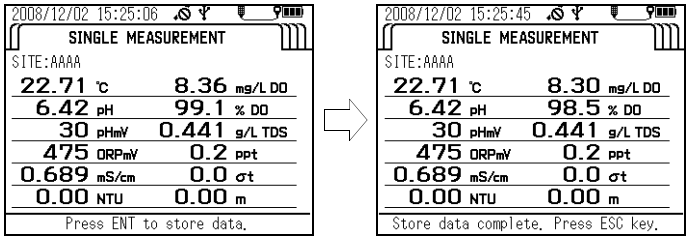


3. **Submerge the sensor probe in the sample, gently shaking them in the sample to remove any air bubbles from the sensors.**
If the sample is non-flowing, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) to ensure that fresh sample is continuously supplied to the DO sensor.

4. **When the non-turbidity meter measurement values are stable, press the MEAS key to start the sequence above.**



5. **When the sequence has finished, hold the measurement values. Press the ENTER key to store the held measurement values, or press the ESC key to cancel the operation.**



3.4.2 Automatic, continuous measurement

● Interval measurement

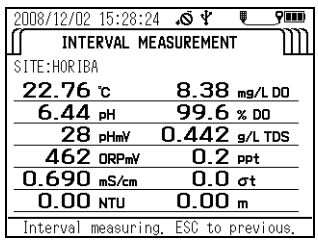
1. **Select the "Interval measurement" measurement setting (see " 3.2.1 Setting measurement methods " (page 18)).**

2. **Press the up (△) and down (▽) keys to set the interval value to the desired value (U-51/U-52: minimum interval: 10 seconds, U-53: minimum interval: 30 seconds), then press the ENTER key.**
The measurement screen appears automatically, and the system becomes ready for measurement.

3. **Check that each sensor and sensor guard is mounted.**

4. **Submerge the sensor probe in the sample, gently shaking them in the sample to remove any air bubbles from the sensors.**
If the sample is non-flowing, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) to ensure that fresh sample is continuously supplied to the DO sensor.

5. **Press the ENTER key to start measurement.**



3.5 Data operations

Use the procedures below to retrieve data stored in memory, delete all the data, check the remaining data memory capacity, and check the calibration record.

3.5.1 Displaying data

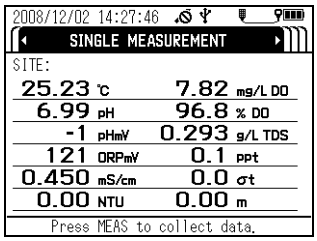
For maximum efficiency, there are 3 methods of displaying data.

- Displaying the data for a specified site
- Displaying the data for a specified date/time
- Displaying all the data

Use the method that best suits your requirements.

● **Displaying the data for a specified site**

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

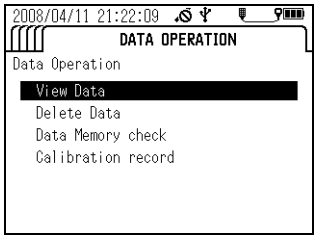


Note

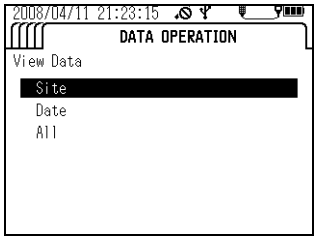
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**

3. **Press the down (▽) key to move the cursor to "View Data", then press the ENTER key.**

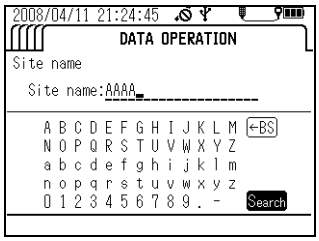


4. **Move the cursor to "Site", then press the ENTER key.**



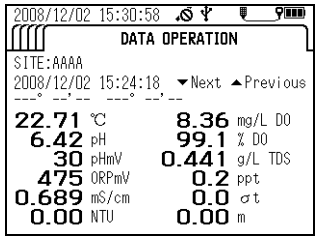
5. **Press the up (△), down (▽), left (◁) and right (▷) keys to enter the site to retrieve.**

6. **Move the cursor to "Search", then press the ENTER key.**



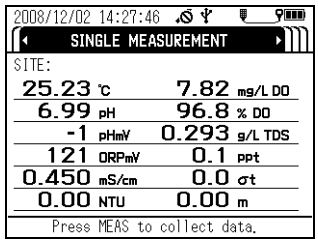
All site names that begin with the entered text are displayed.
The most recently measured data for the entered site is displayed.

7. **Press the up (△) and down (▽) keys to display earlier data.**



● Displaying the data for a specified date/time

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

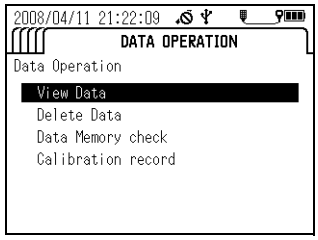


Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

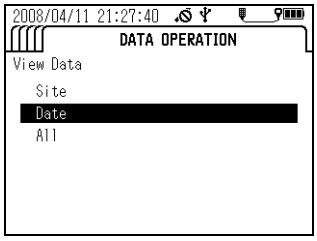
2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**

3. **Press the down (▽) key to move the cursor to "View Data", then press the ENTER key.**



4. **Move the cursor to "Date", then press the ENTER key.**

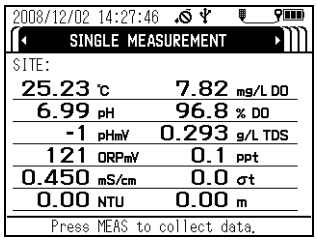
5. **With the cursor on the Date, press the ENTER key.**



6. **Press the up (△), down (▽), left (◁) and right (▷) keys to enter the desired date/ time, then press the ENTER key to apply the setting.**
7. **The cursor moves to "Search". Press the ENTER key to start the search.**
8. **Press the up (△) and down (▽) keys to display earlier data.**

● Displaying all the data

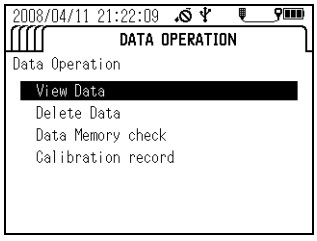
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



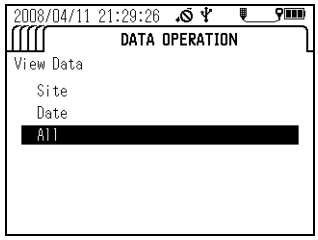
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "View Data", then press the ENTER key.**



4. **Move the cursor to "All", then press the ENTER key.**
The most recently measured data is displayed.

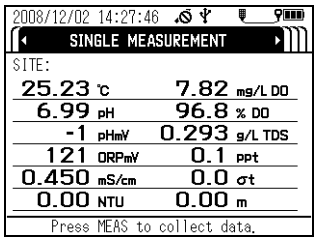


5. **Press the up (△) and down (▽) keys to display earlier data.**

3.5.2 Deleting data

Follow the steps below to delete all the data stored in memory.

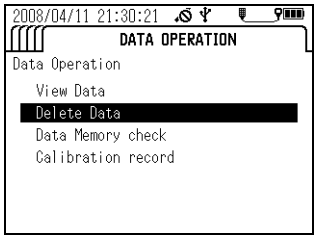
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



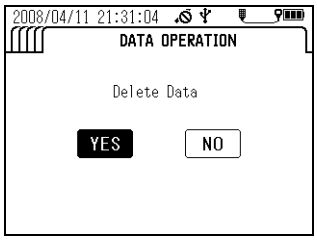
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "Delete Data", then press the ENTER key.**



4. **Press the left (◁) key to move the cursor to YES, then press the ENTER key.**
   All the data has been deleted when the indicator appears along with the message "No data exists".

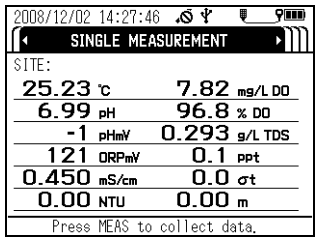


3.5.3 Checking the data memory

You can check the used data capacity and the remaining data capacity.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

The "MEASUREMENT" screen appears after about 10 seconds.

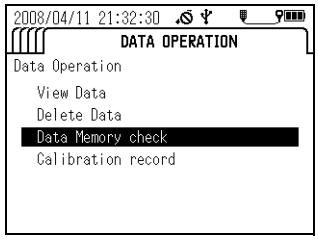


Note

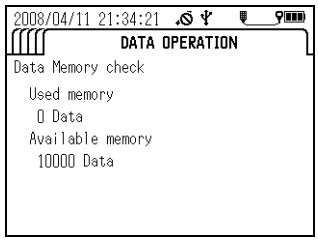
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**

3. **Press the down (▽) key to move the cursor to "Data Memory Check", then press the ENTER key.**



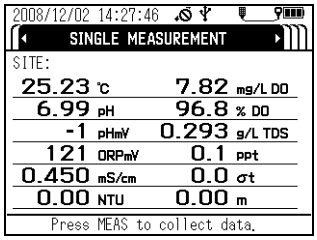
The amount of memory in use and amount of available memory are displayed.



3.5.4 Checking the calibration record

Follow the steps below to check the latest calibration history.

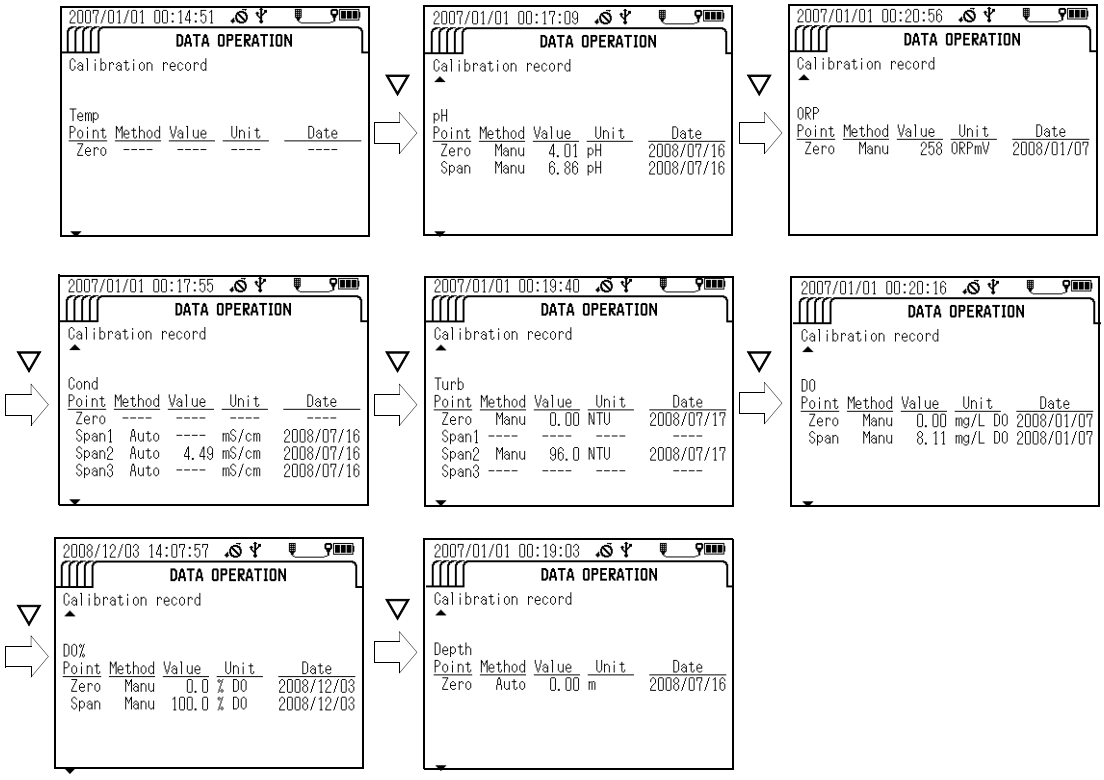
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "Calibration record", then press the ENTER key.**
   The latest calibration record is displayed.



3.5.5 GPS data operations

The menu for GPS data operations appears on the display to which the GPS unit is mounted.

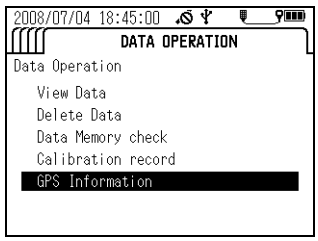
● GPS information

Follow the steps below to display acquired GPS information.

Note

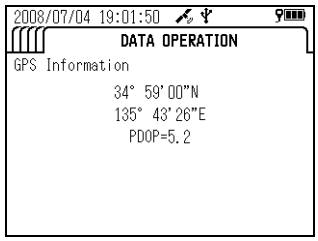
Turning the power OFF erases the GPS information.

1. **Press the right (▷) key to switch the display to the "DATA OPERATION" screen.**
2. **the down (▽) key to move the cursor to "GPS Information", then press the ENTER key.**

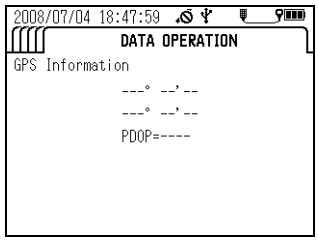


The last GPS information acquired is displayed.

● When received data exists

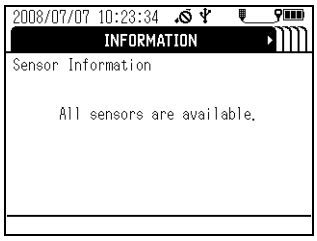


● When no received data exists

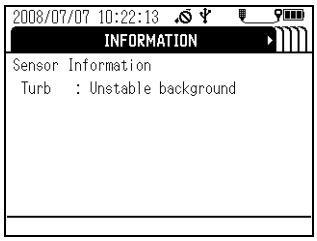


3.6 Sensor information

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.
2. **Press the left (◁) key once to display the "INFORMATION" screen.**
   The "Sensor Information" screen displays the sensor probe's status.
   ● When the sensor probe is normal, the display below appears.



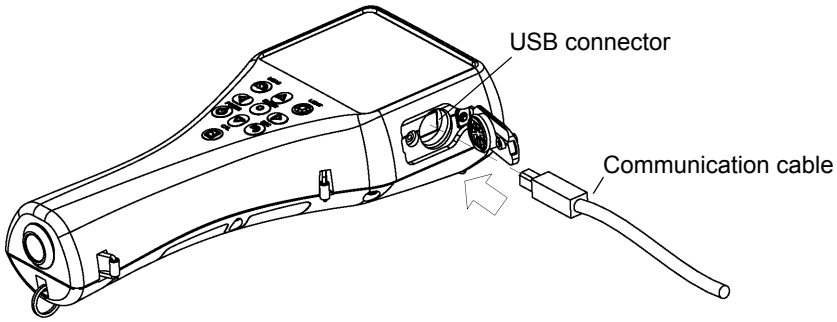
   ● When there is a sensor probe problem, individual measurement parameters generate messages such as the one shown below. Follow the troubleshooting information to remove the problem before continuing to operate the system.



3.7 USB communication

The separately-sold, dedicated PC connection cable comes with data collection software. This software allows data to be downloaded from the control unit in CSV format.
This section contains instructions for communication commands used for USB communication.

● Connecting the cable



Dedicated cable
Part name: Communication cable (with data collection software)
Part no.: 3200174823

● Cautions when using USB communication

Take care to observe the following when using USB communication.

- Use the dedicated cable (with data collection software) or a commercially-available USB cable (A-B type) to connect to a PC.
- Be sure to match the transmission format on the control unit and the computer.
  The control unit uses the following transmission format:

Baud rate:	19200 bps
Number of stop bits:	1 bit
Data bit length:	8 bits
Parity:	None
Flow control:	None

Tip

If the transmission formats do not match, a communication error occurs and USB communication will not function normally. After changing the transmission format, restart the control unit and the computer.

- If received data is not sent back or an error occurs after a data request has been sent, adjust the program configuration so that it allows a little waiting time before a data request is sent again. This will enable more stable communication.
- The unit does not use DCD, CTS, or DSR signals. Take care of this when creating programs.

3.7.1 Communication settings

Baud rate:	19200 bps
Number of stop bits:	1 bit
Data bit length:	8 bits
Parity:	None
Flow control:	None

3.7.2 Commands

● Instant data requests

● Request command format

#	RD	@	XX	[CR]	[LF]
1	2	3	4		

1	Header	1 character
2	Command	2 characters
3	Delimiter character	1 character
4	Frame check sequence (FCS)	2 characters

The two ASCII-code characters created by converting the 8 bits of data created by successively combining the value of each character from # through @ in an exclusive OR (XOR) operation with the value of the next character.

Example: #RD@

(1)	0	XOR	35	(ASCII code of # symbol)	⇒	35
(2)	35	XOR	82	(ASCII code of R)	⇒	113
(3)	113	XOR	68	(ASCII code of D)	⇒	53
(4)	53	XOR	64	(ASCII code of @ symbol)	⇒	117 (decimal) ↓ 75 (hex) ↓ Sets "75".

Example: 35 XOR 82 operation

35 in binary	⇒	0	0	1	0	0	0	1	1	
82 in binary	⇒	0	1	0	1	0	0	1	0	
XOR result		0	1	1	1	0	0	0	1	⇒ 113 (decimal)

Note: Set "XX" if you do not want to test for communication frame errors with FCS.

● Response format

#	RD	AAAAAAAAAAAAAAAAAAAA	X	X	XXXX	XX	X	X	XXXXX	X
1	2	3	4	5	6	7	8	9	10	11

XX	X	X	XXXXX	X	XX	X	X	XXXXX	X	XX	X	X	XXXXX	X
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

XX	X	X	XXXXX	X	XX	X	X	XXXXX	X	XX	X	X	XXXXX	X
27	28	29	30	31	32	33	34	35	36	37	38	39	40	41

XX	X	X	XXXXX	X	XX	X	X	XXXXX	X	XX	X	X	XXXXX	X
42	43	44	45	46	47	48	49	50	51	52	53	54	55	56

```
XX  X  X  XXXXX  X  XX  X  X  XXXXX  X  XX  X  X  XXXXX  X
57  58 59 60      61 62  63 64 65      66 67  68 69 70      71

XX XX XX XX XX XX XX XX XX X  X  XXX XX XX X  X  @  XX [CR] [LF]
72 73 74 75 76 77 78 79 80 81 82 83  84 85 86 87 88 89
```

1	Header		1 character
2	Command		2 characters
3	Site name	Upper- and lowercase letters, numbers, periods (.) hyphens (-) and spaces ( )	20 characters
4	Probe status	(3) Status code	1 character
5	Probe error	(4) Status error code	1 character
6	Unused		4 characters
7	Parameter 1 code	(1) Parameter code	2 characters
8	Parameter 1 status	(5) Parameter status code	1 character
9	Parameter 1 error	(6) Parameter error code	1 character
10	Parameter 1 data	5 characters including decimal point, right-justified with blanks filled	5 characters
11	Parameter 1 unit	(2) Unit code	1 character
12	Parameter 2 code	(1) Parameter code	2 characters
13	Parameter 2 status	(5) Parameter status code	1 character
14	Parameter 2 error	(6) Parameter error code	1 character
15	Parameter 2 data	5 characters including decimal point, right-justified with blanks filled	5 characters
16	Parameter 2 unit	(2) Unit code	1 character
17	Parameter 3 code	(1) Parameter code	2 characters
18	Parameter 3 status	(5) Parameter status code	1 character
19	Parameter 3 error	(6) Parameter error code	1 character
20	Parameter 3 data	5 characters including decimal point, right-justified with blanks filled	5 characters
21	Parameter 3 unit	(2) Unit code	1 character
22	Parameter 4 code	(1) Parameter code	2 characters
23	Parameter 4 status	(5) Parameter status code	1 character
24	Parameter 4 error	(6) Parameter error code	1 character
25	Parameter 4 data	5 characters including decimal point, right-justified with blanks filled	5 characters
26	Parameter 4 unit	(2) Unit code	1 character
27	Parameter 5 code	(1) Parameter code	2 characters
28	Parameter 5 status	(5) Parameter status code	1 character
29	Parameter 5 error	(6) Parameter error code	1 character
30	Parameter 5 data	5 characters including decimal point, right-justified with blanks filled	5 characters
31	Parameter 5 unit	(2) Unit code	1 character
32	Parameter 6 code	(1) Parameter code	2 characters
33	Parameter 6 status	(5) Parameter status code	1 character
34	Parameter 6 error	(6) Parameter error code	1 character

35	Parameter 6 data	5 characters including decimal point, right-justified with blanks filled	5 characters
36	Parameter 6 unit	(2) Unit code	1 character
37	Parameter 7 code	(1) Parameter code	2 characters
38	Parameter 7 status	(5) Parameter status code	1 character
39	Parameter 7 error	(6) Parameter error code	1 character
40	Parameter 7 data	5 characters including decimal point, right-justified with blanks filled	5 characters
41	Parameter 7 unit	(2) Unit code	1 character
42	Parameter 8 code	(1) Parameter code	2 characters
43	Parameter 8 status	(5) Parameter status code	1 character
44	Parameter 8 error	(6) Parameter error code	1 character
45	Parameter 8 data	5 characters including decimal point, right-justified with blanks filled	5 characters
46	Parameter 8 unit	(2) Unit code	1 character
47	Parameter 9 code	(1) Parameter code	2 characters
48	Parameter 9 status	(5) Parameter status code	1 character
49	Parameter 9 error	(6) Parameter error code	1 character
50	Parameter 9 data	5 characters including decimal point, right-justified with blanks filled	5 characters
51	Parameter 9 unit	(2) Unit code	1 character
52	Parameter 10 code	(1) Parameter code	2 characters
53	Parameter 10 status	(5) Parameter status code	1 character
54	Parameter 10 error	(6) Parameter error code	1 character
55	Parameter 10 data	5 characters including decimal point, right-justified with blanks filled	5 characters
56	Parameter 10 unit	(2) Unit code	1 character
57	Parameter 11 code	(1) Parameter code	2 characters
58	Parameter 11 status	(5) Parameter status code	1 character
59	Parameter 11 error	(6) Parameter error code	1 character
60	Parameter 11 data	5 characters including decimal point, right-justified with blanks filled	5 characters
61	Parameter 11 unit	(2) Unit code	1 character
62	Parameter 12 code	(1) Parameter code	2 characters
63	Parameter 12 status	(5) Parameter status code	1 character
64	Parameter 12 error	(6) Parameter error code	1 character
65	Parameter 12 data	5 characters including decimal point, right-justified with blanks filled	5 characters
66	Parameter 12 unit	(2) Unit code (6) Parameter error code	1 character
67	Parameter 13 code	(1) Parameter code	2 characters
68	Parameter 13 status	(5) Parameter status code	1 character
69	Parameter 13 error	(6) Parameter error code	1 character
70	Parameter 13 data	5 characters including decimal point, right-justified with blanks filled	5 characters
71	Parameter 13 unit	(2) Unit code	1 character
72	Year	00 to 99	2 characters

73	Month	01 to 12	2 characters
74	Day	01 to 31	2 characters
75	Hour	00 to 23	2 characters
76	Minute	00 to 59	2 characters
77	Second	00 to 59	2 characters
78	Longitude (degrees)	00 to 90 or "--" (no GPS data)	2 characters
79	Longitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
80	Longitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
81	Unused	1 character	1 character
82	North latitude/South latitude	N: North; S: South	1 character
83	Latitude (degrees)	000 to 180 or "---" (no GPS data)	3 characters
84	Latitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
85	Latitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
86	Unused		1 character
87	East longitude/West longitude	E: East; W: West	1 character
88	Delimiter character		1 character
89	Frame check sequence (FCS)		2 characters

● Memory data requests

● Request command format

#	RM	X	X	AAAAAAAAAAAAAAAAAAAA	XX	XX	XX	@	XX	[CR]	[LF]
1	2	3	4	5	6	7	8	9	10		

1	Header		1 character
2	Command		2 characters
3	Data specification[*1]	0: Start search; 1: Next data item; 2: Previous data item; 3: Request same data again	1 character
4	Search method specification	0: All data; 1: Site search; 2: Date search	1 character
5	Search site[*2]	Upper- and lowercase letters, numbers, periods (.) hyphens (-) and spaces ( )	20 characters
6	Search year[*3]	00 to 99	2 characters
7	Search month[*3]	01 to 12	2 characters
8	Search day[*3]	01 to 31	2 characters
9	Delimiter character		1 character
10	Frame check sequence (FCS)		2 characters

*1: When sending the RM command, first send 0 [Start search], then 1 [Next data item], 2 [Previous data item] or 3 [Request same data again].

*2: [Search site] is only needed when [Site search] is specified as the search method. If another search method is specified, fill this field with spaces.

*3: [Search year], [Search month] and [Search day] are only needed when [Date search] is specified as the search method. If another search method is specified, fill this field with spaces.

● **Response format**

(when data exists)

```
#    RM  AAAAAAAAAAAAAAAAAAAA   XX  X    X    XXXXX   X
1    2   3                      4   5    6    7       8

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
9   10  11  12      13  14  15  16  17      18  19  20  21  22      23

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
24  25  26  27      28  29  30  31  32      33  34  35  36  37      38

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
39  40  41  42      43  44  45  46  47      48  49  50  51  52      53

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
54  55  56  57      58  59  60  61  62      63  64  65  66  67      68

XX  XX  XX  XX  XX  XX  XX  XX  XX  X   X   XXX  XX  XX  X   X   @   XX  [CR]  [LF]
69  70  71  72  73  74  75  76  77  78  79  80   81  82  83  84  85  86
```

1	Header		1 character
2	Command		2 characters
3	Site name	Upper- and lowercase letters, numbers, periods (.) hyphens (-) and spaces ( )	20 characters
4	Parameter 1 code	(1) Parameter code	2 characters
5	Parameter 1 selection	0: No selection; 1: Selection made	1 character
6	Parameter 1 error	(6) Parameter error code	1 character
7	Parameter 1 data	5 characters including decimal point, right-justified with blanks filled	5 characters
8	Parameter 1 unit	(2) Unit code	1 character
9	Parameter 2 code	(1) Parameter code	2 characters
10	Parameter 2 selection	0: No selection; 1: Selection made	1 character
11	Parameter 2 error	(6) Parameter error code	1 character
12	Parameter 2 data	5 characters including decimal point, right-justified with blanks filled	5 characters
13	Parameter 2 unit	(2) Unit code	1 character
14	Parameter 3 code	(1) Parameter code	2 characters
15	Parameter 3 selection	0: No selection; 1: Selection made	1 character
16	Parameter 3 error	(6) Parameter error code	1 character
17	Parameter 3 data	5 characters including decimal point, right-justified with blanks filled	5 characters
18	Parameter 3 unit	(2) Unit code	1 character
19	Parameter 4 code	(1) Parameter code	2 characters
20	Parameter 4 selection	0: No selection; 1: Selection made	1 character

21	Parameter 4 error	(6) Parameter error code	1 character
22	Parameter 4 data	5 characters including decimal point, right-justified with blanks filled	5 characters
23	Parameter 4 unit	(2) Unit code	1 character
24	Parameter 5 code	(1) Parameter code	2 characters
25	Parameter 5 selection	0: No selection; 1: Selection made	1 character
26	Parameter 5 error	(6) Parameter error code	1 character
27	Parameter 5 data	5 characters including decimal point, right-justified with blanks filled	5 characters
28	Parameter 5 unit	(2) Unit code	1 character
29	Parameter 6 code	(1) Parameter code	2 characters
30	Parameter 6 selection	0: No selection; 1: Selection made	1 character
31	Parameter 6 error	(6) Parameter error code	1 character
32	Parameter 6 data	5 characters including decimal point, right-justified with blanks filled	5 characters
33	Parameter 6 unit	(2) Unit code	1 character
34	Parameter 7 code	(1) Parameter code	2 characters
35	Parameter 7 selection	0: No selection; 1: Selection made	1 character
36	Parameter 7 error	(6) Parameter error code	1 character
37	Parameter 7 data	5 characters including decimal point, right-justified with blanks filled	5 characters
38	Parameter 7 unit	(2) Unit code	1 character
39	Parameter 8 code	(1) Parameter code	2 characters
40	Parameter 8 selection	0: No selection; 1: Selection made	1 character
41	Parameter 8 error	(6) Parameter error code	1 character
42	Parameter 8 data	5 characters including decimal point, right-justified with blanks filled	5 characters
43	Parameter 8 unit	(2) Unit code	1 character
44	Parameter 9 code	(1) Parameter code	2 characters
45	Parameter 9 selection	0: No selection; 1: Selection made	1 character
46	Parameter 9 error	(6) Parameter error code	1 character
47	Parameter 9 data	5 characters including decimal point, right-justified with blanks filled	5 characters
48	Parameter 9 unit	(2) Unit code	1 character
49	Parameter 10 code	(1) Parameter code	2 characters
50	Parameter 10 selection	0: No selection; 1: Selection made	1 character
51	Parameter 10 error	(6) Parameter error code	1 character
52	Parameter 10 data	5 characters including decimal point, right-justified with blanks filled	5 characters
53	Parameter 10 unit	(2) Unit code	1 character
54	Parameter 11 code	(1) Parameter code	2 characters
55	Parameter 11 selection	0: No selection; 1: Selection made	1 character
56	Parameter 11 error	(6) Parameter error code	1 character
57	Parameter 11 data	5 characters including decimal point, right-justified with blanks filled	5 characters
58	Parameter 11 unit	(2) Unit code	1 character
59	Parameter 12 code	(1) Parameter code	2 characters

60	Parameter 12 selection	0: No selection; 1: Selection made	1 character
61	Parameter 12 error	(6) Parameter error code	1 character
62	Parameter 12 data	5 characters including decimal point, right-justified with blanks filled	5 characters
63	Parameter 12 unit	(2) Unit code	1 character
64	Parameter 13 code	(1) Parameter code	2 characters
65	Parameter 13 selection	0: No selection; 1: Selection made	1 character
66	Parameter 13 error	(6) Parameter error code	1 character
67	Parameter 13 data	5 characters including decimal point, right-justified with blanks filled	5 characters
68	Parameter 13 unit	(2) Unit code	1 character
69	Year	00 to 99	2 characters
70	Month	01 to 12	2 characters
71	Day	01 to 31	2 characters
72	Hour	00 to 23	2 characters
73	Minute	00 to 59	2 characters
74	Second	00 to 5	2 characters
75	Longitude (degrees)	00 to 90 or "--" (no GPS data)	2 characters
76	Longitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
77	Longitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
78	Unused		1 character
79	North latitude/South latitude	N: North; S: South	1 character
80	Latitude (degrees)	000 to 180 or "---" (no GPS data)	3 characters
81	Latitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
82	Latitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
83	Unused		1 character
84	East longitude/West longitude	E: East; W: West	1 character
85	Delimiter character		1 character
86	Frame check sequence (FCS)		2 characters

When no data exists, or memory is at capacity)

#	RM	@	XX	[CR]	[LF]
1	2	3	4		

1	Header	1 character
2	Command	2 characters
3	Delimiter character\	1 character
4	Frame check sequence (FCS)	2 characters

● Memory data count request

● Request command format

#	RN	@	XX	[CR]	[LF]
1	2	3	4		

1	Header	1 character
2	Command	2 characters
3	Delimiter character\	1 character
4	Frame check sequence (FCS)	2 characters

● Response format

#	RN	XXXXX	@	XX	[CR]	[LF]
1	2	3	4	5		

1	Header		1 character
2	Command		2 characters
3	Total data count	0 to 10000	5 characters
4	Delimiter character\		1 character
5	Frame check sequence (FCS)		2 characters

● Command parse failure response

#	??	X	XX	X	@	XX	[CR]	[LF]
1	2	3	4	5	6	7		

1	Header	1 character
2	Command	2 characters
3	Command parse failure reason[*4]	1 character
4	Received command[*5]	2 characters
5	(3) Status code for probe status[*5]	1 character
6	Delimiter character	1 character
7	Frame check sequence (FCS)	2 characters

*4: List of command parse failure reasons

1: Frame length error
2: FCS mismatch
3: Undefined command
4: Data error
5: Data out of range
6: No "@" delimiter character
7: No "#" header character
8: No [Carriage return] + [Line feed] footer
9: Cannot accept command in this timing.

*5: Only set for command parse failure reason 9, [Cannot accept command in this timing]. Otherwise this field is filled with spaces.

4 Maintenance

Tip

HORIBA recommends regular manufacturer maintenance checks in order to ensure a long product life.

4.1 Routine care

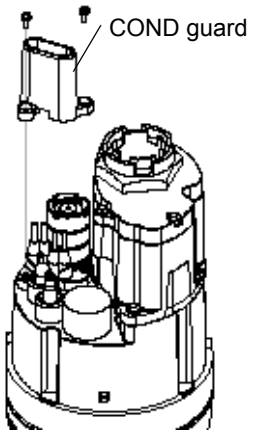
● **After measurement**

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power OFF.**

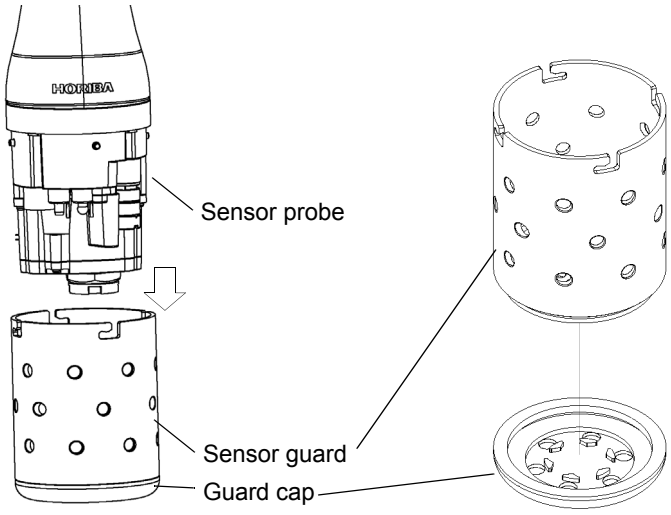
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Remove the sensor guard, and clean the sensor with tap water.**
3. **Clean the turbidity sensor with the cleaning brush provided.**
4. **Remove the two screws securing the COND guard, and the COND guard itself, and use a test tube brush to gently remove any dirt from the electrical conductivity electrode.**



5. **Wipe off any dirt with a soft cloth. If parts are very dirty, clean them with neutral detergent, then rinse them. If parts are contaminated by oil, wipe it off with a soft cloth soaked in alcohol.**
6. **Put the COND guard back in place.**
7. **Remove the sensor guard's guard cap, wash off any dirt with tap water, then put the guard cap back in place.**



4.2 Every 2 months maintenance

● Dissolved oxygen (DO) sensor

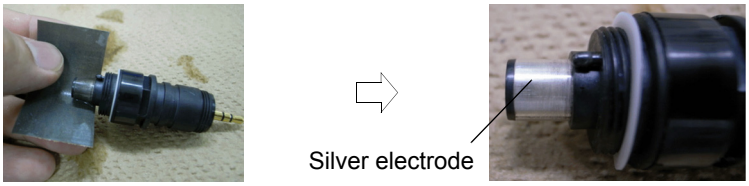
Note

- **The DO sensor's internal solution is potassium chloride (KCl). Although KCl is harmless, protective equipment such as gloves and goggles should be worn when working with it.**
- **Internal solution can be disposed of down a sink.**

- Replace the membrane cap.
- Polish the gold and silver electrodes when replacing the membrane cap.
  The gold electrode does not need to be polished if it is not dirty.

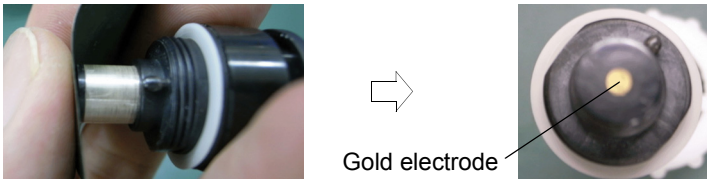
● **Silver electrode**

Polish a silver electrode part with sandpaper (#500) and then wash metal electrode parts with water.



● **Gold electrode**

Polish a gold electrode part with sandpaper (#8000) and then wash metal electrode parts with water.



Replace a membrane cap after clean metal electrodes parts.
Refer to “ 4.5 Replacing the membrane cap ” (page 87).

● **Reference electrode**

Note

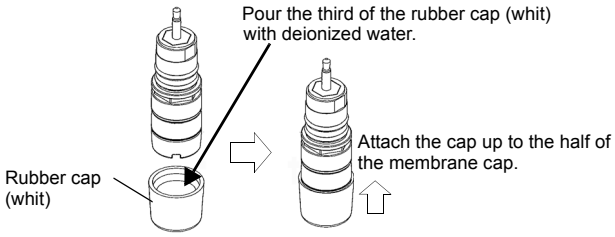
- **The pH reference internal solution is potassium chloride (KCl). Although KCl is harmless, protective equipment such as gloves and goggles should be worn when working with it.**
- **Internal solution can be disposed of down a sink.**

1. **Remove the rubber liquid junction plug from the reference electrode and dispose of the internal solution.**
2. **To prevent air entering, fill the reference electrode to the brim with its internal solution (No. 330).**
3. **Put the rubber liquid junction plug back in place.**
   If the rubber liquid junction plug is dirty, replace the liquid junctions (set of two; No. 9037005100). The reference electrode's internal solution will spill when replacing the liquid junctions. Rinse parts with tap water and dry them with a soft cloth.

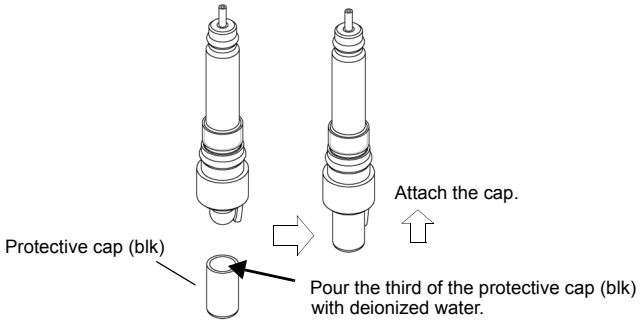
4.3 Storage

● Short-term (under 2 months) storage

- Before storing the DO sensor, pour the third of the rubber cap (whit) provided with deionized water and cover the DO sensor with them.



- Before storing the pH sensor, pour the third of the protective cap (blk) provided with deionized water and cover the pH sensor with them.



Note

Before measuerment, remove the rubber cap (whit) and the protective cap (blk).

● Long-term (2 months or more) storage

- Remove a membrane cap from DO sensor, and wash the gold electrode and silver electrode parts with water. Wipe off the moisture before storing DO sensor in the pack.
- Prevent internal solution seeping out of the reference chip by taping over the point of seepage with electrical tape.
- Before storing the system, remove the control unit's batteries to prevent battery leakage.

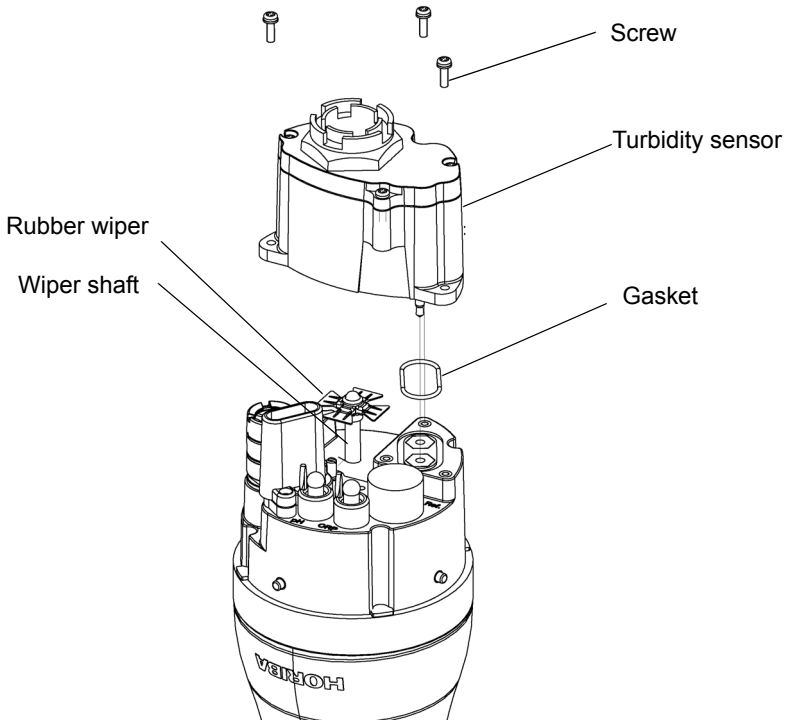
4.4 Replacing the turbidity sensor

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power OFF.**

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Remove the sensor guard, and clean the sensor probe with tap water.**
3. **Use dry air to blow away and dry off any moisture.**
4. **Remove the three screws holding the turbidity sensor by using No. 2 Phillips head screwdriver.**
5. **Pull out the turbidity sensor horizontally.**
6. **Remove the rubber wiper and gasket, and use a soft cloth to wipe off any dirt from the wiper shaft and turbidity sensor attachment. If parts are very dirty, use a soft cloth soaked in neutral detergent or alcohol.**
7. **Replace the rubber wiper and gasket with new ones. Coat the gasket with a thin layer of grease (No. 3014017718).**
8. **Attach the new turbidity sensor and fasten it in place with the three screws.**
9. **Perform four-point calibration before using the sensor.**



4.5 Replacing the membrane cap

● Replacement procedure

1. **Prepare the DO sensor.**

- Take a DO sensor out of pack (newly purchasing).
- Remove a DO sensor from the sensor probe (after use).



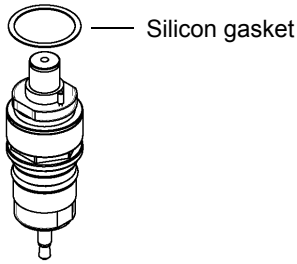
Newly purchasing



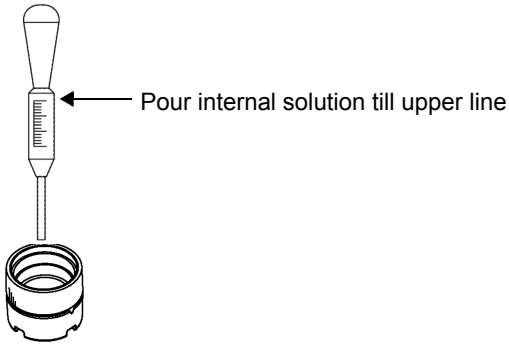
Undo a DO sensor from the sensor probe

- Twist a membrane cap from DO sensor.
- Wash the gold electrode and silver electrode parts with water.

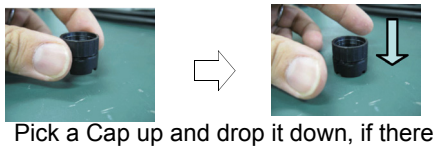
2. **Replace the silicone gasket with a new one.**



3. **Pour internal solution into a membrane cap with a dropper.**

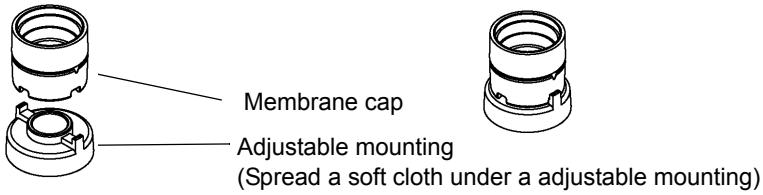


- Check air bubbles in a membrane cap.

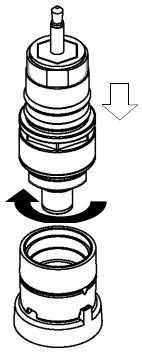


Pick a Cap up and drop it down, if there is air bubbles in internal solution of it.

4. **Set up a membrane cap on a adjustable mounting.**



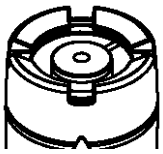
5. **Attach a membrane cap to DO sensor**



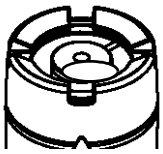
Twist a DO sensor
with holding a membrane cap tight.

6. **Check for membrane surface**

Check air bubbles in a membrane cap.



Good: Limited air bubbles



NG: Air bubbles of more than 5 mm in diameter

- NG → Replace a membrane cap again.
- Check that span calibration can be performed.

If the membrane cap is not attached correctly, sensitivity may be lost or response speed may decrease.

4.6 Troubleshooting

Note

If the sensor probe is removed while the control unit is indicating an error, errors cannot be canceled by using the ESC key. Either reconnect the sensor probe or restart the control unit.

4.6.1 Error displays

Error	Cause	Solution
Probe ADC error	Internal IC failure	Contact your nearest sales outlet to have the sensor probe repaired.
Probe EEPROM error/Factory	Internal IC failure	Turn the power OFF, then restart the system. If the error persists, initialize the system from the "System" menu. If the error still persists, contact your nearest sales outlet to have the sensor probe repaired.
Probe EEPROM error/User	Internal IC failure	Turn the power OFF, then restart the system. If the error persists, initialize the system from the "System" menu. If the error still persists, contact your nearest sales outlet to have the sensor probe repaired.
Turbidity sensor light source error	Turbidity sensor light source failure	Turn the power OFF, wipe off any water droplets on the probe, then remove the turbidity sensor. Check there are no water droplets around the turbidity sensor connector, then mount the sensor again. If the error persists, replace the turbidity sensor.
Turbidity sensor wiper motor error	The turbidity sensor wiper is not operating.	Press the ESC key. Check there are no obstacles near the wiper, then perform the measurement again. If the error persists, the motor will need to be replaced. Contact your nearest sales outlet to have the sensor probe repaired.
Probe capacitor error	Low battery voltage or internal IC failure	Turn the power OFF. Replace the display's batteries. If the error persists, contact your nearest sales outlet to have the sensor probe repaired.
Probe EEPROM error	Internal IC failure	Press the ESC key, then redo the operation. If the error persists, turn the power OFF, then restart the system (the current data will not be saved). If the error still persists, contact your nearest sales outlet to have the display repaired.
Probe board error	Probe board failure	Turn the power OFF. Contact your nearest sales outlet to have the sensor probe repaired.

Error	Cause	Solution
Zero-point calibration error	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	COND sensor 1. There is moisture on the sensor. 2. The sensor is dirty. 3. The COND sensor is broken.	COND sensor 1. Blow-dry the moisture off the sensor. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. There are air bubbles in the internal solution. 2. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the DO sensor.
	Water depth sensor 1. The water depth sensor is dirty. 2. The water depth sensor has failed.	Water depth sensor 1. Clean the water depth sensor. 2. Contact your nearest sales outlet.

Error	Cause	Solution
Span calibration error	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	ORP sensor 1. The ORP standard solution is contaminated. 2. The ORP electrode is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The ORP electrode has failed.	ORP sensor 1. Replace the standard solution with new solution. 2. Clean the ORP electrode. 3. Refil the reference electrode's internal solution. 4. Replace the ORP electrode.
	COND sensor 1. The calibration solution is not correct. 2. The sensor is dirty. 3. The COND sensor has failed.	COND sensor 1. Use the correct calibration solution for calibration. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. The diaphragm is torn. 2. There are air bubbles in the internal solution. 3. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 3. Replace the DO sensor.
	Temperature sensor The temperature sensor has failed.	Temperature sensor Contact your nearest sales outlet.
Calibration stability error	The calibration value of an individual parameter is not stable. 1. The sensor is dirty. 2. The sensor has not adjusted to the standard solution. 3. The temperature was unstable during calibration.	1. Clean the sensor. 2. Fill the transparent calibration cup with pH 4 standard solution, and wait for at least 20 minutes of conditioning before starting calibration. 3. Start calibration after the temperature has stabilized.
Turbidity calibration error	Error in turbidity measurement sequence	Turbidity calibration failed. Redo calibration after removing the displayed error.
Wet check	The cable connector is submerged.	Turn the power OFF and disconnect the cable connector. Wipe or blow-dry off all the water droplets on the probe. If the error persists, contact your nearest sales outlet to have the display and sensor probe repaired.
Power voltage error	The display's power board has failed.	This error could also be caused by poor cable contact. Turn the power OFF and disconnect the cable connector. Reconnect the connector and turn the power ON. If the error persists, contact your nearest sales outlet to have the display and sensor probe repaired.
Turbidity lamp power voltage error	The remaining battery level is low.	Turn the power OFF and replace the display's batteries with new ones.

Error	Cause	Solution
Display RTC error	The time display is incorrect.	Replace the coin battery.
Display FROM error	Internal IC failure	Contact your nearest sales outlet to have the control unit repaired.
Display EEPROM error	Internal IC failure	Contact your nearest sales outlet to have the control unit repaired.
Display save error	Insufficient memory space	Move data from the display, use the data operations screen to delete data, then redo the measurement.
Measurement sequence error	● When the measurement item is turbidity 1. The battery power is low. 2. The wiper is not operating normally. 3. The light source lamp is not lit. ● If items other than turbidity are also displayed 4. Board failure	1. Replace the batteries with new ones. 2. Check there are no obstacles near the wiper, then redo the measurement. If the error persists, the motor will need to be replaced. Contact your nearest sales outlet to have the sensor probe repaired. 3. Wipe off any water droplets on the probe, then remove the turbidity sensor. Check there are no water droplets around the turbidity sensor connector, then mount the sensor again. If the error persists, replace the turbidity sensor. 4. Contact your nearest sales outlet to have the sensor probe repaired.
Out of measurement range	The attempted measurement is outside the measurement range supported for that item.	The system must be used within its supported measurement ranges.
Last zero-point calibration invalid	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	COND sensor 1. There is moisture on the sensor. 2. The sensor is dirty. 3. The COND sensor has failed.	COND sensor 1. Blow-dry the moisture off the sensor. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. There are air bubbles in the internal solution. 2. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the DO sensor.
	Water depth sensor 1. The water depth sensor is dirty. 2. The water depth sensor has failed.	Water depth sensor 1. Clean the water depth sensor. 2. Contact your nearest sales outlet.
Out of measurement range	[See above.]	[See above.]
Last zero-point calibration invalid		

Error	Cause	Solution
Last span calibration invalid	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	ORP sensor 1. The ORP standard solution is contaminated. 2. The ORP electrode is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The ORP sensor glass is broken.	ORP sensor 1. Replace the standard solution with new solution. 2. Clean the ORP electrode. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	COND sensor 1. The calibration solution is not correct. 2. The sensor is dirty. 3. The COND sensor has failed.	COND sensor 1. Use the correct calibration solution for calibration. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. The diaphragm is torn. 2. There are air bubbles in the internal solution. 3. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 3. Replace the DO sensor.
	Temperature sensor ● The temperature sensor has failed.	Temperature sensor ● Contact your nearest sales outlet.
Out of measurement range Last zero-point calibration invalid	[See above.]	[See above.]
Last span calibration invalid	The calibration value of an individual parameter is not stable. 1. The sensor is dirty. 2. The sensor has not adjusted to the standard solution. 3. The temperature was unstable during calibration.	1. Clean the sensors. 2. Fill the transparent calibration cup with pH 4 standard solution, and wait for at least 20 minutes of conditioning before starting calibration. 3. Start calibration after the temperature has stabilized.
Out of measurement range Last zero-point calibration invalid	[See above.]	[See above.]
Calibration value is factory default value.	Internal IC failure	Turn the power OFF, then restart the system. If the error persists, initialize the system from the "System" menu. If the error still persists, contact your nearest sales outlet to have the sensor probe repaired.

Error	Cause	Solution
Sample is unstable.	1. The concentration of the sample is unstable. 2. External light disturbance has affected the sensor. 3. Water has entered the turbidity sensor's connector.	1. Use a stirrer to agitate the sample during measurement. 2. Perform measurement away from direct sunlight. 3. Turn the power OFF, wipe off any water droplets on the probe, then remove the turbidity sensor. Check there are no water droplets around the turbidity sensor connector, then mount the sensor again. If the error persists, replace the turbidity sensor.

4.6.2 Error displays in sensor information

Error display	Cause	Solution
Measurement sequence error	Measurement sequence error	Turn the power OFF, then restart the system. If the error persists, have the probe repaired.
Out of measurement range	The measurement value is outside the measurement range.	Samples for measurement must be within the measurement range.
Last calibration invalid	The last calibration failed.	Redo calibration.
Calibration invalid	The calibration value is the factory default value.	Redo calibration.
Background unstable	The U-53 turbidity sensor is exposed to direct light.	Mount the guard cap and sensor guard and perform measurement away from direct sunlight.
	The turbidity value changed rapidly during measurement.	Measure a sample that has stable turbidity.

5 Specifications

Specification		Basic value	Model				
			U-51	U-52	U-52G	U-53	U-53G
Sensor probe	Measurement temperature range	−10°C to 55°C	✓	✓	✓	✓	✓
	Maximum sensor outer diameter	Approx. 96 mm					
	Sensor length	Approx. 340 mm					
	Cable length	2 m (standard) 10 m/30 m (options)					
	Mass	Approx. 1800 g					
	Auto calibration function	Uses pH 4 standard solution.					
	Measurement depth	30 m max.	✓	✓	✓	✓	✓
	Wet-part materials*3	PPS, glass, SUS316L, SUS304, FKM, PEEK, Q, titanium, FEP membrane, POM					
	Waterproofing standard	IP-68					
Control unit	Outer dimensions (W × D × H)	115 × 66 × 283 mm	✓	✓	—	✓	—
		115 × 66 × 335 mm	—	—	✓	—	✓
	Mass	Approx. 800 g	✓	✓	✓	✓	✓
	LCD	320 × 240 mm graphic LCD (monochrome) with backlight	✓	✓	✓	✓	✓
	Memory data items	10000	✓	✓	✓	✓	✓
	Communication interface	USB peripheral	✓	✓	✓	✓	✓
	Batteries	C-size dry cells (×4)	✓	✓	✓	✓	✓
	Waterproofing standard	IP-67	✓	✓	✓	✓	✓
	GPS unit	● Reception method (12 channel parallel) ● Measurement precision [With PDOP (high precision): 30 m or less (2 drms)]	—	—	✓	—	✓
	Estimated battery life*1	—	70 hours (no backlight)			500 measurements (no backlight)	
	Storage temperature range	−10°C to 60°C	✓	✓	✓	✓	✓
	Ambient temperature range	−5°C to 45°C					

Specification		Basic value	Model				
			U-51	U-52	U-52G	U-53	U-53G
pH measurement Two calibration	Measurement method	Glass electrode method	✓	✓	✓	✓	✓
	Range	pH 0 to 14					
	Resolution	0.01 pH					
	Precision*2	±0.1 pH					
Dissolved oxygen measurement ● Salinity conversion (0 to 70 PPT, automatic) ● Automatic temperature compensation	Measurement method	Polarographic method	✓	✓	✓	✓	✓
	Film thickness	25 μm					
	Range	0 mg/L to 50.0 mg/L					
	Resolution	0.01 mg/L					
	Precision*2	0 mg/L to 20 mg/L: ±0.2 mg/L 20 mg/L to 50 mg/L: ±0.5 mg/L					
Electrical conductivity measurement ● Auto range ● Automatic temperature conversion (25°C)	Measurement method	Four-AC-electrode method	✓	✓	✓	✓	✓
	Range	0 S/m to 10 S/m (0 mS/cm to 100 mS/cm)					
	Resolution	0.000 mS/cm to 0.999 mS/cm: 0.001 1.00 mS/cm to 9.99 mS/cm: 0.01 10.0 mS/cm to 99.9 mS/cm: 0.1 0.0 mS/m to 99.9 mS/m: 0.1 0.100 S/m to 0.999 S/m: 0.001 1.00 S/m to 9.99 S/m: 0.01					
	Precision*2	1% of full-scale (midpoint of two calibration points)					
Salinity measurement	Measurement method	Electrical conductivity conversion	✓	✓	✓	✓	✓
	Range	0 PPT to 70 PPT (parts per thousand)					
	Resolution	0.1 PPT					
	Precision	±3 PPT					
TDS (total dissolved solid) measurement ● Conversion coefficient setting	Measurement method	Electrical conductivity conversion	✓	✓	✓	✓	✓
	Range	0 g/L to 100 g/L					
	Resolution	0.1% of full-scale					
	Repeatability	±2 g/L					
	Precision	±5 g/L					
Seawater specific gravity measurement ● σt, σ0, σ15 display	Measurement method	Electrical conductivity conversion	✓	✓	✓	✓	✓
	Range	0 σt to 50 σt					
	Resolution	0.1 σt					
	Precision	±5 σt					

Specification		Basic value	Model				
			U-51	U-52	U-52G	U-53	U-53G
Temperature measurement	Measurement method	Platinum temperature sensor	✓	✓	✓	✓	✓
	Range	−10°C to 55°C					
	Resolution	0.01°C					
	Sensor	Platinum temperature sensor, JIS Class B (0.3 + 0.005 |t|)					
Turbidity measurement	Measurement method		—	LED forward 30° transmission/ scattering method		Tungsten lamp 90° transmission scattering method	
	Range			0 NTU to 800 NTU		0 NTU to 1000 NTU	
	Resolution			0.1 NTU		0.01 NTU	
	Precision*2			±5%of readout or ±1 NTU, whichever is larger		● ±0.5NTU (for 0 NTU to 10 NTU measurement range) ● 3% of readout or 1 NTU, whichever is larger (for 10 NTU to 1000 NTU measurement range)	
	Turbidity sensor wiper			—		✓	
Water depth measurement	Measurement method	Pressure method	—	—	✓	✓	✓
	Range	0 m to 30 m					
	Resolution	0.05 m					
	Precision*2	±0.3 m					
ORP (oxidation reduction potential) measurement	Measurement method	Platinum electrode method	✓	✓	✓	✓	✓
	Range	−2000 ～ +2000 mV					
	Resolution	1 mV					
	Precision*2	±15 mV					

*1: Battery life is estimated under following conditions.
- Continuous operation
- Using batteries: C-size alkaline dry cells
- Ambient temperature of the control unit: 20°C or more
- Backlight off

*2: The precision is defined by measuring the standard solution in the following cases.
- Turbidity and conductivity: after four point calibration
- pH and DO: after two point calibration
- Water depth and ORP: after one point calibration

*3: Metallic parts are made of stainless steel. Immersing in seawater may erode metallic parts.

6 Reference

6.1 Consumable parts

● Sensor

Name	Model	No.	Description
pH sensor	#7112	3014057312	Standard type pH sensor
pH sensor ToupH	#7113	3200170923	Tough glass type pH sensor
ORP sensor	#7313	3200170920	
DO sensor	#7543	3200170924	
Reference electrode	#7210	3200043582	
R bush unit	—	3200043587	Reference electrode liquid junction
TURB cell U-52	#7800	3200172803	For U-52/U-52G
TURB cell U-53	#7801	3200172800	For U-53/U-53G
Membrane cap	—	3200170194	For DO sensor

● Standard solution and inner solution

Name	Model	No.	Description
pH 4 (For automatic calibration) 500 mL	#100-4	3200043638	Standard solution for auto calibration. Also used for manual pH span calibration.
pH 4 (For automatic calibration) 4 L	#140-4	3200174430	
pH 7 500 mL	#100-7	3200043637	Standard solution for pH zero-point calibration.
pH 9 500 mL	#100-9	3200043636	Standard solution for pH manual span calibration.
Powder for ORP standard solution 10 packs	#160-51	3200043618	For ORP calibration.
Powder for ORP standard solution 10 packs	#160-22	3200043617	
Inner solution for DO sensor, 50 mL	#306	3200170938	Internal solution for DO sensor.
Internal solution for pH, 250 mL	#330	3200043641	Supplementary internal solution for pH reference electrode.

● Others

Name	Model	No.	Description
Silicone grease	—	3014017718	Silicone grease for coating sensor O-ring.
Sponge brush unit	—	3200169531	Brush for cleaning sensor probe.
O-ring set for reference electrode	—	3200169376	O-rings for reference electrode.
O-ring set for DO sensor	—	3200169426	O-rings for DO sensor.
Rubber cap set for sensor guard	—	3200169428	Rubber caps used between sensor guard and sensor probe.
O-ring set for pH and ORP sensor	—	3200169520	O-rings for pH and ORP sensors.
Wiper unit	—	3200169789	Rubber wiper for U-53/U-53G turbidity sensors.
Protective cap (blk) for pH sensor	—	3200175019	Cap attached to tip of pH sensor for sensor probe storage.
Rubber cap (whit) for DO sensor	—	3200175020	Cap attached to tip of DO sensor for sensor probe storage.

6.2 Options sold separately

Name	Model	No.	Description
Bag	U-5030	3200174772	Storage bag for sensor probes and flow cell. Can be carried in one hand.
Flow cell assy	—	3200156570	Used when collecting measurement samples by pump.
Probe guard	—	3200167002	Used for taking measurements in locations where there is a current or where there is a thick layer of sludge.
Communication cable	—	3200174823	A PC connection cable. Comes with data collection software.

6.3 pH measurement

6.3.1 Principle of pH measurement

U-50 series use the glass electrode method for pH measurements. The glass electrode method measures a potential difference between the glass film for pH and the reference electrode. For more information, refer to “JIS Z 8802 pH measurement method”.

6.3.2 Temperature compensation

The electromotive force generated by the glass electrode changes depending on the temperature of the solution.

Temperature compensation is used to compensate for the change in electromotive force caused by temperature.

This function does not compensate the change in pH caused by the temperature of the solution. When pH is to be measured, the temperature of the solution must be recorded along with that pH value, even if a pH meter has automatic temperature compensation function. If the solution temperature is not recorded, the results of the pH measurement may be meaningless.

6.3.3 Standard solutions

When measuring pH, the pH meter must be calibrated using standard solution. There are five kinds of standard solutions specified in “JIS Z 8802 pH measurement”. For normal measurement, two of standard solutions with pH of 4, 7, and 9 are sufficient to accurately calibrate the meter.

For standard solutions, refer to “JIS Z 8802 pH measurement”.

pH 4 standard solution: (Phthalate)	0.05 mol/L potassium hydrogen phthalate aqueous solution
pH 7 standard solutio: (Neutral phosphate)	0.025 mol/L potassium dihydrogenphosphate, 0.025 mol/L disodium hydrogenphosphate aqueous solution
pH 9 standard solution: (Borate)	0.01 mol/L sodium tetraborate aqueous solution

Table 2 pH values of pH standard solutions at various temperatures settings

Temp. (℃)	pH 4 standard solution Phthalate	pH 7 standard solution Neutral phosphate	pH 9 standard solution Borate
0	4.01	6.98	9.46
5	4.01	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14
35	4.02	6.84	9.10
40	4.03	6.84	9.07
45	4.04	6.84	9.04

6.4 DO measurement

6.4.1 Principle of DO measurement

Dissolved oxygen (DO) refers to the amount of oxygen that is contained in water.
The concentration of dissolved oxygen is generally given as mg/L or as a percentage value (the dissolved oxygen saturation ratio).
Dissolved oxygen is essential for maintaining the self-purifying ability of rivers and seas and also for fish to live. The concentration of dissolved oxygen acts as an indicator of water quality. It is often measured when processing waste water and managing water quality. Fig. 1 provides an overview of the principles behind dissolved oxygen sensor measurement.

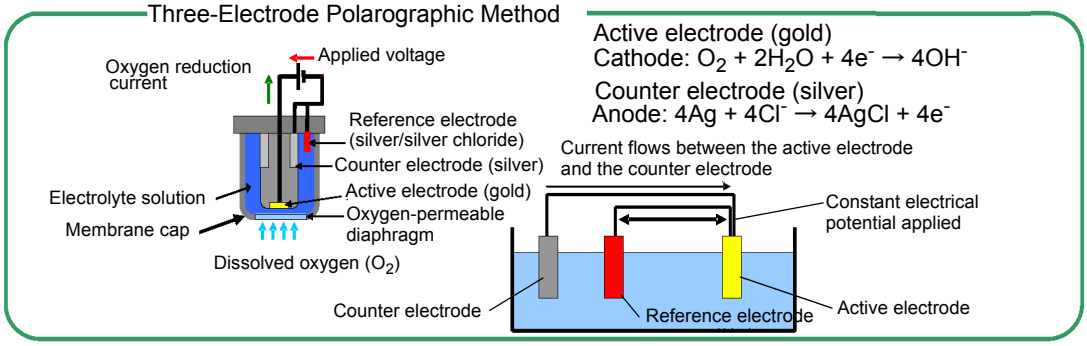


Fig. 1 Overview of principles behind dissolved oxygen sensor

The polarographic oxygen sensor is an enclosed sensor wherein voltage is applied to a cathode made of a precious metal (such as gold or platinum) and an anode also made of a precious metal (such as silver) via an external circuit, and a cap with an oxygen permeable diaphragm (membrane) is filled with electrolyte solution. As indicated in Fig. 1, the concentration of dissolved oxygen can be measured by measuring the current proportional to the amount of reduced oxygen when oxygen that has dispersed through the oxygen permeable diaphragm produces a reductive reaction on the surface of the active electrode (gold). The method of measuring dissolved oxygen based on the above principle is called the Membrane Electrode Method. Compared to the Chemical Analysis Method, which requires complicated pre-processing to alleviate the effect of reduced materials and oxidizing materials, this method allows dissolved oxygen to be measured very easily. It is also easy to remove undesired buildup from the silver electrode by polishing and cleaning if an insulator forms on it due to oxidation, making the method reusable.

6.4.2 Salinity calibration

When the solution and air come into contact and form an equilibrium (i.e. saturation), the relationship between the concentration of dissolved oxygen in the solution, C, [mol/L], and the partial pressure of oxygen in the air, Ps, [MPa/(mg/L)], can be represented by the following formula:

$$C = Ps/H$$

Where H [MPa/(mg/L)] is the Henry constant, a value that changes according to the composition of the solution. As H typically becomes larger as the salinity of the water increases, C becomes smaller.

The DO sensor detects the partial pressure of oxygen (Ps) in the above formula. Accordingly, if the DO sensor is immersed in deionized water saturated with air, or in an aqueous solution containing salt, the output current does not change, resulting in an erroneous measurement. For example, when salt is added to a sample, the amount of oxygen that can be dissolved in the solution decreases, but because the partial pressure of oxygen does not change, the value displayed by the control unit stays the same regardless of salt content. This concept is indicated in graph form below. (Fig. 2)

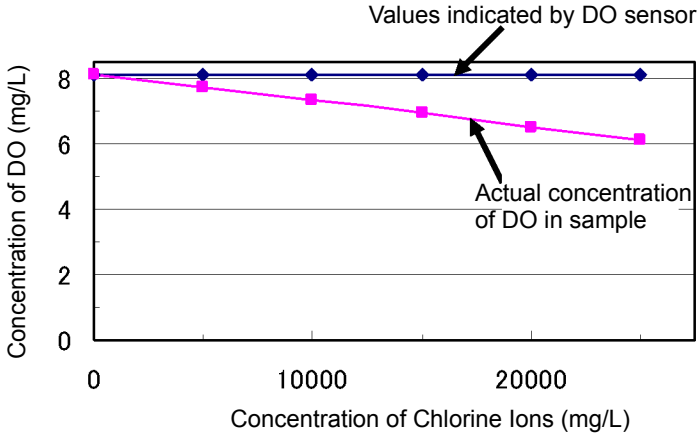


Fig. 2 Relationship between chlorine ion concentration and dissolved oxygen concentration

In samples with a high salt concentration, the solubility of oxygen is lower, but as the partial pressure of oxygen does not change, the value actually indicated on the control unit is higher than the actual value. In order to obtain a measurement of the concentration of dissolved oxygen in an aqueous solution that contains salt, it is therefore necessary to first perform salinity compensation. Conventionally, dissolved oxygen sensors have performed salinity compensation by inputting the salinity of the sample. This is fine as long as the salinity is already known. However, in most cases salinity is unknown, so even if dissolved oxygen sensors contained a salinity compensation function, it was of no practical use.

The U-50 Series can calculate and measure salinity in samples from electrical conductivity values, and can thus be used to automatically compensate for salinity.

6.5 Conductivity (COND) measurement

6.5.1 Four-AC-electrode method

Conductivity is an index of the flow of electrical current in a substance.

Salts dissolved in water are separated into cations and anions. Such solution is called electrolytic solution.

Electrolytic solution has the property of allowing the flow of current according to Ohm's law. This property is referred

to as ionic conductivity, since current flow is caused by ion movement in electrolytic solution.

Metals, on the other hand, allow the flow of current by means of electrons. This property is called electronic conductivity,

which is distinguished from ionic conductivity.

A cube with 1 m on each side, as shown in Fig. 3, is used to demonstrate an electrolytic solution. Two electrode plates are placed on opposite sides, and the cube is filled with solution. If the resistance between these two electrode plates is represented by r(Ω), the conductivity of the solution L($S \cdot m^{-1}$) is represented as L=1/r. S stands for Siemens, a unit of measurement of conductance.

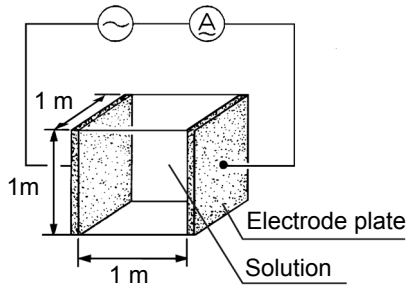


Fig. 3 Definition of conductivity

The most general method for measuring conductivity is based on the above principle, and is called the 2-electrode method.

In the 2-electrode method the influence of polarization cannot be ignored for solutions with high conductivity and conductivity cannot be measure accurately. In addition, contamination on the surface of the electrode increases apparent resistance, resulting in inaccurate measurement of conductivity.

The U-50 series has adopted the 4-electrode method to overcome these disadvantages of the the 2-electrode method.

As shown in Fig. 4, the U-50 series uses two voltage-detecting electrodes and two voltage-applying electrodes, for a total of four electrodes. The voltage-detecting electrodes are for detecting AC voltage, and the voltage-applying electrodes are for applying AC voltage.

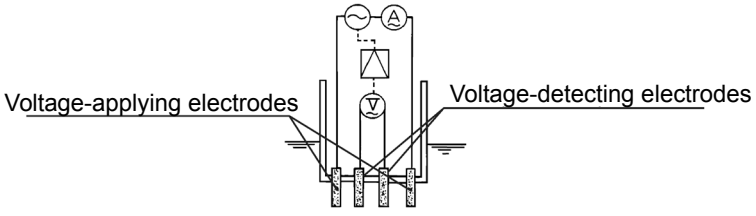


Fig. 4 Principle of the 4-electrode method

Let us assume that the current, I(A), flows in a sample of conductivity L – under automatic control of the voltage-applying electrodes – so that the voltage at the voltage-detecting-electrodes, E(V), remains constant at all times.
Then, the resistance of the sample, R(Ω), across the voltage-detecting electrodes is represented as R=E/I. The resistance, R, of the sample is inversely proportional to its conductivity, L. Accordingly, a measurement of current, Is,
of a standard solution of known conductivity, Ls, enables calculation of conductivity of a sample according to the formula L = Ls (I/Is) from the ratio L : Ls = I : Is.
Even in the 4-electrode method, polarization occurs, since AC current flows in the voltage-applying electrodes. The voltage-detecting electrodes are, however, free from the effects of polarization, since they are separated from the voltage-applying electrodes, and furthermore, current flow is negligible. Therefore, the 4-electrode method is an excellent method to enable measurement of conductivity covering a very high range.

6.5.2 SI units

New measurement units, called SI units, have been in use from 1996. Accordingly, the U-50 series also uses SI units. The following conversion table is provided for people who use the conventional kind of conductivity meter.
Note that along with the change in unit systems, the measurement values and cell counts have also changed.

	Former units	→	SI unit
Measurement value	0.1 mS/cm	→	0.01 S/m
	1 mS/cm	→	0.1 S/m
	100 mS/cm	→	10 S/m

6.5.3 Temperature coefficient

In general, the conductivity of a solution varies largely with its temperature.
The conductivity of a solution depends on the ionic conductivity, described earlier. As the temperature rises, conductivity becomes higher since the movement of the ions becomes more active.
The temperature coefficient shows the change in % of conductivity per °C, with a certain temperature taken as the reference temperature. This is expressed in units of %/°C. The temperature coefficient assumes the premise that the conductivity of a sample changes linearly according to temperature.
Strictly speaking, with actual samples, however, conductivity changes along a curve. Furthermore, the cuve varies with the type of sample. In the ranges of smaller temperature changes, however, samples are said to have the temperature coefficient of 2%/°C (at reference temperature 25°C); this holds for most samples, except in certain special cases.
(The temperature coefficients for various types of solutions are listed on the next page.)
The U-50 series uses an automatic temperature conversion function to calculate conductivity at 25°C at a temperature
coefficient of 2 %/°C based on the measured value of the temperature. Results are displayed on the readout.
The U-50 series's temperature conversion function is based on the following formula.
$L_{25} = L_t / \{ 1 + K (t - 25) \}$
L_{25} : Conductivity of solution converted to 25°C
t : Temperature of solution at time of measurement (°C)
L_t : Conductivity of solution at t (°C)
K : Temperature coefficient (%/°C)

● Conductivity and temperature coefficient for various solutions

Conductivity and related temperature coefficients of representative substances (at 25°C) are shown in the table below.

Substance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp.coef. (%/°C)	Substance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp.coef. (%/°C)
NaOH	15	5	19.69	2.01	NaCl	18	5	6.72	2.17
		10	31.24	2.17			10	12.11	2.14
		15	34.63	2.49			15	16.42	2.12
		20	32.70	2.99			20	19.57	2.16
		30	20.22	4.50			25	21.35	2.27
		40	11.64	6.48	Na_2SO_4	18	5	4.09	2.36
KOH	15	25.2	54.03	2.09			10	6.87	2.49
		29.4	54.34	2.21			15	8.86	2.56
		33.6	52.21	2.36	Na_2CO_3	18	5	4.56	2.52
		42	42.12	2.83			10	7.05	2.71
NH_3	15	0.1	0.0251	2.46			15	8.36	2.94
		1.6	0.0867	2.38	KCl	18	5	6.90	2.01
		4.01	0.1095	2.50			10	13.59	1.88
		8.03	0.1038	2.62			15	20.20	1.79
		16.15	0.0632	3.01			20	26.77	1.68
HF	18	1.5	1.98	7.20			21	28.10	1.66
		4.8	5.93	6.66	KBr	15	5	4.65	2.06
		24.5	28.32	5.83			10	9.28	1.94
HCl	18	5	39.48	1.58			20	19.07	1.77
		10	63.02	1.56	KCN	15	3.25	5.07	2.07
		20	76.15	1.54			6.5	10.26	1.93
		30	66.20	1.52			—	—	—
H_2S0_4	18	5	20.85	1.21	NH_4Cl	18	5	9.18	1.98
		10	39.15	1.28			10	17.76	1.86
		20	65.27	1.45			15	25.86	1.71
		40	68.00	1.78			20	33.65	1.61
		50	54.05	1.93			25	40.25	1.54
		60	37.26	2.13	NH_4NO_3	15	5	5.90	2.03
		80	11.05	3.49			10	11.17	1.94
		100.14	1.87	0.30			30	28.41	1.68
		—	—	—			50	36.22	1.56
HNO_3	18	6.2	31.23	1.47	$CuSO_4$	18	2.5	10.90	2.13
		12.4	54.18	1.42			5	18.90	2.16
		31	78.19	1.39			10	32.00	2.18
		49.6	63.41	1.57			15	42.10	2.31
		62	49.64	1.57	CH_3COOH	18	10	15.26	1.69
H_3PO_4	15	10	5.66	1.04			15	16.19	1.74
		20	11.29	1.14			20	16.05	1.79
		40	20.70	1.50			30	14.01	1.86
		45	20.87	1.61			40	10.81	1.96
		50	20.73	1.74			60	4.56	2.06

6.6 Salinity (SAL) conversion

The U-50 series is designed to calculate salinity as well as the other parameters.
Note that the “salinity” here is the salinity of sea water. There is a constant relation between conductivity and salinity at certain temperatures.
Therefore, if data on the conductivity and temperature are available, the corresponding salinity can be known. In other words, the salinity measurement of the U-50 series is based on the principle of calculating the salt content, making use of the measured values of conductivity and temperature.
Note therefore, that measured results of all substances whose conductivity is detected are displayed as salinity. For example, the measured result is displayed as NaCl concentration, even if in fact the sample component is, hydrochloric acid (HCl).

6.7 TDS conversion

TDS is short for Total Dissolved Solids and means the total dissolved solid amount.
The conductivity of a solution is affected by the amount of salinity, minerals, and dissolved gases. That is, conductivity is an index that shows the total amount of all substances in the solution. Of these substances, TDS indicates only the amount of dissolved solids.
TDS can be used for a comparison of the state of substances composed of a single component such as NaCl. However, the use of TDS for the comparison of solutions of different types causes serious errors.
Conductivity and TDS are expressed by the following formulas.
Conductivity in SI units (S/m) ..... TDS(g/L) = L (S/m) $\times$ K $\times$ 10
TDS(g/L) = L (mS/m) $\times$ K $\div$ 100
Conductivity in the old units (mS/cm) ..... TDS(g/L) = L (mS/cm)$\times$ K
K = TDS coefficient
Initial settings use the values listed in the table (Page 80) that generally uses TDS coefficients.
For accurate TDS comparisons, find the TDS coefficient from measured conductivity values. Then set the value thus obtained and make measurements.

6.8 σt conversion

- **Specific gravity of seawater**

The density and specific gravity of seawater are equal numerically and generally are not distinguished strictly. Since seawater density ρ is between 1.000 and 1.031, 1 is subtracted from ρ and σ is obtained by multiplying the value by 1000.
The resultant value is used as the specific gravity of seawater.
$\sigma = (\rho - 1) \times 1000$
The density of seawater ρ is expressed by function of temperature, hydraulic pressure, and salinity. The density of seawater under the atmospheric pressure is expressed as σ_t. The density of seawater under the atmospheric pressure is determined by temperature and salinity.
The U-50 Series models make salinity measurement through temperature measurements and conductivity conversion and find σ_t through calculations.
In Japan σ_{15} at 15°C is called a standard specific gravity and widely used while in foreign countries σ_0 at 0°C is employed. σ_{15} and σ_0 are determined by the function of salinity.
In ocean surveys, in particular, these values σ_t, σ_{15}, and σ_0 are more widely used than conductivity and salinity and, in the U-50 Series models, newly added as measurement components.

6.9 Turbidity (TURB) measurement

6.9.1 Principle of turbidity measurement

U-52 and U-53 sensors measure turbidity using the Transmitting and Scattering Method shown in Fig. 5. U-52 sensors use a pulse light LED (infra-red emitting diode) as a light source, and detect scattered light from a 30° angle off center. U-53 sensors use a tungsten lamp as a light source and detect scattered light from a 90° angle. Both models display turbidity as a ratio of scattered light to transmitted light to reduce the affect of the color of the sample. The U-53 method conforms to EPA Method 180.1, and employs wipers to reduce the affect of air bubbles.

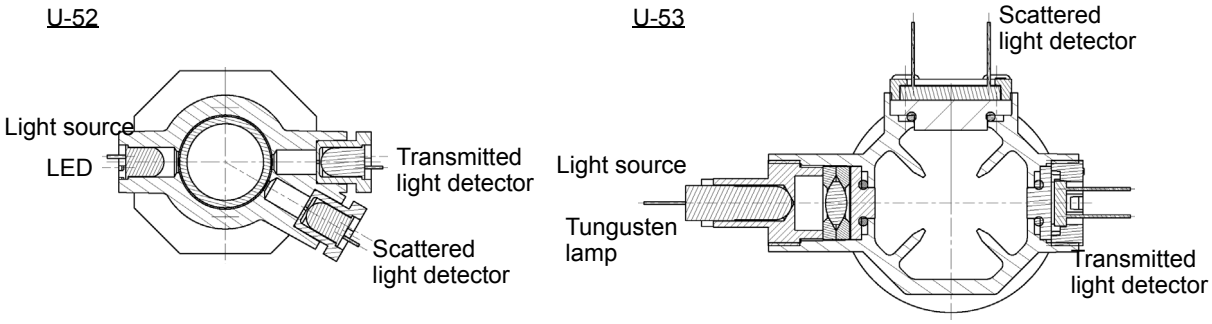


Fig. 5 Turbidity cell

6.9.2 Standard solution

U-50 series can perform calibration using formazin (NTU) or kaolin standard solutions as a turbidity standard solution. However, units for the solution used for calibration should be displayed in measurements. Do not use more than 400 mg/L of kaolin standard solution because it increases precipitation speed, resulting in measurement error.

6.10 Depth (DEPTH) measurement

6.10.1 Principle of depth measurement

For the W-22XD and W-23XD models, depth measurement can be made through use of a pressure gauge. The principle of the depth measurement uses the relation between depth and pressure.

Although the measurement with the depth sensor is affected by atmospheric pressure, the depth sensor, however, makes zero-point adjustments through the automatic calibration before measurements.

6.10.2 Influence of temperature and calibration

The depth sensor depends greatly on temperature. For a wide difference between the temperature at which the sensor has been automatically calibrated and the temperature of the measurement sample, the sensor can make depth measurements with a higher accuracy by the following method:

1. **Immerse the depth sensor of the sensor probe in the sample.**
2. **Keep the sensor immersed in the sample for about 30 minutes until the temperatures of the sensor and the sample are the same.**
3. **Then make the zero calibration of the sensor manually.**

6.11 Oxidation reduction potential (ORP) measurement

6.11.1 Principle of ORP measurement

ORP is an abbreviation for oxidation-reduction potential. ORP is the energy level (potential) determined according to the state of equilibrium between the oxidants (M^{Z+}) and reductants $M^{(Z-N)+}$ that coexist within a solution.

$$M^{Z+} + ne^- \Leftrightarrow M^{(Z-N)+} \quad \cdots (1)$$

If only the solution, forming the ORP measuring system shown in Fig. 6. The difference of potential between two electrodes is generally expressed by the following equation.

$$E = E_0 - \frac{RT}{nF} \ln \frac{a_M{}^{(z-n)+}}{a_M{}^{z+}} \quad \cdots (2)$$

E: Electric potential E_0 : Constant R: Gas constant T : Absolute temperature
n: Electron count F : Faraday constant a : Activity

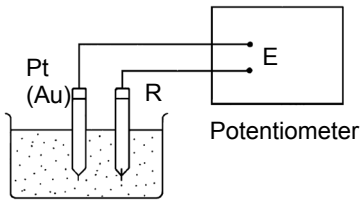


Fig. 6 Measuring mV

For example, for a solution in which trivalent iron ions coexist with bivalent iron ions, equations 1 and 2 would be as follows.

$$Fe^{3+} + e^- \Leftrightarrow Fe^{2+} \quad \cdots (1)$$

$$E = E_0 - \frac{RT}{F} \ln \frac{a_{Fe}{}^{2+}}{a_{Fe}{}^{3+}} \quad \cdots (2)$$

When only one type of state of equilibrium uniquely by equation (Fe^{3+}) and the reductant (Fe^{2+}) (using the equation $a_{Fe}{}^{2+}/ a_{Fe}{}^{3+}$). Actually, however many kinds of states of equilibrium exist simultaneously between various kinds of ions, in most solutions. This means that under actual circumstances, ORP cannot be expressed using the simple equation shown above and that the physical and chemical significance with respect to the solution is not very clear.
In this respect, the value of ORP must be understood to be only one indicator of the property of a solution. The measurement of ORP is widely used, however, as an important index in the analysis of solutions (potentiometric titration) and in the waste water treatment.

6.11.2 Standard electrode (reference electrode) types and ORP

The ORP is obtained comparing with corresponding reference electrode employed.
If different kinds of reference electrodes are used for measurement, the ORP value of the same solution may appear to be different. HORIBA's reference electrode uses Ag/AgCl with 3.33 mol/L KCl as inner solution. According to general technical literature, normal hydrogen electrodes (N.H.E.) are often used as the standard electrode.
The relationship between N.H.E. and the ORP that is measured using an Ag/AgCl with 3.33 mol/L KCl electrode is expressed by the following equation.
$E_{N.H.E.} = E + 206 - 0.7(t - 25)$ mV t = 0 - 60°C
$E_{N.H.E.}$: Measured ORP value using N.H.E. as the reference electrode

E: Measured ORP value using Ag/AgCl with 3.33 mol/L KCl as the reference electrode
Potential sign
Standard ORP is expressed in the following way, in literature related to electrochemistry and analytical chemistry.

A $Li^{+} + e^{-} \rightarrow Li$
$E_0 = -3.024$ V VS N.H.E.

However, in some literature, the "+" and "-" signs are reversed.

B $Li \rightarrow Li^{+} + e^{-}$
$E_0 = +3.024$ V VS N.H.E.

In expressions like B, above, the reaction is just reversed and there is no essential difference. But this kind of expression does invite confusion. The majority of the world, today, is consistent in its use of the signs as they are used in A, above.
For this reason, HORIBA, too, uses signs concerning ORP that are consistent with A, above.

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SOP-14: CONTINUOUS WATER LEVEL MONITORING

1.0 Purpose

This standard operating procedure (SOP) provides guidelines for the use of pressure transducers and programmable data loggers for continuous water level monitoring of groundwater or surface water to support remedial investigations. The objective of this procedure is to ensure that pressure transducers are installed and used in wells or piezometers in a consistent manner.

Groundwater and surface water level evaluations can be accomplished using different data collection methods. Continuous water level monitoring using dataloggers and pressure transducers have the ability to collect large amounts of data quality reliably and accurately. They may also be used to record groundwater and surface water level behavior as part of an aquifer pumping test or for long-term monitoring of aquifers, lakes, or streams.

Continuous groundwater level monitoring typically occurs in multiple monitoring wells as part of the continuous groundwater monitoring program. The specifics of a continuous groundwater monitoring program depend on the groundwater conceptual site model (including its potential relationship to surface water systems), the availability and spatial distribution of data monitoring points (monitoring well locations and depths), and the data quality objectives of the program.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors who install and perform continuous water level monitoring with pressure transducers and programmable data loggers at site projects.

This SOP focuses on the most commonly used continuous groundwater monitoring tasks and applications anticipated at Site Projects and should be used in conjunction with other applicable project SOPs, including the following*:*

- *SOP- Field Documentation*
- *SOP- Groundwater Level Measurement*
- *SOP- Groundwater Sampling Procedures*
- *SOP- Equipment Decontamination Procedures*
- *SOP- Field Procedure Change Management*

3.0 Procedures

3.1 Instruments

Commonly used equipment and supplies that can be used for continuous groundwater level monitoring include, but are not limited to, the following:

- Vented pressure transducer
- Datalogger
- Water level indicator

- Decontamination equipment
- Installation hardware and equipment
- Portable handheld data reader or laptop computer
- Communication data cables
- Stopwatch

3.2 Continuous Groundwater Level Monitoring Procedures

3.2.1 Pre-test and Post-test Activities

The general procedures for continuous groundwater level monitoring activities are as follows:

- Decontaminate all downhole equipment (pressure transducers and water level monitoring devices) before and after use, according to *the SOP for Equipment Decontamination Procedures*.
- Calibrate and test pressure transducers and data loggers before they are deployed in the field. Test the operational integrity and the configuration of the datalogger by running an inherent self-test program in the unit. Connect pressure transducers to the datalogger and check for operation by placing the pressure transducer below the water table at a known depth and taking a reading, moving the pressure transducer, and taking another reading.
- Synchronize all time-recording devices to the same clock.
- Take manual water levels in all wells prior to data-logger deployment.

3.2.2 Monitoring Well Field Installation

The procedure for installation of pressure transducers in monitoring wells is as follows:

- Measure the water level and depth to the bottom of the well relative to the top of the well casing using an electronic water level indicator before installation.
- Lower the vented pressure transducer gently down the well and install below the lowest anticipated change in water level, but not so low that the range of the transducer might be exceeded at the highest anticipated change in level.
- Do not install the pressure transducer to a depth less than 1 foot from the bottom of the well, to keep the transducer out of any fine sediment that may accumulate in the bottom of the well.
- Secure the pressure transducer in place by attaching it to the well casing or monument at the surface.
- Bundle any excess of cable connected to the pressure transducer at the surface and place it back into the well or coil and suspend from the well casing. Do not plug the end of the cable as this line also acts as a vent to the transducer. A notch may be cut in the well cap to fit over the cable. Ensure not to completely seal the well to allow the water level in the well to fluctuate with pressure variances.

3.2.3 Groundwater Level Data Collection Activities

The datalogger should be programmed according to the manufacturer's instructions and as discussed in the Work Plan to meet the investigation objectives.

- To prevent data loss because of equipment or battery failures, periodically download partial data from the datalogger (for example, monthly or quarterly).
- In addition, conduct periodic manual water level measurement throughout the continuous groundwater monitoring program to determine if there is measurement drift.
- Record the date and time that the manual reading was taken and the pressure head reading of the transducer.
- Record all data collection events and continuous groundwater level monitoring activities in field log books or on field datasheets.

4.0 Decontamination

Decontaminate pressure transducer, cables, and water level indicators according to the decontamination procedures in *SOP for Equipment Decontamination Procedures*.

5.0 Service and Maintenance

Perform service and maintenance according to the manufacturer's instructions.

6.0 Records

Record the brand and model number, unique identification number, measurement location, date and time, installation methods, programming set-up, manual water level, and any additional information relevant to continuous water level monitoring activities in the Field Log Book or on a Field Datasheet according to *SOP-XX, Note Taking and Field Log Books.* Back up all downloaded digital data and store to a project server or file transfer protocol (FTP) site as detailed in QAPP.

7.0 References

American Society for Testing and Materials (ASTM). January 1, 2004. *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. ASTM Standard D5092, ASTM International, West Conshohocken, PA.

Driscoll, F.G. 1986. *Groundwater and Wells.* 2nd edition. St. Paul, MN: Johnson Division. Kruseman, G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*,

2nd Edition, International Institute for Land Reclamation and Improvement. Wageningen, The Netherlands.

Lohman, S.W. 1972. *Ground Water Hydraulics.* U.S. Geological Survey Professional Paper 708.

Nielsen, D.M. 1991. *Practical Handbook of Ground-Water Monitoring.* Lewis Publishers. Thornhill, Jerry T. 1989. *Accuracy of Depth to Ground Water Measurements.* In *EPA*

Superfund Ground Water Issue. EPA/540/4-89/002.

U.S. Department of the Interior (USDI). 1981. *Groundwater Manual, A Water Resource Technical Publication.* Water and Power Resources Services. Denver, CO: U.S. Government Printing Office.

U.S. Environmental Protection Agency (EPA). 1993. *Suggested Operating Procedures for Aquifer Pumping Tests*. EPA/540/S-93/503.

8.0 Definitions

Monitoring well: a well that is constructed in various ways for the purpose of extracting groundwater for physical, chemical, or biological sampling, or for measuring water levels.

Piezometer: a well that is constructed in various ways for the purpose of measuring water levels.

Pressure transducer: a submersible probe used to monitor changes in water level. A pressure transducer senses changes in pressure, measured in pounds per square inch (psi), exerted by a column of water or other fluid. One psi is equal to 2.30667 feet of water.

Datalogger: a programmable field instrument capable of measuring and recording parameters, such as water level and pressure, at previously determined frequencies for long periods of time. Dataloggers are designed for unattended use.

9.0 Attachments

Attachment 1: *Pressure Transducer-Datalogger Information*

Attachment 2: *Pressure Transducer-Datalogger Manufacturers Specifications and Manual*

Operator's Manual

Rugged TROLL® 100 and 200 and Rugged BaroTROLL Instruments



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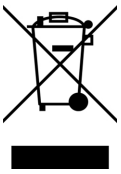

The presence of the Waste Electrical and Electronic Equipment (WEEE) marking on the product indicates that the device is not to be disposed via the municipal waste collection system of any member state of the European Union.

For products under the requirement of WEEE directive, please contact your distributor or local In-Situ office for the proper decontamination information and take back program, which will facilitate the proper collection, treatment, recovery, recycling, and safe disposal of the device.

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Introduction

The Rugged TROLL Instrument is a compact, modular system for measuring level and temperature in natural groundwater, surface water, industrial waters, and other installations.

Scope

This document is intended to describe the characteristics, operation, calibration, and maintenance of the instrument. Communication registers and SDI-12 programming information can be found in the Modbus and SDI-12 Reference Guides on the In-Situ website.

Serial Number Location

The serial number is engraved on the instrument housing. It is also programmed into the instrument and is displayed when the instrument is connected to a computer running Win-Situ Software.

Certification

See the Declarations of conformity at end of this manual.

Unpacking and Inspection

Your instrument was carefully inspected before shipping. Check for any physical damage sustained during shipment. Notify In-Situ and file a claim with the carriers involved if there is any shipping damage. Accessories may be shipped separately and should also be inspected for physical damage and the fulfillment of your order.

> ⚠ Please save packing materials for future storage and shipping. The shipping boxes have been performance-tested and provide protection for the instrument and its accessories.

Warranty

See the product specification tables for warranty information.

Contact Information

Mailing and Shipping Address:

In-Situ
221 East Lincoln Avenue
Fort Collins, CO 80524-2533
U.S.A.

Phone: 970-498-1500 (international & domestic)

Fax: 970-498-1598

Internet: *www.in-situ.com*

Support: 800-446-7488 (U.S.A. & Canada)

Product Specifications

Rugged TROLL 100 and 200 Specifications

General	Rugged TROLL 100 and 200
Temperature ranges[1]	Operational: 0 to 50° C (32-122° F) Storage: -40-80° C (-40-176° F) Calibrated: 0-50° C (32-122° F)
Diameter	2.62 cm (1.03 in.)
Length	14.43 cm (5.68 in.)
Weight	137 g (0.30 lb)
Materials	Titanium body; Delrin nose cone, hanger, backend
Output options	Rugged TROLL 100: USB or RS232 via docking station Rugged TROLL 200: USB or RS232 via docking station; Modbus/RS485 or SDI-12 via Rugged TROLL 200 Cable; Wireless TROLL Com
Battery type & life[2]	3.6 V lithium; 10 years or 2M readings
External power	Rugged TROLL 100: NA Rugged TROLL 200: 8-36 VDC
Memory Data records[3] Data logs	2.0 MB 120,000 Rugged TROLL 100: 1 log; Rugged TROLL 200: 2 logs
Fastest logging rate	1 per second
Fastest output rate	Rugged TROLL 200 only: Modbus & SDI-12: 1 per second
Log types	Linear, Fast Linear, and Event
Sensor Type/Material	Piezoresistive; Ceramic
Range	9.0 m (30 ft) (Burst: 18 m; 60 ft) 30 m (100 ft) (Burst: 40 m; 134 ft) 76 m (250 ft) (Burst: 112 m; 368 ft)
Accuracy (FS)[4]	±0.1%
Resolution	±0.01% FS or better
Units of measure	Pressure: psi, kPa, bar, mbar, mmHg, inHg Level: in, ft, mm, cm, m
Temperature Sensor	
Accuracy	±0.3° C
Resolution	0.01° C or better
Units of measure	Celsius or Fahrenheit
Warranty	2 years
Footnotes	[1] Temperature range for non-freezing liquids [2] Typical battery life when used within the factory-calibrated temperature range [3] 1 data record = date/time plus 2 parameters logged (no wrapping) from device within the factory-calibrated temperature range, 360,000 total data points [4] Across factory-calibrated pressure and temperature ranges. Defined as greater than 98% of all readings fall within spec across temperature and pressure range Specifications are subject to change without notice. Delrin is a registered trademark of E.I. du Pont de Nemours and Company.

Rugged BaroTROLL Specifications

General	Rugged BaroTROLL
Temperature ranges[1]	Operational: 0-50° C (32-122° F) Storage: -40-80° C (-40-176° F) Calibrated: 0-50° C (32-122° F)
Diameter	2.62 cm (1.03 in.)
Length	14.43 cm (5.68 in.)
Weight	137 g (0.30 lb)
Materials	Titanium body; Delrin nose cone, hanger, backend
Output options	USB or RS232 via docking station; Modbus/RS485 or SDI-12 via Rugged TROLL 200 Cable
Battery type & life[2]	3.6 V lithium; 10 years or 2M readings
External power	8-36 VDC
Memory Data records[3] Data logs	2.0 MB 120,000 2 logs
Fastest logging rate	1 per minute
Fastest output rate	Modbus & SDI-12: 1 per second
Log types	Linear
Sensor Type/Material	Piezoresistive; Ceramic
Range	7.0 to 30.0 psi; 0.5 to 2 bar
Accuracy (FS)[4]	±0.1%
Resolution	±0.01% FS or better
Units of measure	Pressure: psi, kPa, bar, mbar, mmHg, inHg
Temperature Sensor	
Accuracy	±0.3° C
Resolution	0.01° C or better
Units of measure	Celsius or Fahrenheit
Warranty	2 years
Footnotes	[1] Temperature range for non-freezing liquids [2] Typical battery life when used within the factory-calibrated temperature range. [3] 1 data record = date/time plus 2 parameters logged (no wrapping) from device within the factory-calibrated temperature range [4] Across factory-calibrated pressure range and temperature ranges. Defined as greater than 98% of all readings fall within spec across temperature and pressure range Specifications are subject to change without notice. Delrin is a registered trademark of E.I. du Pont de Nemours and Company.

Overview

Rugged TROLL Overview

The Rugged TROLL 100 and 200 instruments are designed to measure pressure, level, and temperature in natural groundwater and surface water. They also can be used at industrial sites, landfills, and other installations.

Both instruments have completely sealed housings that contain an absolute (non-vented) pressure sensor, temperature sensor, real-time clock, microprocessor, lithium battery, and internal memory.

The Rugged TROLL 100 is designed to hang by a backshell hanger from a suspension wire. The Rugged TROLL 200 can utilize the backshell hanger or can connect to a cable for easy top-of-well RS485 communications via laptop computer or mobile device. Additionally, Rugged TROLL 200 cables with stripped-and-tinned cable ends can communicate with data loggers, TROLL Link Telemetry Systems, or PLC devices via RS485 or SDI-12.

Rugged BaroTROLL Overview

The Rugged BaroTROLL measures and logs barometric pressure and temperature in air. This data is used to correct the Rugged TROLL 100 and 200 data by compensating for barometric pressure effects during the course of a log.

Communication Accessories

- Rugged TROLL 100:
  - USB or RS232 docking station
  - Wireless Rugged TROLL COM
- Rugged TROLL 100,200 and Rugged BaroTROLL Instruments:
  - USB or RS232 docking station
  - USB or RS232 Rugged TROLL Com
  - Wireless RuggedTROLL Com
- Win-Situ 5 Software or VuSitu mobile app for programming and downloading
- Optional software: Win-Situ Baro Merge for barometric compensation; Software Manager to check for updates

Other Accessories

Rugged TROLL 100

- Suspension cable
- Rugged BaroTROLL for logging barometric pressure data

Rugged TROLL 200

- Suspension cable
- Rugged BaroTROLL for logging barometric pressure data
- SDI-12 compatible cable with stripped-and-tinned uphole termination
- RS485 compatible cable with stripped-and-tinned uphole termination
- RS485 top-of-well cable
- Rugged TROLL 200 cable suspension kit (Use this kit to create a weight-bearing loop capable of suspending up to 45.5 kg (100 lbs.) of cable and instrument.)

Equipment Configuration Table

Data Logger	Deployment Options	Communication Device
Rugged TROLL 100	Suspension Wire –one per Rugged TROLL & Rugged Baro TROLL –one per network of Rugged TROLLs –requires an additional suspension wire	Wireless Rugged TROLL Com Rugged TROLL Docking Station*
Rugged TROLL 200	OPTION (A) Suspension Wire –one per Rugged TROLL & Rugged Baro TROLL –one per network of Rugged TROLLs –requires an additional suspension wire	Wireless Rugged TROLL Com Rugged TROLL Docking Station*
	OPTION (B) RS485 Direct-Read Cable –one per Rugged TROLL & Rugged BaroTROLL –one per network of Rugged TROLLs –requires additional RS485 cable for real-time data	Wireless Rugged TROLL Com Rugged TROLL Com** –one per cable for top-of-well data –one per network—download only
	OPTION (C) SDI-12 Direct-Read Cable & Rugged BaroTROLL –one per network of Rugged TROLLs –requires additional SDI-12 cable for real-time data	Wireless Rugged TROLL Com PLC/SCADA & Rugged TROLL Docking Station***

* A Rugged TROLL Docking station can connect to one data logger at a time.

** In this deployment option, make sure to include an additional Rugged TROLL Com for real-time data from the Rugged BaroTROLL.

*** In this deployment option, a Rugged TROLL Docking Station is required for communication with the data loggers when not connected to the SDI-12 Direct-Read Cable.

Getting Started

You will need the following items.

- Rugged TROLL 100 or 200 instrument
- Rugged BaroTROLL (optional)
- One of the communication devices below
    - USB or RS232 docking station and Rugged TROLL Com (for Rugged TROLL 200 and Rugged BaroTROLL).
    - Wireless Rugged TROLL Com (if using the VuSitu mobile app)

Install Software

You can configure and deploy your In-Situ instrument with the VuSitu mobile app or Win-Situ 5 software for PC. To use Win-Situ, install it from the software CD or download from www.in-situ.com. Download VuSitu on your mobile device from the Google Play Store at play.google.com.

Win-Situ 5 Software

1. Click the Win-Situ 5 link and follow the installation instructions.
2. Make sure that you select the option to "Install USB Drivers."

Win-Situ Baro Merge Software

Install Baro Merge Software if you plan to post-correct level data to compensate for barometric pressure.

About VuSitu

VuSitu is the mobile user interface and control application for In-Situ water quality instruments. You can use VuSitu on mobile devices with Android operating system 4.4, *Bluetooth* 2.0 and newer. Download the latest version of the app from the Google Play Store at play.google.com.

VuSitu allows you to accomplish the following tasks.

- View live readings that update every 10 seconds
- Change parameters and units
- Set up a data log
- Record data
- Email data in spreadsheet format
- Download data to mobile device
- Transfer data from mobile device to a computer
- Organize data by Location
- Calibrate Sensors and View Reports

Verify the VuSitu Mobile App Version

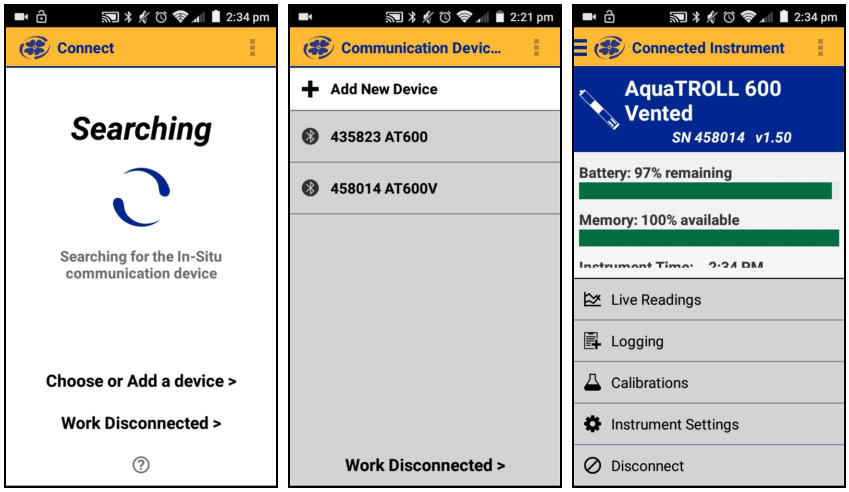
To avoid potential compatibility issues, it is important to use the most recent version of the VuSitu Mobile App. Find version information and app updates from the Google Play Store.

Connecting Your Instrument to VuSitu

To use VuSitu, you will need a Bluetooth-enabled mobile device, a Wireless TROLL Com and a deployment cable.

Attach one end of the cable to the Wireless TROLL Com and secure the other end to the instrument. Press the power button on the Wireless TROLL Com and open the VuSitu mobile app on your phone or tablet.

VuSitu will automatically search for Bluetooth devices nearby, but you will need to select the correct instrument when connecting for the first time. Select **Choose or Add a Device**. You should see the serial number of the instrument you wish to pair. Tap the serial number to connect. Tap the **Back** button on your device to view the Connected Instrument screen.

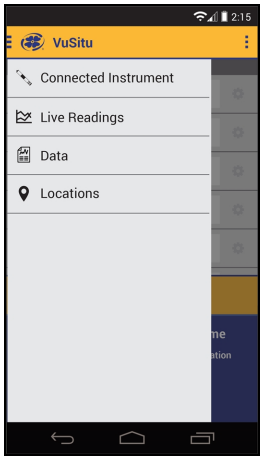


VuSitu Menu Options

The features available in the VuSitu mobile app vary slightly depending on the instrument to which it is connected. Tap the menu icon in the upper left portion of the screen to view the features included in VuSitu. Tap the menu icon again to close the menu.

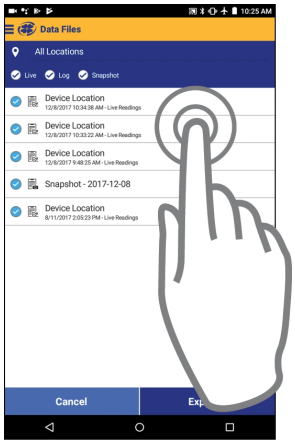
Menu Options when Connected to Instrument

Some features, such as sensor calibration, are not available when you are not connected to an instrument.



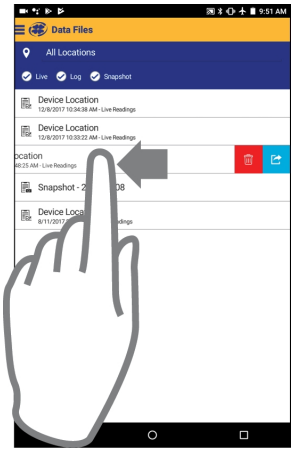
Selecting with Long-press and Swipe

Long Press



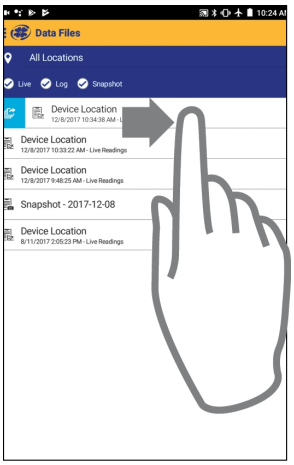
Press and hold any item in a list of files. You can now select multiple files.

Swipe Left



Press an item and swipe left to reveal the delete and share icons.

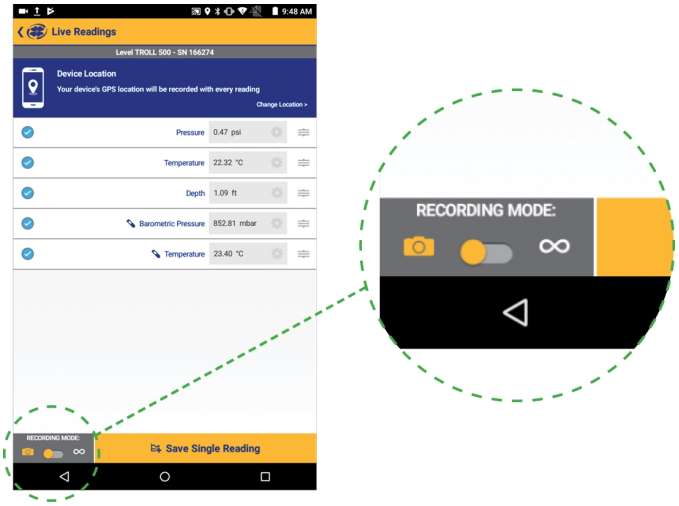
Swipe Right

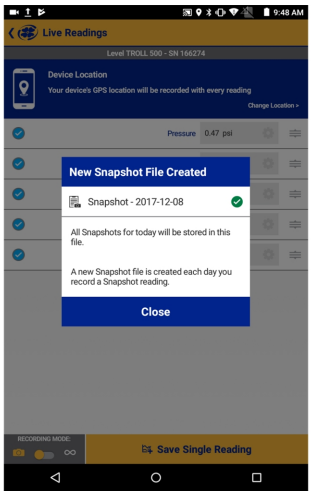


Press any item in a list and swipe right to reveal the sharing icon.

Taking live readings in VuSitu

Snapshot Mode

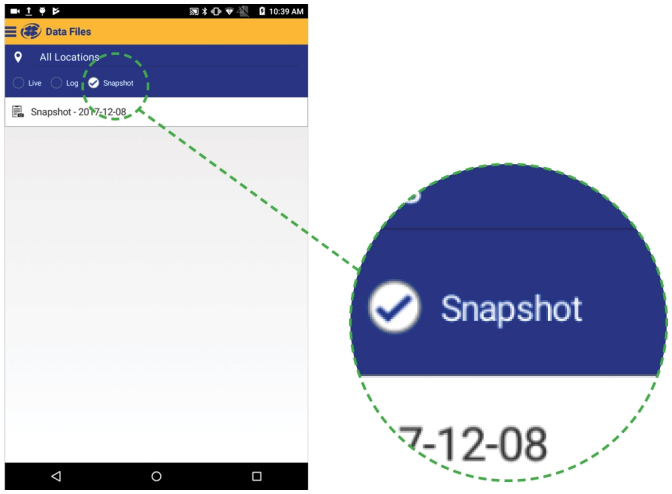




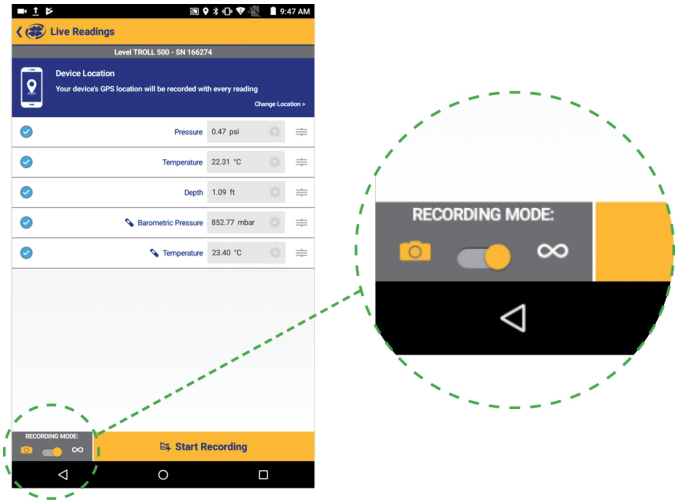
Take a single reading and save to Snapshot file.

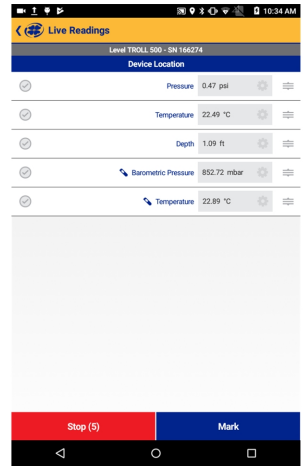
View Snapshot file from Menu > Data Files.

Check Snapshot option.



Live Readings Mode

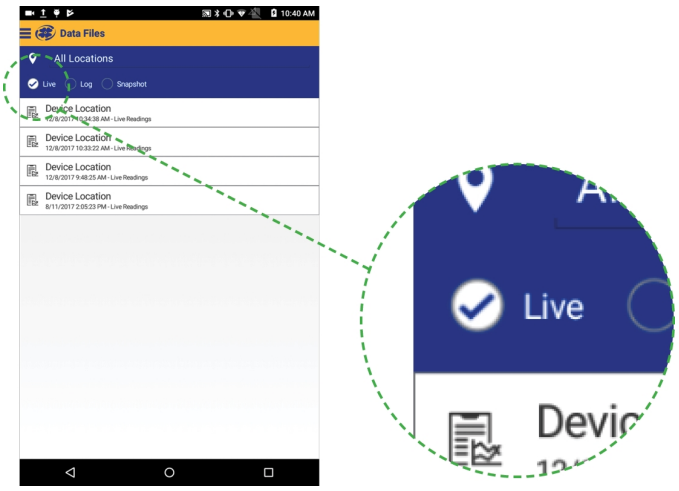




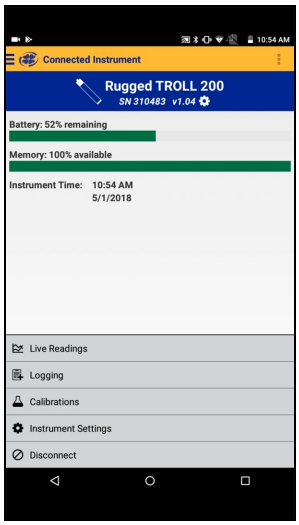
Take readings at two-second intervals.

View readings from Menu > Data Files.

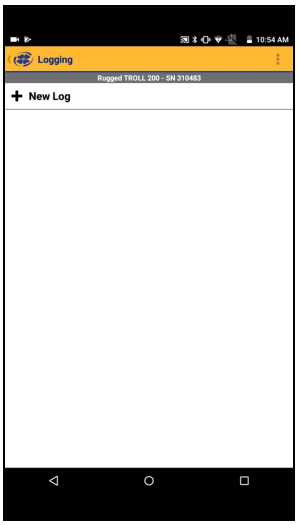
Check Live option.



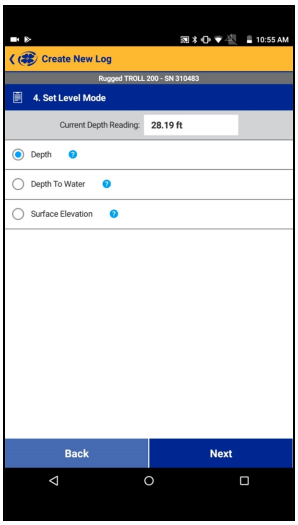
Setting Up a Log



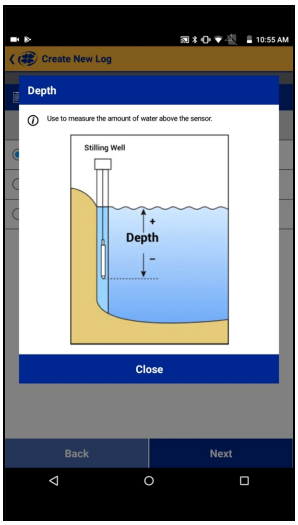
From the Connected Instrument screen, select **Logging**.



Tap **New Log** and follow the prompts to create a name, select a location and choose the parameters you wish to monitor.



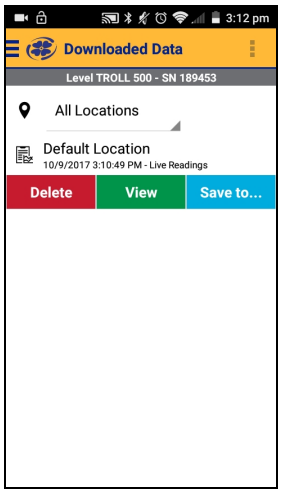
Select a level mode in step 4. Tap the blue circle to the right of each option for an explanation of how the mode works.



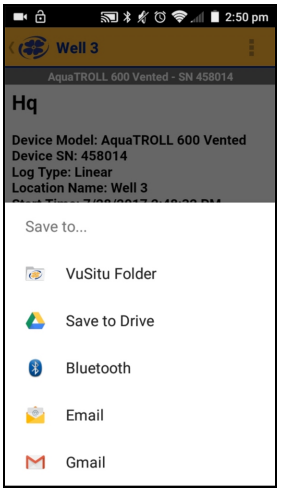
For Depth to Water and Surface Elevation modes, enter a level reference. See "About the Level Reference" on page 36 of this manual for complete information about level modes and level references.

Downloading and sharing your data.

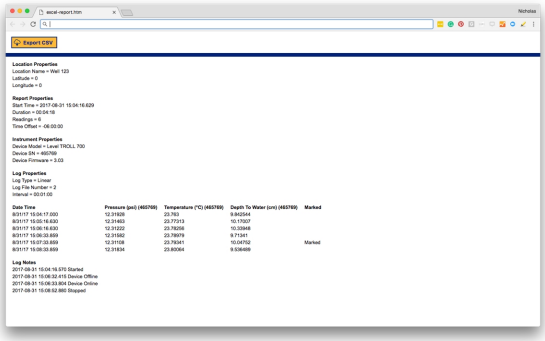
You can download VuSitu data as an HTML file and share it via email, SMS or a cloud storage service such as Google Drive. To download a log, select it from the Downloaded Data screen and tap **Save to**.



Choose one of the download options from the menu. You can transfer a data file from your mobile device to a PC via Bluetooth, email it to yourself or any valid email address, save the file to the VuSitu folder on your device or upload it to Google Drive.



View your data in any web browser by double-clicking the file. You can then export a CSV file by clicking the **Export a CSV** link at the top of the page.



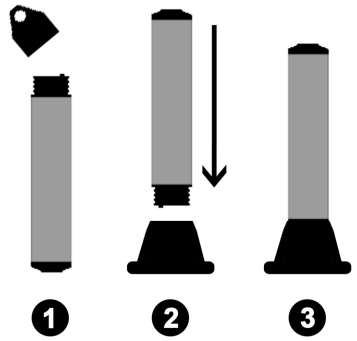
Connect to the Rugged TROLL Docking Station

The docking station is intended for use with the Rugged TROLL 100, 200 and Rugged BaroTROLL Instruments that are not deployed with a communication cable. Once connected, you can program the instrument, view readings, and download the data.

1. Unscrew and remove the hanger from the instrument.

   > ✔ The hanger is the only removable part of the instrument. Do not attempt to take the instrument apart. There are no user-serviceable parts in the instrument.

2. Invert the instrument. Align the notch on the instrument with the tab on the rim of the docking station. This will ensure that the pins are aligned to enable communication.
3. Place the instrument into the docking station.



4. Connect the docking station to a computer.



Connect to the Rugged TROLL Com

The Rugged TROLL Com is used as a communication interface between a Rugged TROLL 200 or a Rugged BaroTROLL instrument, the Rugged TROLL 200 cable and a computer.

An internal 9 volt battery powers the Rugged TROLL Com, but it does not provide power to the instrument. The Rugged TROLL Com connects to the uphole end of the Rugged TROLL 200 cable. Once connected, you can program the instrument, view real-time readings, and download the data.

> ⚠ Do not submerge the Rugged TROLL Com Device.

Rugged TROLL Com Battery Installation

1. Open the battery compartment door.
2. Attach the battery leads to the battery terminals.
3. Push the battery into the compartment.



4. Close the battery compartment door.

Connections

1. Attach the Rugged TROLL Com to the Rugged TROLL 200 cable via snap-on connection to the uphole end of the cable.



2. Connect the communication cable to the PC.



3. The Rugged TROLL Com requires a minimum of 8 VDC. If you lose connection to the instrument, particularly when using a long cable, replace the 9 V battery on the TROLL Com.
4. Release the connection to the uphole cable end by pushing in the white tab on the TROLL Com.

Deploying the Instruments

You can deploy a Rugged TROLL Instrument with or without a Rugged BaroTROLL Instrument. Use the Rugged BaroTROLL Instrument when you want to compensate water level measurements for atmospheric pressure.

Use the following steps for each instrument.

1. Connect the instrument to a computer with Win-Situ 5 or a mobile device with VuSitu.
2. Make sure that you sync the clock  .
3. Program a log. See the Win-Situ 5 or VuSitu section of this document for more details.

> ✓ The BaroTROLL measurements can be taken far apart as long as they cover the general time period as the Rugged TROLL log.
>
> If the Rugged TROLL log uses the reference "Set first logged reading to," the Rugged BaroTROLL log should start before the Rugged TROLL log to ensure that barometric pressure is measured when the first level reading is captured.

4. Disconnect the BaroTROLL, attach the hanger, and deploy it suspended or lying in a protected location above water level near the submerged Rugged TROLL 100 or 200. One possibility is shown in Figure 11.1 .

> ⚠ Do not submerge the Rugged BaroTROLL Instrument.

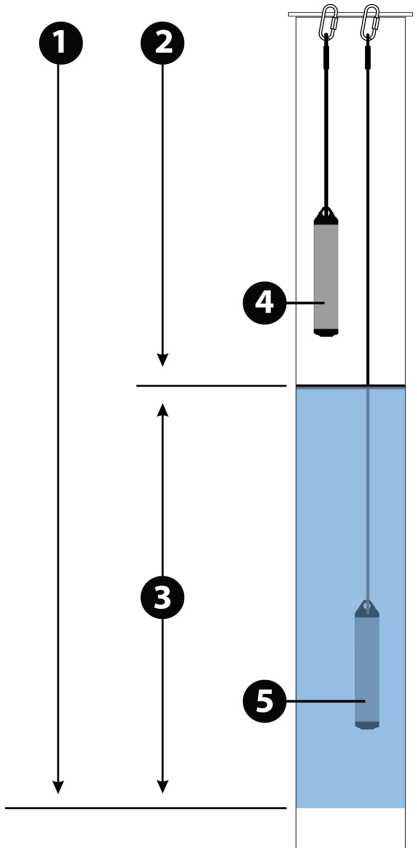


Figure 11.1 Rugged BaroTROLL and Rugged TROLL deployment

1	Pressure due to atmosphere + water column (measured by Rugged TROLL)
2	Pressure due to atmosphere (measured by Rugged BaroTROLL)

3	Pressure due to water column (calculated by subtracting Rugged BaroTROLL data from Rugged TROLL data)
4	Rugged BaroTROLL Instrument
5	Rugged TROLL Instrument

Rugged TROLL 200 Cable Suspension

When a Rugged TROLL 200 Instrument or a Rugged BaroTROLL Instrument needs to be installed with a secure fastener, such as a carabiner, In-Situ Inc. recommends using the Rugged TROLL 200 Cable Suspension Kit (Part Number 0080880).

When installed correctly the connector can support a combined cable and instrument weight of up to 45.4 kg (100 lbs).

1. Create a loop on the uphole end of the cable and loosely bind it with one zip tie.



2. Place the metal loop inside the cable loop. Push the zip tie up to form a tight band around the metal loop. Tighten the zip tie.



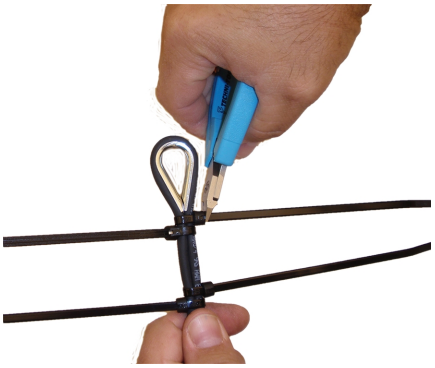
3. Place the second zip tie directly below the first and tighten.



4. Place the third zip tie about 2.5 cm (1 in.) below the first two ties. Place the fourth zip tie snugly against the third.



5. Hand tighten the zip ties. Do not over tighten.
6. Clip the excess tie material from the unit.



7. Deploy from a well dock or other secure location.



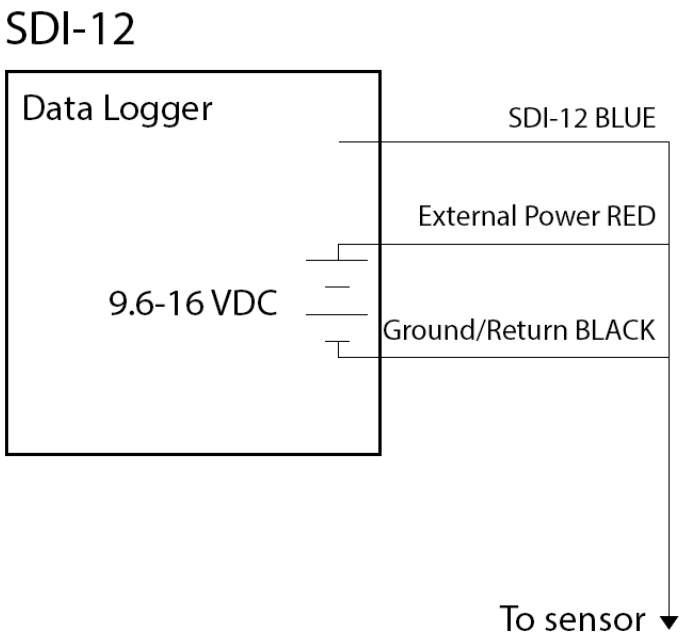
Wiring Connections for Stripped-and-Tinned Cable

The Rugged TROLL 200 Cable can be ordered with stripped-and-tinned wires that can be connected to an SDI-12 or RS485 data recorder or controller.

SDI-12 Connections

- Blue = serial data
- Red = 12 V power supply
- Black = ground

Terminate remaining wires at the data recorder.

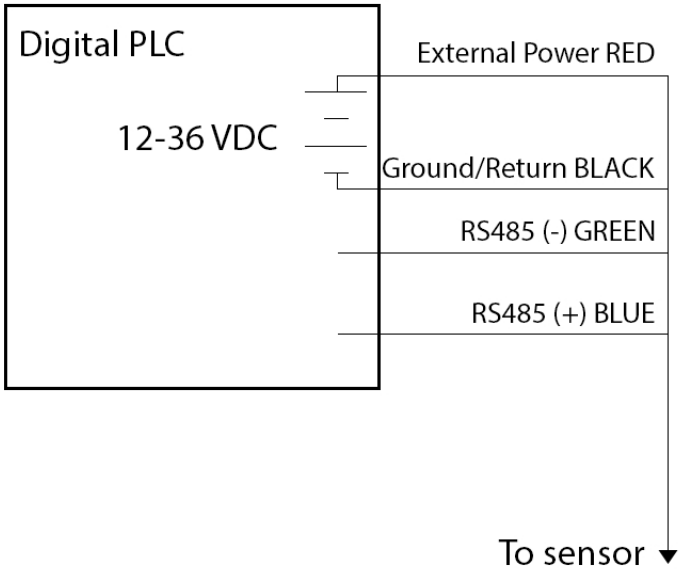


RS485 Connections

- Red = 12 V power supply
- Black = ground
- Green = RS485 (-)
- Blue = RS485 (+)

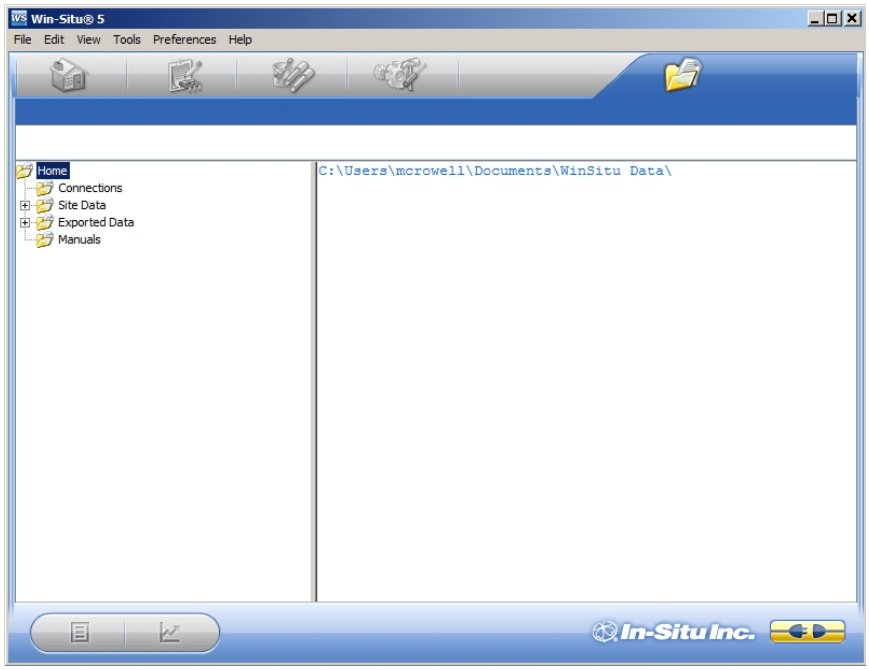
Terminate remaining wires at the data recorder.

Modbus Master
(RS485 built in)



Data Tab

When you open Win-Situ 5 Software, the **Data** tab appears. The left side of the screen contains a file tree where you can view previously downloaded site data as well as data you have exported to Microsoft Office Excel. The links on the right side of the screen show where downloaded data are stored on your computer. The disconnected plug icon in the lower-right corner of the screen indicates that the software is not yet communicating with an instrument.

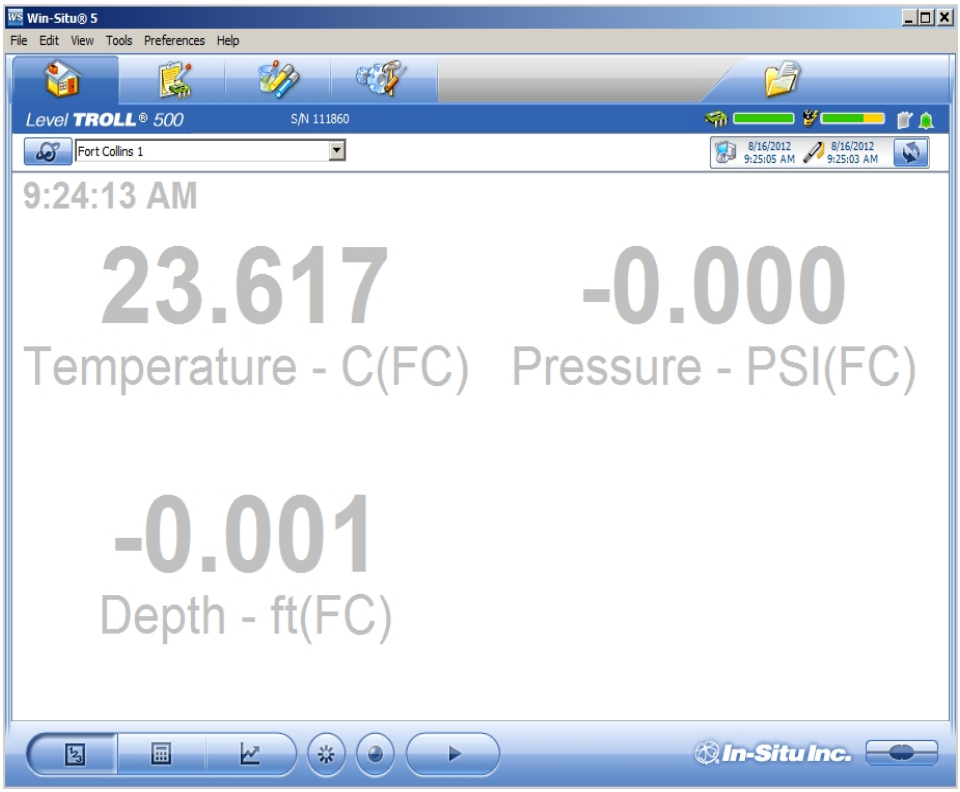


Screen Element	Definition
	The disconnected plug indicates the instrument is not communicating with the software. Click to establish communication with a connected instrument.
	The connected plug indicates the instrument is communicating with the software. Click to disconnect the software from the instrument.
	The **Home** tab displays real-time readings from the instrument. When connection to the instrument is first established, the software displays one reading of all available parameters in light gray. You must click the **Play** button  at the bottom of the screen to view real-time readings.
	The **Logging** tab displays a list of logs stored in the connected instrument. When you click the **Logging** tab, it can take a moment for the software to retrieve information from the instrument. (Not applicable for the RDO PRO-X and the Aqua TROLL 400.)

Screen Element	Definition
	The **Sensors** tab lists the sensors in the connected instrument, along with their serial numbers and the dates of factory calibration and user calibration. Use the buttons in this tab to calibrate sensors that support user calibration and configure sensors that are supported by the instrument.
	The **Device Setup** tab allows access to instrument information and settings such as instrument name, serial number, firmware version, communication settings, diagnostics, and factory reset options.

Home Tab

The **Home** tab displays real-time readings from a connected instrument. When you first establish communication, the software displays one reading of all available parameters in light gray.



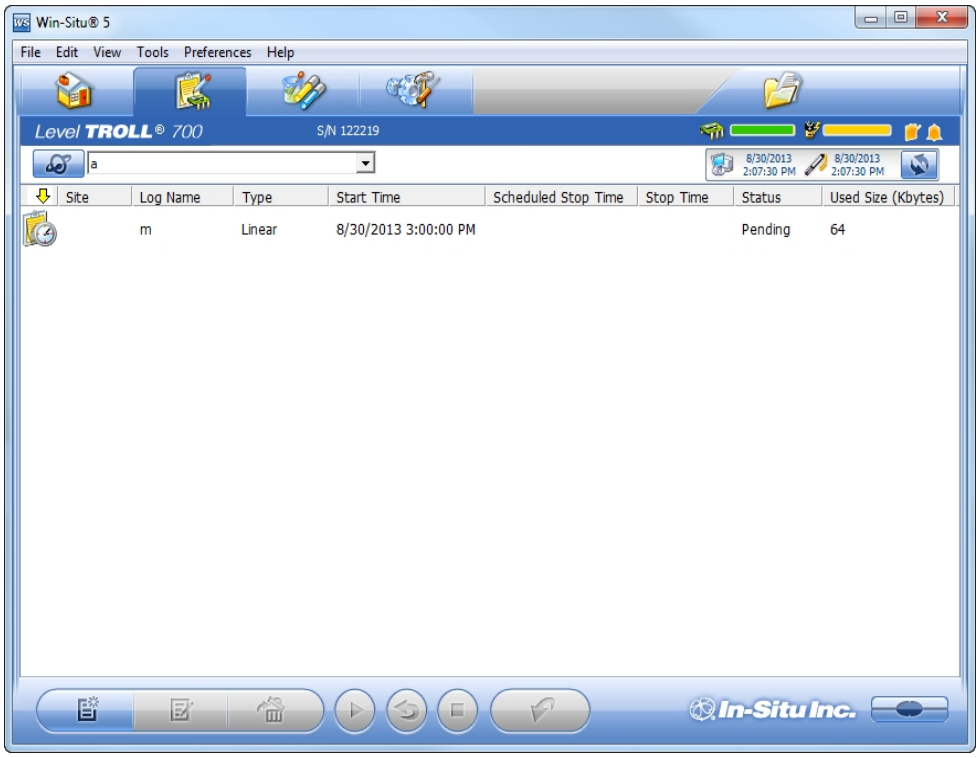
Screen Element	Definition
	The **Sites** button allows you to add, edit, or delete a site. Click the drop-down arrow next to the button to view the list of sites.
	The **Device Memory** gauge turns yellow when the internal memory is used. Note: Non-logging instruments do not have internal memory, however, the gauge shows 100 percent green when power is applied.
	The **Device Battery** gauge turns yellow as the battery is depleted. This example shows 80 percent of the battery remaining (green) and 20 percent used (yellow). Note: Non-logging instruments do not have internal batteries, however, the gauge shows 100 percent green when power is applied.

Screen Element	Definition
	The **Logging Status** icon: Green—The instrument is actively logging data. Gray—The instrument has no logs pending or running. Non-logging instruments always show a gray status icon. Yellow—The instrument has log data that was collected according to specific instructions in the "Pending" or "Suspended" state.
	The **Alarm** icon provides additional instrument status information. Green—No alarms or warnings Yellow—One or more warnings Red—One or more alarms Move the cursor over the alarm icon to view a description. Click the **Device Setup** tab for detailed information on the alarm or warning. Note: Disregard the **Device Reset** alarm for non-logging instruments such as the RDO PRO Probe or the Aqua TROLL 400.
	**System Time** is displayed on the left. **Device Time** is displayed on the right. Clocks are updated once every two seconds. When the **Device Time** is displayed in red, it differs from the current **System Time**, and should be synchronized.
	The **Time Sync** button is used to write the current PC time to the instrument. If you need to set the instrument clock to a time other than the system (PC) time, use the **Set Clock** button on the **Device Setup** tab.
	**Meter View** shows the last known parameter values, displayed with current units and time stamp. Readings are sized to occupy the entire screen. This is the default display in the **Home** tab. If the type is black, the readings are updating in real time.
	**List View** is a running list of the most recent records. New readings are continuously added to the top of the list and old readings scroll off the bottom.
	**Graph View** shows a real-time trend graph of the selected parameters.

Screen Element	Definition
	The **Snapshot** button records one set of readings.
	The **Record** button logs data to a CSV file that can be opened in a spreadsheet program. This is not the same as recording data in a log on the instrument.

Logging Tab

The **Logging** tab displays a list of logs in the instrument. When you click the **Logging** tab, it may take a moment for the software to retrieve information from the instrument.



Log Information

Columns across the **Logging** screen show information about the logs in the instrument.

- **Symbol**—This is a graphic representation of the information in the **Status** column.
- **Site**—The site that was specified when the log was configured.
- **Log Name**—The name that was entered when the log was configured.
- **Type**—The logging method that was selected when the log was configured.
- **Start Time**—For a Pending log, the scheduled start time is shown. For a Ready log that has not yet started, this column displays “Manual.” For a Running or Stopped log, the actual start time is shown.
- **Scheduled Stop Time**—For a log with a scheduled stop, the scheduled stop time is shown. For a log without a scheduled stop time, this column is blank.
- **Stop Time**—For a Pending or Ready log, this column is blank. For a Running log, the time of the last data point is shown. For a Stopped log, the actual stop time is shown.
- **Status**—Each log has a specific status. See **Log Status** for details.
- **Used Size**—Kilobytes of instrument memory allocated for this log. For a Pending or Ready log, the current size of the log configuration is shown. For a Completed log, the size of the entire log file is shown. For a Running log, the current size of the log up to the last data point is shown.

Log Status

The status of each log in the instrument is displayed in the Logging tab by a symbol beside the log name, and in the Status column.

 **Ready**—Manual Start log is ready to start.

 **Pending**—Scheduled start log is ready to start at its programmed time, or when you click the **Start** button.

 **Running**—The log is actively logging data.

 **Suspended**—The log has been paused (stopped temporarily).

 **Stopped**—The log has been stopped, either manually or on a schedule.

 **Deleted**—The log has been marked for deletion and will be deleted from the instrument when memory is needed. The software manages this automatically.

 **Invalid**—The log as programmed cannot be run.

> **Ready**, **Pending**, **Running**, and **Suspended** logs are considered active. Only one log can be active in the instrument.

Log Control Buttons

You can control the status of a log by selecting the log and clicking the appropriate button in the **Logging** tab control panel:

 The **Start** button starts a **Ready** or **Pending** log, or resumes a **Suspended** log.

 The **Pause** button pauses a **Running** log allowing you the option to resume it.

 The **Restart** button restarts the selected **Running** log from the beginning. This can be useful during aquifer testing using a logarithmic data collection schedule.

 The **Stop** button permanently stops the selected **Running** log.

Log Operations

Use the buttons in the control panel to perform the following actions:

 Create a new log.

The **New** button is disabled if a Ready, Pending, Running, or Suspended log is on the instrument. When the instrument contains its maximum number of logs, the New button is unavailable.

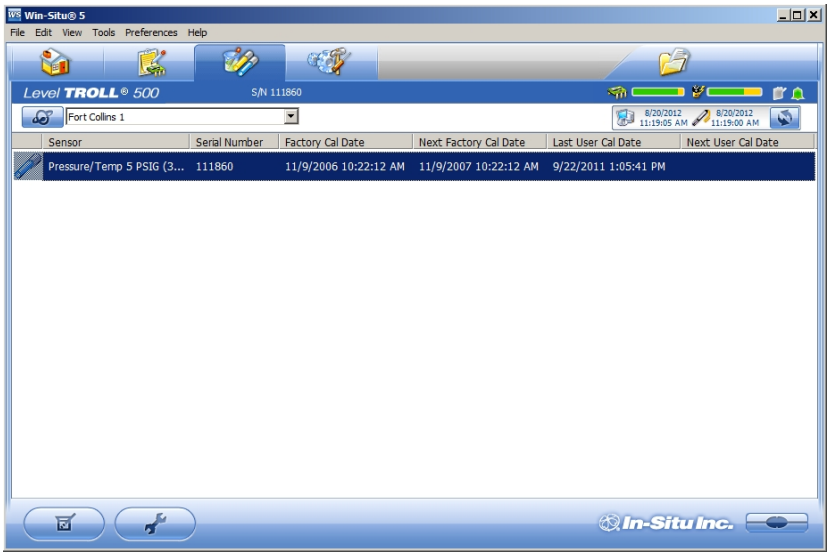
 **Edit** (or review) the log configuration for a Ready, Pending, or Invalid log.

 **Delete** the log. (Note that you must delete a log twice before it is permanently removed.)

 **Download** the log to a PC.

Sensors Tab

The **Sensors** tab lists the sensors in the instrument, along with their serial numbers and calibration dates. Use the buttons in this tab to calibrate and configure sensors.



Calibrate

Use the **Calibration** button to calibrate sensors or to adjust a level reference that is currently stored on the instrument. The **Calibrate** button is not available when the instrument does not support calibration (e.g. BaroTROLL Instrument).

1. With the instrument connected to the software, select the **Sensors** tab.
2. Select the parameter you intend to calibrate.
3. Click the **Calibrate** button  .

Configure

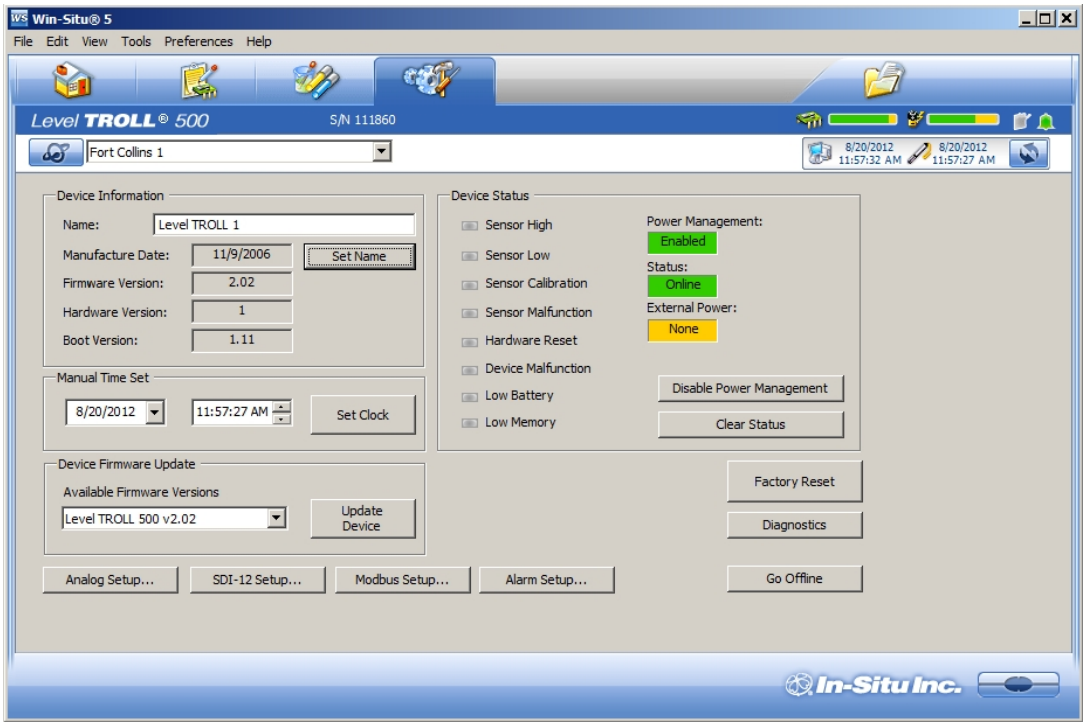
Use the **Configure** button to select parameter units and to configure parameters that support configuration. Examples include Level/Depth, Specific Conductivity, and Total Dissolved Solids. Parameters cannot be configured while the instrument is showing live data on the **Home** screen or while the instrument contains an active log.

1. With the instrument connected to the software, select the **Sensors** tab.
2. Select the parameter you intend to configure.
3. Click the **Configure** button  .

> ✔ When you configure the Level parameter using the **Sensors** tab, the settings are stored in the instrument and are available for use in Modbus, SDI-12, or analog communication (if available). If desired, a different configuration can be selected when setting up a log.

Device Setup Tab

In general, you should not use the **Device Setup** tab unless you are corresponding with the In-Situ technical support team. However, you can use this screen to set up communication protocols if you are connecting the instrument to a PLC or data logger.



✔ See the online Help for more details.

Using Win-Situ 5 Software

Connecting an Instrument to the Software

When you open Win-Situ 5 Software, you are asked if you want to connect to your device. Click **Yes**. Synchronize the instrument clock to the PC clock. 

The software displays an error message if a connection cannot be established.

Selecting the Correct COM Port

If you are using a USB TROLL Com, select the correct COM port by following the steps below. If you are using a serial TROLL Com, the Win-Situ Software should default to the correct COM port, which is usually COM 1.

Steps for Windows 8.1 and Windows 10 systems.

1. Right-click the **Start** button.
2. Click **Device Manager**.
3. Click the arrow next to **Ports (COM and LPT)**, and locate the USB Serial Port listing. The number listed next to this entry is your COM port address.

Steps for Windows 8 systems.

1. Right-click the **Start** screen.
2. Select **All Apps**.
3. Click **Control Panel**.
4. Open the **Device Manager**.
5. Click the arrow next to **Ports (Com and LPT)**, and locate the USB Serial Port listing. The number listed next to this entry is your COM port address.

Steps for Windows 7 systems.

1. Click the **Start** button, and open the **Control Panel**.
2. Click **Hardware and Sound**, and open the **Device Manager**.
3. Click the arrow next to **Ports (COM and LPT)**, and locate the USB Serial Port listing. The number listed next to this entry is your COM port address.

Steps for Windows XP systems.

1. Click the **Start** button, and open the **Control Panel**.
2. Double-click the **System** icon. Click the **Hardware** tab, and open the **Device Manager**.
3. Click the plus sign next to **Ports (COM and LPT)**, and locate the USB Serial Port listing. The number listed next to this entry is your COM port address.

> ✔ **The following steps apply for all Windows operating systems.**

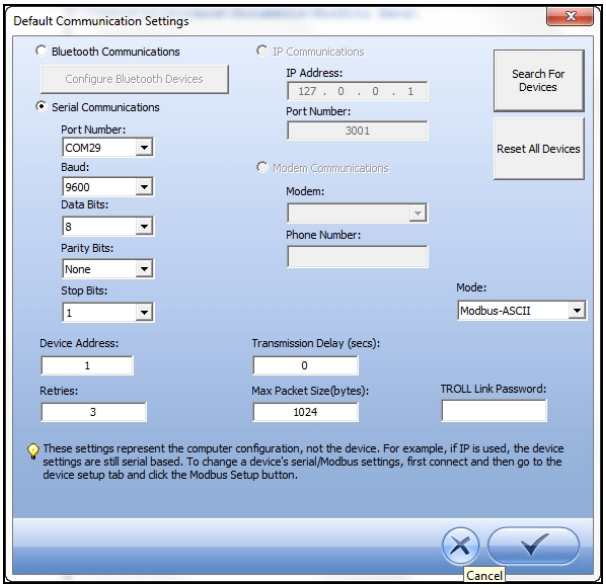
1. Once you have determined the correct COM port address in your operating system, reopen Win-Situ 5 Software.
2. Close any open windows in Win-Situ Software.
3. Click **Preferences**.
4. Click **Comm Settings**, and then click the **Port Number** menu.

5. Scroll down to find the correct COM port address. Click the **check mark** to accept the changes.
6. Click the yellow **Connect** button in the lower right corner to establish a connection to the instrument.

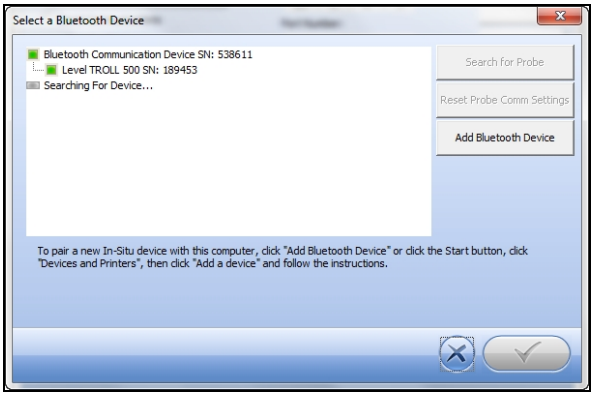
Bluetooth & Wireless TROLL Com

Alternatively, your instrument can communicate with Win-Situ software via a Wireless Rugged TROLL Com and Bluetooth.

Connect the cable to the Wireless TROLL Com and the Rugged TROLL instrument. Turn on the Wireless TROLL Com and open Win-Situ 5. Choose **File > Connect** to access the Default Communication Settings window.



Select the radio button labeled **Bluetooth Communications** and click **Configure Bluetooth Devices**. You will see a list of nearby Bluetooth devices. Click the Wireless TROLL Com you are using and click the check mark.



Finally, click the yellow **Connect** button  at the bottom right of the screen to complete the connection.

Setting the Instrument Time

The instrument time and the current PC time are shown at the top of the screen when an instrument is connected to the software.



The PC time appears on the left, the instrument time on the right. Both clocks are updated at 0.5 Hz (once every two seconds). The device time is displayed in red if it differs by more than a few seconds from the current PC time. Data logging schedules depend on a correct instrument time.

To synchronize the instrument time to the current PC time, click the **Clock Sync** button  . Win-Situ writes the current PC time to the instrument.

Adding a New Site

To add a new site to the site database in your working directory do one of the following:

On the **Data** tab, click the **Site Data** folder, select **File**> **New** > **Site**.

or

On the **Home** tab, click the **Site** button to display the site list, then click **New** . Enter a name for the site. This is the only required field.

Click **Save** to save the new site. The new site will appear in the **Site Data** folder, and Win-Situ will add it to the site database in the working directory on your computer. It is now available to select for any instrument log.

Log Setup

The Log Setup Wizard presents sequential screens to help you supply all the information necessary to set up a data log in the instrument.

To access the Log Setup Wizard the instrument must be connected to the software.

1. Click the **Logging** tab  .
2. Click the **New** button  .

> ✔ The **New** button may be disabled or may show a warning if an active log already exists on the instrument, or if the instrument is polling live data (see the **Home** screen), or if the device already contains its maximum number of logs.

3. Select the **Site** where the set of data will be logged and supply a name for the log.
4. Click the **right arrow** to continue after each step.
5. Select the parameters you intend to measure, choose the measurement units, and specify the order in which the selected parameters will be logged.
6. Select the logging method you intend to use. See page 35.
7. Select the log interval. A log interval is how often a measurement will be taken and stored.
8. Select the start condition, stop condition, and specify how to handle full device memory.
9. If you selected **Level** or **Depth** as a parameter to measure, specify how you intend to log this parameter. See page 36.
10. The final screen summarizes the log setup. Click the **check mark** to write this information to the instrument.

Logging Method Descriptions

The following is a list of log types and their descriptions. The log types that are available on an instrument vary depending upon the capabilities of the instrument.

Logging Methods for Long-Term Monitoring

Linear

Linear log type measures and records at a user-defined fixed interval of one minute or more. This method is used for long-term studies, landfill monitoring, stream gauging, tidal studies, and background monitoring prior to aquifer testing. Intervals are measured in days, hours, or minutes.

Linear Average

Linear Average log type can smooth out anomalous highs and lows that may occur in a data set, for example, when a water wave passes over the instrument. Each stored measurement is the average of several rapid measurements. This method is used for long-term studies, stream gauging, tidal and open-water studies where trends are more important than accuracy. Intervals are measured in days, hours, minutes, or seconds.

Event

Linear Event log type combines basic fixed-interval logging of specified parameters with the ability to log data at a faster interval when a single-parameter event condition is present.

About the Level Reference

A Level Reference, also called an offset, is a user-specified starting point for logged Level readings. It is entered in the Logging Setup Wizard when a log is configured, or it can be stored in the device without configuring a log using the **Configure** button in the **Sensors** tab.

Depth mode does not require that you enter a Level Reference.

The Level Reference can be any value you choose. Here are some examples:

- **Elevation**—If you calculate the water level above mean sea level (MSL) and enter this as the Level Reference, then elevations above MSL will be logged.
- **Depth to Water**—If you measure the depth to the water surface (DTW) from the top of the well casing and enter this as the Level Reference, then DTW (also called drawdown) values will be logged.
- **Gauge Height or Stage**—Logged readings track water level as related to markings on a nearby staff gauge.
- **Zero**—A Level Reference of 0 effectively sets the probe to zero at the start of the log. Changes, both positive and negative, from the starting water level, will be logged.

Once you have determined the value of your Level Reference, the software gives you three options for entering it. These control when the level reference is applied.

- **New Reference**—This option is designed to be used with an active software connection when the device is installed in the water.

> ⚠ **A new level reference must be entered while the device's pressure sensor is submerged in its final position in the water.** This is because the current probe reading is set equal to the Level Reference to create the offset that takes effect at the start of the data log. The log header will show the probe reading at the time you entered the Level Reference.

During log setup, the software presents two additional options for entering the Level Reference:

- **Set first logged reading**—Use this option when the instrument will be deployed on wire rather than cable because you will not be able to communicate with the instrument when it is submerged.
- **Remind me to set reference later**—Use this option to defer the entry of the Level Reference during log setup and set a reminder to enter it when the device is submerged in its final position.

Starting a Log

Every log is programmed for either a manual or a scheduled start. A log with a manual start time is displayed in the Logging screen with **Ready** in the **Status** column. A log with a scheduled start time is displayed with **Pending** in the **Status** column.

Starting a Pending Log

A **Pending** log automatically starts at the scheduled time without any user intervention.

> ✔ A scheduled log with **Pending** status can be manually started at any time before its scheduled start.

Starting a Manual Log

With the instrument connected to the software, select the **Logging** tab.

Select the Ready log you want to start.

Click the **Start Log** button  . The log starts and the symbol changes. The **Status** column displays **Running**.

Suspending (Pausing) a Log

A running log may be temporarily paused. For example, you might want to reposition an instrument, calibrate a sensor, or clean a sensor and later resume the log. A log can be suspended and resumed three times.

1. With the instrument connected to the software, select the **Logging** tab  .
2. Select the log you intend to suspend.
3. Click the **Suspend** button  . **Suspended** appears in the **Status** column.

Resuming a Suspended Log

1. To resume logging after a log has been suspended, select the **Logging** tab.
2. Select the **Suspended** log.
3. Click the **Start Log** button  . Logging resumes. **Running** appears in the **Status** column. The data file will show the time when the log was suspended and the time when it restarted.

Stopping a Log

A log can be manually stopped at any time, even if a stop time has been previously scheduled. If you did not specify a stop condition when you defined the log, the log will run until the instrument is out of memory or battery power, or until you manually stop it.

> ✔ A log that has been stopped cannot be resumed. If you intend to resume a log later, you should suspend a log rather than stop it.

1. To manually stop a log, the instrument must be connected to the software.
2. Select the **Logging** tab  .
3. Select the running log you intend to stop.
4. Click the **Stop Log** button  .

Downloading Data to a PC

This procedure copies the data log from the instrument to a PC. It does not remove the data log from the instrument. After a log is downloaded, it can be exported to a CSV file format that can be used by spreadsheet programs. The time shown in the log name is the time the log was downloaded.

1. With an instrument connected, select the **Logging** tab  .
2. Select the log you intend to download.
3. Choose a Running, Suspended, Stopped, or Deleted log.
4. Click the **Download**  button.
5. In the next screen, select one of the three download options.
   - All data
   - New data (data logged since the last download)
   - Time interval to download

   
   New data is downloaded by default to a new log file. To append new data to the last download of this log, be sure the option "Append logs on download" is selected in the **General Settings** dialog (**Preferences** > **General Settings**).
2. The log is copied to the connected PC into your Win-Situ working directory folder. View or change the working directory using **File** > **Settings**.
3. At the end of the download, Win-Situ gives you the option of viewing the data.
   - Select **Yes** and the log is displayed in the **Data** screen.
   - Select **No** and the **Logging** screen appears. You can view the data at any time by selecting it in the **Data** tab.

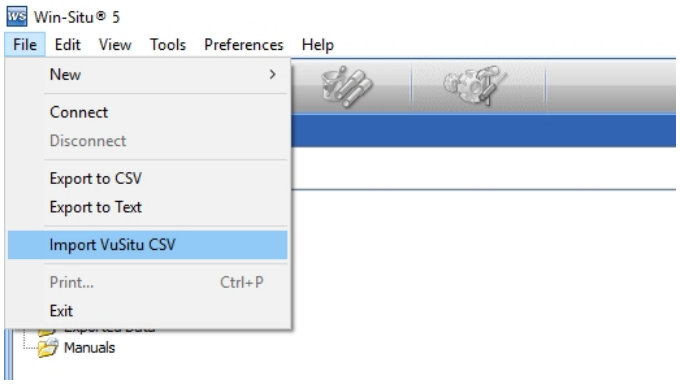
Viewing Logged Data

1. To view the data stored in the instrument, you must first download the data. A connection to an instrument is not needed after the data log has been downloaded.
2. Select the **Data** tab  .
3. On the left side of the screen, select the log you want to view. To expand a folder shown in the navigation tree, double-click the folder. The content of the data log is displayed on the right side of the screen in text or graph format.

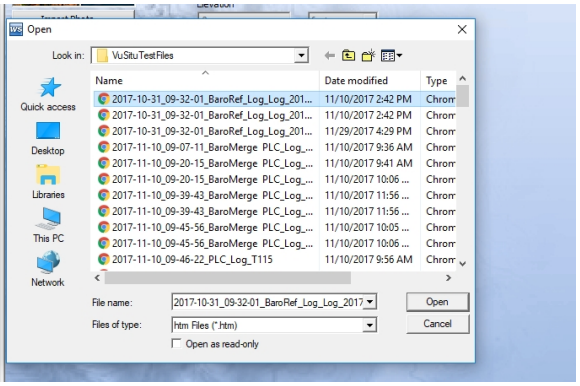
   
   To switch between view formats, click the **Text** or the **Graph** button in the control panel. To customize the text or graph view, select **Preferences** > **Graph Settings** or **Preferences** > **Data View Settings**. These options apply to all downloaded data until you change the options.

Importing VuSitu Data to Win-Situ

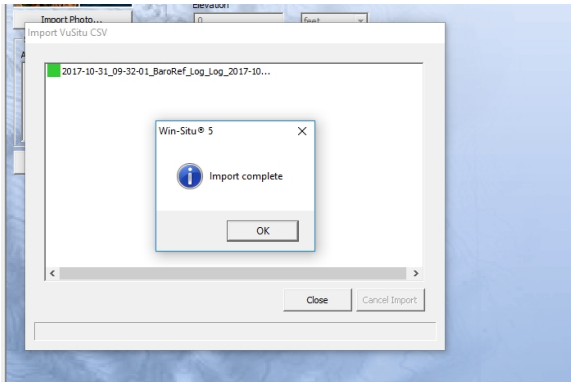
You can import data files from VuSitu into Win-Situ 5 from the File menu.



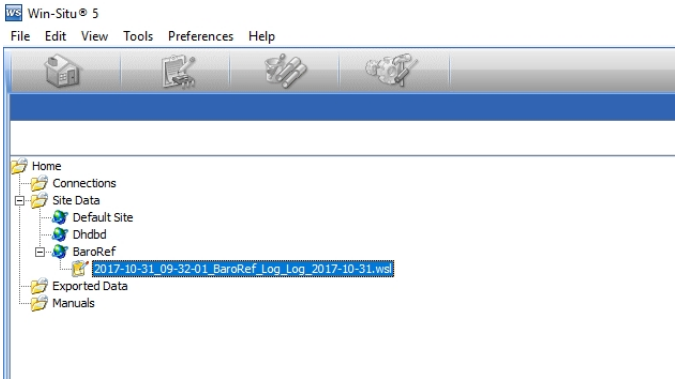
A. Click **File > Import VuSitu CSV** in the menu bar at the top of the screen.



B. Select the file you wish to import and click **Open**.



C. Select **OK** at the prompt.



D. Click on the file name to view it.

Using BaroMerge Software

BaroMerge Software is used to post-correct absolute (non-vented) level sensor data to eliminate barometric pressure effects from the measurements. BaroMerge Software can be accessed through the Win-Situ 5 Software **Tools** menu. BaroMerge provides three options to correct data.

- **Fixed Correction**—A single offset value is applied to all selected log data. Use this option if you know the barometric pressure of the site during the log, and know that it did not change.
- **Manual Entry**—Specify two or more correction values to apply to the log data. Use this option if you wish to manually enter a data set of barometric pressure values.
- **BaroTROLL log file**—Absolute level sensor data points are individually corrected to reflect barometric pressure changes that were logged by a BaroTROLL instrument during the approximate time period.



Baro Merge Input—Fixed Correction

If you select the **Apply a fixed correction** option, a single correction is applied to all values in the log.

To use this correction method you need barometric pressure values from a reliable source. Choose a single value that represents the actual ambient barometric pressure during the time period the log was recorded. You also need to know the file names of the logs you want to correct.

1. From the **Tools** menu, select **Win-Situ Baro Merge**.



2. Select the **Apply a fixed correction** option.
3. Enter the barometric correction value and select units from the drop-down menu.
4. Click the **right arrow** button.
5. Select the log files to which the correction will be applied and click the **check mark** button.
6. Compensated data files can be viewed or exported from the **Data** tab.

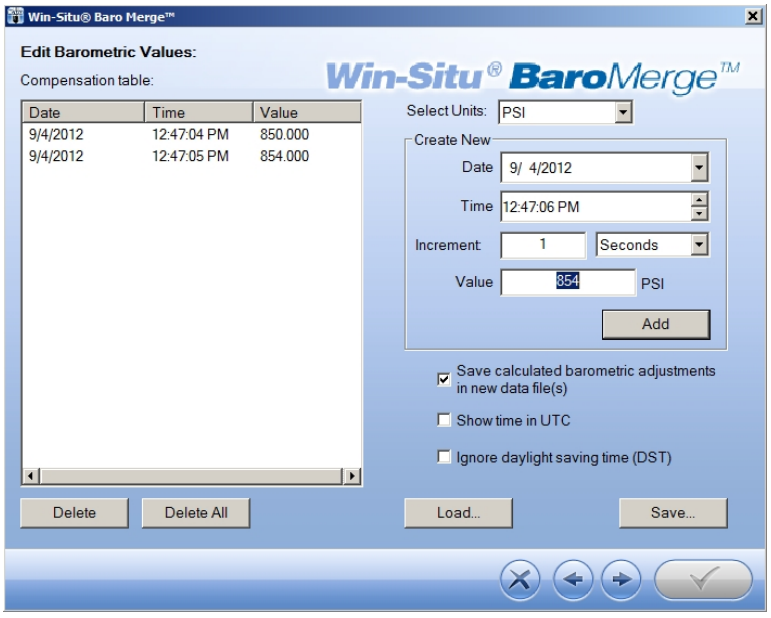
Baro Merge Input—Manual Entry

When you select the **Fixed Correction** and **Manual Entry** options, it is important to know the barometric pressure for the general time period covered by the log or logs you want to correct.

1. From the **Tools** menu, select **Win-Situ BaroMerge**.



2. Select the **Enter one or more values manually** option.
3. The compensation table appears that allows you to build a table of barometric data that corresponds to the time the log was recorded. The compensation table has three preference options:



- The first option, **Save calculated barometric adjustments in the new data file(s)** is the default option. It adds additional columns depending on which parameters were selected for the absolute/non-vented log in the corrected BaroMerge file that uses the compensation table values. This is intended to show how the adjustments were done in the BaroMerge file. If you do not want to show these adjustments, clear this option.

- When the second option, **Show time in UTC** is selected, the compensation table time stamp displays in Coordinated Universal Time (UTC) time, formally known as Greenwich Mean Time (GMT).
- If the third option, **Ignore daylight saving time (DST)** is selected, the compensation table time stamp format without the daylight savings time adjustment will be shown.

3. Build a table that contains at least two barometric pressure values.
4. Click the right arrow and select the absolute (non-vented) log file or files you intend to correct.
5. Click the check mark and the barometric compensation is applied.
6. Compensated data files can be viewed or exported from the **Data** tab.

BaroMerge Output

Your original log file is not changed. A new, corrected log file with the same name and path is created. The original ".wsl" extension is replaced by "-Baro Merge.wsl".

Disconnecting an Instrument from the Software

Click the plug icon  in the lower-right corner of the screen to disconnect the instrument from the software.

Disconnect the instrument from the communication device. Attach a desiccant pack if you are using a vented cable.

Maintenance, Cleaning, and Storage

O-ring Inspection and Replacement

Examine O-rings for wear, dryness, discoloration, stretching, cracks, nicks, and brittleness. Replace O-rings when any of these conditions are present. Replacing O-rings on an annual basis, regardless of their condition, is the best way to protect against moisture damage.

Perform the following steps to replace an O-ring.

1. Remove and discard the damaged O-ring.
2. Use a clean, dry, soft cloth to clean the O-ring groove to remove dirt or residue.
3. Lubricate the new O-ring using high-vacuum grease.
    a. Wash your hands thoroughly.
    b. Apply a small amount of grease to the pad of your index finger, and rub your index finger and thumb together to spread the grease evenly.
    c. Inspect the new O-ring and remove any debris stuck to it.
    d. Rub your fingers around the O-ring until there is a thin layer of grease on the entire O-ring.
4. Install the O-ring in the groove and remove any excess lubricant with a clean cloth.

    Do not allow water or lubricant to enter the connector.

Cleaning the Instrument

Clean the instrument body with water and a soft brush or plastic scouring pad, or soak overnight in a mild acidic solution, such as household vinegar. ***NEVER*** submerge the connector portion of the instrument when it is not connected to a cable.

If the ports near the pressure sensor are clogged with silt or mud, try the following procedures.

- Agitate the instrument vigorously in a bucket of clean water.
- Apply a gentle rinse of water from a wash bottle.

Do not attempt to remove material from the instrument by tapping the instrument against a surface. **You void the instrument's warranty by inserting anything into the sensor opening.** If contamination cannot be removed using the recommendations above, please contact In-Situ for cleaning.

Storage

Store the instrument in a clean, dry place. Store the instrument where it will not roll off a bench onto a hard surface or sustain other mechanical shock. Protect the instrument from temperature extremes.

Store the Rugged TROLL within the temperature range -40° C to +80° C (-40° F to +176° F).

Service

Return Materials Authorization (RMA) Form

To obtain a factory calibration, fill out and return the online Return Materials Authorization (RMA) form located at ***www.in-situ.com/***.

Obtaining Repair Service

If you suspect your system is malfunctioning and repair is needed, you can help assure efficient servicing by following these guidelines:

1. Call or email In-Situ Technical Support. Have the product model and serial number available.
2. Be prepared to describe the problem, including how the product was used and the conditions noted at the time of the malfunction.
3. If Technical Support determines that service is needed, they will ask your company to fill out the RMA form and pre-approve a specified monetary amount for repair charges. When the form and pre-approval is received, Technical Support will assign an RMA (Return Material Authorization) number.
4. Clean the product as described in the manual.
5. If the product contains a removable battery, remove and retain it unless you are returning the system for a refund or Technical Support states otherwise.
6. Carefully pack your product in its original shipping box, if possible.
7. Mark the RMA number clearly on the outside of the box.
8. Send the package, shipping prepaid, to:

In-Situ
ATTN: Repairs
221 East Lincoln Avenue
Fort Collins, CO 80524-2533

The warranty does not cover damage during transit. In-Situ recommends insurance for all shipments. Warranty repairs will be shipped back prepaid.

Outside the U.S.

Contact your international In-Situ distributor for repair and service information.

Guidelines for Cleaning Returned Equipment

Please help us protect the health and safety of our employees by cleaning and decontaminating equipment that has been subjected to any potential biological or health hazards, and labeling such equipment. Unfortunately, we cannot service your equipment without such notification. Please complete and sign the form in your Operator's Manual (or a similar statement certifying that the equipment has been cleaned and decontaminated) and send it with each returned instrument.

- We recommend a cleaning solution, such as Alconox®, which is a glassware cleaning product available from In-Situ (part number 0029810) or laboratory supply houses.
- Clean all cabling. Remove all foreign matter.
- Clean cable connector(s) with a clean, dry cloth. Do not submerge cable connectors.
- Clean the probe body—including the nose cone, cable head, and protective caps. Remove all foreign matter.

If an instrument is returned to our Service Center for calibration or repair without a statement that it has been cleaned and decontaminated, or in the opinion of our Service Representatives presents a potential health or biological hazard, we reserve the right to withhold service until proper certification has been obtained.

Decontamination and Cleaning Form

Decontamination & Cleaning Statement

Company Name_____ Phone _____

Address _____

City _____ State _____ Zip _____

Instrument Type_____ Serial Number_____

Contaminant(s) (if known) _____

_____

Decontamination procedure(s) used _____

_____

Cleaning verified by_____ Title_____

Date_____

In-Situ Inc.

Declarations of Conformity and Similarity

Rugged TROLL 100

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: Rugged TROLL
Model: Rugged TROLL 100
Product Description: The Rugged TROLL measures and logs level and temperature in natural groundwater and surface water.

is in compliance with the following Directives:

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Including Amendments A1:1998, A2:2001, A3:2003, Electric Equipment for Measurement, Control and Laboratory Use

- **Emissions**
  Class A requirements of EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Date of Issue: April 26, 2010

Signature: 
Name: Bruce Barker
Title: Director of New Product Development

CE FC

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: Rugged TROLL
Model: Rugged TROLL 200
Product Description: The Rugged TROLL measures and logs level and temperature in natural groundwater and surface water.

is in compliance with the following Directives:

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Including Amendments A1:1998, A2:2001, A3:2003, Electric Equipment for Measurement, Control and Laboratory Use

- **Emissions**
  Class A requirements of EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Date of Issue: April 26, 2010

Signature: 
Name: Bruce Barker
Title: Director of New Product Development

CE FC

EMC Verification
Declaration of Similarity

Equipment

Type of equipment:	Measurement instrumentation
Product name:	Rugged BaroTROLL®
Model:	Rugged BaroTROLL
Manufacturer:	In-Situ, Inc. 221 East Lincoln Avenue Fort Collins, CO 80524 USA

Category	Standards
Emission:	EN 61326 & FCC Part 15, Subpart B
Immunity:	EN61326

Summary

We confirm that the equipment referenced above, without reasonable doubt, will fulfill the requirements concerning electromagnetic compatibility according to the above mentioned standards harmonized with the EMC Directive 89/336/EEC. The Rugged TROLL 200 was tested and found to be in compliance in the month of April 2010.

Date of Issue: July 3, 2013

Signature: 

Name: Jon Firooz
Title: Vice President, Research and Development

Innovations in **Water Monitoring**

Operator's Manual

Level TROLL® 400, 500, 700, 700H Instruments



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Internet: *www.in-situ.com*

Support: 800-446-7488 (U.S.A. & Canada)

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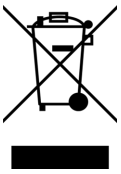

The presence of the Waste Electrical and Electronic Equipment (WEEE) marking on the product indicates that the device is not to be disposed via the municipal waste collection system of any member state of the European Union.

For products under the requirement of WEEE directive, please contact your distributor or local In-Situ office for the proper decontamination information and take back program, which will facilitate the proper collection, treatment, recovery, recycling, and safe disposal of the device.

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Introduction

The Level TROLL Instrument is a compact, modular system for measuring level and temperature in natural groundwater, surface water, industrial waters, and other installations.

Scope

This document is intended to describe the characteristics, operation, calibration, and maintenance of the instrument. Communication registers and SDI-12 programming information can be found in the Modbus and SDI-12 Reference Guides on the In-Situ website.

Serial Number Location

The serial number is engraved on the instrument housing. It is also programmed into the instrument and is displayed when the instrument is connected to a computer running Win-Situ Software.

Certification

See the Declarations of conformity at end of this manual.

Unpacking and Inspection

Your instrument was carefully inspected before shipping. Check for any physical damage sustained during shipment. Notify In-Situ and file a claim with the carriers involved if there is any shipping damage. Accessories may be shipped separately and should also be inspected for physical damage and the fulfillment of your order.

> ⚠ Please save packing materials for future storage and shipping. The shipping boxes have been performance-tested and provide protection for the instrument and its accessories.

Warranty

See the product specification tables for warranty information.

Contact Information

Mailing and Shipping Address:

In-Situ
221 East Lincoln Avenue
Fort Collins, CO 80524
U.S.A.

Phone: 970-498-1500 (international & domestic)

Fax: 970-498-1598

Internet: *www.in-situ.com*

Support: 800-446-7488 (U.S.A. & Canada)

Product Specifications

Level TROLL 400 Instrument

General	Level TROLL 400
Temperature ranges[1]	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: -5-50° C (23-122° F)
Diameter	1.83 cm (0.72 in.)
Length	21.6 cm (8.5 in.)
Weight	124 g (0.27 lb)
Materials	Titanium body; Delrin nose cone
Output options	Modbus/RS485, SDI-12, 4-20 mA
Battery type & life[2]	3.6 V lithium; 10 years or 2M readings
External power	8-36 VDC
Memory Data records[3] Data logs	2.0 MB 130,000 50
Log types	Linear, Fast Linear, and Event
Fastest logging rate & Modbus rate	2 per second
Fastest SDI-12 & 4-20 mA output rate	1 per second
Real-time clock	Accurate to 1 second/24-hr period
Sensor Type/Material	Piezoresistive; titanium
Calibrated Range (Usable Depth)	*Absolute (non-vented)* 30 psia (11 m, 35 ft) 100 psia (60 m, 197 ft) 300 psia (200 m, 658 ft) 500 psia (341 m, 1120 ft)
Burst pressure	Max. 2x range; burst > 3x range
Accuracy (FS)[4]	±0.05%
Long-term stability[5]	< 0.1% FS
Resolution	±0.005% FS or better
Units of measure	Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH_2O, inH_2O Level: in, ft, mm, cm, m
Temperature Sensor	
Accuracy & resolution	±0.1° C; 0.01° C or better
Units of measure	Celsius or Fahrenheit
Warranty	3 years Extended warranties are available for all instruments—call for details

Footnotes	[1] Temperature range for non-freezing liquids [2] Typical battery life when used within the factory-calibrated temperature range [3] 1 data record = date/time plus 2 parameters logged (no wrapping) from device within the factory-calibrated temperature range [4] Across factory-calibrated pressure and temperature ranges. Defined as greater than 98% of all readings fall within spec across full temperature and pressure [5] Includes linearity and hysteresis over one year Specifications are subject to change without notice. Delrin is a registered trademark of E.I. du Pont de Nemours and Company.

Level TROLL 500 Instrument

General	Level TROLL 500
Temperature ranges[1]	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: -5-50° C (23-122° F)
Diameter	1.83 cm (0.72 in.)
Length	21.6 cm (8.5 in.)
Weight	124 g (0.27 lb)
Materials	Titanium body; Delrin nose cone
Output options	Modbus/RS485, SDI-12, 4-20 mA
Battery type & life[2]	3.6 V lithium; 10 years or 2M readings
External power	8-36 VDC
Memory Data records[3] Data logs	2.0 MB 130,000 50
Log types	Linear, Fast Linear, and Event
Fastest logging rate & Modbus rate	2 per second
Fastest SDI-12 & 4-20 mA output rate	1 per second
Real-time clock	Accurate to 1 second/24-hr period
Sensor Type/Material	Piezoresistive; titanium
Calibrated Range (Usable Depth)	*Gauged (vented)* 5 psig (3.5 m, 11.5 ft) 15 psig (11 m, 35 ft) 30 psig (21 m, 69 ft) 100 psig (70 m, 231 ft) 300 psig (210 m, 692 ft) 500 psig (351 m, 1153 ft)
Burst pressure	Max. 2x range; burst > 3x range
Accuracy (FS)[4]	±0.05%
Resolution	±0.005% FS or better
Long-term stability[5]	< 0.1% FS
Units of measure	Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH_2O, inH_2O Level: in, ft, mm, cm, m
Temperature Sensor	
Accuracy & resolution	±0.1° C; 0.01° C or better
Units of measure	Celsius or Fahrenheit

Warranty	3 years Extended warranties are available for all instruments—call for details
Footnotes	See See page 8.

Level TROLL 700 Instrument

General	Level TROLL 700
Temperature ranges[1]	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: -5-50° C (23-122° F)
Diameter	1.83 cm (0.72 in.)
Length	21.6 cm (8.5 in.)
Weight	124 g (0.27 lb)
Materials	Titanium body; Delrin nose cone
Output options	Modbus/RS485, SDI-12, 4-20 mA
Battery type & life[2]	3.6 V lithium; 10 years or 2M readings
External power	8-36 VDC
Memory Data records[3] Data logs	4.0 MB 260,000 50
Log types	Linear, Fast Linear, Linear Average, Event, Step Linear, True Logarithmic
Fastest logging rate & Modbus rate	4 per second
Fastest SDI-12 & 4-20 mA output rate	1 per second
Real-time clock	Accurate to 1 second/24-hr period
Sensor Type/Material	Piezoresistive; titanium
Calibrated Range (Usable Depth)	*Absolute (non-vented)* 30 psia (11 m, 35 ft) 100 psia (60 m, 197 ft) 300 psia (200 m, 658 ft) 500 psia (341 m, 1120 ft) 1000 psia (693 m, 2273 ft) *Gauged (vented)* 5 psig (3.5 m, 11.5 ft) 15 psig (11 m, 35 ft) 30 psig (21 m, 69 ft) 100 psig (70 m, 231 ft) 300 psig (210 m, 692 ft) 500 psig (351 m, 1153 ft)
Burst pressure	Max. 2x range; burst > 3x range
Accuracy (FS)[4]	±0.05%
Resolution	±0.005% FS or better
Long-term stability[5]	< 0.1% FS
Units of measure	Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH_2O, inH_2O Level: in, ft, mm, cm, m
Temperature Sensor	
Accuracy & resolution	±0.1° C; 0.01° C or better
Units of measure	Celsius or Fahrenheit
Warranty	3 years Extended warranties are available for all instruments—call for details
Footnotes	See See page 8.

Level TROLL 700H Instrument

Comply with the Office of Surface Water by using the most accurate pressure transducer available. The Level TROLL 700H meets the surface-water specification of ±0.01 foot.

For accuracy under all operating conditions, instruments are calibrated over the full pressure and temperature range. Each instrument includes a serialized, NIST-traceable calibration report.

General	Level TROLL 700H
Temperature ranges[1]	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: 0-40° C (32-104° F)
Diameter	1.83 cm (0.72 in.)
Length	21.6 cm (8.5 in.)
Weight	124 g (0.27 lb)
Materials	Titanium body; Delrin nose cone
Output options	Modbus/RS485, SDI-12, 4-20 mA
Battery type & life[2]	3.6 V lithium; 10 years or 2M readings
External power	8-36 VDC
Memory Data records[3] Data logs	4.0 MB 260,000 50
Log types	Linear, Fast Linear, Linear Average, Event, Step Linear, True Logarithmic
Fastest logging rate & Modbus rate	4 per second
Fastest SDI-12 & 4-20 mA output rate	1 per second
Real-time clock	Accurate to 1 second/24-hr period
Pressure Sensor Type/Material	Piezoresistive; titanium
Calibrated Range (Usable Depth)	*Gauged (vented)* 15 psig (11 m, 35 ft)
Burst pressure	Max. 2x range; burst > 3x range
Accuracy[5]	±0.01 foot up to 15 ft and ±0.1% of reading > 15 ft
Resolution	±0.005% FS or better
Units of measure	Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH_2O, inH_2O Level: mm, cm, m, in, ft,
Temperature Sensor	
Accuracy & resolution	±0.1° C; 0.01° C or better
Units of measure	Celsius or Fahrenheit
Warranty	3 years Extended warranties are available for all instruments—call for details
Footnotes	See See page 8.

BaroTROLL Instrument

The titanium BaroTROLL measures and logs barometric pressure and temperature. Use the BaroTROLL in conjunction with non-vented In-Situ Instruments.

Win-Situ BaroMerge Software simplifies post-correction of water level data by automatically subtracting barometric readings from data collected by a non-vented instrument to compensate for changes in pressure due to barometric fluctuations.

General	BaroTROLL
Temperature ranges[1]	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: -5-50° C (23-122° F)
Diameter	1.83 cm (0.72 in.)
Length	21.6 cm (8.5 in.)
Weight	124 g (0.27 lb)
Materials	Titanium body; Delrin nose cone
Output options	Modbus/RS485, SDI-12, 4-20 mA
Battery type & life[2]	3.6 V lithium; 10 years or 2M readings
External power	8-36 VDC
Memory Data records[3] Data logs	1.0 MB 65,000 2
Log types	Linear
Fastest logging rate & Modbus rate	1 per minute
Fastest SDI-12 & 4-20 mA output rate	1 per second
Real-time clock	Accurate to 1 second/24-hr period
Sensor Type/Material	Piezoresistive; titanium
Calibrated Range (Usable Range)	30 psia (usable up to 16.5 psi, 1.14 bar)
Burst pressure	Vacuum/over-pressure above 16.5 psi damages sensor
Accuracy @ 15° C[4]	±0.1% FS
Accuracy (FS)[5]	±0.2% FS
Resolution	±0.005% FS or better
Units of measure	Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH_2O, inH_2O
Temperature Sensor	
Accuracy & resolution	±0.1° C; 0.01° C or better
Units of measure	Celsius or Fahrenheit
Warranty	3 years Extended warranties are available for all instruments—call for details
Footnotes	See See page 8.

RuggedCable System

General	RuggedCable System
Operating temp. range	-25° to 80° C (-13° to 176° F)
Jacket options	TPU (thermoplastic polyurethane) Tefzel (ETFE fluoropolymer; generic equivalent to Teflon)
Vent options	Non-vented (absolute) Vented (gauged) with desiccant (used to mitigate moisture/humidity)
Conductors	6 conductors, 24 AWG, polypropylene insulation
Cable diameter	TPU: 6.7 mm (0.265 in.) Tefzel: 6.35 mm (0.25 in.)
Connector diameter	18. 5 mm (0.73 in.)
Weight	Non-vented, TPU: 16 kg/300 m (35.6 lbs/1,000 ft) Non-vented, Tefzel: 14 kg/300 m (32 lbs/1,000 ft) Vented, TPU: 14 kg/300 m (32 lbs/1,000 ft) Vented, Tefzel: 14 kg/300 m (32 lbs/1,000 ft)
Minimum bend radius	2X cable diameter (13.5 mm; 0.54 in.)
Break strength	127 kg (280 lbs)
Maximum cable length	1,219 m (4,000 ft) for RS485
Desiccant pack (required for vented systems)	Large and extra large desiccant packs available with titanium, ABS, or stripped-and-tinned termination.
Warranty	2 years
	Specifications are subject to change without notice.

Suspension Wire

General	Suspension Wire
Material	304 stainless steel, 7 x 7 strand
Coating	15 mil polyester elastomer insulation
Weight	0.28 kg / 30 m (0.60 lb / 100 ft)
Break strength	122 kg (270 lb) with proper clip tightening
	Specifications are subject to change without notice.

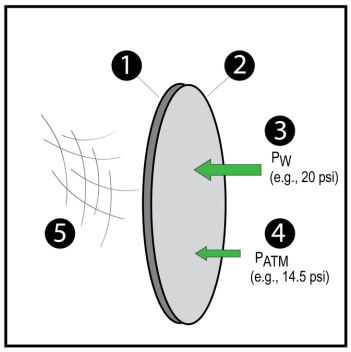
About the Pressure/Level Sensor

A pressure transducer senses changes in pressure, measured in force per square unit of surface area, exerted by water or other fluid on an internal media-isolated strain gauge. In-Situ offers instruments with either absolute (non-vented) or gauged (vented) pressure sensors.

> ⚠ The "Absolute vs. Gauged: Comparing Absolute and Gauged Pressure Sensors" technical note describes the difference between absolute and gauged pressure sensors and explains the proper use of each type of sensor in different applications.

Absolute Pressure Sensor

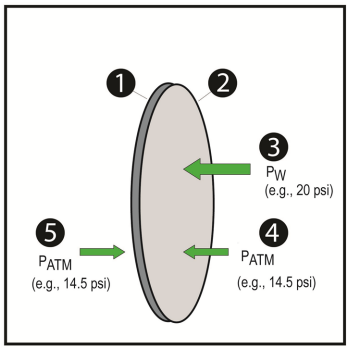
An absolute or non-vented pressure sensor measures all pressure forces detected by the strain gauge, including atmospheric pressure (P_{ATM}). The unit of measure is PSIA (pounds per square inch absolute), measured with respect to zero pressure. The back of an absolute pressure sensor is sealed from the atmosphere. Therefore, the front of the absolute pressure sensor responds to both atmospheric pressure and the pressure head of water above the sensor.



	Absolute Sensor
1	Sensor back
2	Sensor front
3	Water pressure, P_W (e.g., 20 PSI)
4	Atmospheric pressure P_{ATM} (e.g., 14.5 PSI)
5	Vacuum

Gauged Pressure Sensor

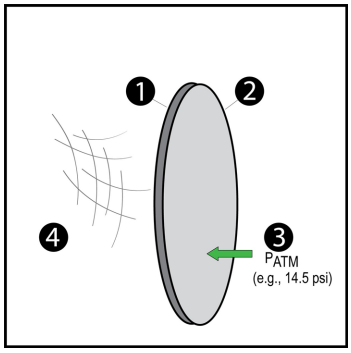
A gauged or vented pressure sensor eliminates the effects of atmospheric pressure because the vent tube in the cable allows atmospheric pressure to be applied to the back of the sensor. The unit of measure is PSIG (pounds per square inch gauge), measured with respect to atmospheric pressure.



	Gauged Pressure Sensor
1	Sensor back
2	Sensor front
3	Water pressure, P_W (e.g., 20 PSI)
4	Atmospheric pressure P_{ATM} (e.g., 14.5 PSI)
5	Atmospheric pressure P_{ATM} (e.g., 14.5 PSI)

BaroTROLL Atmospheric Pressure Sensor

Barometric pressure applies a direct stress upon open wells and surface water. Locally, barometric effects can change significantly from location to location as a result of topographical and micro-meteorological changes. Therefore, it is important to compensate for the barometric pressure changes when monitoring water elevation.

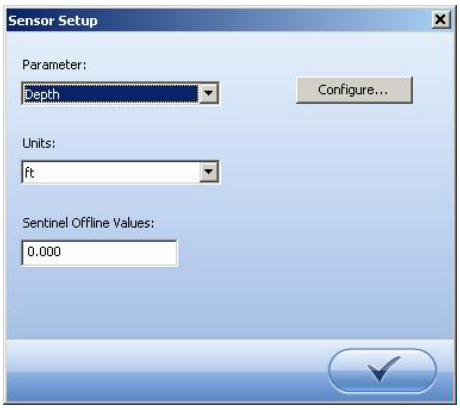


	BaroTROLL Sensor
1	Sensor back
2	Sensor front
3	Atmospheric pressure P_{ATM} (e.g., 14.5 PSI)
4	Vacuum

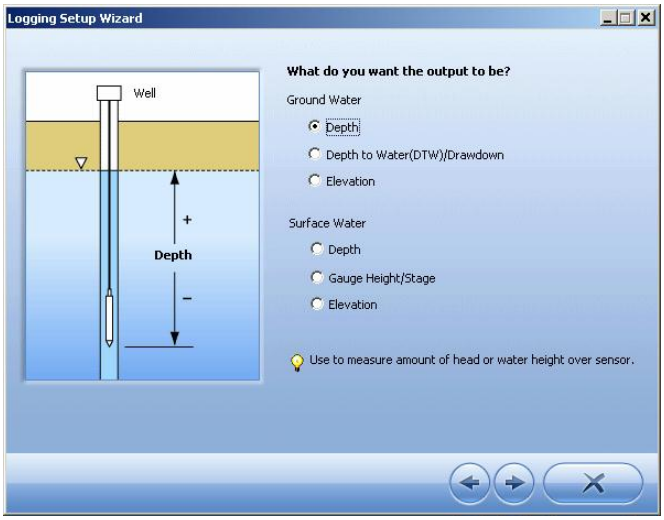
Configuring Depth and Level for PLC or Data Logger

When you configure level using the **Sensors** tab, the settings are stored in the instrument and are available for use in Modbus, SDI-12, or 4-20 mA analog communication. A different configuration can be selected when you set up a log.

1. Connect the instrument to the software.
2. Click the **Sensors** tab  .
3. Select the level/pressure sensor and click the **Configure**  button. The Sensor Setup window appears.



4. In the **Sensor Setup** window, select the Level parameter, then click **Configure** The Level Setup Wizard opens.



5. In the Level Setup Wizard, select the options you want. For more information, view the Help in the Win-Situ 5 Software.

System Components

Instrument

The Level TROLL Instrument is completely sealed and contains no user-serviceable parts. The instrument includes pressure and temperature sensors, a real-time clock, microprocessor, sealed lithium battery, data logger, and memory. Options include a vented or non-vented pressure sensor in a variety of ranges.

RuggedCable System

RuggedCable Systems are custom-built, durable, direct-read cables that include the following items.

- Titanium twist-lock connectors for quick, reliable connections to the instrument, desiccant, and communication cable
- Metal shield beneath the cable jacket to prevent electrical interferences
- Kellems grip for secure instrument deployment
- Small desiccant for vented systems (for storage only)

> ⚠ Non-vented cables are marked with VF, which means vent free.

Vented or Non-Vented Cable

Vented cable is used with vented pressure sensors to produce gauged measurements. The cable vent tube ensures that atmospheric pressure is applied to the back of the sensor diaphragm.

Non-vented cable is used with non-vented instruments for absolute measurements. Compensate absolute measurements by using a BaroTROLL Instrument and Win-Situ Baro Merge Software.

> ⚠ Vented cable is shipped with a small desiccant to protect against condensation. Larger desiccants are necessary for deployment.

Jacket Options

Tefzel (vented) or thermoplastic polyurethane (TPU, vented or non-vented)

Customizable Cable Lengths

Cables can be ordered up to 1,219 m (4,000 ft).

Cable Termination

Cables can be ordered with a twist-lock termination (female connector) on both ends that connect to the instrument, the TROLL Com Communication Device, desiccant, and other accessories.

Cables can also be ordered with stripped-and-tinned termination for wiring to a data logger or controller using SDI-12, analog (4-20 mA), or Modbus communication protocol.



1	RuggedCable System with female to female connectors
2	Stripped-and-tinned RuggedCable System with female connector
3	Stripped-and-tinned RuggedCable System with male connector (short length that converts a cable with a twist-lock connector to a stripped-and-tinned cable)

Suspension Wire

Polyurethane-coated stainless steel suspension cable can be used to deploy instruments with non-vented pressure sensors such as the Level TROLL 400 Instrument, the non-vented Level TROLL 700 Instrument, and the BaroTROLL Instrument. Suspension wire is appropriate to use when direct communication with the instrument is not necessary during deployment.



Description	Part Number
Suspension Wire - 300 feet	0066450
Suspension Wire - 150 feet	0066460
Suspension Wire - 50 feet	0066470

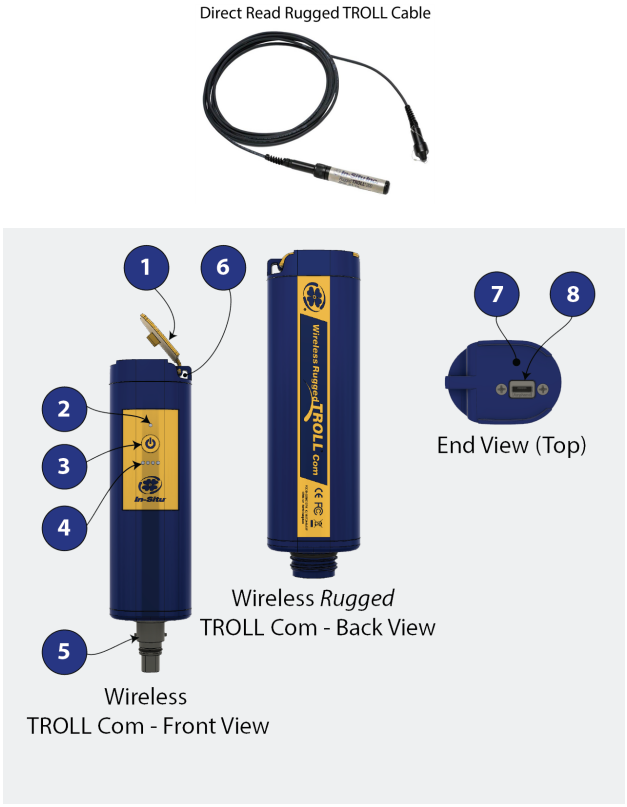
Communication Cables

The TROLL Com Communication Device provides an interface between the instrument and a desktop/laptop PC for calibrating and programming the instrument and for profiling and downloading data. The TROLL Com Communication Device is offered in either a cable-connect or direct-connect configuration including a 0.9 m (3 ft) vented polyurethane cable, external power input jack, and vent with replaceable membrane.

Description

The *Wireless TROLL Com* enables wireless communication between a Bluetooth 2.0-enabled Android or Windows device and an instrument deployed on a cable. You can also use the Wireless TROLL Com as a replacement for a standard wired TROLL Communication Device.

The *Wireless Rugged TROLL Com* permits wireless transmission between a Bluetooth 2.0-enabled device and a Rugged TROLL data logger. You must use a Direct Read Rugged TROLL cable with the Wireless Rugged TROLL Com.



1	Dust cover for the USB connection
2	Connection status **Red (flashing)** = The communication device, instrument, and Bluetooth-enabled device are not connected. **Red (continuous)** = The communication device and instrument are connected, but the communication device is not connected to the Bluetooth-enabled device. -OR- The communication device is connected via USB cable. **Green (flashing)** = The communication device is connected to the Bluetooth-enabled device, but is not connected to the instrument. **Green (continuous)** = The communication device, instrument, and Bluetooth-enabled device are connected.
3	On/Off button
4	Battery charge status:  100% -90%  90% - 75%  75% - 50%  50% - 25%  Less than 25%
5	Cable connector to the instrument
6	Lanyard connector
7	Serial number
8	USB connection to a power source for charging the internal battery or wired connection to a computer

Contents

- Wireless TROLL Com
- USB cable
- AC wall charger (U.S.A. only, universal charger sold separately)
- Lanyard

Charging the Communication Device

1. Remove the protective cover from the USB slot.
2. Connect the USB cable to the device.
3. Plug the USB cable into the wall charger or a powered USB port such as a computer that has a charger plugged in.
4. The device lights will turn on and blink according to charge level.

A fully-charged communication device will run for up to 40-50 continuous hours.

Battery Tips

The communication device uses an internal, rechargeable Lithium-ion (Li-ion) battery to supply power. While these batteries last for years with minimal decrease in performance, there are a few tips to prolong the life of the battery.

- Avoid full discharges and charge the battery more often between uses.
- Avoid storing the communication device in a high temperature (above 86° F / 30° C) area.

Connecting to a Wireless TROLL Com

A Wireless TROLL Com can be used to connect the instrument to software if the sonde is deployed on a cable.

1. Turn on the Wireless TROLL Com.
2. Make sure the cable is connected to the instrument as well as the communication device.
3. Go to Bluetooth settings on your mobile device or computer.
4. From the Bluetooth section, search for devices.
5. Tap or click the serial number of the communication device to pair the device with the phone or computer. The serial number is located under the USB flap.

Connecting to VuSitu

1. Open the VuSitu Mobile App. If you have correctly paired your Wireless TROLL Com with your wireless device, and the instrument is available, the software will connect and display readings.

   ✔ If the Searching screen continues to show, tap "Choose another device" and select the device you are trying to connect to.

Connecting to Win-Situ 5

1. Open Win-Situ 5 Software.
2. When prompted, "Connect to device now?" click **No**.
3. Plug the USB charging cable into the computer and Wireless TROLL Com.
4. Click **Preferences**, then click **Comm Settings**.
5. Select the correct Com port used by the charging cable, then select the communication settings for the instrument you are connecting. The following default communication settings are most common for In-Situ instruments:
   - Baud: 19200
   - Data Bits: 8
   - Parity Bits: Even
   - Stop Bits: 1
   - Device Address: 1
   - Mode: Modbus-RTU

   If you cannot connect using these settings, click the "Search for Devices" or "Reset All Devices" button.
6. Click the checkmark, then click the Connect button in the lower right hand corner.

Power Options

Internal Power—Batteries

Internal batteries are not user-replaceable. The approximate percentage of the power remaining in an internal battery is displayed on the Home Screen when an instrument is connected to Win-Situ Software.

The instrument is powered by 3.6 VDC, supplied by a sealed, non-replaceable AA lithium battery. Battery life depends on sampling speed. The battery typically lasts for 10 years or 2,000,000 readings, whichever occurs first.

When an instrument is wired to a data logger or PLC controller, power to the instrument is supplied by the data logger or controller.

AC Adapter

The AC adapter provides 24 VDC, 0.75 A, AC input 100-250 V and includes a North American power cord. The TROLL Com Communication Device includes an external power input port for connection to the AC adapter.

Description	Part Number
AC Adapter 24 VDC	0052440

> ⚠ Use only In-Situ Inc.'s AC adapter. Damage to the instrument caused by the use of third-party converters is not covered by the warranty.

External Power—External Battery Packs

External battery packs can significantly increase the life of an instrument, either for long-term deployments or to preserve an aging instrument.

TROLL Battery Pack

The sealed, submersible TROLL Battery Pack supplements internal battery power when an instrument is used for fast, frequent sampling or during long-term deployments. When this power source is connected, the instrument will use the external battery source first and switch to the internal batteries when external battery power is depleted. Total battery life depends on the sampling speed.



Description	Part Number
TROLL Battery Pack	0051450

The sealed, submersible TROLL Battery Pack supplies 14.4 V. When this power source is connected, the Level TROLL will use the external battery source first and switch to the internal batteries when external battery power is depleted.

0.5 second sampling interval	1.2 months
1 second sampling interval	2.3 months
1 minute (or longer) sampling interval	1 year

TROLL Replaceable Battery Pack

The TROLL Replaceable Battery Pack supplements internal battery power when a Level TROLL or Aqua TROLL 100 or 200 Instrument is used for frequent, fast sampling or during long-term deployments. When this power source is connected, the TROLL instrument will use the external battery source first and switch to the internal batteries when external battery power is depleted. Battery life depends on sampling rate. This battery pack allows for 1.5 V UM-3 or size AA batteries (8) that are replaced by the user.

> ✔ The TROLL Replaceable Battery Pack is not submersible.



Description	Part Number
TROLL Replaceable Battery Pack	0090000

Estimated Battery Lifetime

TROLL Battery Pack	Level TROLL Family
15 minute logging rate*	1.1 years
1 hour logging rate*	1.1 years

*Logging with all sensors. Actual battery lifetime varies based on site conditions.

TROLL Replaceable Battery Pack	Level TROLL Family
15 minute logging rate*	1.6 years
1 hour logging rate*	1.7 years

*Logging with all sensors. Actual battery lifetime varies based on site conditions.

Installation Accessories

NPT Adapter

The 0.25 in. NPT adapter allows instrument installation in piping.

Part Number	Image	Description
0051470		NPT Adapter

Cable Extender

The cable extender connects two lengths of RuggedCable System to meet varying installation needs.

Description	Image	Part Number
Cable Extender		0051490

Twist-Lock Hanger

The Twist-Lock Hanger is used with a suspension wire to install a non-vented instrument when the user does not require direct communication.

Part Number	Image	Description
0051480		Twist-Lock Hanger, titanium for Level TROLL 400, 700, 700H, BaroTROLL

Bulkhead Connector

The panel-mounted bulkhead connector provides connection between RuggedCable System and a controller panel.

Part Number	Image	Description
0053240		Bulkhead Connector

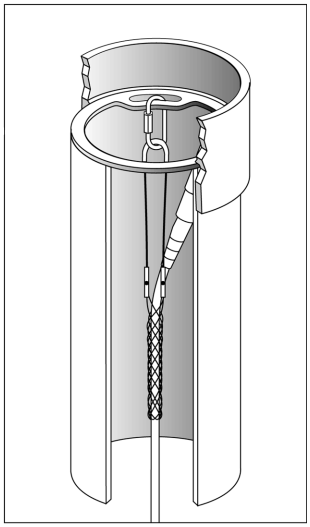
Locking Well Cap



Description	Part Number
Locking Well Cap, 2"	0020360
Locking Well Cap, 2" vented	0020370
Locking Well Cap, 4"	0020380
Locking Well Cap, 4" vented	0020390

Well Dock Installation Ring

The well dock installation ring provides installation support for 2", 4", and 6" well casings.



Description	Part Number
Well Dock Installation Ring 2"	0004690
Well Dock Installation Ring 4"	0004700
Well Dock Installation Ring 6"	0020650

Software

TheLevel TROLL can be programmed using the VuSitu Mobile App for Android, or using Win-Situ 5 Software.

About VuSitu

VuSitu is the mobile user interface and control application for In-Situ water quality instruments. You can use VuSitu on mobile devices with Android operating system 4.4, *Bluetooth* 2.0 and newer. Download the latest version of the app from the Google Play Store at play.google.com.

VuSitu allows you to accomplish the following tasks.

- View live readings that update every 10 seconds
- Change parameters and units
- Set up a data log
- Record data
- Email data in spreadsheet format
- Download data to mobile device
- Transfer data from mobile device to a computer

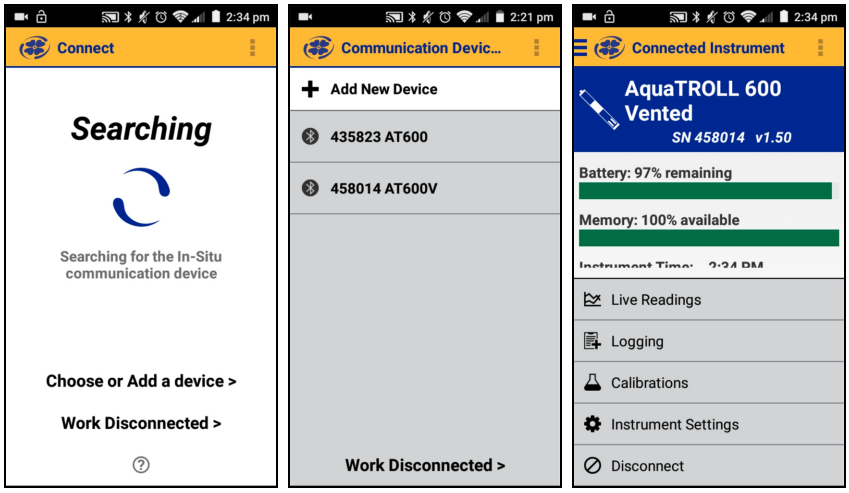
- Organize data by Location
- Calibrate Sensors and View Reports

Connecting Your Instrument to VuSitu

To use VuSitu, you will need a Bluetooth-enabled mobile device, a Wireless TROLL Com and a deployment cable.

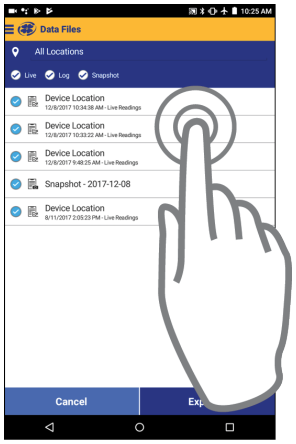
Attach one end of the cable to the Wireless TROLL Com and secure the other end to the instrument. Press the power button on the Wireless TROLL Com and open the VuSitu mobile app on your phone or tablet.

VuSitu will automatically search for Bluetooth devices nearby, but you will need to select the correct instrument when connecting for the first time. Select **Choose or Add a Device**. You should see the serial number of the instrument you wish to pair. Tap the serial number to connect. Tap the **Back** button on your device to view the Connected Instrument screen.



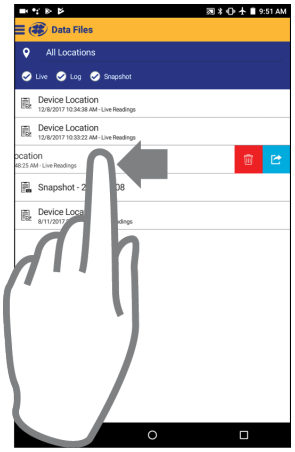
Selecting with Long-press and Swipe

Long Press



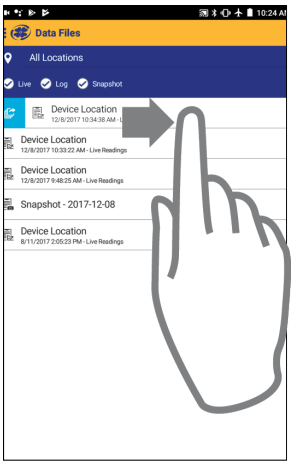
Press and hold any item in a list of files. You can now select multiple files.

Swipe Left



Press an item and swipe left to reveal the delete and share icons.

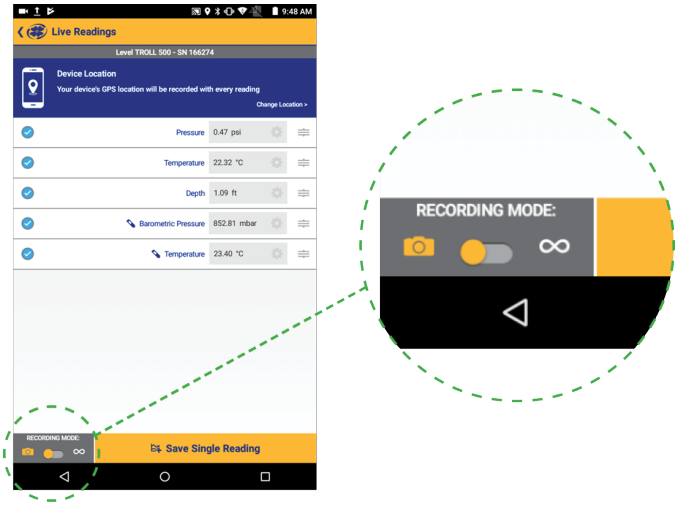
Swipe Right

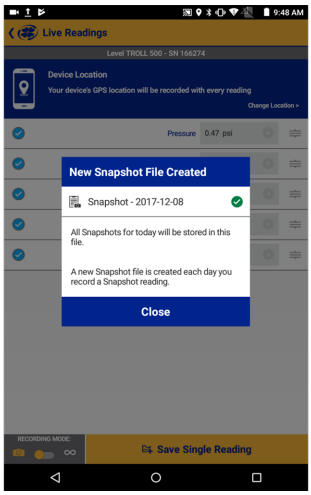


Press any item in a list and swipe right to reveal the sharing icon.

Taking live readings in VuSitu

Snapshot Mode

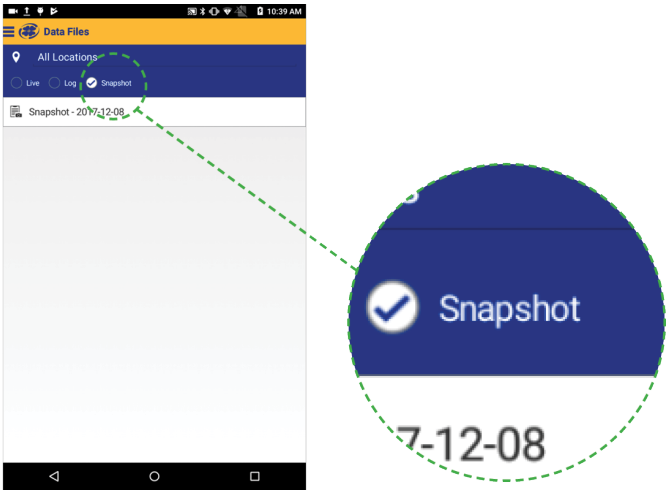




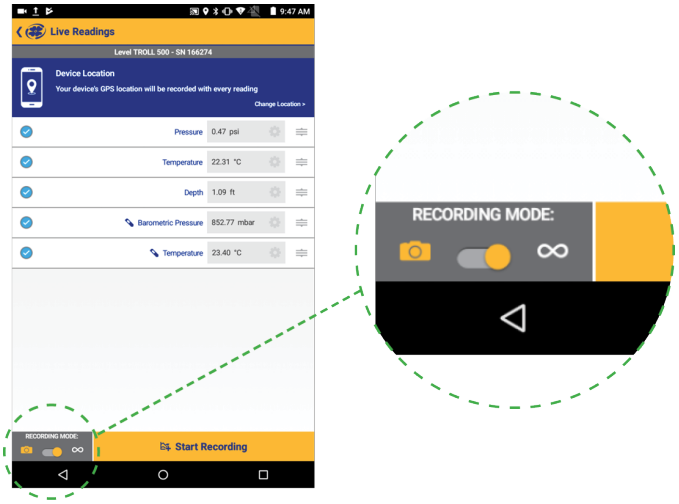
Take a single reading and save to Snapshot file.

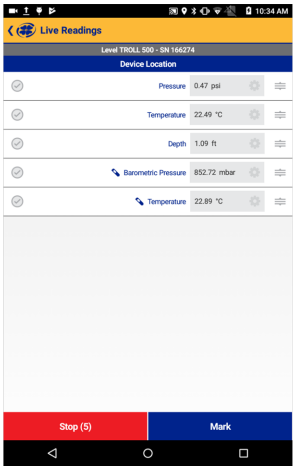
View Snapshot file from Menu > Data Files.

Check Snapshot option.



Live Readings Mode

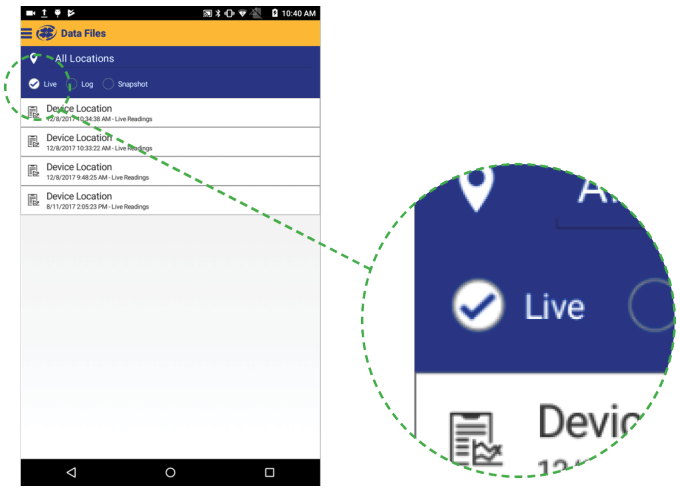




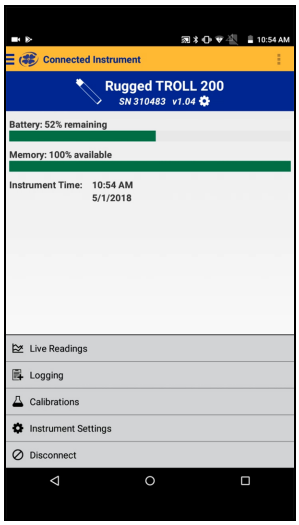
Take readings at two-second intervals.

View readings from Menu > Data Files.

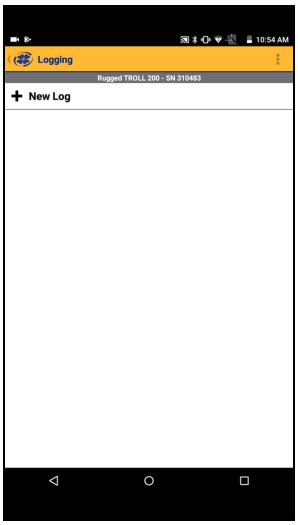
Check Live option.



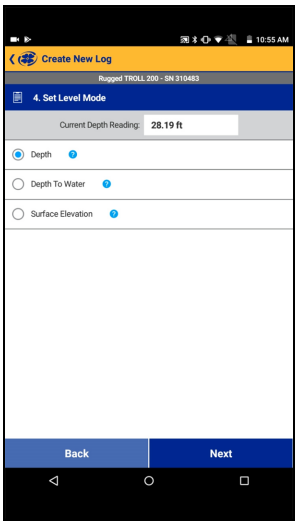
Setting Up a Log



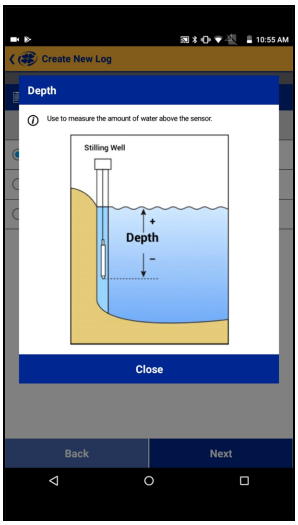
From the Connected Instrument screen, select **Logging**.



Tap **New Log** and follow the prompts to create a name, select a location and choose the parameters you wish to monitor.



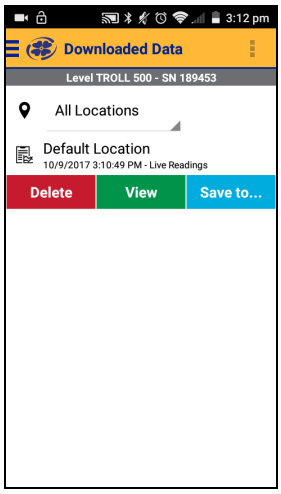
Select a level mode in step 4. Tap the blue circle to the right of each option for an explanation of how the mode works.



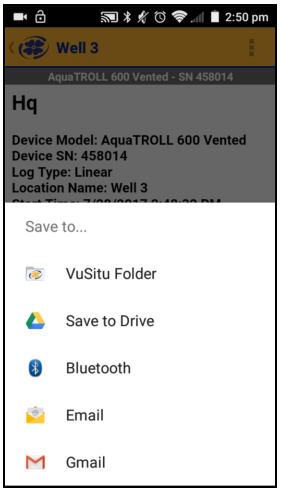
For Depth to Water and Surface Elevation modes, enter a level reference. See "About the Level Reference" on page 55 of this manual for complete information about level modes and level references.

Downloading and sharing your data.

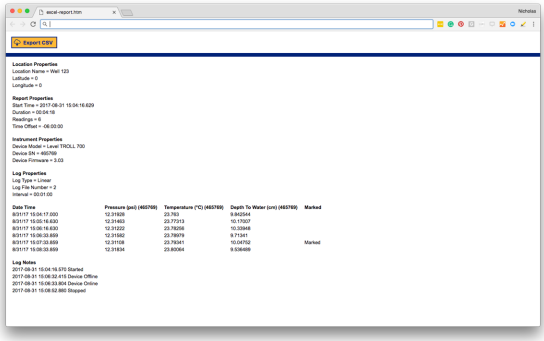
You can download VuSitu data as an HTML file and share it via email, SMS or a cloud storage service such as Google Drive. To download a log, select it from the Downloaded Data screen and tap **Save to**.



Choose one of the download options from the menu. You can transfer a data file from your mobile device to a PC via Bluetooth, email it to yourself or any valid email address, save the file to the VuSitu folder on your device or upload it to Google Drive.



View your data in any web browser by double-clicking the file. You can then export a CSV file by clicking the **Export a CSV** link at the top of the page.



Getting Started

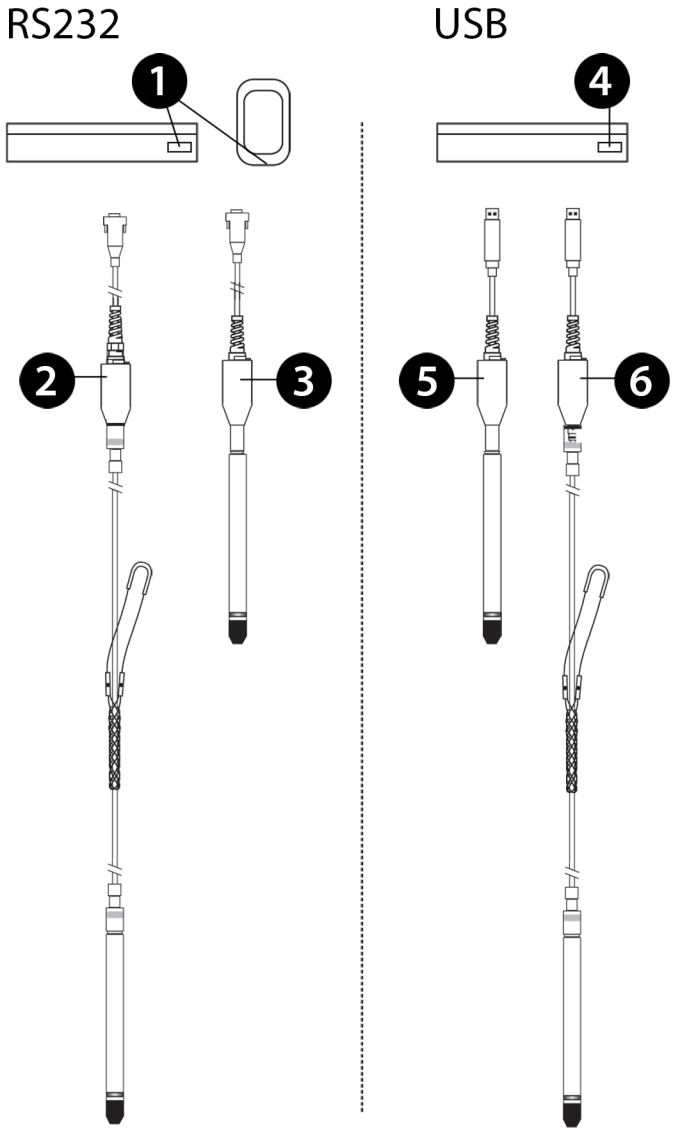
This section provides an overview of the initial steps necessary to prepare the instrument to log data.

- Select the appropriate TROLL Com Communication Device. This determines the hardware connections, and may influence the software installation. The drawing on the following page shows the function of the different TROLL Com Communication Device models.
- Install the software.
- Connect the hardware.
- Open the software and establish communication with the instrument.

Select a TROLL Com Communication Device

The subsequent figure shows the function and connection features of the TROLL Com Communication Device models.

- A Direct-Connect TROLL Com might be preferred for programming an instrument that will be deployed on a suspension cable.
- A RuggedCable System and a Cable-Connect TROLL Com are required if you intend to communicate with the instrument while it is deployed. However, you can program the instrument with any TROLL Com.
- A Wireless TROLL Com will allow you to connect to the VuSitu mobile app, which you can use to configure and deploy your instrument.



1	Cable-Connect TROLL Com Communication Device, serial connection, for field use
2	Direct-Connect TROLL Com Communication Device, serial connection, programming only, not submersible
3	USB port on a PC/laptop
4	Direct-Connect TROLL Com Communication Device, USB connection, programming only, not submersible
5	Cable-Connect TROLL Com Communication Device, USB connection, for field use

Connecting RuggedCable

Connect the Instrument to the RuggedCable

1. Remove the protective caps from the instrument and cable. Ensure that the O-ring on the instrument connector is clean. Apply a small amount of vacuum grease to the o-ring.
2. Position the instrument and cable flat edges so they will connect properly. Insert the instrument connector firmly into the cable connector.



3. Hold the textured section of the sleeve in one hand and the instrument in the other. Push and twist until you hear a click. The click ensures the cable and instrument are securely attached.



Connect TROLL Com Communication Device to the RuggedCable System

1. If a desiccant is present, remove the desiccant from the cable. Twist the desiccant and cable sleeve in opposite directions to unlock the desiccant from the cable.
2. Position the TROLL Com and cable flat edges so they will connect properly. Push and twist until you hear a click.

Install the Software

Win-Situ 5 Software

Install Win-Situ 5 Software from the In-Situ software/resource CD or from the In-Situ website. Click the Win-Situ 5 link, and follow the instructions to install Win-Situ 5 to your local hard drive.

USB TROLL Com Drivers

If you are using a USB TROLL Com Communication Device, be sure to select the option "Install USB TROLL Com Drivers" during the Win-Situ 5 installation. Two drivers will be loaded to your hard drive, one for the USB TROLL Com, one for the USB TROLL Com serial port.

Field Deployment

Program the Instrument

In order to set up a log or download data, you must connect the instrument to a computer running Win-Situ 5 software or to a mobile device with the VuSitu app. See page 52.

Position the Instrument

Place the instrument at the desired depth. Position the instrument below the lowest anticipated water level, but not so low that the pressure sensor range might be exceeded at the highest anticipated water level. Refer to the tables below to determine usable depth.

> ⚠ A BaroTROLL Instrument can be deployed with a non-vented instrument to compensate level data for changes in atmospheric pressure. Make sure the clocks on both instruments are synchronized, and install the BaroTROLL in a location that will never be submerged in water. See page 41.

Non-Vented Level TROLL Instrument

Range	**Effective Range**		**Usable Depth**	
PSIA	PSIA	kPA	Meters	Feet
30	15.5	106.9	11	35
100	85.5	589.5	60	197
300	285.5	1968	200	658
500	485.5	3347	341	1120
1000	985.5	6795	693	2273

* Effective range for psia sensors is limited by an estimated 14.5 PSI atmospheric pressure at sea level.

Vented Level TROLL Instrument

Range		**Usable Depth**	
PSIG	kPA	Meters	Feet
5	34.5	3.5	11.5
15	103.4	11	35
30	206.8	21	69

Range		Usable Depth	
100	689.5	70	231
300	2068	210	692
500	3447	351	1153

Verify Instrument Depth

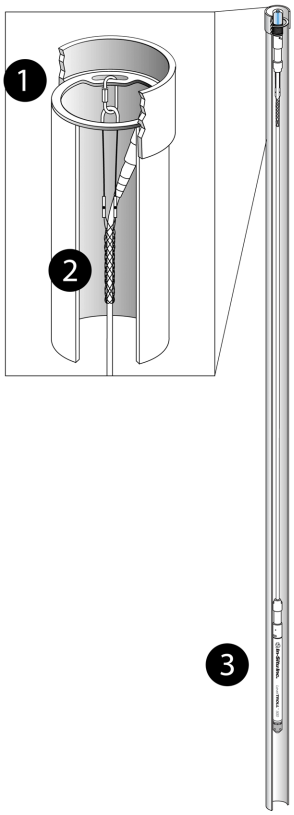
After you have installed the instrument, it is possible to connect the instrument to a computer or mobile device, open the software, and take a reading to verify the installation position. If the reading confirms that the instrument is in the correct position, you can secure it as described below.

During log setup there was an option to "Remind Me Later" for setting a level reference. If you set the log to remind you later, ensure that the instrument is submerged and set the level reference when prompted. See page 55.

Secure the Cable

The RuggedCable System includes a Kellems grip near the up-hole end. You can compress the wire mesh and slide the grip to the desired location on the cable. Pull on the grip to tighten it on the cable.

Use the loop on the Kellems grip to anchor the cable to a convenient stationary object such as the In-Situ well dock installation ring. To install the Kellems grip to the installation ring, insert the loop into the locking clip on the well dock and position the assembly at the top of a well casing.



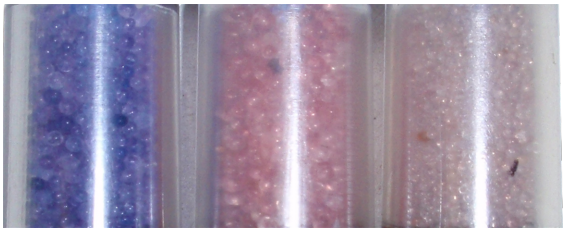
1	Well Dock Installation Ring
2	Kellems Grip
3	Instrument Installed in Well

Install the Desiccant

> ⚠ Vented cable must be protected with a desiccant pack that is properly sized for site conditions.

Desiccant

Desiccant protects cables, connections, and internal components from condensation, which can cause irreparable damage and loss of data. Indicating desiccant changes from blue to pink as it becomes saturated with moisture.

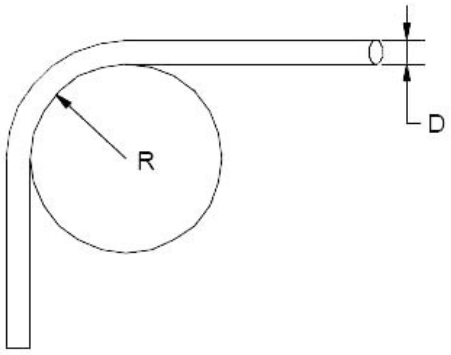


Desiccant stages (from left)
New, nearly expired (replace now), expired

It is **extremely important** to use a properly-sized desiccant for your deployment and to **change desiccant often**. Desiccant should be changed before the entire volume has turned pink, and you should use enough desiccant to effectively keep your equipment dry until your next scheduled maintenance. Desiccant longevity is dependent on site conditions and can vary from one site to the next.

Installation Guidelines

- Never let the instrument fall freely down a well. Doing so will damage the sensor.
- After you have installed the instrument, verify the water level reading. Move the instrument and take another reading to ensure that the instrument shows reasonable change. The instrument could be wedged against the well casing with a loop of cable hanging below. An instrument in such a position could become dislodged and move while it is logging data, which would record a false change in the water level.
- For accurate measurements, the instrument should remain immobile while it is logging data.
- Make sure that the uphole cable end is protected. The vented cable must be protected with a desiccant, and the non-vented cable must be protected with a dust cap. The uphole cable end must be positioned above the highest anticipated water level. Avoid placing this end in a location that might flood.
- Do not deploy instruments in such a way that ice may form on or near the sensor or cable connections. Ice formation is a powerful expansive force that can over-pressurize the sensor or otherwise cause damage. Damage associated with ice formation is not covered by the instrument warranty.
- Do not allow vented cable to bend enough to obstruct the internal vent tube. The recommended bend radius is 13.5 mm (0.54 in), which is twice the cable diameter.



R	Bend radius 13.5 mm (0.54 in)
D	Cable diameter

Stabilization Time

After you have installed the instrument, allow it to stabilize to the environment for about 10 minutes before logging data. The T95 response time for temperature is less than 9 minutes.

A generous stabilization time is always desirable, especially in long-term deployments. Even though the cable is shielded, temperature stabilization, stretching, and relaxing can cause changes to readings.

> ⚠ If you intend to monitor water levels to the instrument's stringent accuracy specifications, allow up to 60 minutes for the probe and cable to stabilize to the environment.

BaroTROLL Instrument Installation

The BaroTROLL Instrument is designed to log barometric pressure from 0 to 16.5 PSIA (1.14 bar, 33.59 inHg) at the surface near a submerged non-vented Level TROLL Instrument or Aqua TROLL 200 Instrument. BaroTROLL data may then be used to correct the water level data for barometric pressure fluctuations. See page 15.



Programming the Baro TROLL Instrument

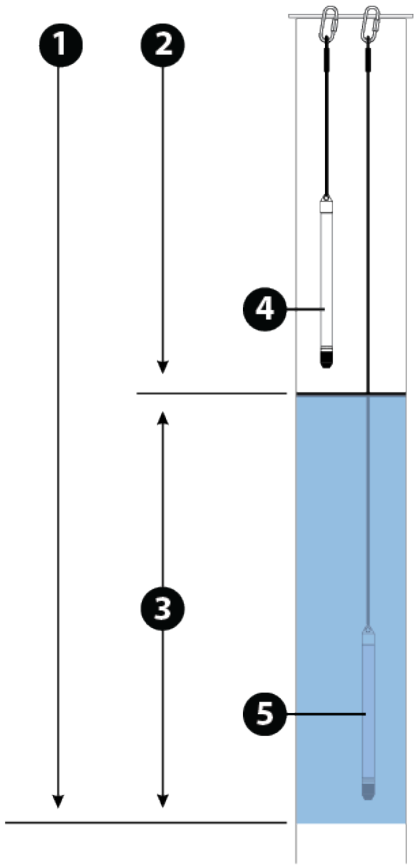
Connect the BaroTROLL to Win-Situ 5 software or the VuSitu mobile app and sync the clock.See page 53.

Set up a log with the same start time and sample interval as you set up in the non-vented level instrument. See page 54.

Installation

After the BaroTROLL Instrument is programmed, install it in a protected location above the water level near the submerged water level instrument. One installation configuration option is shown below using a twist-lock hanger and a suspension wire.

> ⚠ To prevent flooding of the BaroTROLL electronics, attach the twist-lock hanger before you install the BaroTROLL. Do not submerge the Baro TROLL Instrument.

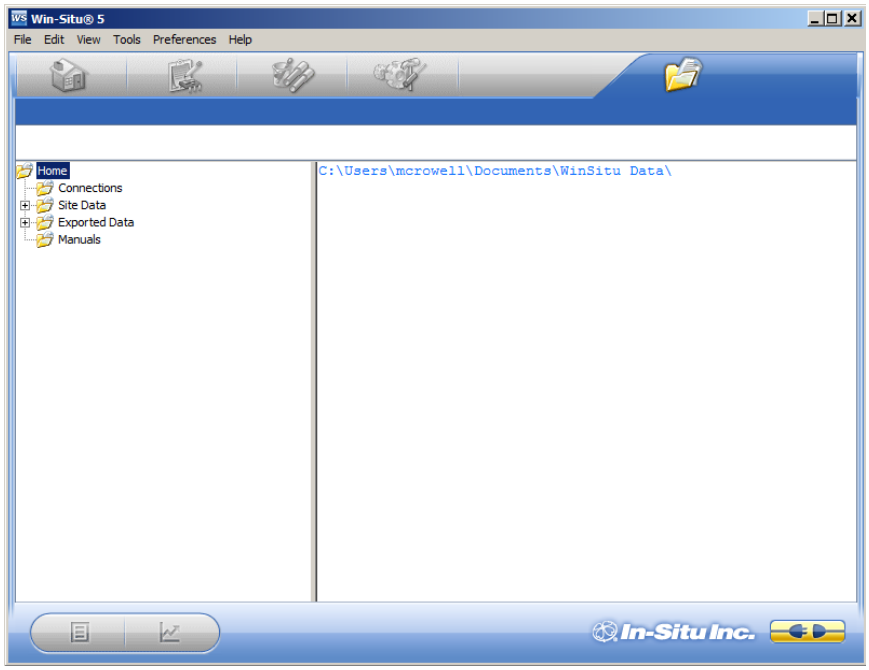


1	Atmospheric pressure + water pressure (as measured by a non-vented pressure sensor)
2	Atmospheric pressure (as measured by the BaroTROLL)
3	Water pressure (as measured by a vented pressure sensor, or by subtracting BaroTROLL data from non-vented pressure sensor data)
4	BaroTROLL Instrument (Do not submerge.)
5	Non-vented Level TROLL Instrument

⚠ To merge atmospheric pressure data with water level data, See page 59.

Data Tab

When you open Win-Situ 5 Software, the **Data** tab appears. The left side of the screen contains a file tree where you can view previously downloaded site data as well as data you have exported to Microsoft Office Excel. The links on the right side of the screen show where downloaded data are stored on your computer. The disconnected plug icon in the lower-right corner of the screen indicates that the software is not yet communicating with an instrument.

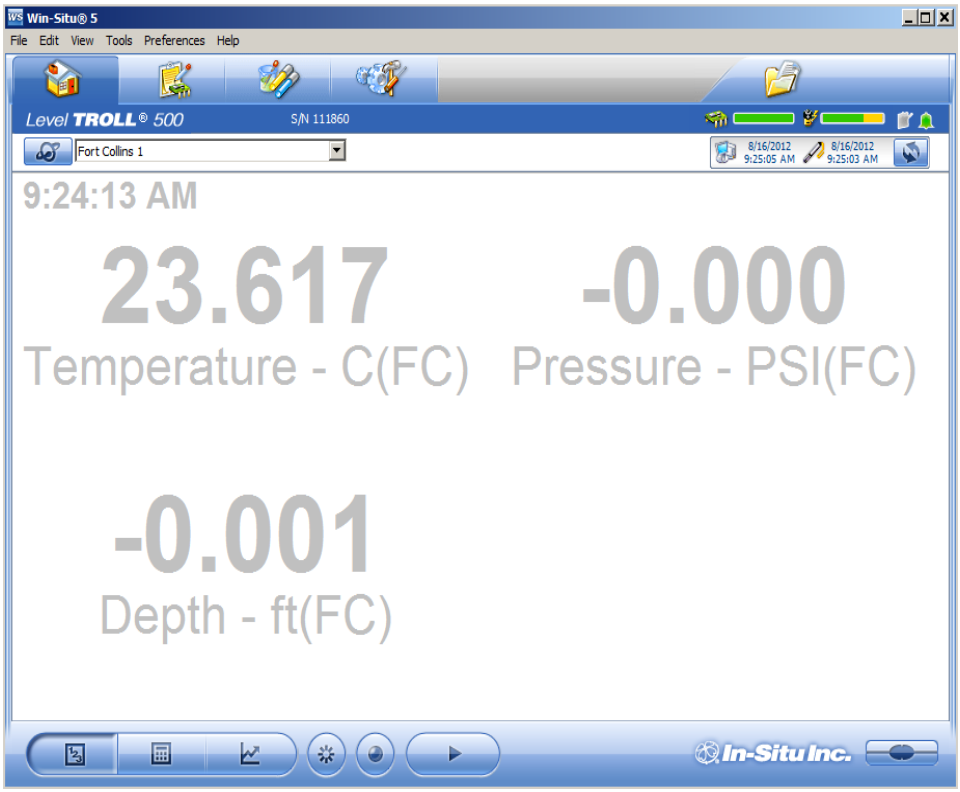


Screen Element	Definition
	The disconnected plug indicates the instrument is not communicating with the software. Click to establish communication with a connected instrument.
	The connected plug indicates the instrument is communicating with the software. Click to disconnect the software from the instrument.
	The **Home** tab displays real-time readings from the instrument. When connection to the instrument is first established, the software displays one reading of all available parameters in light gray. You must click the **Play** button  at the bottom of the screen to view real-time readings.
	The **Logging** tab displays a list of logs stored in the connected instrument. When you click the **Logging** tab, it can take a moment for the software to retrieve information from the instrument. (Not applicable for the RDO PRO-X and the Aqua TROLL 400.)

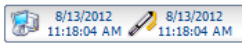
Screen Element	Definition
	The **Sensors** tab lists the sensors in the connected instrument, along with their serial numbers and the dates of factory calibration and user calibration. Use the buttons in this tab to calibrate sensors that support user calibration and configure sensors that are supported by the instrument.
	The **Device Setup** tab allows access to instrument information and settings such as instrument name, serial number, firmware version, communication settings, diagnostics, and factory reset options.

Home Tab

The **Home** tab displays real-time readings from a connected instrument. When you first establish communication, the software displays one reading of all available parameters in light gray.



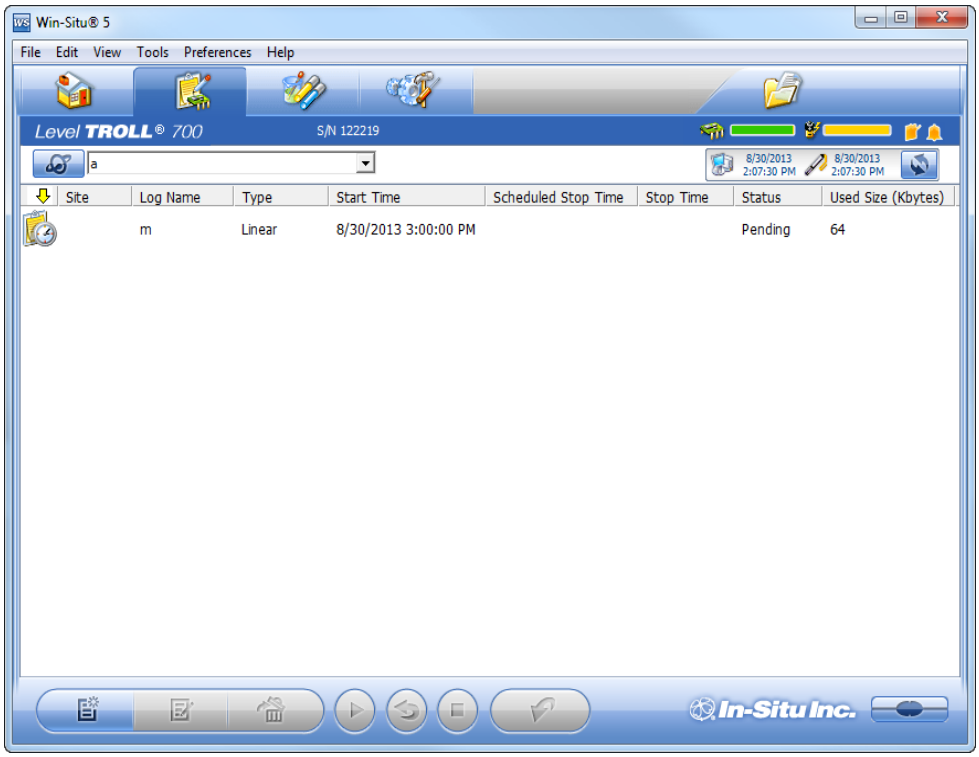
Screen Element	Definition
	The **Sites** button allows you to add, edit, or delete a site. Click the drop-down arrow next to the button to view the list of sites.
	The **Device Memory** gauge turns yellow when the internal memory is used. Note: Non-logging instruments do not have internal memory, however, the gauge shows 100 percent green when power is applied.
	The **Device Battery** gauge turns yellow as the battery is depleted. This example shows 80 percent of the battery remaining (green) and 20 percent used (yellow). Note: Non-logging instruments do not have internal batteries, however, the gauge shows 100 percent green when power is applied.

Screen Element	Definition
	The **Logging Status** icon: Green—The instrument is actively logging data. Gray—The instrument has no logs pending or running. Non-logging instruments always show a gray status icon. Yellow—The instrument has log data that was collected according to specific instructions in the "Pending" or "Suspended" state.
	The **Alarm** icon provides additional instrument status information. Green—No alarms or warnings Yellow—One or more warnings Red—One or more alarms Move the cursor over the alarm icon to view a description. Click the **Device Setup** tab for detailed information on the alarm or warning. Note: Disregard the **Device Reset** alarm for non-logging instruments such as the RDO PRO Probe or the Aqua TROLL 400.
	**System Time** is displayed on the left. **Device Time** is displayed on the right. Clocks are updated once every two seconds. When the **Device Time** is displayed in red, it differs from the current **System Time**, and should be synchronized.
	The **Time Sync** button is used to write the current PC time to the instrument. If you need to set the instrument clock to a time other than the system (PC) time, use the **Set Clock** button on the **Device Setup** tab.
	**Meter View** shows the last known parameter values, displayed with current units and time stamp. Readings are sized to occupy the entire screen. This is the default display in the **Home** tab. If the type is black, the readings are updating in real time.
	**List View** is a running list of the most recent records. New readings are continuously added to the top of the list and old readings scroll off the bottom.
	**Graph View** shows a real-time trend graph of the selected parameters.

Screen Element	Definition
	The **Snapshot** button records one set of readings.
	The **Record** button logs data to a CSV file that can be opened in a spreadsheet program. This is not the same as recording data in a log on the instrument.

Logging Tab

The **Logging** tab displays a list of logs in the instrument. When you click the **Logging** tab, it may take a moment for the software to retrieve information from the instrument.



Log Information

Columns across the **Logging** screen show information about the logs in the instrument.

- **Symbol**—This is a graphic representation of the information in the **Status** column.
- **Site**—The site that was specified when the log was configured.
- **Log Name**—The name that was entered when the log was configured.
- **Type**—The logging method that was selected when the log was configured.
- **Start Time**—For a Pending log, the scheduled start time is shown. For a Ready log that has not yet started, this column displays “Manual.” For a Running or Stopped log, the actual start time is shown.
- **Scheduled Stop Time**—For a log with a scheduled stop, the scheduled stop time is shown. For a log without a scheduled stop time, this column is blank.
- **Stop Time**—For a Pending or Ready log, this column is blank. For a Running log, the time of the last data point is shown. For a Stopped log, the actual stop time is shown.
- **Status**—Each log has a specific status. See **Log Status** for details.
- **Used Size**—Kilobytes of instrument memory allocated for this log. For a Pending or Ready log, the current size of the log configuration is shown. For a Completed log, the size of the entire log file is shown. For a Running log, the current size of the log up to the last data point is shown.

Log Status

The status of each log in the instrument is displayed in the Logging tab by a symbol beside the log name, and in the Status column.

Ready—Manual Start log is ready to start.

 **Pending**—Scheduled start log is ready to start at its programmed time, or when you click the **Start** button.

 **Running**—The log is actively logging data.

 **Suspended**—The log has been paused (stopped temporarily).

 **Stopped**—The log has been stopped, either manually or on a schedule.

 **Deleted**—The log has been marked for deletion and will be deleted from the instrument when memory is needed. The software manages this automatically.

 **Invalid**—The log as programmed cannot be run.

> ✔ **Ready**, **Pending**, **Running**, and **Suspended** logs are considered active. Only one log can be active in the instrument.

Log Control Buttons

You can control the status of a log by selecting the log and clicking the appropriate button in the **Logging** tab control panel:

 The **Start** button starts a **Ready** or **Pending** log, or resumes a **Suspended** log.

 The **Pause** button pauses a **Running** log allowing you the option to resume it.

 The **Restart** button restarts the selected **Running** log from the beginning. This can be useful during aquifer testing using a logarithmic data collection schedule.

 The **Stop** button permanently stops the selected **Running** log.

Log Operations

Use the buttons in the control panel to perform the following actions:

 Create a new log.

The **New** button is disabled if a Ready, Pending, Running, or Suspended log is on the instrument. When the instrument contains its maximum number of logs, the New button is unavailable.

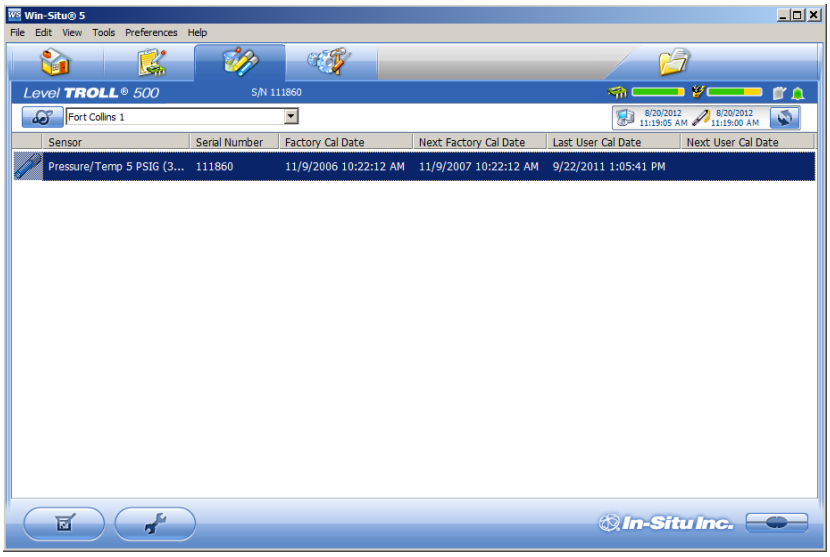
 **Edit** (or review) the log configuration for a Ready, Pending, or Invalid log.

 **Delete** the log. (Note that you must delete a log twice before it is permanently removed.)

 **Download** the log to a PC.

Sensors Tab

The **Sensors** tab lists the sensors in the instrument, along with their serial numbers and calibration dates. Use the buttons in this tab to calibrate and configure sensors.



Calibrate

Use the **Calibration** button to calibrate sensors or to adjust a level reference that is currently stored on the instrument. The **Calibrate** button is not available when the instrument does not support calibration (e.g. BaroTROLL Instrument).

1. With the instrument connected to the software, select the **Sensors** tab.
2. Select the parameter you intend to calibrate.
3. Click the **Calibrate** button  .

Configure

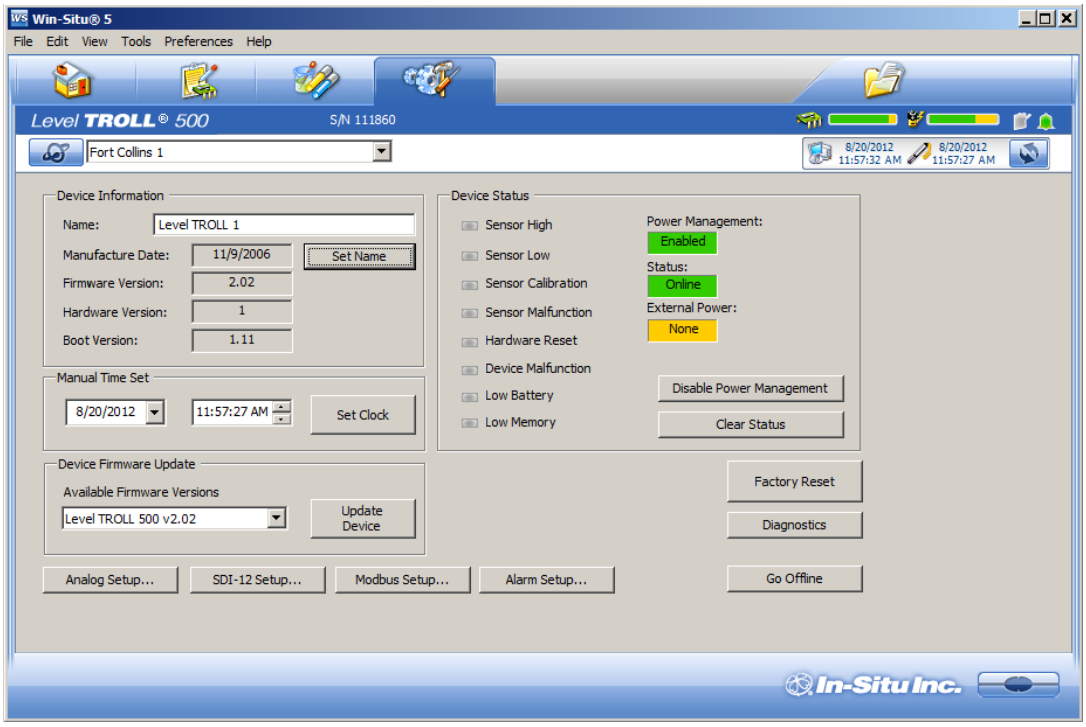
Use the **Configure** button to select parameter units and to configure parameters that support configuration. Examples include Level/Depth, Specific Conductivity, and Total Dissolved Solids. Parameters cannot be configured while the instrument is showing live data on the **Home** screen or while the instrument contains an active log.

1. With the instrument connected to the software, select the **Sensors** tab.
2. Select the parameter you intend to configure.
3. Click the **Configure** button  .

> ✔ When you configure the Level parameter using the **Sensors** tab, the settings are stored in the instrument and are available for use in Modbus, SDI-12, or analog communication (if available). If desired, a different configuration can be selected when setting up a log.

Device Setup Tab

In general, you should not use the **Device Setup** tab unless you are corresponding with the In-Situ technical support team. However, you can use this screen to set up communication protocols if you are connecting the instrument to a PLC or data logger.



✔ See the online Help for more details.

Using Win-Situ 5 Software

Connecting an Instrument to the Software

When you open Win-Situ 5 Software, you are asked if you want to connect to your device. Click **Yes**. Synchronize the instrument clock to the PC clock. 

The software displays an error message if a connection cannot be established.

Selecting the Correct COM Port

If you are using a USB TROLL Com, select the correct COM port by following the steps below. If you are using a serial TROLL Com, the Win-Situ Software should default to the correct COM port, which is usually COM 1.

Steps for Windows 8.1 and Windows 10 systems.

1. Right-click the **Start** button.
2. Click **Device Manager**.
3. Click the arrow next to **Ports (COM and LPT)**, and locate the USB Serial Port listing. The number listed next to this entry is your COM port address.

Steps for Windows 8 systems.

1. Right-click the **Start** screen.
2. Select **All Apps**.
3. Click **Control Panel**.
4. Open the **Device Manager**.
5. Click the arrow next to **Ports (Com and LPT)**, and locate the USB Serial Port listing. The number listed next to this entry is your COM port address.

Steps for Windows 7 systems.

1. Click the **Start** button, and open the **Control Panel**.
2. Click **Hardware and Sound**, and open the **Device Manager**.
3. Click the arrow next to **Ports (COM and LPT)**, and locate the USB Serial Port listing. The number listed next to this entry is your COM port address.

Steps for Windows XP systems.

1. Click the **Start** button, and open the **Control Panel**.
2. Double-click the **System** icon. Click the **Hardware** tab, and open the **Device Manager**.
3. Click the plus sign next to **Ports (COM and LPT)**, and locate the USB Serial Port listing. The number listed next to this entry is your COM port address.

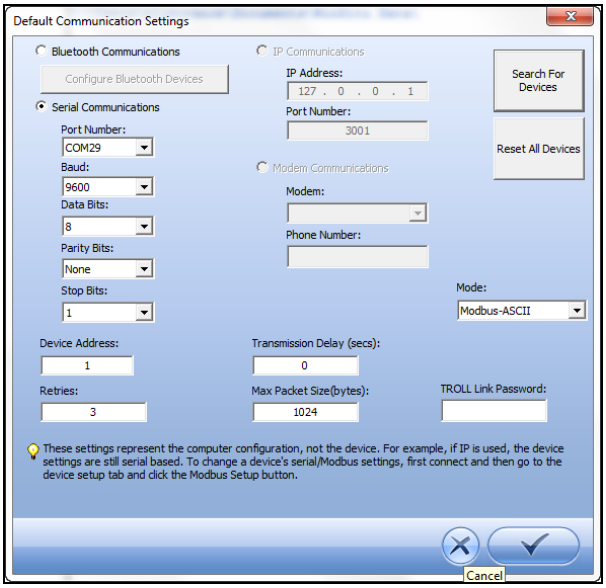
> ✔ **The following steps apply for all Windows operating systems.**

1. Once you have determined the correct COM port address in your operating system, reopen Win-Situ 5 Software.
2. Close any open windows in Win-Situ Software.
3. Click **Preferences**.
4. Click **Comm Settings**, and then click the **Port Number** menu.

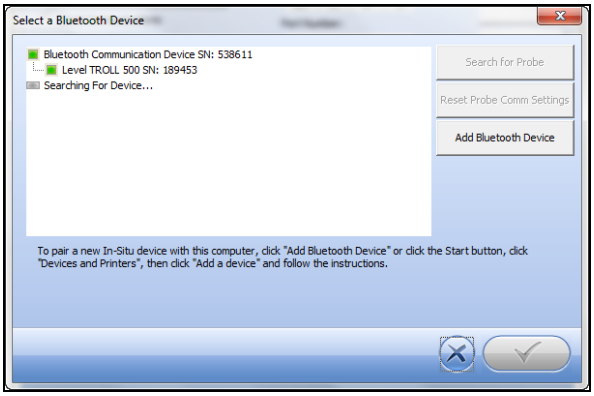
5. Scroll down to find the correct COM port address. Click the **check mark** to accept the changes.
6. Click the yellow **Connect** button in the lower right corner to establish a connection to the instrument.

Bluetooth & Wireless TROLL Com

Connect the cable to the Wireless TROLL Com and the Level TROLL instrument. Turn on the Wireless TROLL Com and open Win-Situ 5. Choose **File > Connect** to access the Default Communication Settings window.



Select the radio button labeled **Bluetooth Communications** and click **Configure Bluetooth Devices**. You will see a list of nearby Bluetooth devices. Click the Wireless TROLL Com you are using and click the check mark.



Finally, click the yellow **Connect** button  at the bottom right of the screen to complete the connection.

Setting the Instrument Time

The instrument time and the current PC time are shown at the top of the screen when an instrument is connected to the software.



The PC time appears on the left, the instrument time on the right. Both clocks are updated at 0.5 Hz (once every two seconds). The device time is displayed in red if it differs by more than a few seconds from the current PC time. Data logging schedules depend on a correct instrument time.

To synchronize the instrument time to the current PC time, click the **Clock Sync** button  . Win-Situ writes the current PC time to the instrument.

Adding a New Site

To add a new site to the site database in your working directory do one of the following:

On the **Data** tab, click the **Site Data** folder, select **File**> **New** > **Site**.

or

On the **Home** tab, click the **Site** button to display the site list, then click **New** . Enter a name for the site. This is the only required field.

Click **Save** to save the new site. The new site will appear in the **Site Data** folder, and Win-Situ will add it to the site database in the working directory on your computer. It is now available to select for any instrument log.

Log Setup

The Log Setup Wizard presents sequential screens to help you supply all the information necessary to set up a data log in the instrument.

To access the Log Setup Wizard the instrument must be connected to the software.

1. Click the **Logging** tab  .
2. Click the **New** button  .

   > The **New** button may be disabled or may show a warning if an active log already exists on the instrument, or if the instrument is polling live data (see the **Home** screen), or if the device already contains its maximum number of logs.

3. Select the **Site** where the set of data will be logged and supply a name for the log.
4. Click the **right arrow** to continue after each step.
5. Select the parameters you intend to measure, choose the measurement units, and specify the order in which the selected parameters will be logged.
6. Select the logging method you intend to use. See page 54.
7. Select the log interval. A log interval is how often a measurement will be taken and stored.
8. Select the start condition, stop condition, and specify how to handle full device memory.
9. If you selected **Level** or **Depth** as a parameter to measure, specify how you intend to log this parameter. See page 55.
10. The final screen summarizes the log setup. Click the **check mark** to write this information to the instrument.

Logging Method Descriptions

The following is a list of log types and their descriptions. The log types that are available on an instrument vary depending upon the capabilities of the instrument.

Logging Methods for Long-Term Monitoring

Linear

Linear log type measures and records at a user-defined fixed interval of one minute or more. This method is used for long-term studies, landfill monitoring, stream gauging, tidal studies, and background monitoring prior to aquifer testing. Intervals are measured in days, hours, or minutes.

Linear Average

Linear Average log type can smooth out anomalous highs and lows that may occur in a data set, for example, when a water wave passes over the instrument. Each stored measurement is the average of several rapid measurements. This method is used for long-term studies, stream gauging, tidal and open-water studies where trends are more important than accuracy. Intervals are measured in days, hours, minutes, or seconds.

Event

Linear Event log type combines basic fixed-interval logging of specified parameters with the ability to log data at a faster interval when a single-parameter event condition is present.

Logging Methods for Aquifer Testing

True Logarithmic

True Logarithmic log type captures early-time water-level data during aquifer testing. Measurements are very closely spaced at the start of the test (4 measurements per second) and move further apart on a logarithmically decaying schedule as the test progresses. There are 40 measurements per log decade. This log type is commonly used for rapid step-drawdown pump tests, constant-rate pump tests, and slug tests.

Fast Linear

Fast Linear log type measures and records at a user-defined fixed interval of one minute or less. The interval is small (seconds, milliseconds), and the test is usually of short duration due to the volume of data logged and the impact of very fast sampling on battery life.

Step Linear

Step Linear log type measures and records data according to a number of user-defined elapsed time intervals or "steps" within a schedule. Both the elapsed time and the number of measurements within each step can vary. After completing the elapsed time for each step, the schedule will automatically move to the next step. Up to 10 separate steps can be defined.

About the Level Reference

A Level Reference, also called an offset, is a user-specified starting point for logged Level readings.

Depth mode does not require that you enter a Level Reference.

The Level Reference can be any value you choose. Here are some examples:

- **Elevation**—If you calculate the water level above mean sea level (MSL) and enter this as the Level Reference, then elevations above MSL will be logged.
- **Depth to Water**—If you measure the depth to the water surface (DTW) from the top of the well casing and enter this as the Level Reference, then DTW (also called drawdown) values will be logged.
- **Zero**—A Level Reference of 0 effectively sets the probe to zero at the start of the log. Changes, both positive and negative, from the starting water level, will be logged.

Once you have determined the value of your Level Reference, the software gives you three options for entering it. These control when the level reference is applied.

- **New Reference**—This option is designed to be used with an active software connection when the device is installed in the water.

> **A new level reference must be entered while the device's pressure sensor is submerged in its final position in the water.** This is because the current probe reading is set equal to the Level Reference to create the offset that takes effect at the start of the data log. The log header will show the probe reading at the time you entered the Level Reference.

During log setup, the software presents two additional options for entering the Level Reference:

- **Set first logged reading**—Use this option when the instrument will be deployed on wire rather than cable because you will not be able to communicate with the instrument when it is submerged.
- **Remind me to set reference later**—Use this option to defer the entry of the Level Reference during log setup and set a reminder to enter it when the device is submerged in its final position.

Starting a Log

Every log is programmed for either a manual or a scheduled start. A log with a manual start time is displayed in the Logging screen with **Ready** in the **Status** column. A log with a scheduled start time is displayed with **Pending** in the **Status** column.

Starting a Pending Log

A **Pending** log automatically starts at the scheduled time without any user intervention.

> A scheduled log with **Pending** status can be manually started at any time before its scheduled start.

Starting a Manual Log

With the instrument connected to the software, select the **Logging** tab.

Select the Ready log you want to start.

Click the **Start Log** button  . The log starts and the symbol changes. The **Status** column displays **Running**.

Suspending (Pausing) a Log

A running log may be temporarily paused. For example, you might want to reposition an instrument, calibrate a sensor, or clean a sensor and later resume the log. A log can be suspended and resumed three times.

1. With the instrument connected to the software, select the **Logging** tab  .
2. Select the log you intend to suspend.
3. Click the **Suspend** button  . **Suspended** appears in the **Status** column.

Resuming a Suspended Log

1. To resume logging after a log has been suspended, select the **Logging** tab.
2. Select the **Suspended** log.
3. Click the **Start Log** button  . Logging resumes. **Running** appears in the **Status** column. The data file will show the time when the log was suspended and the time when it restarted.

Stopping a Log

A log can be manually stopped at any time, even if a stop time has been previously scheduled. If you did not specify a stop condition when you defined the log, the log will run until the instrument is out of memory or battery power, or until you manually stop it.

> ✔ A log that has been stopped cannot be resumed. If you intend to resume a log later, you should suspend a log rather than stop it.

1. To manually stop a log, the instrument must be connected to the software.
2. Select the **Logging** tab  .
3. Select the running log you intend to stop.
4. Click the **Stop Log** button  .

Downloading Data to a PC

This procedure copies the data log from the instrument to a PC. It does not remove the data log from the instrument. After a log is downloaded, it can be exported to a CSV file format that can be used by spreadsheet programs. The time shown in the log name is the time the log was downloaded.

1. With an instrument connected, select the **Logging** tab  .
2. Select the log you intend to download.
3. Choose a Running, Suspended, Stopped, or Deleted log.
4. Click the **Download**  button.
5. In the next screen, select one of the three download options.
   - All data
   - New data (data logged since the last download)
   - Time interval to download

> ✔ New data is downloaded by default to a new log file. To append new data to the last download of this log, be sure the option "Append logs on download" is selected in the **General Settings** dialog (**Preferences** > **General Settings**).

2. The log is copied to the connected PC into your Win-Situ working directory folder. View or change the working directory using **File** > **Settings**.
3. At the end of the download, Win-Situ gives you the option of viewing the data.
   - Select **Yes** and the log is displayed in the **Data** screen.
   - Select **No** and the **Logging** screen appears. You can view the data at any time by selecting it in the **Data** tab.

Viewing Logged Data

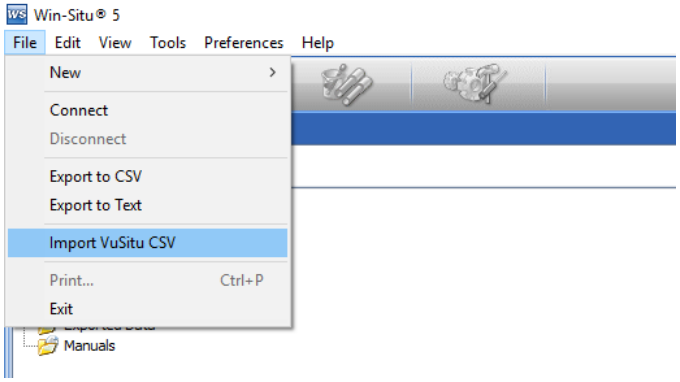
1. To view the data stored in the instrument, you must first download the data. A connection to an instrument is not needed after the data log has been downloaded.
2. Select the **Data** tab  .

3. On the left side of the screen, select the log you want to view. To expand a folder shown in the navigation tree, double-click the folder. The content of the data log is displayed on the right side of the screen in text or graph format.

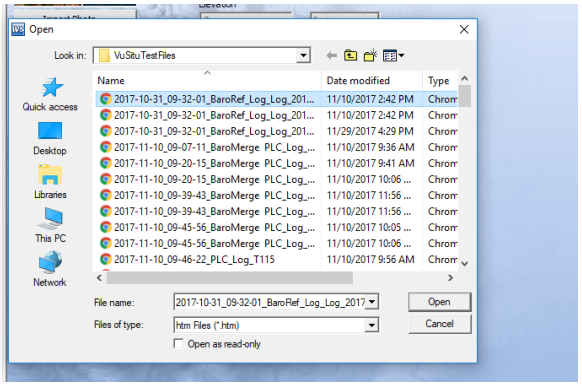
> ✔ To switch between view formats, click the **Text** or the **Graph** button in the control panel. To customize the text or graph view, select **Preferences** > **Graph Settings** or **Preferences** > **Data View Settings**. These options apply to all downloaded data until you change the options.

Importing VuSitu Data to Win-Situ

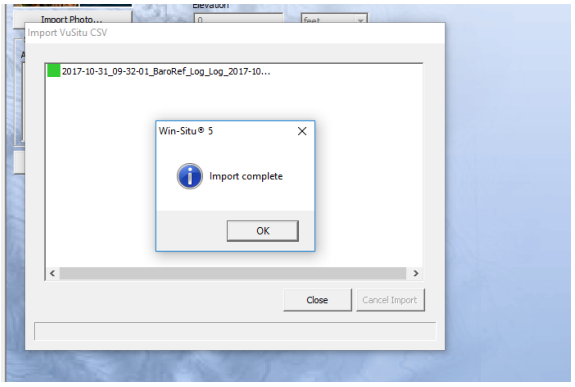
You can import data files from VuSitu into Win-Situ 5 from the File menu.



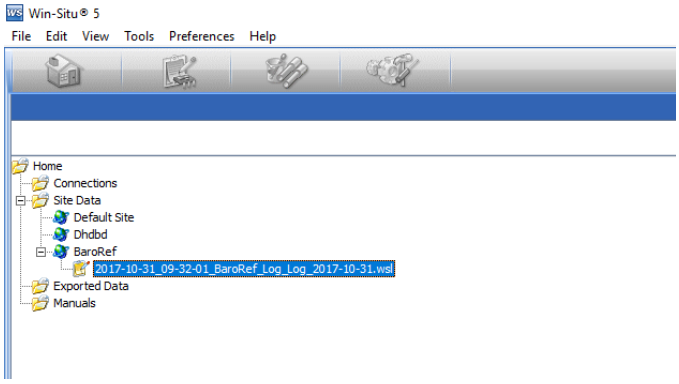
A. Click **File > Import VuSitu CSV** in the menu bar at the top of the screen.



B. Select the file you wish to import and click **Open**.



C. Select **OK** at the prompt.



D. Click on the file name to view it.

Using BaroMerge Software

BaroMerge Software is used to post-correct absolute (non-vented) level sensor data to eliminate barometric pressure effects from the measurements. BaroMerge Software can be accessed through the Win-Situ 5 Software **Tools** menu. BaroMerge provides three options to correct data.

- **Fixed Correction**—A single offset value is applied to all selected log data. Use this option if you know the barometric pressure of the site during the log, and know that it did not change.
- **Manual Entry**—Specify two or more correction values to apply to the log data. Use this option if you wish to manually enter a data set of barometric pressure values.
- **BaroTROLL log file**—Absolute level sensor data points are individually corrected to reflect barometric pressure changes that were logged by a BaroTROLL instrument during the approximate time period.



BaroMerge Input—BaroTROLL File

Log files that contain absolute data can be barometrically compensated using values logged by the In-Situ Inc. BaroTROLL Instrument. Select this method when you have access to a BaroTROLL log file covering approximately the same time period as the data file you intend to correct.

To use this correction method, you need the name of the BaroTROLL log file and the name(s) of the absolute log file(s) you want to correct.

1. From the **Tools** menu in Win-Situ 5 Software, select **Win-Situ BaroMerge**.



2. Select the "Use a BaroTROLL file:" option.
3. Click the browse button to the right of the file field.
4. Select a BaroTROLL file and click the **check mark**.
5. Values from the BaroTROLL file will be displayed in the next window. You can edit these values if necessary.
6. Click the **right arrow** button.
7. Select the log file(s) you intend to correct and click the **check mark**.
8. Compensated data files can be viewed or exported from the **Data** tab.

BaroMerge Output

Your original log file is not changed. A new, corrected log file with the same name and path is created. The original ".wsl" extension is replaced by "-Baro Merge.wsl".

Disconnecting an Instrument from the Software

Click the plug icon  in the lower-right corner of the screen to disconnect the instrument from the software.

Disconnect the instrument from the communication device. Attach a desiccant pack if you are using a vented cable.

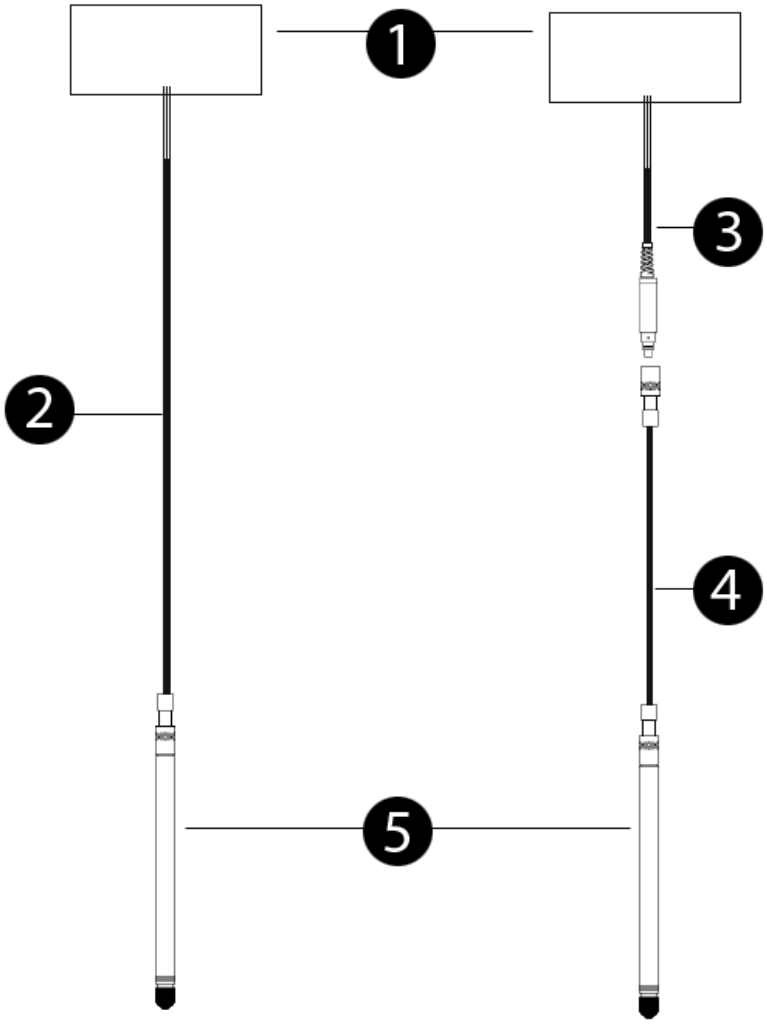
Connect to a Data Logger or PLC Controller

The instrument can be connected to a data logger or controller via a stripped-and-tinned RuggedCable System for communication using one of the following protocols.

- Analog (4-20 mA)
- SDI-12
- RS485 Modbus
- RS232 Modbus (with a customer-supplied converter)

Stripped-and-tinned RuggedCable System includes a female connector on one end that connects to the instrument. The uphole end terminates in stripped-and-tinned wires for connection to a PLC controller or data logger.

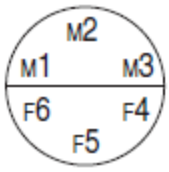
A shorter length Stripped-and-tinned RuggedCable System with a male connector is available to convert a female to female RuggedCable System to a stripped-and-tinned configuration.



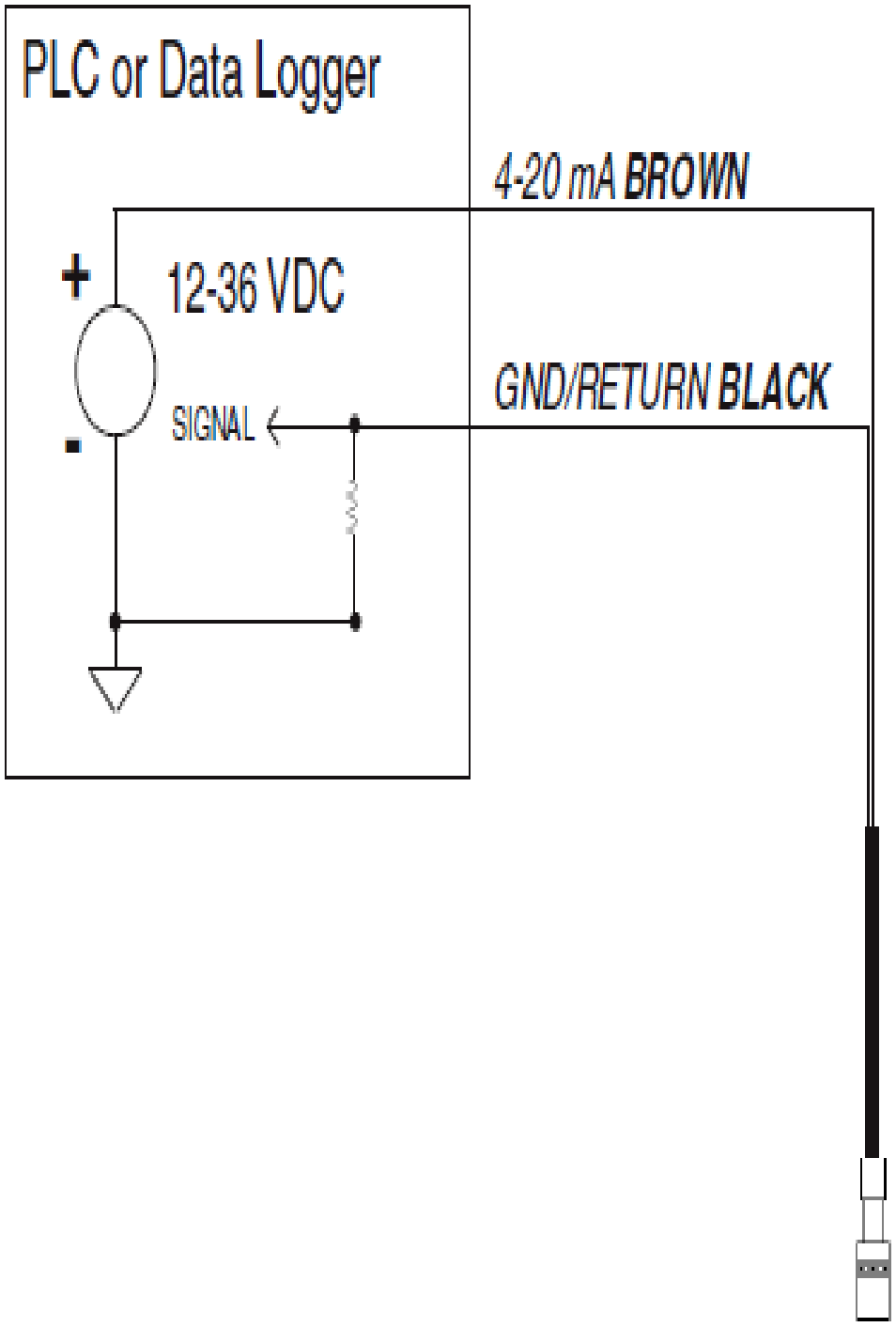
1	PLC or Data Logger
2	Stripped-and-tinned RuggedCable System with female connector
3	Short stripped-and-tinned RuggedCable System with male connector
4	RuggedCable System with female to female twist-lock connector
5	Instrument

Wiring

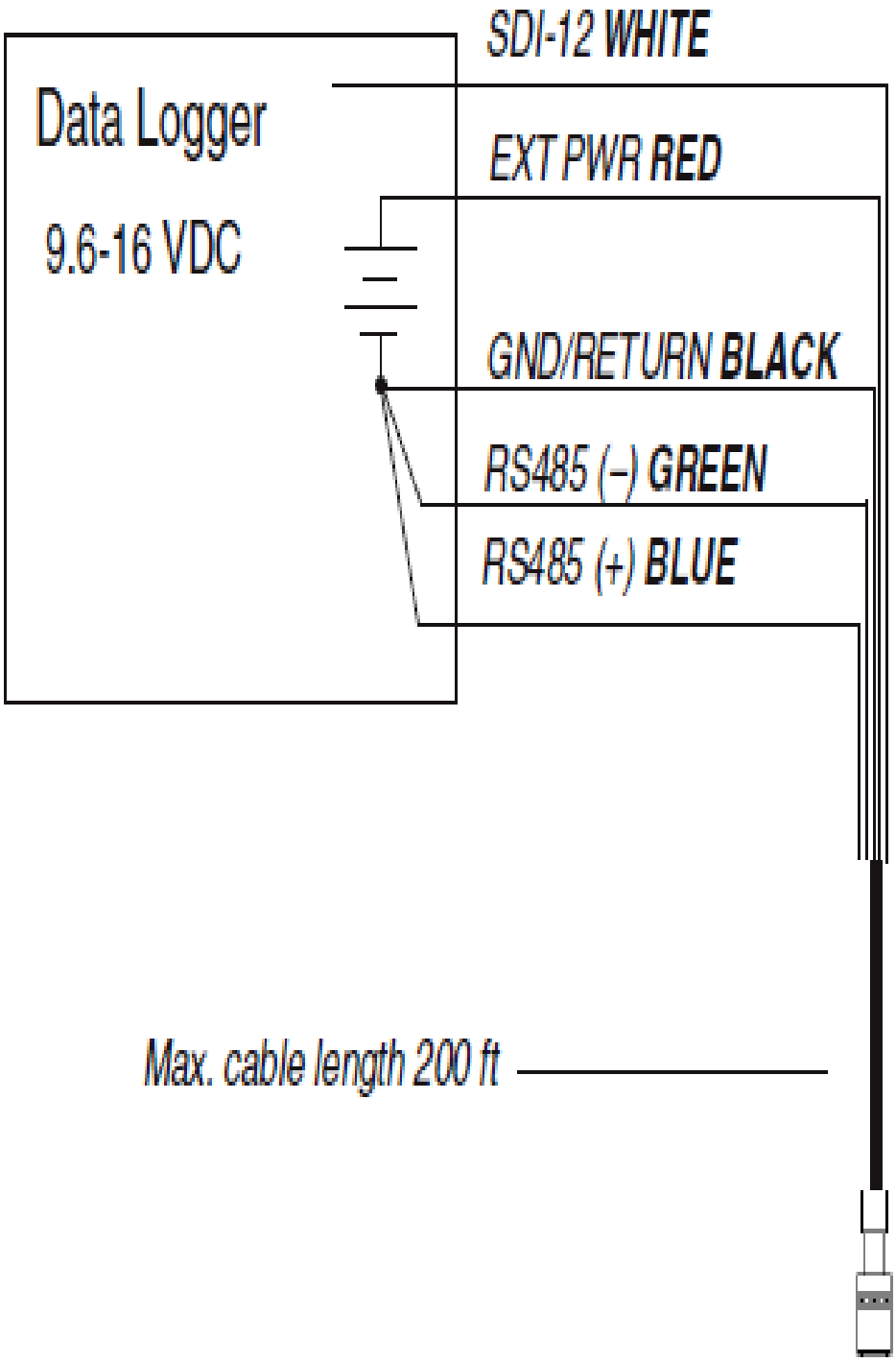
Refer to the diagrams on the following pages for wiring information. Make sure that you trim and insulate unused wires. The shield must be wired to a chassis ground or earth ground.

Signal	Color	Pin	
Gnd/Return	Black	6	
Ext Power	Red	5	
4-20 mA	Brown	4	
RS485(-)	Green	3	
RS485(+)	Blue	2	
SDI-12	White	1	

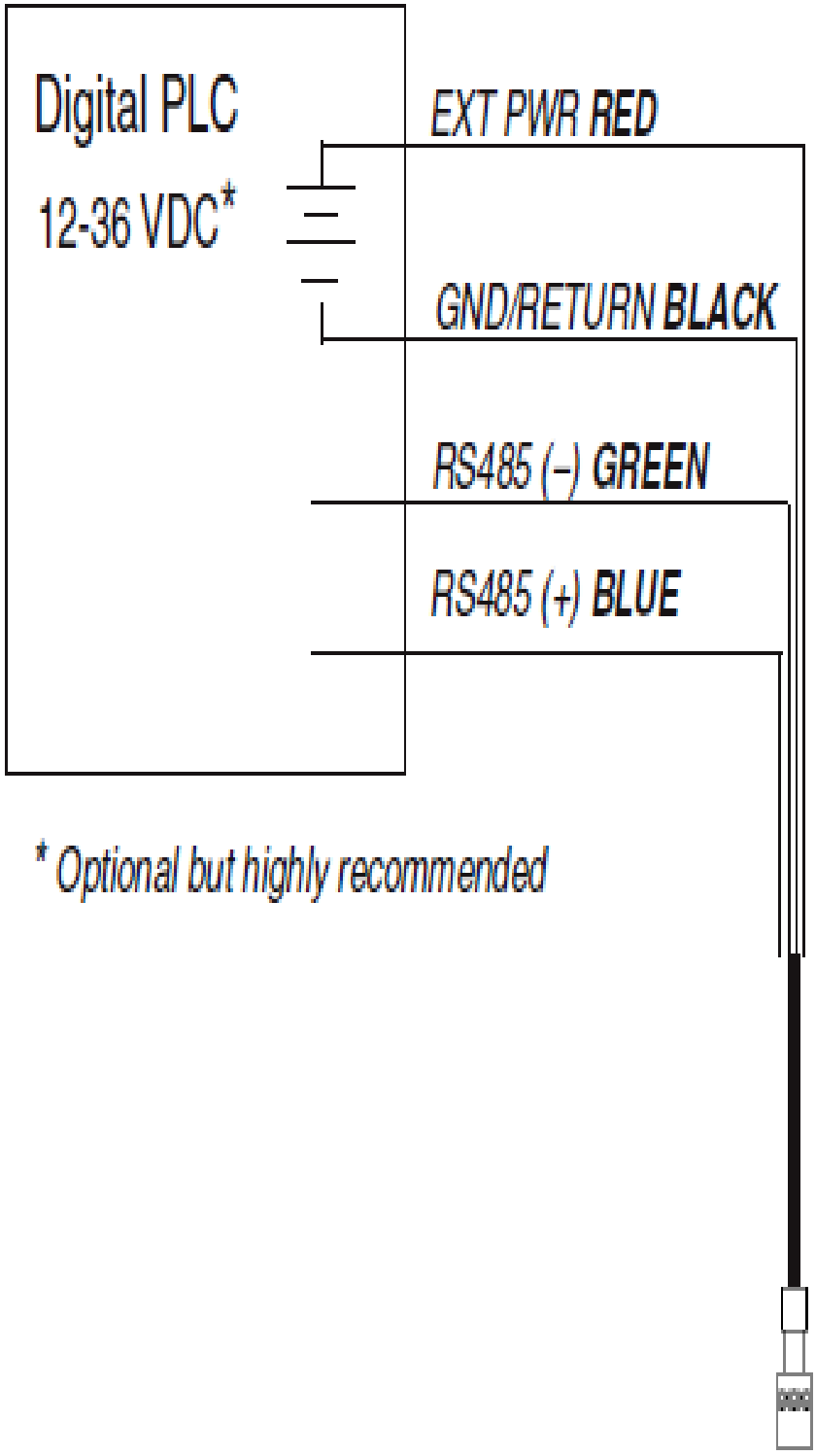
Analog (4-20 mA) 2 Wire



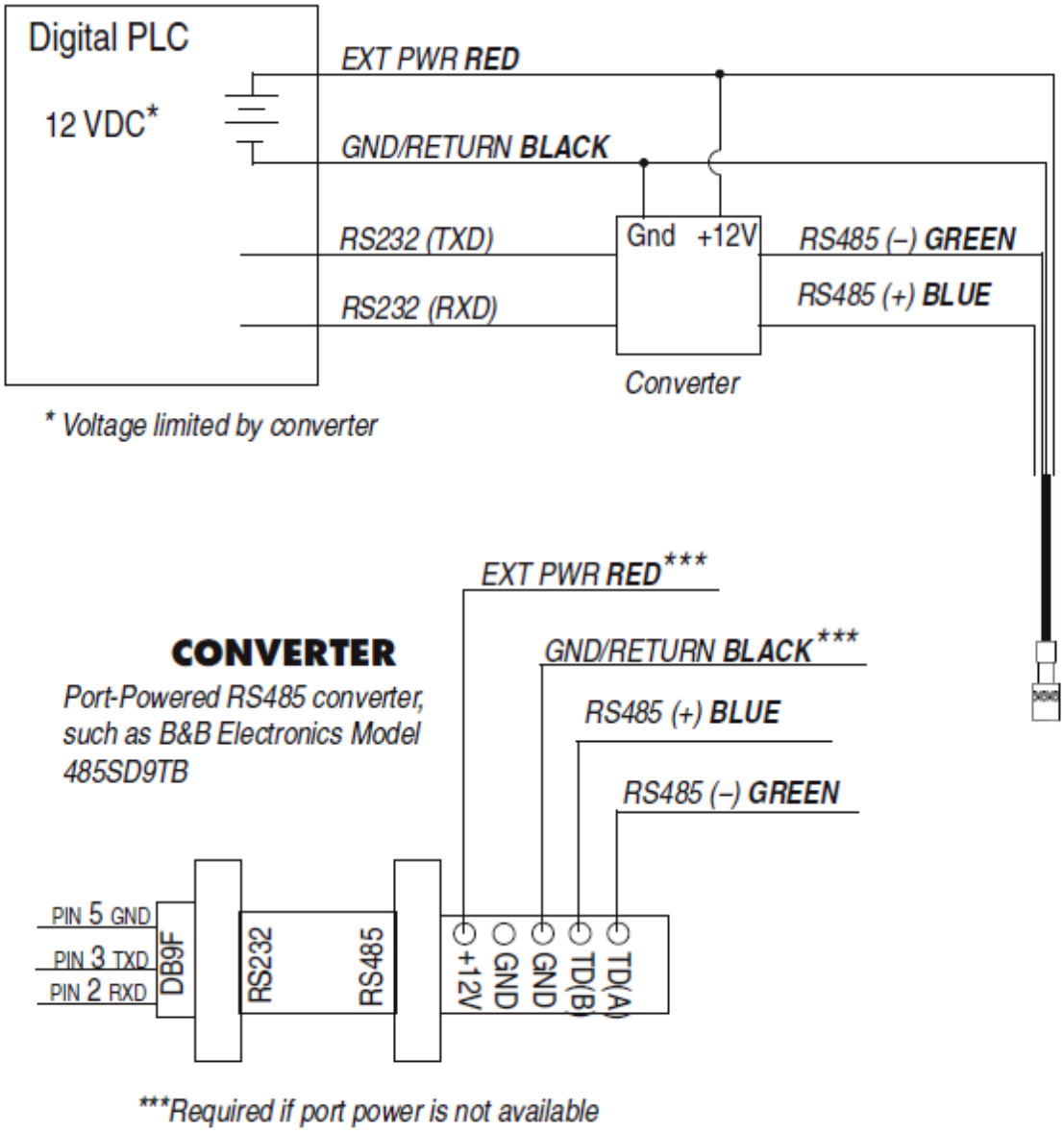
SDI-12 3 Wire


SDI-12 WHITE
Data Logger
EXT PWR RED
9.6-16 VDC
GND/RETURN BLACK
RS485 (–) GREEN
RS485 (+) BLUE
Max. cable length 200 ft

Modbus Master



Modbus Master with RS232 (Converter Required)



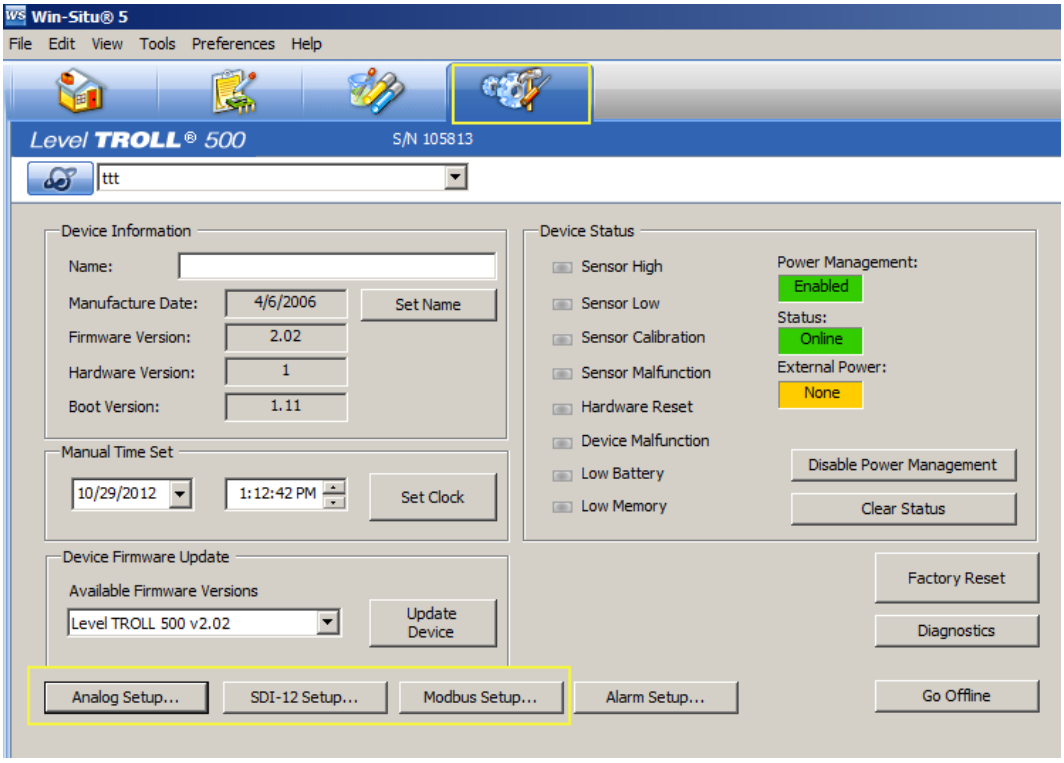
Power Connections

The Red wire provides power for Modbus and SDI-12 modes. The Brown wire provides power for the 4-20 mA mode. If power is present on the Brown wire and not on the Red wire, the device enters the 4-20 mA mode automatically and stays in the 4-20 mode until power is removed from the Brown wire or is applied to the Red wire. The Red wire has priority. If power is applied to the Red and Brown wires at the same time, the device will operate in Modbus or SDI-12 modes but not in 4-20.

Communication Protocols

The device automatically switches between Modbus and SDI-12 modes depending on which of the two interfaces has activity. Modbus and SDI-12 cannot be used at the same time. The communication protocol that is currently in use will block communication on the other.

Win-Situ 5 Software provides options for configuring analog/SDI-12 communications and Modbus communications on the **Tools** tab.



> ⚠ For additional information on Modbus and SDI-12 communications, including the SDI-12 commands and Modbus registers, see ***www.in-situ.com/Technical_notes*** and scroll to the Communications and Software Technical Notes section.

Redundant Logging

The instrument is capable of internal logging while participating in a Modbus, SDI-12 or analog network. However, Win-Situ 5 Software cannot communicate with the instrument while it is transmitting Modbus, SDI-12, or 4-20 mA analog data, and the instrument cannot receive or respond to Modbus, SDI-12, or 4-20 mA analog commands while connected to a PC serial port.

If the PLC or data logger loses data, the data that was logged internally on the instrument can be retrieved using Win-Situ 5 Software.

If the PLC or data logger experiences power loss, the instrument will continue to collect data using its internal batteries and clock.

A port-powered RS485 converter like that shown for Modbus connections may be used for temporary connection of the Level TROLL to a serial port on a PC.

Cleaning and Maintenance

Overview

It is important for users to perform scheduled maintenance on their instruments to sustain the accuracy and longevity of the probes and cables. The frequency of this maintenance depends on the characteristics of the deployment site, including humidity levels and the degree of fouling.

Users should be aware of the conditions at their deployment sites and develop appropriate maintenance schedules to replace desiccant, clean the instruments, and send in the instruments for factory calibration. Users should check instruments often during the first portion of the deployment to determine the frequency of maintenance. General maintenance should be performed as often as possible. Factory maintenance and calibration should be performed every 12 to 18 months.

Operating Considerations

The instrument has been designed to withstand harsh field conditions. However, as with any electronic instrument, it can be permanently damaged if used outside its operating specifications.

Temperature

Review the instrument specifications to determine the operating range. Do not deploy instruments in such a way that ice may form on or near the sensors or cable connections. Ice formation is a powerful expansive force that can over-pressurize the sensor or otherwise cause damage that is not covered by the warranty.

Pressure Range

The instrument can withstand pressures of up to two times (2X) the rated range of the pressure sensor without damage, although it may not read correctly at such pressure. If the pressure range is exceeded by 3X, the sensor will be destroyed.

Batteries

Internal batteries in the instrument are not user-replaceable. The approximate percentage remaining is displayed in Win-Situ software or the Vu-Situ mobile app when the instrument is connected.

If batteries are completely exhausted, external power and battery pack options are available. See page 24.

Desiccant Pack Options

Small Desiccant

The Small Desiccant is a disposable cap that ships with In-Situ products. The small desiccant is meant to protect the instrument and cable ***only during shipping and should not be used for deployments***.



Large and Extra Large Desiccant

The Large and Extra-Large Desiccant are used to protect equipment deployed in the field. The Large Desiccant is best suited for low-humidity environments or deployments where maintenance occurs regularly. The Extra-Large Desiccant is designed for high-humidity environments or deployments where maintenance occurs infrequently. Extra-Large Desiccants provide six times the drying capability of the Large Desiccant. When the desiccant expires, both can be refilled with fresh desiccant and re-used (see Desiccant Refill Kit below). The Large Desiccant is available with an ABS or a titanium twist-lock connector, while the Extra Large Desiccant uses a titanium connector only.

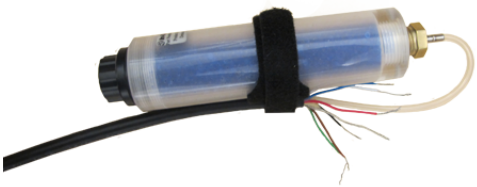




Description	Part Number
Large Desiccant, Titanium	0051810
Large Desiccant, ABS	0053550
Extra Large Desiccant	0090420

Outboard Desiccant

The Outboard Desiccant is a replaceable desiccant pack designed to attach to the vent tube of a stripped-and-tinned cable.



Description	Part Number
Outboard Desiccant	0051380

Desiccant Refill Kit

The Desiccant Refill Kit supplies desiccant for the Large Desiccant, Extra Large Desiccant, and the Outboard Desiccant. It also contains replacement glass wool.

Description	Part Number
Desiccant Refill Kit	0029140

Installing Desiccant with Twist-Lock Connectors

1. Remove the protective dust cap from the bottom of the desiccant pack, if applicable.
2. Remove expiring desiccant (if present) from the cable by grasping the textured section of the cable connector in one hand and the desiccant in the other. Twist in opposite directions to unlock the desiccant from the cable.
3. Attach the new desiccant pack to the twist-lock connector on the cable.



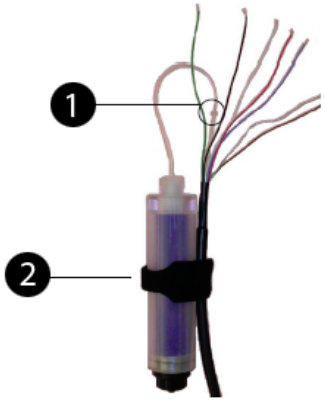
Installing Outboard Desiccant

Vented cable must be installed with outboard desiccant to protect the cable and instrument electronics from condensation in high-humidity environments.

The desiccant can be removed from the vent tube, if necessary, to trim the conductor wires. However, you must reinstall the desiccant after trimming and connecting the wires.

1. Cut off the knot at the bottom of the vent tube extension.
2. Firmly attach the vent tube extension to the cable vent tube. Cover at least 6.4 mm (0.25 in.) of the cable vent tube for a secure attachment.
3. Use the attached hook-and-loop strap to secure the desiccant to the cable, below the stripped wires.

4. Remove the red dust cap from the black nylon cap to allow air to reach the cable's vent tube.



1	Outboard desiccant is attached to the cable vent tube.
2	Desiccant is secured to the cable with a strap.

Using the Desiccant Refill Kit

1. Remove the black nylon vent cap from the top of the desiccant.
2. Pour out and discard the used desiccant. Check the glass wool in the bottom of the container and replace if necessary.

> ⚠ The glass wool prevents the desiccant beads from falling out the cable end of the desiccant pack. If the wool glass does this effectively, there is no need to replace it when refilling the desiccant.

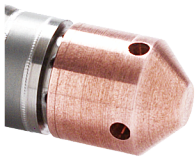
3. Fill the container with fresh desiccant. Replace the vent cap. Reattach to cable if removed.

Antifouling

TROLL Shield Nose Cone

The copper TROLL Shield Nose Cone is designed to reduce macro- and micro-fouling of the pressure sensor on Level TROLL and Aqua TROLL Instruments. Reduced fouling on the sensor improves measurement accuracy and extends the length of deployments.

For optimum performance, the TROLL Shield Nose Cone should be replaced every 12 months or sooner if site conditions are extremely harsh.



Description	Part Number
TROLL Shield Nose Cone	0081480

O-ring Inspection and Replacement

Examine O-rings for wear, dryness, discoloration, stretching, cracks, nicks, and brittleness. Replace O-rings when any of these conditions are present. Replacing O-rings on an annual basis, regardless of their condition, is the best way to protect against moisture damage.

Perform the following steps to replace an O-ring.

1. Remove and discard the damaged O-ring.
2. Use a clean, dry, soft cloth to clean the O-ring groove to remove dirt or residue.
3. Lubricate the new O-ring using high-vacuum grease.
    a. Wash your hands thoroughly.
    b. Apply a small amount of grease to the pad of your index finger, and rub your index finger and thumb together to spread the grease evenly.
    c. Inspect the new O-ring and remove any debris stuck to it.
    d. Rub your fingers around the O-ring until there is a thin layer of grease on the entire O-ring.
4. Install the O-ring in the groove and remove any excess lubricant with a clean cloth.

    Do not allow water or lubricant to enter the connector.

Cleaning and Storage

Cleaning the Instrument

Clean the instrument body with water and a soft brush or plastic scouring pad, or soak overnight in a mild acidic solution, such as household vinegar. ***NEVER*** submerge the connector portion of the instrument when it is not connected to a cable.

If the ports near the pressure sensor are clogged with silt or mud, try the following procedures.

- Agitate the instrument vigorously in a bucket of clean water.
- Apply a gentle rinse of water from a wash bottle.
- In severe cases, remove the nose cone and clean out the holes with a soft brush or pipe cleaner.

Do not attempt to remove material from the instrument by tapping the instrument against a surface. To avoid damage to the pressure sensor diaphragm, do not insert any object into the sensor opening or attempt to dig out dirt or other materials. **You void the instrument's warranty by inserting anything into the sensor opening.** If contamination cannot be removed using the recommendations above, please contact In-Situ for cleaning.



*A TROLL pressure sensor with the nose cone removed. Do not insert **ANY** object into the sensor opening. Doing so voids the warranty.*

Twist-Lock Connectors

Keep the pins on all connectors free of dirt and moisture by using the soft protective dust caps when cable is not attached.

Storage

Store the instrument in a clean, dry place. Place the protective red dust cap on the cable end or store with cable attached to protect the connector pins and O-ring. For vented cables, ensure the desiccant used is the appropriate size and change it when needed. Store the instrument where it will not roll off a bench onto a hard surface or sustain other mechanical shock. Protect the instrument from temperature extremes using the following guidelines:

- Level TROLL Instruments—store within the temperature range -40° C to +80° C (-40° F to +176° F)

Factory Calibration and Service

In-House Factory Calibration

Factory calibration of In-Situ instruments should be performed every 12 to 18 months, or at any point when the data appears to drift significantly. Factory calibration includes a thorough cleaning, all operational checks, necessary firmware upgrades, O-ring replacement, and full range calibrations of the pressure sensor, temperature sensor, and conductivity sensor (when applicable).

Return Materials Authorization (RMA) Form

To obtain a factory calibration, fill out and return the online Return Materials Authorization (RMA) form located at ***www.in-situ.com/***.

Obtaining Repair Service

If you suspect your system is malfunctioning and repair is needed, you can help assure efficient servicing by following these guidelines:

1. Call or email In-Situ Technical Support. Have the product model and serial number available.
2. Be prepared to describe the problem, including how the product was used and the conditions noted at the time of the malfunction.
3. If Technical Support determines that service is needed, they will ask your company to fill out the RMA form and pre-approve a specified monetary amount for repair charges. When the form and pre-approval is received, Technical Support will assign an RMA (Return Material Authorization) number.
4. Clean the product as described in the manual.
5. If the product contains a removable battery, remove and retain it unless you are returning the system for a refund or Technical Support states otherwise.
6. Carefully pack your product in its original shipping box, if possible.
7. Mark the RMA number clearly on the outside of the box.
8. Send the package, shipping prepaid, to:

In-Situ
ATTN: Repairs
221 East Lincoln Avenue
Fort Collins, CO 80524

The warranty does not cover damage during transit. In-Situ recommends insurance for all shipments. Warranty repairs will be shipped back prepaid.

Outside the U.S.

Contact your international In-Situ distributor for repair and service information.

Guidelines for Cleaning Returned Equipment

Please help us protect the health and safety of our employees by cleaning and decontaminating equipment that has been subjected to potential biological or health hazards, and labeling such equipment. Unfortunately, we cannot service your equipment without such notification. Please complete and sign the form on page 78 (or a similar statement certifying that the equipment has been cleaned and decontaminated) and send it to us with each instrument.

- We recommend the glassware cleaning product, Alconox, available from In-Situ and from laboratory supply companies.
- Clean all cables and remove all foreign matter.
- Clean the cable connectors with a clean, dry cloth. Do not submerge the connectors.
- Clean the instrument including the nosecone, cable head, and protective caps.

> ⚠ If an instrument is returned to our Service Center for repair or recalibration without a statement that it has been cleaned and decontaminated, or if it is the opinion of our Service Representatives that the equipment presents a potential health or biological hazard, we reserve the right to withhold service until proper certification is obtained.

Decontamination and Cleaning Form

Decontamination & Cleaning Statement

Company Name_____ Phone _____

Address _____

City _____ State _____ Zip _____

Instrument Type_____ Serial Number_____

Contaminant(s) (if known) _____

_____

Decontamination procedure(s) used _____

_____

Cleaning verified by_____ Title_____

Date_____

In-Situ Inc.

Troubleshooting

In addition to the following troubleshooting items, the In-Situ website includes instructional videos, technical notes, and more. See ***www.in-situ.com/***.

Problem	Possible Cause	Possible Solution
Win-Situ 5 Software cannot connect to the instrument.	Wrong COM port is selected, communication settings are incompatible, cable connections are loose or dirty, or batteries are low.	Make sure cable connections are tight and connectors are clean and dry. Make sure the cable is securely attached to the instrument. Make sure the correct COM port is selected (select **Preferences** > **Comm Settings** to verify). Make sure the communication settings in Win-Situ and in the instrument match. To reset the device communication settings to the serial defaults, click "Reset all Devices" in the Comm Settings dialog (**Preferences** > **Comm Settings**). Make sure the internal battery has voltage remaining, or external power is supplied. See ***www.in-situ.com/Technical_notes*** and scroll to the Communications and Software Technical Notes section for more information.
Real-time readings display the wrong units.	Default units are being used.	Click the **Sensors** tab, select the sensor, click the configure button and select the desired units for each parameter in the Sensor Setup window.
Cannot add a new log.	Only one active log can reside in the device at a time—an active log is a log that is Ready, Pending, Running, or Suspended as shown in the Status column of the Logging Tab. The device has its maximum number of logs already stored—the Level TROLL 300, 500, and Baro TROLL have a capacity of 2 logs.	Stop or delete the log if possible. Alternatively, configure the new log after the active log is completed. Download, and then delete a log you no longer need. This will make room for an additional log on the device.
New log exceeds available memory (software message).	The log as configured would exceed the device memory.	Edit the log and select a longer sampling interval. If available, select the "wrap data" option. This causes more recent data to overwrite older data when memory is full. For a log with a scheduled start, select None as the stop condition, or select a stop time that is closer to the start time.

Problem	Possible Cause	Possible Solution
Cannot configure level or other parameters using the **Configure** button on the **Sensors** tab. The **Sensor Setup** screen is shown, but the **Configure**... button is dim.	The instrument is actively polling (continually updating real-time readings) in the **Home** tab.	Return to the **Home** tab and stop real-time readings by clicking the **Play** button.
	The instrument has an active log—a log that is Ready, Pending, Running, or Suspended as shown in the **Status** column of the **Logging** tab. Only one active log can reside in the device at a time.	Stop or delete the log if possible. Alternatively, configure parameters after the log is complete.

Declarations of Conformity and Similarity

Level TROLL 400 Instrument

EMC Verification
Declaration of Similarity

Equipment

Type of equipment:	Measurement instrumentation
Product name:	Level TROLL® 400
Model:	Level TROLL® 400
Manufacturer:	In-Situ, Inc. 221 East Lincoln Avenue Fort Collins, CO 80524 USA

Category	Standards
Emission:	EN 61326 & FCC Part 15, Subpart B
Immunity:	EN61326

Summary

We confirm that the equipment referenced above, without reasonable doubt, will fulfill the requirements concerning electromagnetic compatibility according to the above mentioned standards harmonized with the EMC Directive 89/336/EEC. The Level TROLL 700 was tested and found to be in compliance in the month of January 2006.

Date of Issue: August 30, 2013



Ben Kimbell
Vice President of Research and Development

Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: Level TROLL
Model: Level TROLL 500
Product Description: The Level TROLL measures and logs level and temperature in natural groundwater and surface water.

is in compliance with the following Directives:

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use
- **Emissions**
  Class A requirements of EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Todd Campbell

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
January 17, 2006

CE FC

Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: Level TROLL
Model: Level TROLL 700
Product Description: The Level TROLL measures and logs level and temperature in natural groundwater and surface water.

is in compliance with the following Directives:

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use
- **Emissions**
  Class A requirements of EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
January 17, 2006

Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: TROLL Com
Model: USB TROLL Com
Product Description: RS485 to USB converter

is in compliance with the following Directive

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326, Electrical Equipment for Measurement, Control and Laboratory Use, Industrial Location
- **Emissions**
  Class A requirements of EN 61326, Electrical Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Todd Campbell

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
June 17, 2006

Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: Level TROLL
Product name: Baro TROLL
Product Description: The Baro TROLL measures and logs barometric pressure and temperature.

is in compliance with the following Directives:

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use
- **Emissions**
  Class A requirements of EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Todd Campbell

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
January 17, 2006

SOP-15: GROUNDWATER SAMPLING PROCEDURES

1.0 Purpose

The purpose of this standard operating procedure (SOP) is to describe the methodology for planning groundwater sampling events, well purging, and collection of groundwater samples through the use of positive displacement, submersible pumps, utilizing Low-Flow purging, monitoring and sample collection techniques.

Groundwater sampling consists of collecting a water sample that is representative of the in-situ conditions and chemistry of a specific aquifer, or portion of an aquifer. The groundwater sampling method addressed in this SOP, consists of the United States Environmental Protection Agency (USEPA) Low-Flow method; the following sections include summaries and procedures for this method.

Unless otherwise approved by the Agency, newly constructed wells may not be sampled for at least 48 hours after well development. Disturbance of the well, water column, and samples must be minimized, and only discrete grab samples may be obtained prior to the end of said 48-hr period.

Composite groundwater samples are unacceptable. If multiple groundwater monitoring wells are to be sampled during the same sampling event, samples must be collected from the monitoring wells expected to be uncontaminated or to have only low levels of contamination first, and then progressing to wells expected to have higher levels of contaminant last. This practice helps reduce the potential for cross-contamination between monitoring wells.

Groundwater samples must be collected within the central portion of each respective well screen zone. If further vertical delineation of contaminant concentration(s) is necessary, groundwater samples should be collected at the interval(s) within the water column based on the physical characteristics of the contaminant. If multiple different contaminant analytes are to be sampled from the same well, samples must be transferred to sample containers in the order of volatility. Contaminant analytes should be collected in the following order:

1. In-field water quality parameters (see *SOP for Field Water Quality Measurement and Calibration*)
2. Volatile natural attenuation parameters including methane, and carbon dioxide (CO_2)
3. Total organic carbon (TOC)
4. Inorganic compounds (such as total metals, dissolved metals, nitrate/nitrite, and sulfide)

At the request of the Agency, the baseline groundwater monitoring event will include emerging contaminant analyses, specifically perfluorinated chemicals Perfluorooctane sulfonate (PFOS) and Perfluorooctanoic acid (PFOA). Special consideration for the protocols and procedures related to the collection of groundwater samples for PFOA/PFOS are included within this SOP and incorporated into the standard protocols and procedures for the collection of groundwater samples for chemicals of concern (COC) analyses and pre/post remedial monitoring analytes related to this Facility.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in who are engaged in groundwater sampling at the former DuPont East Chicago facility, Indiana (DuPont EC) site projects and tasks.

This SOP focuses on the most commonly used monitoring well development tasks and applications anticipated at DuPont EC and should be used in conjunction with other applicable project SOPs, including the following*:*

- *SOP- Note Taking and Field Log Books*
- *SOP- Organic Vapor Monitoring and Air Monitoring*

- *SOP- Hollow Stem Auger and Direct Push Drilling Methods*
- *SOP- Monitoring Well/Piezometer Installation*
- *SOP- Monitoring Well Development*
- *SOP- Groundwater Level Measurement*
- *SOP- Field Water Quality Measurements and Calibration*
- *SOP- Equipment Decontamination Procedures*
- *SOP- Field Procedure Change Management*
- *SOP- Well Decommissioning and Abandonment*
- *SOP- Sample Identification and Nomenclature*

3.0 Protocols and Procedure Description

3.1 Equipment and Materials

The choice of sampling device will be based on Facility-specific considerations including the well diameter, depth of groundwater, and well sampling method, as well as to eliminate potential interferences related to the collection of groundwater samples for PFOA/PFOS analyses. Groundwater sampling devices must compliment the intended data use and Facility decisions, and selected groundwater purging and sampling equipment should minimize increases in sample temperature, water column agitation, and sample agitation, as well as minimize potential interferences to sample analyses.

Obtaining a representative sample is dependent on the methodology and technology used to obtain the sample. Each method uses different sampling technology and equipment, as necessary to accommodate the appropriate well installation and construction, drilling and sampling methods (such as conventional or DPS methods) employed, and project objectives. The use of positive displacement pumps is preferred to obtain the best sample and geochemical parameter data. These types of pumps include certified PFOA/PFOS, free stainless steel bladder, gear, and piston pumps. Submersible pumps are acceptable for most analytes; however, take care to select the proper submersible pump for the estimated sample depth so that the pump does not become overheated and alter the well chemistry.

If PFOS/PFOA sampling analyses are required, field personnel must adhere to the following restrictions:

- Field notes are to be recorded on non-waterproof paper with a pen. Aluminum field clipboards or Masonite clipboards may be used. The use of waterproof field books, post-it notes, plastic clipboards/binders/hard cover notebooks and/or waterproof markers may introduce bias to the resultant PFOS/PFOA analyses; the use of said field notation items is strictly prohibited., but
- Field personnel are required to wear well laundered clothing made of natural fibers (preferably cotton) without the use of fabric softeners. Wearing “new” cotton clothing or synthetic water resistant, waterproof, or stain-treated clothing, clothing treated with Gore-Tex, Clothing laundered with fabric softener, Boots containing Gore-Tex or treated with water resistant spray and/or Tyvek may introduce bias to the resultant PFOS/PFOA analyses; the use of said clothing items is strictly prohibited.
- Field personnel may only use Natural, non-toxic, and natural sunscreens/insect repellents prior to and during sample collection. The use of cosmetics, moisturizers, hand cream etc. as part of personal cleaning/showering routine, or non- natural toxic containing sunscreens and insecticides may introduce

bias to the resultant PFOS/PFOA analyses; the use of said items is strictly prohibited.

- Field personnel may bring bottled water with hydration fluids (i.e. Gatorade and Powerade) to the Facility and consumed only in staging areas; all other food/drink items are prohibited.
- Field personnel must avoid travelling in vehicles to the facility, equipped with fabrics, carpets and mats that may contain PFAAs
- Resultant PFOA/PFOS samples must be packed in a cooler and temperature stabilized with wet-ice; chemical ice packs are prohibited.

Personnel designated to conduct the groundwater sampling work will follow these basic equipment setup guidelines for the submersible pumps, when setting up groundwater sampling equipment:

- Connect the pump to the sample intake-discharge tubing. Connect the pump power control cable to the pump. Tightly secure the tubing to the pump with one or two zip-tie fasteners.
- Slowly and carefully lower the pump with HDPE tubing (and cable) into the well to the desired well depth. Lower the pump with the deployment cable and tubing within the well. Please note that LDPE tubing is prohibited when groundwater samples are to be analyzed for PFOA/PFOS
- Secure the pump and tubing to the top of the casing by the deployment cable (if used) or the most secure and largest diameter tubing or cable attached. Use with multiple zip-tie fasteners or a spring clamp if the pump is relatively light and the well is shallow.
- Connect the opposite end of the air pressure tubing or the pump power control cable to the pump flow controller.
- Clamp the other end of the sample intake-discharge tubing to the purge bucket in a way that discharging purge water will flow into the bucket.
- Connect the pump controller directly to a generator using an extension power cord as appropriate.
- Place the generator downwind of the sampling area a significant distance away (~20 feet or more). If a bladder pump is used, the generator should not be operating while a sample is being collected.
- Make sure that the generator supplying power to the pump is sufficiently fueled before purging and sampling to avoid power loss.

Materials used during groundwater sampling must not absorb, desorb, or leach contaminants of concern from or into a potential groundwater sample. The materials used must be resistant to chemical and biological degradation. If bailers are used, the bailer must be made of glass, stainless-steel, other suitable materials, or of disposable materials such as Teflon® or polyethylene. Polyvinyl chloride (PVC) bailers are not acceptable for sampling of volatile natural attenuation parameters.

3.2 Pre-Sample Collection Tasks

- Historic Data Review: The FTL should work with the PM and FM to obtain historical information on which wells have historically had contaminants present, so that wells with the greatest concentrations may be sampled last to minimize potential cross contamination. Site background information (historical Well Purge and Sampling Datasheets), including depth to water, well total depth, and water quality parameters from previous events (if available), should be obtained before the field sampling event to augment data quality and allow for verification of data consistency. An evaluation of historic groundwater elevation data from monitoring wells at the site will be performed to determine the range of seasonal water level fluctuations that occur at the site and the shallowest and deepest observed water levels over the period of record. This information defines the depth interval of the saturated zone, as the water table elevation rises and falls

with seasonal water level fluctuations. *SOP- Attachment 1* summarizes the range of seasonal water level fluctuations that occurs at the Dupont EC site and highlights the permanently saturated zones.

Groundwater samples will be collected from the permanently saturated zone beneath each suspected source area and upgradient/downgradient from each source area, from permanent monitoring well installations (see *SOP*). These samples will be used to determine the mass flux contribution from the vadose zone to the permanently saturated zone beneath each source area. Expected purge volumes will be estimated (to the extent practical) before field deployment such that purge water management may be planned.

- Equipment Decontamination: Clean (and/or decontaminate) all equipment and materials used during groundwater sampling before use, as discussed in *SOP for Equipment Decontamination Procedures*. Groundwater sampling equipment that typically requires decontamination before purging a well includes the water level or oil-water interface probe, water quality meters and probes, and the inside of flow-thru cells. Decontaminate submersible pumps between sampling at each well. Portable decontamination supplies (for example, decontamination water containers, spray bottles, Alconox, and deionized water containers) should be available during sampling so that all appropriate accessory equipment can be decontaminated in the field. The use of Decon 90, and liquinox are strictly prohibited when groundwater samples are to be analyzed for PFOA/PFOS. Place used decontamination solutions in the purged well water containers and managed as investigation-derived waste (IDW).

- Field Equipment Calibration: Before going into the field, the FTL or designee will verify that field instruments are operating properly and that there are no obvious defects that could prevent proper operation. Calibrate all instruments before obtaining field data to within an acceptable range, according to *SOP for Field Water Quality Measurements and Calibration*. Minimize field sampling time or data quality lost because of malfunctioning equipment through proper pre- event planning and by using adequate backup equipment, as necessary. Make field measurements for temperature, pH, turbidity, specific conductance, dissolved oxygen, temperature, and oxidation-reduction potential (ORP) according to said SOP.

3.3 Groundwater Sampling Preparation

The following procedures should be performed at each well in preparation for groundwater sampling:

- Wear PFOS/PFOA-free PPE and take any other precautions as specified in the HASP.
- Inspect the condition any permanent monitoring wells for any unusual site or well conditions. Record the condition of the well monument, concrete well pad, protective posts, or other well condition surrounding the well on *SOP- Attachment 3: Well Condition Inspection Datasheet* and/or in a Field Notebook. Any deficiencies encountered will be immediately reported to the FTL and FM prior to initiating the sample collection work.

3.4 Low-Flow Groundwater Sampling Procedures

Low-flow sampling is a method of collecting samples from a well that does not require purging large volumes of water from the well and relies on natural flow of formation water through the well. Using this method, the water flowing into and through the well is representative of the groundwater with the formation surrounding the screen and thus representative groundwater samples can be obtained by slowly pumping.

Most groundwater methods (except no-purge sampling methods) require purging of the well before groundwater sampling. The purpose of well purging is to remove stagnant water from the well and obtain a water sample representative of the aquifer being sampled with a minimum of disturbance to the water column. Using the low-flow or the well-volume approach methodology, each well will be purged from the middle of its respective well screen interval until field parameters (such as DO, ORP, conductivity, pH, turbidity, and temperature) have stabilized, until three well casing volumes are purged, or until the well is purged dry according to *SOP for Field Water Quality Measurements and Calibration*. Groundwater samples will not be collected from a well until the groundwater level and the groundwater parameters have stabilized according to the criteria indicated in *the SOP for Groundwater Level Measurement.*

"Low-flow" refers to the velocity with which water enters the pump intake and is imparted during pumping to the formation pore water adjacent to the well screen (American Society for Testing and Materials [ASTM] D6771). Low-flow does not necessarily refer to the flow rate of water discharged by a pump at the surface, which can be affected by valves, connections, and discharge tubing restrictions. However, typical low-flow surface discharger rates should be limited to less than 0.5 liters per minute (L/min). Low-flow sampling methods emphasize minimal stress to the groundwater by low water-level drawdown and low pumping rates in order to collect samples with minimal alterations to water chemistry, not to exceed low-stress drawdown threshold in excess of 0.3 feet (U.S. Environmental Protection Agency [EPA], 2002; ASTM D6771). This is the preferred method for natural attenuation monitoring, which requires careful measurements of DO and oxidation-reduction sensitive analytes, such as iron and manganese.

Low-flow sampling is typically conducted using positive displacement pumps, submersible pumps, or peristaltic pumps. The low-flow pump selected for this work is the QED submersible pump (see *SOP- Attachment 4*).

Low-flow groundwater sampling should be conducted as follows and should be used along with *SOP for Field Water Quality Measurements and Calibration*:

3.4.1 Setup

1. Measure the depth of the static water level and the total well depth with a water level probe to the nearest 0.01 foot from the measurement reference point on the well casing pipe as described in SOP for Groundwater Level Measurement. This information will be recorded on the *SOP, Attachment 2: Well Purge and Sampling Datasheet*. If previous total well depth information is available from either well construction or previous sampling events, compare the current total well depth with the previously measured total well depth and note any differences greater than 0.5 foot on the on the *SOP-, Attachment 2: Well Purge and Sampling Datasheet*. Notify the FTL and/or FM of the observation

2. Set up the sampling equipment and pump as described in Section 3.1 and according to the manufacturer's instructions.

3. Secure the water quality meter to the flow-through cell and connect a short discharge tube to the effluent connector at the top of the flow-through cell and run the other end of the discharge tube into a 5-gallon graduated purge water discharge bucket. Securing the discharge tube to the 5-gallon bucket with a metal spring clamp is recommended.

4. Very slowly lower the pump or pump intake tubing down the well to the desired sample intake depth (preferably within the screened interval). Record the approximate pump or pump intake tubing depth on the *SOP-, Attachment 2: Well Purge and Sampling Datasheet.*

5. Run the aboveground end of the intake tube from the pump directly into the 5-gallon purge water bucket.

3.4.2 Purging

Turn on the pump and start to pump on the lowest setting. Adjust the flow slowly until water begins to discharge. at a purge rate not to exceed 0.1 gal/min for approximately 1 to 2 minutes, or until the purge water begins to visually clear up. The intent is to limit any initial high turbidity water from filling and settling in the flow-through cell.

1. Once the majority of the observable turbidity has cleared, briefly turn off the pump and secure the tube from the pump to the influent connector at the bottom of the flow-through cell. Turn on the pump again and then allow the flow-through cell to completely fill with water. A continuous effort should be made to keep air bubbles and significant air volume from collecting in the flow-through cell. To remove any collected air volume within the flow- through cell, partially unscrew the multi-meter sonde from the flow-through cell while pumping until all the air escapes and water begins to slowly leak from the sonde/flow- through cell connection.

2. Continue pumping and begin low-flow purging the monitoring well at a flow rate of approximately 100 ml/min or less every 3 minutes or 0.1 gal/min, such that the pumping rate does not lower the water level more than 0.3 feet. Initially monitor the drawdown frequently, to establish a steady pumping rate that minimizes drawdown. If the minimal drawdown exceeds 0.3 feet, *but remains stable*, continue purging.

3. Purge the water through the flow-through cell and into a 5-gallon graduated purge water discharge bucket. Observe the purge rate and cumulative total discharge volume based on the graduated marks on the purge bucket. Empty the purge bucket into an IDW drum or dispose of the purge water according to Appendix B, Project-specific Waste Management Plan.

4. Routinely measure and record the DO, ORP, conductivity, pH, turbidity, temperature, current groundwater level, and cumulative total purge volume throughout the purge at approximately every 3 to 5-minute interval. A minimum of three of groundwater parameter measurements, 5 minutes apart should be monitored and recorded. The groundwater level should be measured frequently during purging to verify that the water level has not dropped lower than the desired 0.3 foot threshold. Record the groundwater parameters, groundwater level, and cumulative total purge volume on a *SOP for Attachment 2: Well Purge and Sampling Field Datasheet*.

5. Stabilization of water quality parameters is the primary criterion for sample collection by this method, while concurrently maintaining a low, aquifer stress threshold below 0.3 foot of drawdown. Continue to measure and record the groundwater parameters and current groundwater level until the parameters stabilize according to the following stabilization criteria. Groundwater parameters are considered stable after purging if three successive readings are within the following parameters:

Water-Quality Indicator Parameters (ASTM Standard D6771-02)

Parameter	Stabilization Criteria
pH	Difference of ±0.2
specific electric conductance	**Difference of ± 3%**
temperature	Difference of ± 0.5 ºC
turbidity	±10% (when turbidity is greater than 10 NTUs)
oxidation -reduction potential (ORP)	± 20 millivolts
dissolved oxygen (DO)	10% or ±0.2 mg/L, whichever is greater

If it does not appear that the groundwater parameters are approaching stabilization after the removal of two well volumes and *SOP*- and *SO* have been strictly followed, check the calibration of the field instrument or try using a different water quality instrument. If the instrument check or recalibration shows that the field instruments are working properly and parameter stabilization is still not occurring, the FTL may elect to collect the sample after a minimum of three or maximum of six well casing volumes have been purged.

The FTL will contact the FM when this behavior is observed and will record in the *SOP-XX, Attachment 2: Well Purge and Sampling Field Datasheet* that parameter stabilization could not be achieved.

6. If water quality indicator parameters have stabilized for three consecutive measurements, five minutes apart, but stabilized well-stress is above the drawdown threshold of 0.3 ft (pumping rate less than 100 ml/min), field personnel will continue purging for an additional 15 minutes to determine whether drawdown recovery "recovers" to less than the 0.3 foot threshold. If drawdown does not recover, field personnel will temporarily cease well purge activities and immediately contact the Project Manager. The project manager will immediately contact the USEPA Project Manager for the Site, concurrently review recorded well development logs, soil boring logs and well construction logs for the well in question and determine whether re-development of the well is the best course of action, or whether sample purge/sample collection may continue after water quality parameter stabilization is achieved.

   If the second option is approved, a subsequent deviation correspondence will be prepared by the Project Manager, submitted to Agency and include a copy of said deviation correspondence to the data validator for review and commentary (related to sample quality from samples collected from this well)..
7. If and once groundwater parameters have stabilized or a minimum of 3 well casing volumes have been purged, record the final parameter measurements, water level, total purge volume, and any other purge observations on the *SOP- Attachment 2: Well Purge and Sampling Field Datasheet*.

3.4.3 Sample Collection

1. Following purging, collect groundwater samples without altering the flow rate or extensively interrupting the flow. If PFOA/PFOS analyses are required, these samples are required to be collected first by disconnecting the tubing to connected to flow through cell inlet while the pump is still in operation and collect PFOS/PFOA samples immediately and place said samples in a dedicated PFC (iced) cooler). Next, very briefly turn off the pump and disconnect the aboveground end of the pump intake tube from water quality meter and flow-through cell before sampling. Do not sample from the discharge of the flow-through-cell.

2. Turn the pump back on and continue to pump at a flow rate of approximately 0.1 gal/min. Re-verify the pumping rate does not lower the water level in the well by more than 0.3 foot. While sampling, discharge any groundwater pumped between filling sample containers in a 5-gallon groundwater purge bucket. Dispose of this water along with other purge water accumulated.

3. Begin filling the laboratory-supplied analytical sample containers in the order of volatility as previously described in Section 3. Fill the analytical sample containers as discussed in Section 4.5 until complete.

4. Record the sample ID, date and time, sampler, analytes, and other sample information on the sample bottle labels, the sample chain-of-custody, and on the *Attachment 3: Well Purge and Sampling Field Datasheet*, as required (see *SOP for Sample Handling and Custody*).

4.0 Sample Transfer and Containerization Protocols

For all groundwater sample collection methods cited above, the following sample collection procedures will be performed as follows:

- If PFOS/PFOA sampling analyses are required, said samples must be collected first and immediately placed in a PFOS/PFOA dedicated cooler and temperature preserved with wet-ice.

For the remainder of the sample analyses associated with this work:

- Fill sample containers so that the sample is allowed to flow gently along the inside wall of the container. Take care to minimize turbulence, agitation, and aeration of the sample.
- Minimize the headspace in the sample container by filling the sample jar until a positive meniscus is present
- Quickly and adequately seal the containers. Unless otherwise specified, seal the jar using Teflon®-lined screw caps.
- Clean rims before tightening lids.
- Label and handle sample containers as outlined in *SOP for Sample Identification and Nomenclature* and in *SOP for Sample Handling and Custody*.
- Immediately cool the samples to 4°C and maintain this temperature through delivery to laboratory until the samples are analyzed.
-

5.0 Investigation-Derived Waste

If any IDW is generated during purging or sampling, store and dispose of according to *the SOP for Investigative and Remedial Derived Waste Management*.

6.0 Records

Record details regarding the pumping method, parameter readings, purge volumes, and samples collected in the Field Notebook and on a *Attachment 2: Well Purge and Sampling Datasheet*.

7.0 References

American Society for Testing and Materials (ASTM). February 1, 2002. *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations*. ASTM Standard D6771, ASTM International, West Conshohocken, PA.

Kejr Inc. November 2006. *Geoprobe® Screen Point 16 Groundwater Sampler Standard Operating Procedure*. Technical Bulletin No. MK3142.

QED Environmental Systems. 2010. Sample Pro® *Groundwater Sampling Pump*. http://www.qedenv.com/Products/Groundwater_Sampling/Low-flow_Portable_Pump_Overview/. Accessed February 18, 2010.

8.0 Definitions

None.

9.0 Attachments

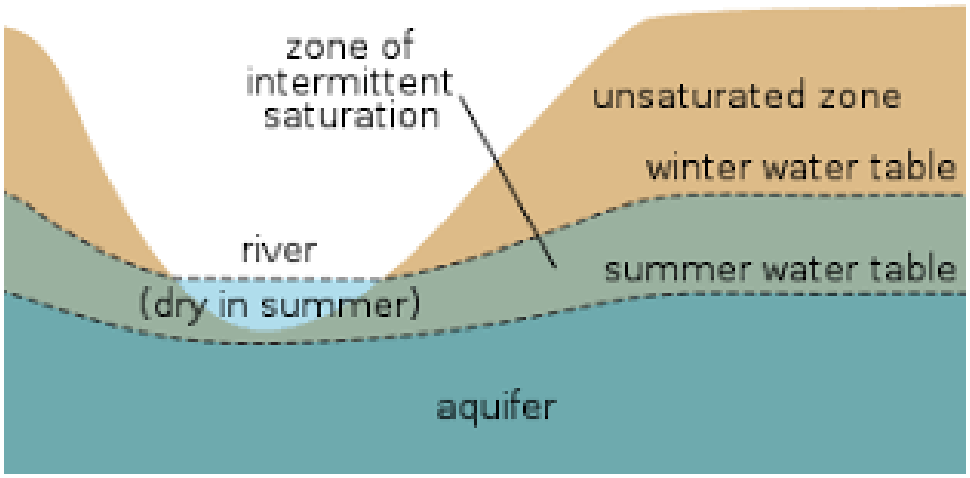
Attachment 1: *Seasonal Water Levels within Onsite Saturated Zones*

Attachment 2: *Well Purge and Sampling Datasheet* Attachment

Attachment 3: *Well Condition Inspection Datasheet* Attachment

Attachment 4: *Low-flow and Passive Sampling Equipment*

Seasonal Water Levels within Onsite Saturated Zones



GROUND-WATER SAMPLING RECORD

Well ID:_____

Station #:_____

Facility Name:_____ Date:____/____/____

Well Depth:_____ Depth to Water:_____ Well Diameter:

Casing Material.:_____ Volume of Water per Well Volume:

Sampling Crew:_____,_____,_____,

Type of Pump:_____ Tubing Material:_____ Pump set at _____ ft.

Weather Conditions:_____ NOTES:

GROUND-WATER SAMPLING PARAMETERS

Time	Water Level	Volume Pumped	Pumping Rate	DO (mg/l)	Temp. (^{O}C)	SEC (µS/cm)	pH	ORP (mV)	Turbidity (NTU)

Other Parameters: _____

Sampled at:_____ Parameters taken with: _____

Sample delivered to _____ by _____ at_____.

Sample CRL #:_____ OTR #:_____ ITR #:_____ SAS #: _____

Attachment 1: Groundwater Monitoring Well Inspection Checklist

Facility Name: Facility					
License/ID #: Inspector	**Facility Location**				
Name:			**Inspection Date**		
Items Inspected					
Is the well clearly labeled on the outside of the well					
Is the well easily found? Is the well locked? Does the well have a metal protective cover or pipe					
Is the pipe at least 24 inches above ground?					
Does the pipe inhibit the well from being closed and locked? Is the pipe more than 4					
inches above the well top making it difficult to record accurate water levels?					
Is the well cap vented?					
Except for wells also used for gas monitoring					
Surface seal type: Is the seal in good condition? Is soil or clay					
mounded over the seal sloped to					
shed water away from the well? If bentonite,					
is it covered with native soil to reduce bentonite desiccation? Has the well moved from its original position? (e.g. heaved, sunk, bent)					
Is a groundwater elevation reference measuring point established on the inner					
casing? Is there evidence of water ponding around the well casing? If flush mounted well Can it be locked? Is the					
well in an area that will not pond water? Is it installed through an impervious surface? (surface type)					
Is the steel cover water tight? Does the well have a water tight cap?					

PASSIVE SAMPLING FOR GROUNDWATER MONITORING: TECHNOLOGY STATUS

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SERDP and ESTCP

Distribution Statement A

PASSIVE SAMPLING FOR GROUNDWATER MONITORING: TECHNOLOGY STATUS

Passive samplers are devices designed to sample groundwater within a screened interval of a permanent monitoring well without pumping or purging. Given that the screened interval is in dynamic equilibrium with the adjacent formation groundwater, passive samplers can obtain representative groundwater samples when used appropriately. Several passive sampling devices have been developed, and testing has shown that passive samplers can replace traditional purge-based sampling and low flow purge methods without loss of data quality. The status of the passive sampling technology is provided in this summary.



Deployment of the Snap Sampler

INTRODUCTION

Long term monitoring (LTM) represents a large fraction of the annual costs and continued liability for the Department of Defense's (DoD) contaminated groundwater sites. Consequently, SERDP and ESTCP has funded research on several technical solutions to reduce these costs. Solutions include passive samplers that can significantly reduce the labor needed and the waste generated during one sampling relative to traditional well purging methods, as well as sampling strategies that can reduce the number of individual sampling events necessary to differentiate between short- (i.e., random) and long-term (i.e., attenuation) variability.

The results of recent research designed to optimize LTM sampling is provided in this summary. All project descriptions and reports are available by project number at the SERDP and ESTCP SERDP and ESTCP website (www.serdp-estcp.org). The key findings are summarized below, with greater detail in the following sections:

Advantages of Passive Samplers

- Passive samplers are valid for most analytes, under a wide range of conditions
- Their limitations are understood and credible guidance is available
- These devices can greatly reduce monitoring costs, without sacrificing data quality

Passive Sampling Strategies

- Frequent sampling at many sites is inefficient because attenuation rates are often slow
- Annual or less frequent sampling may be appropriate for many sites with stable plumes
- Understanding the sources of variability can result in more efficient LTM plans

PASSIVE SAMPLERS

Passive samplers are devices designed to sample groundwater within a screened interval of a permanent monitoring well without pumping or purging. Given that the screened interval is in dynamic equilibrium with the adjacent formation groundwater, passive samplers can obtain

representative groundwater samples when used appropriately. Several passive sampling devices have been developed, and testing has shown that passive samplers can replace traditional purge-based sampling and low flow purge methods without loss of data quality.

There are three general types of passive samplers for groundwater:

1) **Equilibrium samplers** - devices that establish an equilibrium with the groundwater
2) **Sorptive samplers** - devices that accumulate analytes from groundwater over time
3) **Grab samplers** - devices that collect water samples at a specific depth and time

The first commercialized equilibrium sampler was the Polyethylene Diffusion Bag [PDB] sampler (USGS, 2001), and guidance on using PDBs has been available for a decade (ITRC, 2004). However, PDBs have important limitations. Only VOC contaminants can be monitored with the PDB, and many compounds typically monitored during monitored natural attenuation (MNA) cannot diffuse across the polyethylene barrier well enough to establish equilibrium concentrations in a reasonable time. In general, PDBs are valid only for VOCs (primarily chlorinated solvents and BTEX), and should not be used for inorganic compounds, hydrophilic volatile organic compounds (e.g., MTBE, 1,4-dioxane), or semivolatile organics (PCBs, PAHs). Other equilibrium samplers (e.g., Regenerated Cellulose Dialysis Membrane [RCDM] samplers) have been developed to obtain representative samples for a broader range of analytes than PDBs.

Sorptive samplers are deployed in a monitoring well for a short period of time and rely on sorption of organic compounds to a matrix during the exposure period to accumulate a measurable mass. Time of exposure, temperature, and desorbed mass measured during analysis are used to calculate groundwater contaminant concentrations. These devices can be used for a wide range of organic constituents

Passive grab samplers are pre-deployed devices that are activated in place to directly obtain depth- and time-specific samples from monitoring wells. Passive grab sampling collects a whole water sample, so it can be used for any analyte, subject to volume limitations. All three types of passive samplers have been validated through ESTCP and guidance is available from ITRC (2004, 2007) and ASTM (Standard D7929-14 - ASTM, 2014).



Regenerated Cellulose Dialysis Membrane Equilibrium Sampler

Advantages and Limitations of Passive Samplers

The key advantage of passive samplers is the cost savings from reduced time for sampling and decreased waste generation. However, there can be other important advantages, including: 1) no pumps or power supplies are needed; 2) less on-site time is needed, reducing risks to personnel and inconvenience to site operations; and 3) reduction of data artifacts associated with purging (e.g., excessive drawdown, turbidity).

Key limitations include: 1) some passive samplers cannot be used for all analytes, 2) some

passive samplers may not be able to collect sufficient sample volume for all required analyses, 3) some passive samplers may not fit into wells smaller than the common 2-inch diameter well, 4) some devices are not appropriate for "total" or unfiltered sample analysis because of diffusive filtration, and 5) some methods (i.e., sorptive methods) produce a calculated concentration rather than a measured concentration.

A common concern during the transition to passive sampling is that the results may not agree entirely with conventional or low-flow purging methods. Inconsistencies can happen and are largely due to flow changes associated with pumping (or not pumping) the well. Occasional differences within individual wells should be expected, but statistical equivalence has been observed in these demonstrations when comparing results over several wells. Individual well differences can be attributed to the depth-specificity of passive samplers, or a limited integration of the sample zone, whereas purging may provide an integrated sample from a larger volume (i.e., the screen length and beyond). As a result, both methods may be internally "accurate", but each may represent the aquifer slightly differently.

Performance of Passive Samplers

The three passive sampler validation projects funded by ESTCP (ER-200630, ER-200921, and ER-200313) have shown that passive sampling approaches can overcome the limitations of PDB samplers (Table 1). These projects have focused on one grab sampler (the Snap Sampler™), a broad-range equilibrium sampler (the RCDM sampler), and a sorptive sampler (the GORE® Sorbers, now referred to as AGI Universal Samplers), respectively. These are among the most developed passive samplers, and many of the lessons learned from testing these samplers should also apply to other types of devices and technologies.

Table 1: Results of Passive Sampler Demonstrations

Project No.	Sampler	Analytes	Status	Comparison to Low Flow Purging
ER-200313	**RCDM** *(Equilibrium)*	Cl VOCs Explosives Inorganics Perchlorate MNA parameters	Final (2011)	▪ Excellent for most analytes ▪ Linear relationships with slopes = 1.0 ▪ Close correlation with PDBs (100%) ▪ Detection limits within 2-5x MCLs ▪ Estimated cost savings of 45-70%
ER- 200630	**Snap™** *(Grab)*	VOC, Cl VOCs Inorganics Explosives Perchlorate MNA parameters MTBE	Final (2011)	▪ Excellent for most analytes ▪ Linear relationships with slopes = 1.0 ▪ Estimated cost savings of~70%
ER-200921	**AGI** *(Sorptive)*	Cl VOCs BTEX Alkyl benzenes PAHs	Final (2014)	▪ Excellent for most analytes ▪ Linear relationships with slopes = 1.0 ▪ Detection below MCLs (ng/L range) ▪ Estimated cost savings of 30-45%

The results of these passive sampler demonstration projects are highly encouraging. All three devices tested under ESTCP have shown excellent agreement with traditional low-flow sampling results for almost all of the analytes present at several field sites. In 2007, ITRC concluded that these samplers, as well as others, "provided reliable and accurate data when used appropriately"

(ITRC, 2007). These results support that conclusion, and should greatly increase confidence in the use of these passive samplers for LTM.



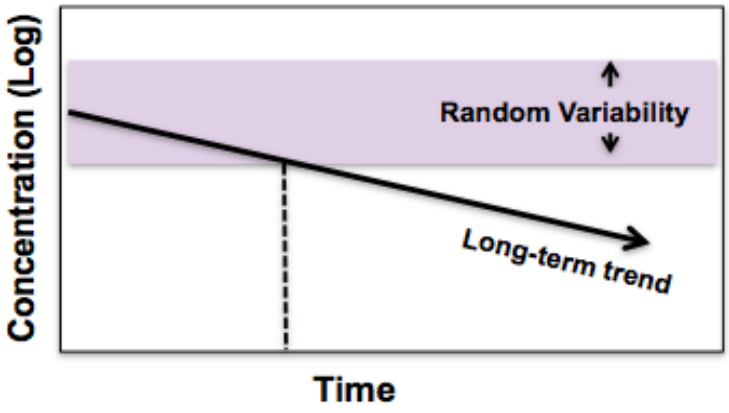
AGI Universal Sampler – A Sorptive Sampler

Precautions that should be followed to ensure accurate data include: 1) use of appropriate samplers for the suite of analytes of concern; 2) avoid problematic monitoring wells (e.g., fouled, bent, long screen >20ft, small diameter [for some methods]); 3) avoid monitoring wells with LNAPL; and 4) recognize potentially problematic analytes (e.g., total Fe). Site-specific evaluations may be desired for unusual site conditions. Such evaluations can be based on comparisons of passive sampler results to historical data, or on paired testing. A conversion evaluation several years after conversion may be useful to understand how the method transition has affected results at individual wells.

The cost savings from converting to passive samplers can be considerable. Savings results largely from the reduced labor and reduced waste compared to traditional purge-based methods. The ESTCP-funded demonstrations suggest that a reduction of 50% in LTM costs is a conservative expectation for grab samplers and equilibrium samplers, while a reduction of at least 30% can be expected when using sorptive samplers. Such savings are significant given that sampling is the dominant cost at MNA sites, and sampling may continue for decades.

IMPROVING PASSIVE SAMPLING

Recent SERDP and ESTCP projects have focused on optimizing LTM sampling frequencies, with and without the use of passive samplers. The goal is to increase the efficiency of LTM by defining the monitoring frequencies needed to quantify long-term trends (see below).



Optimizing Monitoring Frequencies

Project ER-1705 demonstrated that changes in concentrations of chlorinated solvents are generally very slow, with attenuation half-lives typically over 5 years. As a result, the variability in typical quarterly or semiannual monitoring programs is often dominated by shorter-term (i.e., seasonal) fluctuations and yields little insight on the longer-term trends (see figure). Annual or even less frequent sampling may be appropriate for

some sites where stable groundwater plumes have been demonstrated, losing little information regarding long-term trends while reducing costs considerably. Project ER-201209 has shown that simplified low flow sampling procedures and passive sampling may improve cost structures without compromising data quality. The key point in these recently developed findings is that for some methods (e.g., modified low flow) and equipment (e.g., Snap Samplers), time, equipment, and waste generation can be reduced while maintaining data low relative sampling variability.

Project ER-1704 was designed to better understand the relationships between contaminant concentrations measured in a well using either passive samplers (Snap Samplers) or in situ sensors, and the concentrations present in the surrounding formation. The central hypothesis is that many wells are in fact "naturally purged" due to the natural groundwater flow regime, and that passive sampling (or sensor monitoring) in fact provides the ideal sample - a single, inexpensive, representative sample collected directly from the screened interval. Results indicate many wells can be monitored successfully using passive samplers or sensors, at lower costs than conventional sampling. Further, many wells mix contaminants within the well to the point that the stratification that occurs within the aquifer cannot be measured adequately in many screened monitoring wells.

SUMMARY

Passive samplers can provide valid samples for many analytes of concern, under a wide range of conditions. Credible technical and regulatory guidance is now available for using passive samplers, and the results indicate that these devices can greatly reduce monitoring costs, without sacrificing data quality. In addition, a better understanding of the causes for variability in groundwater monitoring results has led to improvements in sampling strategies. At many sites, monitoring events can be less frequent than the typical quarterly to yearly schedules, while still providing the data needed to quantify long-term trends and ensure environmental protection. These improvements promise to further reduce long-term monitoring costs, and therefore overall management costs, especially for sites undergoing MNA.

REFERENCES

Amplified Geochemical Imaging LLC. "AGI Universal Samplers." Accessed 2 January 2015. https://www.agisurveys.net/

ASTM D7929-14, Standard Guide for Selection of Passive Techniques for Sampling Groundwater Monitoring Wells, ASTM International, West Conshohocken, PA, 2014. http://www.astm.org/Standards/D7929.htm. Accessed 2 January 20115.

Britt, SL, Parker, BL, and Cherry, JA, 2010, A Downhole Passive Sampling System to Avoid Bias and Error in Groundwater Sample Handling, Environmental Science and Technology, 44:4917-4923. http://pubs.acs.org/doi/abs/10.1021/es100828u

Imbrigiotta, T. E., Trotsky, J. S., and Place, M. C. 2011. Project Overview: Demonstration and Validation of a Regenerated Cellulose Dialysis Membrane Diffusion Sampler for Monitoring Ground-Water Quality and Remediation Progress at DoD Sites. ESTCP Project No. 200313, ESTCP, Alexandria, VA. https://serdp-estcp.org/Program-Areas/Environmental-

Restoration/Contaminated-Groundwater/Monitoring/ER-200313/ER-200313. Accessed 2 January 2015 2015.

ITRC (Interstate Technology and Regulatory Council). 2004. Technical and Regulatory Guidance for Using Polyethylene Diffusion Bag Samplers to Monitor Volatile Organic Compounds in Groundwater. ITRC, Washington, DC. http://www.itrcweb.org/GuidanceDocuments/DSP-3.pdf. Accessed 2 January 2015.

ITRC. 2006. Technology Overview of Passive Sampler Technologies**.** ITRC, Washington, DC. http://itrcweb.org/Guidance/GetDocument?documentID=26. Accessed 2 January 2015.

ITRC. 2007. Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater. ITRC, Washington, DC http://itrcweb.org/Guidance/GetDocument?documentID=27. Accessed 2 January 2015.

Parker, L., Mulherin, N., Gooch, G., Hall, T., Scott, C., Gagnon, K., Clausen, J., W, Major, Willey, R., Imbrigiotta, T., Gibs, J. and Gronstal, D. 2011. Project Overview: Demonstration/Validation of the Snap Sampler Passive Groundwater Sampling Device. ESTCP, Alexandria, VA. https://serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/Monitoring/ER-200630/ER-200630. Accessed 2 January 2015.

Parker, L., Willey, R., McHale, T., Major, W., Hall, T., Bailey, R., Gagnon, K., and Gordon Gooch. 2014. Project Overview: Demonstration of the AGI Universal Sampler (F.K.A. the GORE® Module) for Passive Sampling of Groundwater. ESTCP Project No. ER-200921, ESTCP, Alexandria, VA. https://serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/Monitoring/ER-200921/ER-200921. Accessed 2 January 2015.

Snap Sampler™, "The Snap Sampler for Passive Groundwater Sampling." Accessed 2 January 2015. http://www.snapsampler.com/

USGS (United States Geological Service). 2001. User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells. USGS, Columbia, SC. http://www.itrcweb.org/Guidance/GetDocument?documentID=23. Accessed 2 January 2015.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

Quality Assurance Unit
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(John Smaldone, Quality Assurance Unit) Date

Revision Page

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1.0 USE OF TERMS

Equipment blank: The equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank needs only to include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after sampling from contaminated wells and not after background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation/reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates: Used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Potentiometric Surface: The level to which water rises in a tightly cased well constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan

SOP: Standard operating procedure

Stabilization: A condition that is achieved when all indicator field parameter measurements are sufficiently stable (as described in the "Monitoring Indicator Field Parameters" section) to allow sample collection to begin.

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): Trip blank is a sample of analyte-free water taken to the sampling site and returned to the laboratory. The trip blanks (one pair) are added to each sample cooler that contains VOC samples.

2.0 SCOPE & APPLICATION

The goal of this groundwater sampling procedure is to collect water samples that reflect the total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions, with minimal physical and chemical alterations from sampling operations. This standard operating procedure (SOP) for collecting groundwater samples will help ensure that the project's data quality objectives (DQOs) are met under certain low-flow conditions.

The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations. Indicator field parameters (e.g., dissolved oxygen, pH, etc.) are monitored during purging in order to determine when sample collection may begin. Samples properly collected using this SOP are suitable for analysis of groundwater contaminants (volatile and semi-volatile organic analytes, dissolved gases, pesticides, PCBs, metals and other inorganics), or naturally occurring analytes. This SOP is based on Puls, and Barcelona (1996).

This procedure is designed for monitoring wells with an inside diameter (1.5-inches or greater) that can accommodate a positive lift pump with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval (Hereafter, the "screen or open interval" will be referred to only as "screen interval"). This SOP is not applicable to other well-sampling conditions.

While the use of dedicated sampling equipment is not mandatory, dedicated pumps and tubing can reduce sampling costs significantly by streamlining sampling activities and thereby reducing the overall field costs.

The goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help to minimize sampling variability.

This procedure describes a general framework for groundwater sampling. Other site specific information (hydrogeological context, conceptual site model (CSM), DQOs, etc.) coupled with systematic planning must be added to the procedure in order to develop an appropriate site specific SAP/QAPP. In addition, the site specific SAP/QAPP must identify the specific equipment that will be used to collect the groundwater samples.

This procedure does not address the collection of water or free product samples from wells containing free phase LNAPLs and/or DNAPLs (light or dense non-aqueous phase

liquids). For this type of situation, the reader may wish to check: Cohen, and Mercer (1993) or other pertinent documents.

This SOP is to be used when collecting groundwater samples from monitoring wells at all Superfund, Federal Facility and RCRA sites in Region 1 under the conditions described herein. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. All changes and modifications must be approved and included in a revised SAP/QAPP before implementation in field.

3.0 BACKGROUND FOR IMPLEMENTATION

It is expected that the monitoring well screen has been properly located (both laterally and vertically) to intercept existing contaminant plume(s) or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, and operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable, for all wells to be sampled, efforts to build a sampling history should commence with the next sampling event.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. For new wells, or for wells without pump intake depth information, the site's SAP/QAPP must provide clear reasons and instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected. If the depths to top and bottom of the well screen are not known, the SAP/QAPP will need to describe how the sampling depth will be determined and how the data can be used.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU, and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection

may still take place provided the indicator field parameter criteria in this procedure are met. If after 2 hours of purging indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event).

It is recommended that low-flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the data quality objectives, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be developed. Ice formation in the flow-through-cell will cause the monitoring probes to act erratically. A transparent flow-through-cell needs to be used to observe if ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

4.0 HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All proper personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples should be handled with suitable protection to skin, eyes, etc.

5.0 CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the below conditions occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethene, ethane, dissolved oxygen, etc.) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in

the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem when using a centrifugal pump or peristaltic pump.

Direct sun light and hot ambient air temperatures may cause the groundwater in the tubing and flow-through-cell to heat up. This may cause the groundwater to degas which will result in loss of VOCs and dissolved gases. When sampling under these conditions, the sampler will need to shade the equipment from the sunlight (e.g., umbrella, tent, etc.). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sun light or ambient air from heating up the groundwater.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water which is denser than warm water sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convection cell. "During low-flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low-flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., dissolved oxygen meter, etc.) can result in faulty data being collected.

Interferences may result from using contaminated equipment, cleaning materials, sample containers, or uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning to avoid ambient air interferences. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely checked to be free from contaminants and equipment blanks collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected and they are a concern, then a more vigorous cleaning procedure will be needed.

6.0 PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. OSHA regulations may require the sampler to take the 40 hour OSHA health and safety training course and a refresher course prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team needs to read, and be familiar with, the site Health and Safety Plan, all relevant SOPs, and SAP/QAPP (and the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest to the understanding of these site documents and that it is recorded.

7.0 EQUIPMENT AND SUPPLIES

A. Informational materials for sampling event

A copy of the current Health and Safety Plan, SAP/QAPP, monitoring well construction data, location map(s), field data from last sampling event, manuals for sampling, and the monitoring instruments' operation, maintenance, and calibration manuals should be brought to the site.

B. Well keys.

C. Extraction device

Adjustable rate, submersible pumps (e.g., centrifugal, bladder, etc.) which are constructed of stainless steel or polytetrafluoroethylene (PTFE, i.e. Teflon®) are preferred. PTFE, however, should not be used when sampling for per- and polyfluoroalkyl substances (PFAS) as it is likely to contain these substances.

Note: If extraction devices constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. This is not mandatory, but is considered a "best practice". For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence value should be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

Adjustable rate, peristaltic pumps (suction) are to be used with caution when collecting samples for VOCs and dissolved gases (e.g., methane, carbon dioxide, etc.) analyses. Additional information on the use of peristaltic pumps can be found in Appendix A. If peristaltic pumps are used, the inside diameter of the rotor head tubing needs to match the inside diameter of the tubing installed in the monitoring well.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling, and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

D. Tubing

PTFE (Teflon®) or PTFE-lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. As discussed in the previous section, PTFE tubing should not be used when sampling for PFAS. In this case, a suitable alternative such as high-density polyethylene tubing should be used.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for metal and other inorganics analyses.

Note: If tubing constructed of other materials is to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

The use of 1/4 inch or 3/8 inch (inside diameter) tubing is recommended. This will help ensure that the tubing remains liquid filled when operating at very low pumping rates when using centrifugal and peristaltic pumps.

Silastic tubing should be used for the section around the rotor head of a peristaltic pump. It should be less than a foot in length. The inside diameter of the tubing used at the pump rotor head must be the same as the inside diameter of tubing placed in the well. A tubing connector is used to connect the pump rotor head tubing to the well tubing. Alternatively, the two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing. The tubing must not be reused.

E. The water level measuring device

Electronic ”tape”, pressure transducer, water level sounder/level indicator, etc. should be capable of measuring to 0.01 foot accuracy. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level “tape” at the start and end of each sampling event.

F. Flow measurement supplies

Graduated cylinder (size according to flow rate) and stopwatch usually will suffice.

Large graduated bucket used to record total water purged from the well.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL, or DNAPL) before purging begins (as needed).

H. Power source (generator, nitrogen tank, battery, etc.)

When a gasoline generator is used, locate it downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate samples.

I. Indicator field parameter monitoring instruments

Use of a multi-parameter instrument capable of measuring pH, oxidation/reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and coupled with a flow-through-cell is required when measuring all indicator field parameters, except turbidity. Turbidity is collected using a separate instrument. Record equipment/instrument identification (manufacturer, and model number).

Transparent, small volume flow-through-cells (e.g., 250 mLs or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume

cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.

Turbidity samples are collected before the flow-through-cell. A "T" connector coupled with a valve is connected between the pump's tubing and flow-through-cell. When a turbidity measurement is required, the valve is opened to allow the groundwater to flow into a container. The valve is closed and the container sample is then placed in the turbidimeter.

Standards are necessary to perform field calibration of instruments. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP which use a Zobell solution as a standard. For dissolved oxygen, a wet sponge used for the 100% saturation and a zero dissolved oxygen solution are used for the calibration.

Barometer (used in the calibration of the Dissolved Oxygen probe) and the conversion formula to convert the barometric pressure into the units of measure used by the Dissolved Oxygen meter are needed.

J. Decontamination supplies

Includes (for example) non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.

K. Record keeping supplies

Logbook(s), well purging forms, chain-of-custody forms, field instrument calibration forms, etc.

L. Sample bottles

M. Sample preservation supplies (as required by the analytical methods)

N. Sample tags or labels

O. PID or FID instrument

If appropriate, to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

P. Miscellaneous Equipment

Equipment to keep the sampling apparatus shaded in the summer (e.g., umbrella) and from freezing in the winter. If the pump's tubing is allowed to heat up in the warm weather, the cold groundwater may degas as it is warmed in the tubing.

8.0 EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field.

Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments are calibrated using U.S Environmental Protection Agency Region 1 *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* March 23, 2017, or latest version or from one of the methods listed in 40CFR136, 40CFR141 and SW-846.

The instruments shall be calibrated at the beginning of each day. If the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is highly recommended to ensure that the instruments did not drift out of calibration. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be qualified or rejected.

9.0 PRELIMINARY SITE ACTIVITIES (as applicable)

Check the well for security (damage, evidence of tampering, missing lock, etc.) and record pertinent observations (include photograph as warranted).

If needed, lay out a sheet of clean polyethylene for monitoring and sampling equipment, unless equipment is elevated above the ground (e.g., on a table, etc.).

Remove well cap and if appropriate measure VOCs at the rim of the well with a PID or FID instrument and record reading in field logbook or on the well purge form.

If the well casing does not have an established reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the altitude of this point should be determined using techniques that are appropriate to site's DQOs.

If water-table or potentiometric surface map(s) are to be constructed for the sampling event, perform synoptic water level measurement round (in the shortest possible time) before any purging and sampling activities begin. If possible, measure water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) the day before sampling begins, in order to allow for re-settlement of any particulates in the water column. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made the day before, it should be measured after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe may not be necessary unless analytical data or field analysis signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternate sampling method. All project modifications must be approved and documented prior to implementation.

If available check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the intake depth or extraction rate(s) used during previous sampling event(s), for either portable or dedicated extraction devices, record new values, and explain reasons for the changes in the field logbook.

10.0 PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) are preferred.

The use of dedicated pumps is recommended to minimize artificial mobilization and entrainment of particulates each time the well is sampled. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

A. Initial Water Level

Measure the water level in the well before installing the pump if a non-dedicated pump is being used. The initial water level is recorded on the purge form or in the field logbook.

B. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the appropriate depth (may not be the mid-point of the screen/open interval). The Sampling and Analysis Plan/Quality Assurance Project Plan should specify the sampling depth (used previously), or provide criteria for selection of intake depth for each new well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Pump tubing lengths, above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

C. Measure Water Level

Before starting pump, measure water level. Install recording pressure transducer, if used to track drawdowns, to initialize starting condition.

D. Purge Well

From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged. This information is recorded on the purge form or in the field logbook.

Start the pump at low speed and slowly increase the speed until discharge occurs. Check water level. Check equipment for water leaks and if present fix or replace the affected equipment. Try to match pumping rate used during previous sampling event(s). Otherwise, adjust pump speed until there is little or no water level drawdown. If the

minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging.

Monitor and record the water level and pumping rate every five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" somewhat as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. If the initial water level is above the top of the screen do not allow the water level to fall into the well screen. The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.

Note: the flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (e.g., bladder, peristaltic), and/or the use of dedicated equipment. For new monitoring wells, or wells where the following situation has not occurred before, if the recovery rate to the well is less than 50 mL/min., or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. The project manager or field team leader will need to make the decision when samples should be collected, how the sample is to be collected, and the reasons recorded on the purge form or in the field logbook. A water level measurement needs to be performed and recorded before samples are collected. If the project manager decides to collect the samples using the pump, it is best during this recovery period that the pump intake tubing not be removed, since this will aggravate any turbidity problems. Samples in this specific situation may be collected without stabilization of indicator field parameters. Note that field conditions and efforts to overcome problematic situations must be recorded in order to support field decisions to deviate from normal procedures described in this SOP. If this type of problematic situation persists in a well, then water sample collection should be

changed to a passive or no-purge method, if consistent with the site's DQOs, or have a new well installed.

E. Monitor Indicator Field Parameters

After the water level has stabilized, connect the "T" connector with a valve and the flow-through-cell to monitor the indicator field parameters. If excessive turbidity is anticipated or encountered with the pump startup, the well may be purged for a while without connecting up the flow-through-cell, in order to minimize particulate buildup in the cell (This is a judgment call made by the sampler). Water level drawdown measurements should be made as usual. If possible, the pump may be installed the day before purging to allow particulates that were disturbed during pump insertion to settle.

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, ORP, DO) at a frequency of five minute intervals or greater. The pump's flow rate must be able to "turn over" at least one flow-through-cell volume between measurements (for a 250 mL flow-through-cell with a flow rate of 50 mLs/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through-cell it would be every ten minutes). If the cell volume cannot be replaced in the five minute interval, then the time between measurements must be increased accordingly. Note: during the early phase of purging, emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments followed by stabilization of indicator parameters. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings are within the following limits:

Turbidity (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Samples for turbidity measurements are obtained before water enters the flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and

continue monitoring activities. Record start and stop times and give a brief description of cleaning activities.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45 degree angle with the port facing upward can help remove bubbles from the flow-through-cell (see Appendix B Low-Flow Setup Diagram). Throughout the measurement process, the flow-through-cell must remain free of any gas bubbles. Otherwise, the monitoring probes may act erratically. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must remain submerged in water at all times.

F. Collect Water Samples

When samples are collected for laboratory analyses, the pump's tubing is disconnected from the "T" connector with a valve and the flow-through-cell. The samples are collected directly from the pump's tubing. Samples must not be collected from the flow-through-cell or from the "T" connector with a valve.

VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the pump's flow rate is too high to collect the VOC/dissolved gases samples, collect the other samples first. Lower the pump's flow rate to a reasonable rate and collect the VOC/dissolved gases samples and record the new flow rate.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help ensure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use the following procedure to collect samples: collect non-VOC/dissolved gases samples first, then increase flow rate slightly until the water completely fills the tubing, collect the VOC/dissolved gases samples, and record new drawdown depth and flow rate.

For bladder pumps that will be used to collect VOC or dissolved gas samples, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL VOC vial.

Use pre-preserved sample containers or add preservative, as required by analytical methods, to the samples immediately after they are collected. Check the analytical methods

(e.g. EPA SW-846, 40 CFR 136, water supply, etc.) for additional information on preservation.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter (transparent housing preferred) is required, and the filter size (0.45 µm is commonly used) should be based on the sampling objective. Pre-rinse the filter with groundwater prior to sample collection. Make sure the filter is free of air bubbles before samples are collected. Preserve the filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

Label each sample as collected. Samples requiring cooling will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

G. Post Sampling Activities

If a recording pressure transducer is used to track drawdown, re-measure water level with tape.

After collection of samples, the pump tubing may be dedicated to the well for re-sampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth annually is usually sufficient after the initial low stress sampling event. However, a greater frequency may be needed if the well has a “silting” problem or if confirmation of well identity is needed.

Secure the well.

11.0 DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well, and then following sampling of each subsequent well. Pumps should not be removed between purging and sampling operations. The pump, tubing, support cable and electrical wires which were in contact with the well should be decontaminated by one of the procedures listed below.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps and tubing are used, only the initial sampling event will require decontamination of the pump and tubing.

Note if the previous equipment blank data showed that contaminant(s) were present after using the below procedure or the one described in the SAP/QAPP, a more vigorous procedure may be needed.

Procedure 1

Decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump and tubing. The pump may be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Optional - flush with isopropyl alcohol (pesticide grade; must be free of ketones {e.g., acetone}) or with methanol. This step may be required if the well is highly contaminated or if the equipment blank data from the previous sampling event show that the level of contaminants is significant.

Flush with distilled/deionized water. This step must remove all traces of alcohol (if used) from the equipment. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

12.0 FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, matrix spike/matrix spike duplicates, trip blanks (VOCs), and temperature blanks.

13.0 FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities (see Appendix C, example table), and record the following for each well:

Site name, municipality, state.

Well identifier, latitude-longitude or state grid coordinates.

Measuring point description (e.g., north side of PVC pipe).

Well depth, and measurement technique.

Well screen length.

Pump depth.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, calculated or measured total volume pumped, and clock time of each set of measurements.

Type of tubing used and its length.

Type of pump used.

Clock time of start and end of purging and sampling activity.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analyses.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions, including approximate ambient air temperature.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling/monitoring equipment used, including trade names, model number, instrument identification number, diameters, material composition, etc.

14.0 DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, field indicator parameters measured during purging, field instrument calibration information, and whatever other field logbook information is needed to allow for a full evaluation of data usability.

Note: the use of trade, product, or firm names in this sampling procedure is for descriptive purposes only and does not constitute endorsement by the U.S. EPA.

15.0 REFERENCES

Cohen, R.M. and J.W. Mercer, 1993, *DNAPL Site Evaluation*; C.K. Smoley (CRC Press), Boca Raton, Florida.

Robert W. Puls and Michael J. Barcelona, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, April 1996 (EPA/540/S-95/504).

U.S. Environmental Protection Agency, 1992, *RCRA Ground-Water Monitoring: Draft Technical Guidance*; Washington, DC (EPA/530-R-93-001).

U.S. Environmental Protection Agency, 1987, *A Compendium of Superfund Field Operations Methods*; Washington, DC (EPA/540/P-87/001).

U.S Environmental Protection Agency, Region 1, *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* March 23, 2017 or latest version.

U.S Environmental Protection Agency, EPA SW-846.

U.S Environmental Protection Agency, 40 CFR 136.

U.S Environmental Protection Agency, 40 CFR 141.

Vroblesky, Don A., Clifton C. Casey, and Mark A. Lowery, Summer 2007, Influence of Dissolved Oxygen Convection on Well Sampling, *Ground Water Monitoring & Remediation* 27, no. 3: 49-58.

APPENDIX A

PERISTALTIC PUMPS

Before selecting a peristaltic pump to collect groundwater samples for VOCs and/or dissolved gases, (e.g., methane, carbon dioxide, etc.) consideration should be given to the following:

- The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data.
- If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable.
- If minor differences in the groundwater concentrations could affect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device should NOT be used for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

EPA and USGS have documented their concerns with the use of the peristaltic pumps to collect water sample in the below documents.

- "Suction Pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987.
- "The agency does not recommend the use of peristaltic pumps to sample ground water particularly for volatile organic analytes" *RCRA Ground-Water Monitoring Draft Technical Guidance*, EPA Office of Solid Waste, November 1992.
- "The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and volatiles loss", *Low-flow (Minimal drawdown) Ground-Water Sampling Procedures*, by Robert Puls & Michael Barcelona, April 1996, EPA/540/S-95/504.
- "Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in the loss of volatile analytes", USGS Book 9 Techniques of Water-Resources Investigation, Chapter A4. (Version 2.0, 9/2006).

APPENDIX B

SUMMARY OF SAMPLING INSTRUCTIONS

These instructions are for using an adjustable rate, submersible pump or a peristaltic pump with the pump's intake placed at the midpoint of a 10 foot or less well screen or an open interval. The water level in the monitoring well is above the top of the well screen or open interval, the ambient temperature is above 32°F, and the equipment is not dedicated. Field instruments are already calibrated. The equipment is setup according to the diagram at the end of these instructions.

1. Review well installation information. Record well depth, length of screen or open interval, and depth to top of the well screen. Determine the pump's intake depth (e.g., mid-point of screen/open interval).

2. On the day of sampling, check security of the well casing, perform any safety checks needed for the site, lay out a sheet of polyethylene around the well (if necessary), and setup the equipment. If necessary a canopy or an equivalent item can be setup to shade the pump's tubing and flow-through-cell from the sun light to prevent the sun light from heating the groundwater.

3. Check well casing for a reference mark. If missing, make a reference mark. Measure the water level (initial) to 0.01 ft. and record this information.

4. Install the pump's intake to the appropriate depth (e.g., midpoint) of the well screen or open interval. Do not turn-on the pump at this time.

5. Measure water level and record this information.

6. Turn-on the pump and discharge the groundwater into a graduated waste bucket. Slowly increase the flow rate until the water level starts to drop. Reduce the flow rate slightly so the water level stabilizes. Record the pump's settings. Calculate the flow rate using a graduated container and a stop watch. Record the flow rate. Do not let the water level drop below the top of the well screen.

If the groundwater is highly turbid or discolored, continue to discharge the water into the bucket until the water clears (visual observation); this usually takes a few minutes. The turbid or discolored water is usually from the well-being disturbed during the pump installation. If the water does not clear, then you need to make a choice whether to continue purging the well (hoping that it will clear after a reasonable time) or continue to

the next step. Note, it is sometimes helpful to install the pump the day before the sampling event so that the disturbed materials in the well can settle out.

If the water level drops to the top of the well screen during the purging of the well, stop purging the well, and do the following:

> Wait for the well to recharge to a sufficient volume so samples can be collected. This may take a while (pump may be removed from well, if turbidity is not a problem). The project manager will need to make the decision when samples should be collected and the reasons recorded in the site's log book. A water level measurement needs to be performed and recorded before samples are collected. When samples are being collected, the water level must not drop below the top of the screen or open interval. Collect the samples from the pump's tubing. Always collect the VOCs and dissolved gases samples first. Normally, the samples requiring a small volume are collected before the large volume samples are collected just in case there is not sufficient water in the well to fill all the sample containers. All samples must be collected, preserved, and stored according to the analytical method. Remove the pump from the well and decontaminate the sampling equipment.

If the water level has dropped 0.3 feet or less from the initial water level (water level measure before the pump was installed); proceed to Step 7. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are be collected.

7. Attach the pump's tubing to the "T" connector with a valve (or a three-way stop cock). The pump's tubing from the well casing to the "T" connector must be as short as possible to prevent the groundwater in the tubing from heating up from the sun light or from the ambient air. Attach a short piece of tubing to the other end of the end of the "T" connector to serve as a sampling port for the turbidity samples. Attach the remaining end of the "T" connector to a short piece of tubing and connect the tubing to the flow-through-cell bottom port. To the top port, attach a small piece of tubing to direct the water into a calibrated waste bucket. Fill the cell with the groundwater and remove all gas bubbles from the cell. Position the flow-through-cell in such a way that if gas bubbles enter the cell they can easily exit the cell. If the ports are on the same side of the cell and the cell is cylindrical shape, the cell can be placed at a 45-degree angle with the ports facing upwards; this position should keep any gas bubbles entering the cell away from the monitoring probes and allow the gas bubbles to exit the cell easily (see Low-Flow Setup Diagram). Note:

make sure there are no gas bubbles caught in the probes' protective guard; you may need to shake the cell to remove these bubbles.

8. Turn-on the monitoring probes and turbidity meter.

9. Record the temperature, pH, dissolved oxygen, specific conductance, and oxidation/reduction potential measurements. Open the valve on the "T" connector to collect a sample for the turbidity measurement, close the valve, do the measurement, and record this measurement. Calculate the pump's flow rate from the water exiting the flow-through-cell using a graduated container and a stop watch, and record the measurement. Measure and record the water level. Check flow-through-cell for gas bubbles and sediment; if present, remove them.

10. Repeat Step 9 every 5 minutes or as appropriate until monitoring parameters stabilized. Note: at least one flow-through-cell volume must be exchanged between readings. If not, the time interval between readings will need to be increased. Stabilization is achieved when three consecutive measurements are within the following limits:

Turbidity (10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

If these stabilization requirements do not stabilize in a reasonable time, the probes may have been coated from the materials in the groundwater, from a buildup of sediment in the flow-through-cell, or a gas bubble is lodged in the probe. The cell and the probes will need to be cleaned. Turn-off the probes (not the pump), disconnect the cell from the "T" connector and continue to purge the well. Disassemble the cell, remove the sediment, and clean the probes according to the manufacturer's instructions. Reassemble the cell and connect the cell to the "T" connector. Remove all gas bubbles from the cell, turn-on the probes, and continue the measurements. Record the time the cell was cleaned.

11. When it is time to collect the groundwater samples, turn-off the monitoring probes, and disconnect the pump's tubing from the "T" connector. If you are using a centrifugal or peristaltic pump check the pump's tubing to determine if the tubing is completely filled with water (no air space).

All samples must be collected and preserved according to the analytical method. VOCs and dissolved gases samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

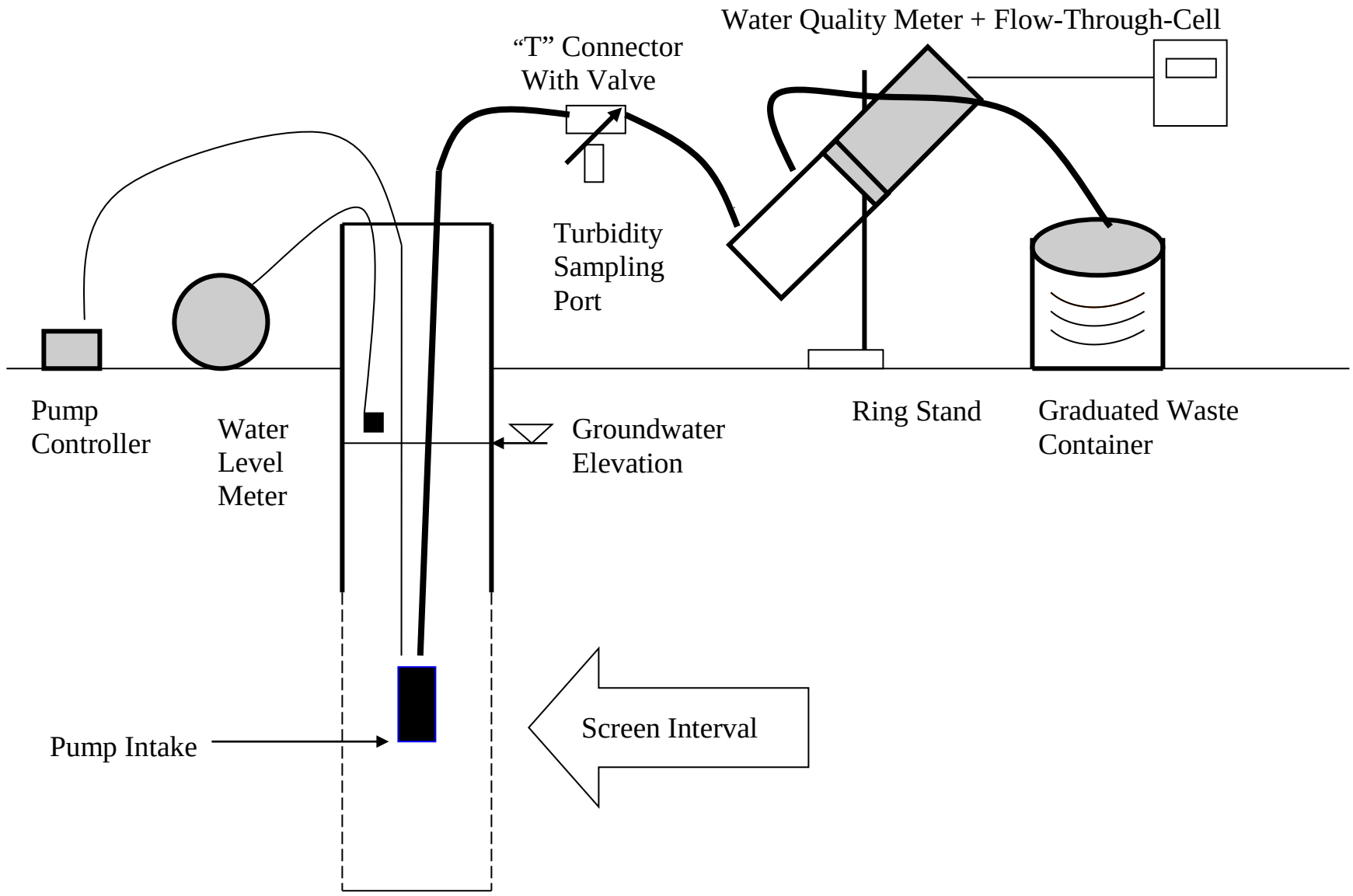
If the pump's tubing is not completely filled with water and the samples are being collected for VOCs and/or dissolved gases analyses using a centrifugal or peristaltic pump, do the following:

> All samples must be collected and preserved according to the analytical method. The VOCs and the dissolved gases (e.g., methane, ethane, ethene, and carbon dioxide) samples are collected last. When it becomes time to collect these samples increase the pump's flow rate until the tubing is completely filled. Collect the samples and record the new flow rate.

12. Store the samples according to the analytical method.

13. Record the total purged volume (graduated waste bucket). Remove the pump from the well and decontaminate the sampling equipment.

Low-Flow Setup Diagram



APPENDIX C

EXAMPLE (Minimum Requirements)

WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)_____ Depth to _____/_____ of screen
Well Number_____ Date_____ (below MP) top bottom
Field Personnel_____ Pump Intake at (ft. below MP)_____
Sampling Organization_____ Purging Device; (pump type)_____
Identify MP_____ Total Volume Purged _____

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. "C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Tur-bidity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	±10 mv	10%	10%	

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25°C.
3. Oxidation reduction potential (ORP)

SOP-16 IN-SITU CHEMICAL FIXATION INJECTION PROCEDURES

1.0 Purpose

The purpose of this standard operating procedure (SOP) is to describe the methodology for conducting in-situ chemical fixation (ISCF) remediation treatment of onsite, arsenic-impacted groundwater utilizing enhanced microbial sulfate reduction soluble treatment additives.

ISCF is a remedial procedure which sequestrates arsenic in the saturated zone by stimulating microbial sulfate reduction processes via the injection of soluble treatment additives in solution based from onsite anoxic groundwater. This process involves the dilution of liquid ferrous sulfate solution, sodium lactate solution and diluted high fructose corn syrup solution into calculated stock solutions (utilizing onsite anoxic makeup groundwater), the metering and mixing of said solutions into a injectate solution, and delivery of the injectate solution to the substratum via pre-existing injection wells.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors who are engaged in ISCF remedial work at the former DuPont East Chicago facility, Indiana (DuPont EC) site projects and tasks.

This SOP focuses on the performance of the ISCF injections anticipated at DuPont EC and should be used in conjunction with other applicable project SOPs, including the following*:*

- *SOP- Field Documentation*
- *SOP- Field Water Quality Measurements and Calibration*
- *SOP- Equipment Decontamination Procedures*
- *SOP – Sample Handling and Custody*
- *SOP – Sample ID and Nomenclature*
- *SOP – Equipment Decontamination Procedures*
- *SOP- Field Procedure Change Management*

3.0 Protocols and Procedure Description

3.1 Equipment and Materials

The following discussion provides descriptions and details for the machinery, equipment, remedial agent, meters and appurtenances to conduct the ISS remedial work at the Site:

- *Ferrous Sulfate Solution: Crown Technologies Inc 5% (iron) ferrous sulfate solution, staged within 275-gallon totes*.
- *Sodium lactate solution: WilClear food grade 60% sodium lactate solution, staged within 275-gallon totes*.
- *High Fructose Corn Syrup (HCFS): 15% food grade HFCS solution, staged within 275-gallon totes*

- *Grundfos submergible pumps:* Two submergible pumps will be employed to purge anoxic groundwater from installed supply wells to the system (use as make-up water and push-water). The pumps will be powered by and controlled from the system trailer and will convey purged groundwater via transfer hoses/piping through a 25-mesh bag filter prior to staging within a series of polyethylene staging tanks.

- *Remediation Trailer: A pre-fabricated soluble amendment dosage trailer (same trailer utilized during the 2015 pilot test) will be employed to control and convey the soluble amendment solution to the injection wells. The system trailer contains:*

    - *Electrical Panel to energize the groundwater purge pumps, in-line booster pumps, trailer heater, tank heater wraps/blankets/mixers and other powered appurtenances. A diesel generator will be utilized to power the system electrical panel.*

    - *In-line sample tap to periodically collect samples to verify arsenic in incoming push water is below the 5 mg/l threshold for use.*

    - *Dosatrons with inline mixer and strainer*

    - *Conveyance manifold lines (with applicable flow control valves and gauges*

- *Dosatron Chemical Dosage Pump: Two* Dosatron *Model D8RE2* water-powered chemical dosage pumps will be utilized to convey soluble additives through the system manifold and subsequently to the injection wells. Installed directly in the push-water supply line, the DOSATRON operates by using water pressure as the power source. The pumped push-water activates the DOSATRON, which takes up the required percentage of concentrate. Inside the DOSATRON, the soluble additives is mixed with the water. The water pressure forces the solution downstream through to an in-line mixer and then to the system distribution manifold. The dose of soluble additives will be directly proportional to the volume of water entering the DOSATRON, regardless of variations in flow or pressure which may occur in the main line. One Dosatron will be dedicated to conveying the diluted sodium lactate/HFCS solution and the second will be dedicated to conveying the liquid ferrous sulfate solution. An inline mixer will mix the soluble additives with the push-water prior to distribution to the conveyance lines.

- *Polyethylene tanks*: polyethylene tanks will be utilized for:

    - Staged purged groundwater (post-filtered by 25-micron mesh bag filter) to store make-up water (soluble agent dilution) and push-wash
    - Dilution tanks, equipped with heated tank wraps and in-tank mixers: utilized for the dilution of the HFCS to reduce amendment viscosity and increase solution solubility, to create a working stock solution
    - Mix tanks: utilized to combine diluted/heated HFCS stock solution with diluted sodium lactate amendment solution; tanks to be equipped with in-line mixer and heat blank to keep viscosity at minimum and solubility at maximum.

- Assured Automation G2 Series inline flow/volume totalizer meters: Utilized specifically for viscous (HFCS) and non-viscous liquids, to measure flow and volume entering the staged purged groundwater tanks, between soluble amendment totes and dilution/mix tanks.

- *Inline industrial solution conveyance/booster pumps*: Utilized with the conveyance of purged groundwater from the supply wells to the sediment bag filter to purged groundwater storage tanks to make-up water and push-water distribution lines. Also utilized for conveyance of diluted HFCS stock solution mix tank and diluted sodium lactate tanks to mix tank

Technical specifications, cut sheets, Chemical SDS forms and associative documentation for the abovementioned of the abovementioned machinery, equipment, remedial agent, meters and appurtenances are provided in *Attachment 1 – Equipment/Reagent Specifications*.

3.2 ISCF Injection Preparation

3.2.1 Reagent Storage and Transfer

A temporary storage container (sea container) will be mobilized to the Facility, prior to the start of the ISCF injection work. The heated storage container will be utilized to store 275-gallon totes of ferrous sulfate, sodium lactate and HFCS agents, prior to use. The storage container will be staged on polyethylene sheeting surrounded and covered by timber, for containment purposes in the event of a release. Mechanical equipment will be utilized to transfer the agent totes from the trailer to the work area.

3.2.2 Work Area Preparation

The following protocols and procedures will be employed during work area preparation

- Mobilize the remediation trailer to the injection area, as centrally located as possible. Stage the remediation trailer on top of a spill prevention pad, consisting of 4-mil (minimum thickness) polyethylene sheeting and timbers.
- Fabricate a soluble amendment tank spill prevention pad adjacent to the remediation trailer.
- Establish electrical connection between the diesel generator and the main electrical bus to the trailer control panel. Energize the panel Inspect and test main and sub panel electrical connections and well as the main bus breaker; connect electrical-powered equipment (pumps, bag filter, submersible pumps, tank blankets, mixers, etc.) to control panel. Ensure that all applicable grounding connections are made prior to energizing main panel and/or equipment attached to panel
- Mobilize tanks and amendment totes to work area decontamination pad, attach connect hoses, inline booster pumps and inline meters to conveyance piping hoses. Install mechanical tank blenders and heated tank/tote wraps to applicable storage vessels.
- Adjust dosimeter flow/blend rates to prescribed settings
- Install submersible pumps within supply wells and affix well head controls to injection wells to be utilized during work; initial run will consist of a shallow and deep injection cluster.

3.2.3 Dosage Calculations

The calculated amendment delivery objective is to prepare and deliver an amendment solution to the substratum, with a final injection concentration of:

- 6 g/l of Ferrous Sulfate (5% iron) solution (868.3 gals per injection well – 25,180.7 gals in total)
- 0.5 g/l of 15% HFCS solution – 9 gals per injection well – 261 gals in total)
- 0.5 g/l 60% Sodium Lactate solution – 37 gals per well – 1,073 gals in total)

The 25% stock solution of Ferrous Sulfate will be direct drawn from the tote into the dedicated dosimeter and comingled directly with push-water. A diluted mixture of HFCS and sodium lactate will be prepared and drawn from a mix tank into a dedicated dosimeter and comingled with push-water.

The HFCS/Sodium Lactate solution preparation will proceed with the heating of the 15% HFCS solution tote and transfered to a mix tank where the heated solution will be diluted to a 5% working stock solution (utilizing make-up

water: 1 gal HFCS to 2 gals make-up water). The mixed and heated 5% HFCS stock solution will be transferred to a second mix tank (HFCS/Lactate Mix Batch Tank), where it will be comingled with the 60% stock sodium lactate solution and additional make-up water to dilute the sodium lactate to the required dosage concentration. The component mix is 27 gallons of diluted (5%) HFCS solution to 22 gallons of stock 60% Sodium Lactate solution to 200 gallons of make-up water.

3.2.4 Injection Procedures

Upon completion of the preparation and HFCS/Sodium Lactate batch mix work, the following procedures will be employed to conduct the injection work.

- Install the submersible pumps into each of the supply wells, ensure that electrical connections from the submersible pumps, booster pumps and bag filters to the remedial trailer are secured. Energize the pumps and bag filter and cease pumping when the supply water tank is filled. Record flow measurements from in-line flow meters and record measurements in field log book.

- Install the injection well head assemblies on the wells to be utilized for the give amendment dosage. Connect piping from the injection well head assembly to the booster pump and remedial trailer injection legs.

  Note: It is recommended to inject the amendment solution within both shallow and deep components of the injection well cluster, to ensure vertical and horizontal injectate coverage within that given section of the substratum.

- Proceed with the transfer of water from the purged groundwater storage tank to the HFCS dilution tank and HFCS/Sodium Lactate Mix tank. Cease transfer when completed, record volume of make-up water utilized for each batch from the inline flow meters.

- Proceed to heat the HFCS tote with the heating wrap, set temperature to between 130°F and 140°F to reduce the viscosity of the solution and increase solubility when mixed with make-up water. Transfer the heated agent into the HFCs dilution tank. Engage the heat wrap encasing the tank to between 80°F and 90°F and turn on the tank mixer. Ensure the tank mixer is at a minimal setting, as not to draw dissolved oxygen from the open top of the tank into the mixture. Record the volume of pre-heated and diluted HFCS solution entering the dilution tank from the inline flow meter.

- Initiate the batch mix by first introducing the heated and diluted HFCS solution into the batch tank with the make-up water. Start up the tank mixer and slowly introduce the sodium lactate solution into the batch tank, while the mixer is engaged (to ensure against pre-mature fermentation of the lactate). Record volume of diluted HFCS solution and sodium lactate solution into the batch tank from each inline flowmeter.

- Install the dedicated Dosatron suction line into the HFCS/sodium lactate batch tank and Dosatron suction line into the ferrous sulfate tote. Adjust the Dosatron flow controller to the manufacture specified settings. Open the specific injection manifold leg valve directly connected to an active injection manifold.

- Once the abovementioned steps are completed, open the flow valve from the supply water tank, and flow direction valve (make-up water/push water) to introduce push water into the remediation trailer. Immediately engage the inline mixer along the Dosatron conveyance line. The Dosatron's will engage once push water flow enters the flow body of each device. Record the pressure and flow along the conveyance line from the supply water tank, along the dosimeter conveyance line and entering the injection leg manifold and each manifold leg. Adjust leg ball valves accordingly. Monitor the vacuum extraction of the prepared remedial solutions from the respective tote/batch tank. Record all measurements and observations; cease operations if leaks are detected within the conveyance train and repair/document said repairs before re-starting.

- Measure and record the pressure and flow entering each injection well manifold. Optimal pressure should be between 5 and 10 psi in shallow injection wells and between 15 to 20 psi in deep injection wells; pressure above 15 psi in shallow injection wells may cause sufficient backpressure to cause at grade daylighting of the solution. Adjust the pressure relief valve on each injection wellhead manifold as needed. Immediately cease injections if daylighting occurs. Record all well head measurements into the field log book.

- Prepare and submit a daily injection report to the Project Manager. Include all flow measurements, adjustments to system settings, deficiencies to injection system with corrective actions.

- Push-water sample(s) collected from the inline sample tap located inside the remediation trailer (prior to the Dosatrons) will be analyzed for arsenic content by the selected laboratory, based on the discretion of the Quality Assurance Manager. This is to confirm arsenic concentrations in the purged groundwater (utilized as make-up water and push water) are below the Agency's threshold concentration criteria of 5 mg/l. Record sample collection date/time in field log book, with associated sample nomenclature for the respective sample.

4.0 Equipment Decontamination

All equipment associated with the solution dilution/batch preparation, solution conveyance lines and wellhead injection assemblies will be decontaminated following the protocols and procedures cited within see *SOP for Equipment Decontamination*.

5.0 Remedial-Derived Waste

In the event that remedial-derived wastes are generated during the ISCF Injection work, the storage, characterization, transportation and storage of said waste will be performed in accordance with the protocols and procedures cited within the SOP for Investigative and Remedial Derived Waste Management.

6.0 Records

Work details observed and recorded during the performance of the ISCR Injection work, including measured reagent volumes delivered to the subsurface and changes in the prescribed ISCR work, in the Field Notebook and within the work form provided in *the SOP for Field Documentation.*

7.0 References

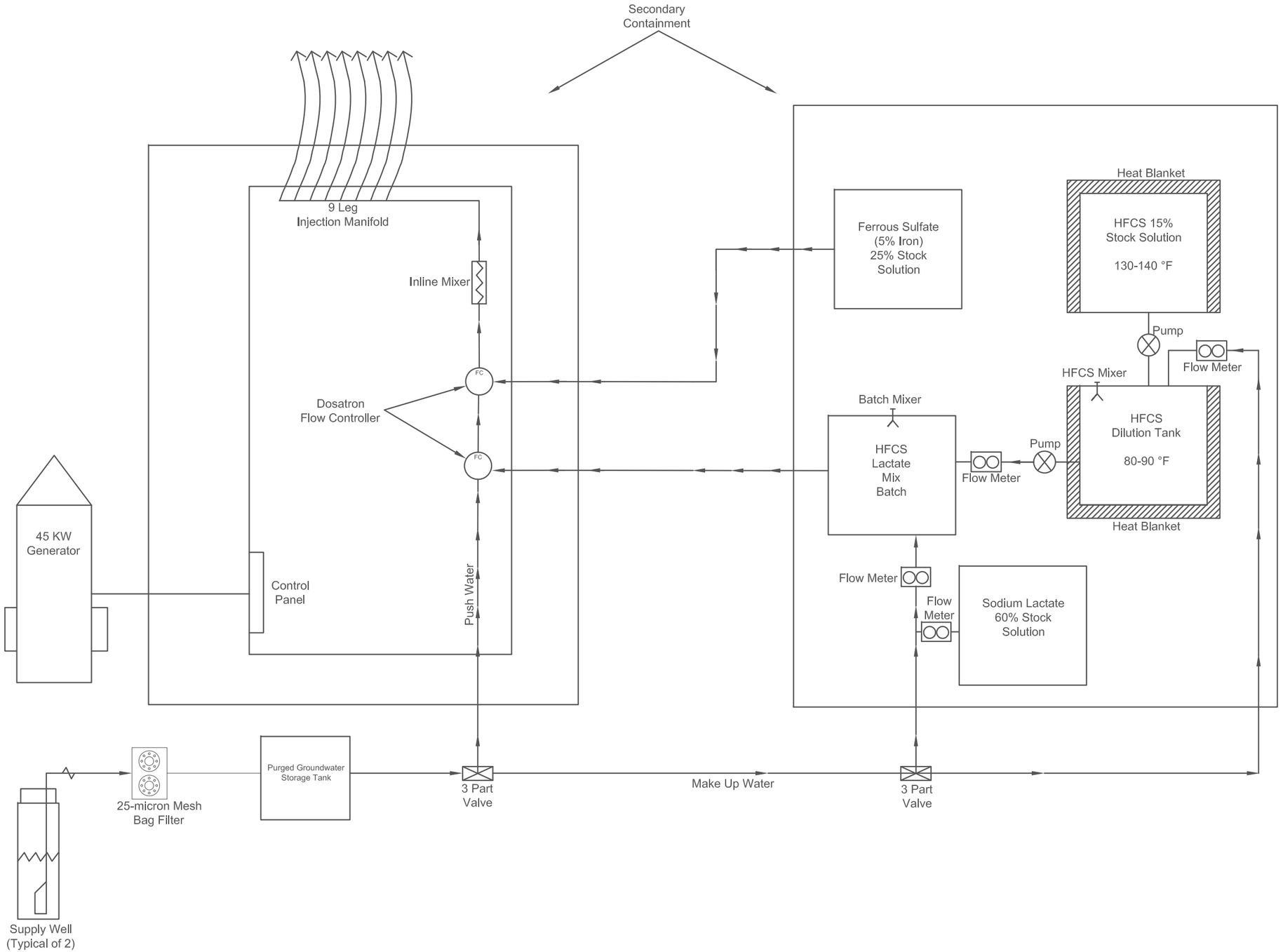
- January 2010, *Addendum to the Principles and Practices Manual: Loading Rates and Impacts of Substrate Delivery for Enhanced Anaerobic Bioremediation*, ESTCP Project Number ER-200627
- February 2010, *Final Report: Loading Rates and Impacts of Substrate Delivery for Enhanced Anaerobic Bioremediation*, ESTCP Project ER-0627
- June 2012, *Final Report & User's Guide: Development of a Design Tool for Planning Aqueous Amendment Injection Systems Soluble Substrate Design Tool*, ESTCP Project ER-200626
- November 2014, Final Pilot Test Work Plan – DuPont East Chicago Site East Chicago, Indiana, Parsons Project Number 448339
- August 25, 2015, Technical Memorandum: Summary of Pilot test Injection Activities and Initial Results – Chemours East Chicago Site, Parsons
- January 2018, Final Comprehensive Pilot Study report – Chemours East Chicago Site East Chicago, Indiana, Parsons Project Number 448339/507991

8.0 Definitions

None.

9.0 Attachments

Attachment 1: *Equipment/Reagent Technical Specifications*



NOTES:

Supplementary Remedial System Schematic Diagram

Former DuPont East Chicago Facility, Indiana
EPA ID: IND 005174354

Figure No: 01

PROJECT NO.	10875-01
DESIGNED BY:	LR
DRAWN BY:	LR
CHECKED BY:	KK
DATE:	06/20/19
SCALE:	N.T.S

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FAX (631) 269-1599

DOSATRON®

WATER POWERED DOSING TECHNOLOGY

40 GPM: D8RE2

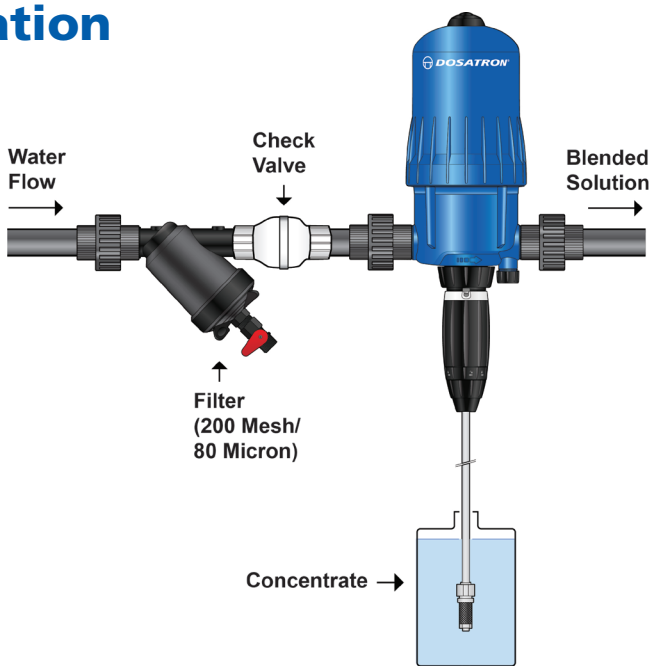
Product Specifications

Call 800-523-8499 to order the Dosatron for your specific application

Dilution Range:	1:500 to 1:50 (.2% to 2%)
Water Flow Range:	2.2 to 40 GPM
Operating Pressure Range:	2.2 to 116 PSI
Available Housing Materials:	Polypropylene (Standard Blue)
Dimensions:	25 1/4" x 8 1/2"
Weight:	12 lbs
Connection Size:	1 1/2" NPT
Maximum Temperature:	104° F
Included Accessories:	6 ft clear suction tube, weighted strainer, mounting bracket and operating manual
Recommended Accessories:	200 mesh filter, check valve.
Optional Accessories:	Bypass, part #: MPDI196



Basic Installation



Dosatron International
2090 Sunnydale Blvd. • Clearwater, FL, USA
800-523-8499 • www.dosatronusa.com

Dosatron International, Inc. is an industry leader in water-powered, proportional chemical injectors. Dosatron products are manufactured according to ISO 9001:2000 and ISO 14001:2004 standards.

HAYWARD TRUE UNION SOLENOID VALVES

INSTALLATION, OPERATION, AND MAINTENANCE INSTRUCTIONS

PLEASE READ THE FOLLOWING INFORMATION PRIOR TO INSTALLING AND USING HAYWARD VALVES, STRAINERS, FILTERS, AND OTHER ASSOCIATED PRODUCTS. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY.

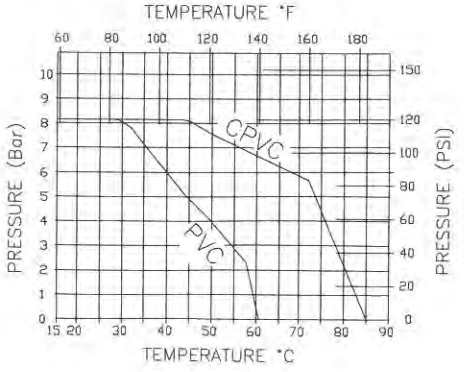
1. Hayward guarantees its products against defective material and workmanship only. Hayward assumes no responsibility for damage or injuries resulting from improper installation, misapplication, or abuse of any product.
2. Hayward assumes no responsibility for damage or injury resulting from chemical incompatibility between its products and the process fluids to which they are subjected. Compatibility charts provided in Hayward literature are based on ambient temperatures of 70F and are for reference only. Customer should always test to determine application suitability.
3. Consult Hayward literature to determine operating pressure and temperature limitations before installing any Hayward product. Note that the maximum recommended fluid velocity through any Hayward product is five feet per second. Higher flow rates can result in possible damage due to the water hammer effect. Also note that maximum operating pressure is dependent upon material selection as well as operating temperature.
4. Hayward products are designed primarily for use with non-compressible liquids. They should NEVER be used or tested with compressible fluids such as compressed air or nitrogen.
5. Systems should always be depressurized and drained prior to installing or maintaining Hayward products.
6. Temperature effect on piping systems should always be considered when the systems are initially designed. Piping systems must be designed and supported to prevent excess mechanical loading on Hayward equipment due to system misalignment, weight, shock, vibration, and the effects of thermal expansion and contraction.
7. Because PVC and CPVC plastic products become brittle below 40F, Hayward recommends caution in their installation and use below this temperature.
8. Published operating torque requirements are based upon testing of new valves using clean water at 70F. Valve torque is affected by many factors including fluid chemistry, viscosity, flow rate, and temperature. These should be considered when sizing electric or pneumatic actuators.
9. Due to differential thermal expansion rates between metal and plastic, transmittal of pipe vibration, and pipe loading forces DIRECT INSTALLATION OF METAL PIPE INTO PLASTIC CONNECTIONS IS NOT RECOMMENDED. Wherever installation of plastic valves into metal piping systems is necessary, it is recommended that at least 10 pipe diameter in length of plastic pipe be installed upstream and downstream of the plastic valve to compensate for the factors mentioned above.

Hayward True Union plastic solenoid valves are designed for process systems requiring an instant ON-OFF actuated valve. They are designed for "FAIL CLOSE" service and will provide bubble-tight shutoff in the event of an electrical failure.
The valves are manufactured from PVC (Polyvinyl Chloride) or CPVC (Chlorinated Polyvinyl Chloride) and will operate safely at pressures and temperatures as shown on the chart below.
The valves are two-way direct acting, normally closed. They can be used for pressurized service to 120 PSIG, vacuum service to 26" HG or drainage applications. They do not require any line pressure to aid in opening or closing. There are no minimum pressure requirements.
The TRUE UNION Design allows for ease of removal from the piping system without having to disconnect any piping or electrical connections.
Visual inspection of the valve DIAPHRAGMS or replacement of the SEAL CARTRIDGE is recommended at fifty thousand cycle intervals to assure trouble free operation.

FEATURES

1. UL & CSA approved NEMA IV coil.
2. 100% or Continuos duty cycle operation.
3. TRUE UNION Design: Valve body can be removed without piping or electrical disconnection.
4. Body Mounting Lugs: For laboratory or panel mount.
5. All plastic construction: No metal parts in contact with process fluid.

Voltage	Current	Voltage	Current
12 VAC	1.6 amp	12 VDC	1.6 amp
24 VAC	0.8 amp	24 VDC	0.8 amp
120 VAC	.16 amp	220 VAC	0.09 amp



INSTALLATION

1. The valve should be installed in an accessible location. This will allow for ease of inspection or service.
2. Reliable electrical line voltage supply must be provided to the coil, per table below. Low line voltage will reduce the operating performance and possibly the service life of the coil.
3. It is recommended that a Hayward "Y-STRAINER" be installed upstream of the valve to prevent clogging or premature wear of the diaphragms due to suspended solids in the process fluid.

MOUNTING POSITIONS

The solenoid valve may be installed in a vertical, horizontal or upside down position. **CAUTION** should be taken when servicing, as accumulated fluid may be retained in the valve. ALWAYS drain system before servicing.

PIPING INSTALLATION

1. **THREADED CONNECTIONS:**
   All piping connections should be made using an acceptable PVC sealant to ensure a proper seal. Apply a maximum of (3) three turns of Teflon tape or PVC pipe sealant to the male threads of the pipe. Screw the pipe into the end connector of the valve HAND TIGHT. Using a STRAP WRENCH, tighten (1/2) one half turn further. Overtightening may damage the end connector.

2. **SOCKET CONNECTION**:

Socket end connections are manufactured to ASTM D2467-87A. Solvent cementing of socket end connections to pipe should be performed per ASTM specifications D2855-87. Cut pipe square. Chamfer and deburr pipe. Surfaces must be cleaned and free of dirt, moisture, oil and other foreign material. Remove assembly nuts and end connectors from valve body. Slide assembly nuts, with threads facing valve, onto pipe to which the end connector is to be cemented. Apply primer to inside socket surface of end connector. Never allow primer or cement to contact valve internal components or end connector o-ring sealing surfaces, as leaking may result. Use a scrubbing motion. Repeat applications may be necessary to soften the surface of the socket. Next, liberally apply primer to the male end of the pipe to the length of the socket depth. Again apply to the socket, without delay apply cement to the pipe while the surface is still wet with primer. Next apply cement lightly, but uniformly to the inside of the socket. Apply a second coat of cement to the pipe, and assemble the end connector to the pipe, rotating the end connector 1/4 turn in one direction as it is slipped to full depth on to the pipe. The end connector should be held in position for approx. 30 seconds to allow the connection to "set". After assembly wipe off excess cement. Full set time is a minimum of 30 minutes at 60 to 100 F. Full cure time should be based on the chart below.

JOINT CURE SCHEDULE:

The cure schedules are suggested as guides. They are based on laboratory test data, and should not be taken to be the recommendations of all cement manufacturers. Individual manufacturer's recommendations for their particular cement should be followed.

Temperature Range During Cure Period(B) °F(°C)	Test Pressure Sizes 1/2 to 1-1/4 In Up to 180 PSI (1240 kPa)	Above 180 PSI (1240 to 2550 kPa)
60 to 100 (15 to 40)	1 h	6 h
40 to 60 (5 to 15)	2 h	12 h
20 to 40 (-7 to 5)	6 h	36 h
10 to 20) (-15 to 7)	8 h	48 h
Colder than 10 (-15)	Extreme care should be exercised on all joints made where pipe, fittings or cement is below 10°F.	

A: It is important to note that at temperatures colder than 20°F on sizes that exceed 3 in., test results indicate that many variables exist in the actual cure rate of the joint. The data expressed in these categories represent only estimated averages. In some cases, cure will be achieved in less time, but isolated test results indicate that even longer periods of cure may be required.

B: These cure schedules are based on laboratory test data obtained on Net Fit Joints (NET FIT=in a dry fit the pipe bottoms snugly in the fitting socket without meeting interference).

ELECTRICAL CONNECTIONS

IMPORTANT, **Before beginning any electrical connections to the solenoid valve operator, be sure the electrical power to the connection service is off**.

The housing of the solenoid operator is non-metallic and should be connected to GROUND through the Hirshmann Connector. THE GROUND TERMINAL IS PERPENDICULAR TO THE (2) TWO PARALLEL POWER CONNECTORS.

The (2) two parallel connectors are to be connected to an appropriate power supply. All connections should be done in accordance with local electrical codes. The "PLUG-ON" connector should be installed onto the coil, using the rubber gasket and mounting screw supplied. POLARITY OF THE CONNECTIONS TO THE POWER TERMINALS IS UNIMPORTANT.

On A.C. (alternating current) installations the internal components are rated at a MAXIMUM of ONE (1) AMPERE and should be protected by the control circuit to the operator or an IN-LINE FUSE. DO NOT EXCEED ONE (1) AMPERE DRAW THROUGH THE SOLENOID OPERATOR.

OPERATION

The Hayward Solenoid Valve is rated for 100% and CONTINUOUS DUTY operation. The valve can be used in either the open (electrically energized) position, or with an ON-OFF sequence, cycled as frequently as desired. When operated 100% or CONTINUOUS DUTY the temperature of the operator can reach approximately 180° F.

HOW IT WORKS:

The Hayward Solenoid Valve is a TWO-WAY, DIRECT ACTING, NORMALLY CLOSED (fail close) actuated valve. When the solenoid coil is energized, a magnetic field is created which generates an upward pulling force on the valve piston, causing it to open. When the coil is de-energized (electrical power shut-off) both the piston spring and the force of inlet pressure an the piston seal close the valve. It must be understood that there are LIMITS as to how much force the operator can overcome to operate properly. These limitations are governed by the following:

1. The maximum "pull-in" force generated by the solenoid operator.
2. The inlet pressure of the process, applying forces to both the diaphragm to open the valve and to the piston seal to close the valve.
3. The back pressure, applying forces to both the diaphragm to open the valve and to the piston seal to close the valve.
4. Line velocity (flow rate in gallons per minute) applying forces to both the diaphragm to open the valve and to the piston seal to close the valve.

PIPE SIZE	¼"	½"	¾"	1"	1 ½"	2"
CONSTANT	40	35	32	31	27	25

Each solenoid model has unique operating characteristics, making it essential properly select the correct model based on process parameters. MAXIMUM INLET PRESSURE (120 PSIG),MAXIMUM BACK PRESSURE (25 PSIG FOR PRESSURES ABOVE 25 PSIG), MAXIMUM FLOW RATES (GALLONS PER MINUTE) AND MAXIMUM LINE VELOCITY (FLOW RATE BELOW 5 FEET PER SECOND). DUE TO THE RAPID RATE AT WHICH SOLENOID VALVES TYPICALLY CLOSE, HIGH LINE VELOCITY MAY CAUSE "WAVE SURGES"(WATER HAMMER) WHICH MAY ULTIMATELY RESULT IN A FAILURE OF THE PIPING SYSTEM AND OR THE SOLENOID VALVE DIAPHRAGMS. See chart below to calculate "WATER HAMMER EFFECT".

THE FOLLOWING WAVE SURGE CONSTANTS MAY BE USED TO QUICKLY CALCULATE LINE PRESSURE RISE DUE TO WATER HAMMER WHERE: "C'= THE WAVE SURGE CONSTANT FROM THE TABLE: BELOW. MULTIPLIED BY -"V"- THE LINE VELOCITY IN FEET PER SECOND THE: RESULTANT NUMBER IS THEN ADDED TO THE LINE PRESSURE TO DETERMINE THE RESULTING WAVE SURGE (WATER HAMMER EFFECT)

MAXIMUM RECOMMENDED FLUID VELOCITY IS FIVE (5) FEET PER SECOND.

SERVICING THE VALVE

Should the orifice of the valve (.405 dia. for 1/4" & 1/2" ; .500 dia. for 3/4" & 1" valve;) become clogged, the Hayward True Union design allows for quick removal of the valve body for cleaning.

1. Turn off electrical supply.
2. Shut off all flow in the piping system.
3. Drain all fluid from the piping system and valve. (consult appropriate **MSDS** data for proper handling of the process fluids)
4. Carefully loosen the bonnet nut connecting the solenoid operator module to the valve body.
5. Carefully loosen the two (2) union nuts connecting the valve body to the piping system.
6. Remove the two (2) union nuts from the valve body, sliding them onto the adjacent pipe.
7. Carefully remove the valve body from the solenoid operator, pulling the valve downward until the operator clears the metal solenoid core and spring.
8. Remove the bonnet assembly from the valve body by slowly twisting while pulling them apart. (Note: be sure to keep the bonnet o-ring clean for reassembly)
9. Clean the orifice and internals of the valve as required.
10. Reassemble in the reverse order, making sure that the bonnet o-ring is clean and HAND TIGHTEN ONLY each of the union nuts and the bonnet nut.
11. Turn on electrical supply.

OPERATION TIPS

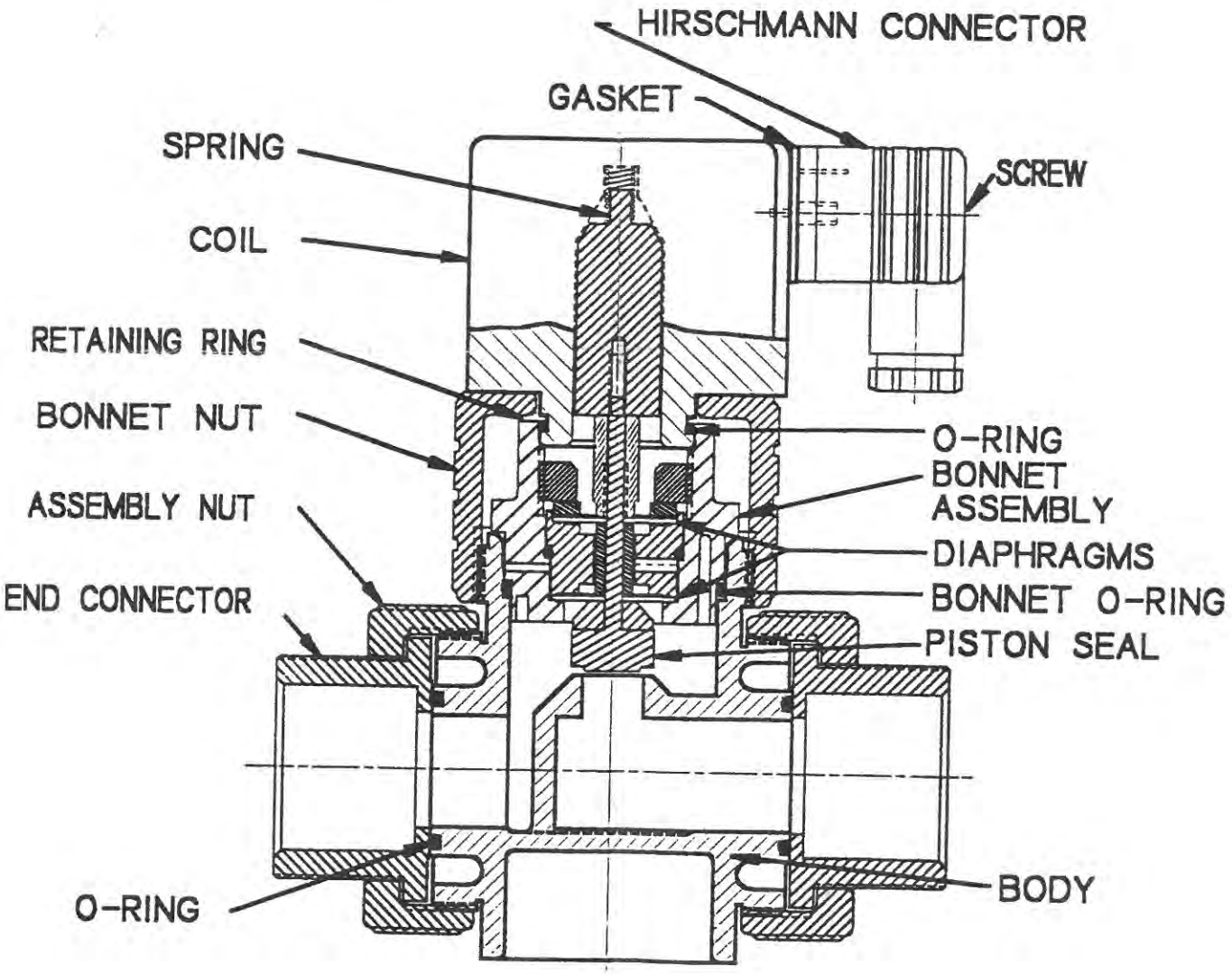
1) Be sure that the system is clean before installing the valve. It is recommended that a Hayward Y-STRAINER or BASKET STRAINER be installed upstream of the solenoid valve as insurance against clogging and for extending the life of the diaphragms.
2) If the flow requirement of the system is greater than the capacity of the largest Hayward Solenoid Valve, two (2) or more can be installed in parallel ,to satisfy the application.
3) There is a flow arrow molded into the outside of the valve body, indicating proper installation direction.

TROUBLE SHOOTING

SHOULD THE SOLENOID VALVE FAIL TO OPERATE AS EXPECTED, CHECK THE FOLLOWING::

1. VALVE WILL NOT OPEN:
   a) Check electrical supply and connections. Be sure valve supplied is rated with the correct voltage
   b) Inlet pressure is too high. (exceeds 120 PSIG)
   c) Solenoid coil is burned out. (typically the result fluid leaking into the coil from ruptured diaphragms caused by excessive dirt in the process, or the result of water hammer).
   d) Valve orifice clogged.

2. VALVE WILL NOT CLOSE:
   a) System has a flow restricting device installed downstream inducing high backpressure (i.e. spray nozzle, partially closed valve, etc.)
   b) Piston seal is worn. Replace cartridge assembly.
   c) Valve orifice is clogged.
   d) Valve installed backwards. Check flow direction.
   e) Line velocity too high. (exceeds 5 F.P.S.)
   f) Diaphragms failed.



AMT®

A Gorman-Rupp Company

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BY

GORMAN-RUPP®

www.amtpump.com

Please read and save this Repair Parts Manual. Read this manual and the General Operating Instructions carefully before attempting to assemble, install, operate or maintain the product described. Protect yourself and others by observing all safety information. The Safety Instructions are contained in the General Operating Instructions. Failure to comply with the safety instructions accompanying this product could result in personal injury and/or property damage! Retain instructions for future reference. AMT reserves the right to discontinue any model or change specifications at any time without incurring any obligation.

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Periodic maintenance and inspection is required on all pumps to ensure proper operation. Unit must be clear of debris and sediment. Inspect for leaks and loose bolts. Failure to do so voids warranty.

Self-Priming Centrifugal Pumps

AMT A Gorman-Rupp Company

High Volume Dewatering Cast Iron Models

Refer to pump manual 1808-634-00 for General Operating and Safety Instructions

DESCRIPTION

These centrifugal pumps are self-priming (to 20 ft. lift) units designed for high volume liquid transfer, irrigation, dewatering, lawn sprinkling, etc. These pumps can also accommodate semi-solids (up to 3/8" dia.), sediment laden liquids, and liquids with entrained air or gases. Units are constructed of cast iron and include Buna elastomers (Viton® elastomers optional, contact factory for availability). They are direct coupled to NEMA 56J frame, 3450 RPM motors which require field wiring; no controls are supplied. Each pump is equipped with a flapper valve to shorten re-prime time after initially filling casing with liquid. Handles liquids from 40° to 180° F (4° to 82° C). For use with nonflammable, non-abrasive liquids compatible with pump component materials.

MAINTENANCE

⚠WARNING

Make certain that [illegible] is disconnected from power source before attempting to service or remove any components!

NOTE: The pump casing should be removed and inspected periodically to ensure that any foreign material is not clogging internal pump parts. This unit is equipped with a dual volute pump casing. One of the volutes runs 180°, all the way from the side opposite the discharge into the discharge through a completely enclosed passageway. If foreign material clogs this area, it can be dislodged by using a wire or long spring.

MECHANICAL SEAL REPLACEMENT

Refer to Figures 1 and 2.

IMPORTANT: Always replace both seal seat (Ref. No. 7) and seal head (Ref. No. 8) to ensure proper mating of components! Recommend replacing casing seal (Ref. No.6) if wear or damage is present.

1. Unthread fasteners (Ref. No. 5) and remove casing (Ref. No. 12) and casing seal (Ref. No. 6) from adapter (Ref. No. 4).
2. Unscrew impeller fastener (Ref. No. 11) and impeller (Ref. No. 10) separately by turning each counterclockwise.

NOTE: Most motors use an open end 7/16" wrench across flats on rear of motor shaft (remove bearing cap for access) to prevent shaft from turning. Other motor shafts have a screwdriver slot instead of flats.

3. Unscrew fasteners (Ref. Nos. 3 & 16) and remove adapter, foot (Ref. No. 17) and handle (Ref. No. 2) from motor (Ref. No. 1) mounting face. Seal head will come loose at this time.
4. Push seal seat from adapter recess with a screwdriver.
5. Clean adapter recess before inserting new seal seat.
6. Carefully wipe polished surface of new seal seat with a clean cloth.
7. Wet rubber portion of seal seat with a light coating of soapy water.
8. Press new seal seat squarely into cavity in adapter. If seal seat does not press squarely into cavity, it can be adjusted in place by pushing on it with a piece of pipe. Always use a piece of cardboard between pipe and seal seat to avoid scratching seal seat. (This is a lapped surface and must be handled very carefully.)
9. After seal seat is in place, ensure that it is clean and has not been marred.
10. Using a clean cloth, wipe shaft and make certain that it is perfectly clean.
11. Secure adapter, foot and handle on motor mounting face. Carefully guide motor shaft through seal seat.
12. Apply a light coating of soapy water to inside rubber portion of seal head and slide onto shaft (with sealing face first) so that rubber portion is just up over shaft shoulder.

⚠ CAUTION

Do not touch or wipe polished face of seal head.

13. Replace any impeller shims (Ref. No. 9) that may have been removed in disassembly. (See "Shim Adjustment" below).
14. Screw impeller back into place, tightening until it is against shaft shoulder.
15. Replace impeller nut and tighten until snug.
16. Remount casing and casing seal on adapter.

SHIM ADJUSTMENT

When installing a replacement impeller (Ref. No. 10) or motor (Ref. No. 1), it may be necessary to adjust number of shims (Ref. No. 9) to ensure proper running clearance between impeller and casing. Proceed as follows:

NOTE: A proper running clearance is less than 0.010".

1. For impeller replacement, add one 0.010" shim in addition to those removed originally.
2. For motor replacement, add two 0.010" shims in addition to those removed during disassembly.
3. Reassemble the pump as described in steps 15, 16 & 17.

IMPORTANT: Be sure that the casing is snugly in place and check shaft to make sure it is turning freely (use screwdriver slot in motor to turn shaft). If it turns freely, check to ensure that adapter and casing are fitted tight together. If they are not, tighten fasteners (Ref. Nos. 3, 5 and 17) and recheck shaft for free turning. Tighten carefully, turning shaft while tightening so that motor bearings are not damaged in the event that too many shims were installed. If shaft seizes before fasteners are completely tight, disassemble pump and remove one shim and repeat reassembly.

Self-Priming Centrifugal Pumps

FLAPPER VALVE ASSEMBLY REPLACEMENT

Remove bolts (Ref. No. 19) and suction plate (Ref. No. 15). Replace flapper valve assembly (Ref. No. 14). Remount suction plate and bolts; tighten bolts evenly to ensure proper seal.

Specifications Information and Repair Parts Manual 2761-95 thru 282D-95 & 2821-95 thru 282M-95

Self-Priming Centrifugal Pumps

For Repair Parts contact dealer where pump was purchased.

Please provide following information:
-Model Number
-Serial Number (if any)

Part description and number as shown in parts list

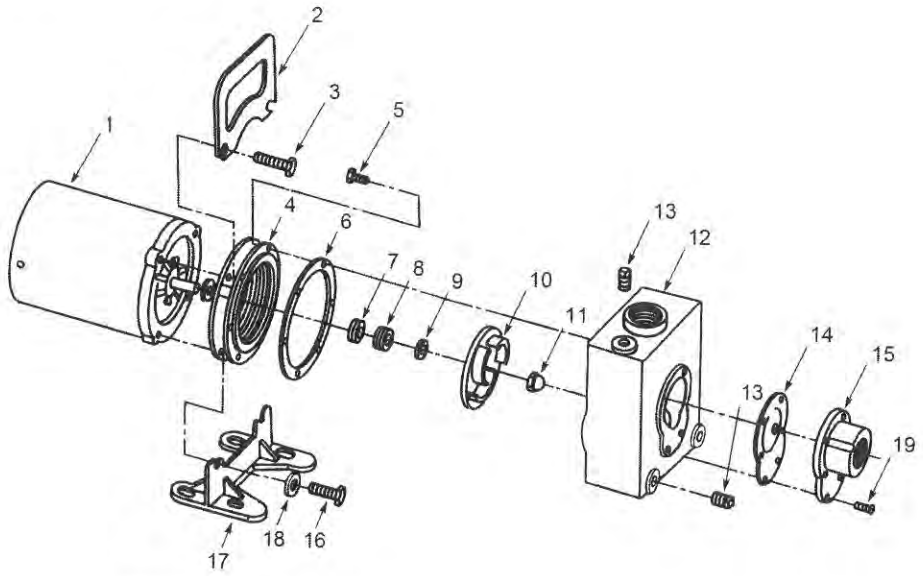

Figure 1 - Repair Parts Illustrations

Repair Parts List

Ref. No.	Description	Part Number for Models: 2827-95 (1/2HP) 282J-95 (1/2HP) 282D-95 (3/4HP) 282F-95 (3/4HP)	2825-95 (3/4HP) 2826-95 (3/4HP) 282C-95 (1HP) 282K-95 (1HP)	2821-95 (1-1/2HP) 2822-95 (1-1/2HP) 282A-95 (2HP) 282B-95 (2HP)	2828-95 (2HP) 282L-95 (2HP) 282E-95 (3HP) 282M-95 (3HP)	Qty
1	Motor - 1 Phase ODP	1626-009-00	1626-010-00	1626-012-00	1626-024-00	1
	Motor - 3 Phase ODP	1626-013-00	1626-014-00	1626-016-00	1626-025-00	1
	Motor - 1 Phase TEFC	1626-302-00	1626-303-00	1626-305-00	1626-306-00	1
	Motor - 3 Phase TEFC	1626-308-00	1626-309-00	1626-311-00	1626-312-00	1
2	Handle	1515-000-00	1515-000-00	1515-000-00	1515-000-00	1
3	Fastener	Incl. w/Ref 4	Incl. w/Ref 4	Incl. w/Ref 4	Incl. w/Ref 4	2
4	Adapter Kit (includes Ref. Nos. 3, 4 and 5)	2820-030-95	2820-030-95	2820-030-95	2820-030-95	1
5	Fastener	Incl. w/Ref 4	Incl. w/Ref 4	Incl. w/Ref 4	Incl. w/Ref 4	4
6	Casing Seal	Incl. w/Ref KIT	Incl. w/Ref KIT	Incl. w/Ref KIT	Incl. w/Ref KIT	1
7 & 8	Shaft Seal Assembly - Buna-N	1640-161-90 & Incl. w/Ref KIT	1640-161-90 & Incl. w/Ref KIT	1640-161-90 & Incl. w/Ref KIT	1640-161-90 & Incl. w/Ref KIT	1
	Shaft Seal Assembly - Viton	1640-161-91 & Incl. w/Ref KIT	1640-161-91 & Incl. w/Ref KIT	1640-161-91 & Incl. w/Ref KIT	1640-161-91 & Incl. w/Ref KIT	1
9	Impeller Shim Set	1657-000-90	1657-000-90	1657-000-90	1657-000-90	1
10	Impeller - 1 Phase	2820-011-01	2820-011-03	2820-011-05	2820-011-07	1
	Impeller - 3 Phase	2820-011-02	2820-011-04	2820-011-06	2820-011-08	1
11	Impeller Fastener	1784-001-00	1784-001-00	1784-001-00	1784-001-00	1
12	Casing Kit - Buna-N	2820-001-B5	2820-001-B5	2820-001-B5	2820-001-B5	1
	Casing Kit - Viton (includes Ref. Nos. 5, 13, 14 and 15)	2820-001-V5	2820-001-V5	2820-001-V5	2820-001-V5	1
13	Pipe Plug	*	*	*	*	3
14	Flapper Valve Assembly - Buna-N	1674-000-90 & Incl. w/Ref KIT	1674-000-90 & Incl. w/Ref KIT	1674-000-90 & Incl. w/Ref KIT	1674-000-90 & Incl. w/Ref KIT	1
	Flapper Valve Assembly - Viton	1674-000-91 & Incl. w/Ref KIT	1674-000-91 & Incl. w/Ref KIT	1674-000-91 & Incl. w/Ref KIT	1674-000-91 & Incl. w/Ref KIT	1
15	Suction Plate	1501-000-01	1501-000-01	1501-000-01	1501-000-01	1
16	Fastener	*	*	*	*	2
17	Foot	1506-000-00	1506-000-00	1506-000-00	1506-000-00	1
18	Washer	*	*	*	*	2
19	Fastener	*	*	*	*	4
KIT	Seal Kit - Buna-N (standard)	2820-304-95	2820-304-95	2820-304-95	2820-304-95	1
	Seal Kit - Viton (optional) (includes Ref. Nos. 6, 7, 8 and 14)	2820-305-95	2820-305-95	2820-305-95	2820-305-95	1

(*) Standard hardware item, available locally.

Self-Priming Centrifugal Pumps

For Repair Parts contact dealer where pump was purchased.

Please provide following information:
-Model Number
-Serial Number (if any)

Part description and number as shown in parts list

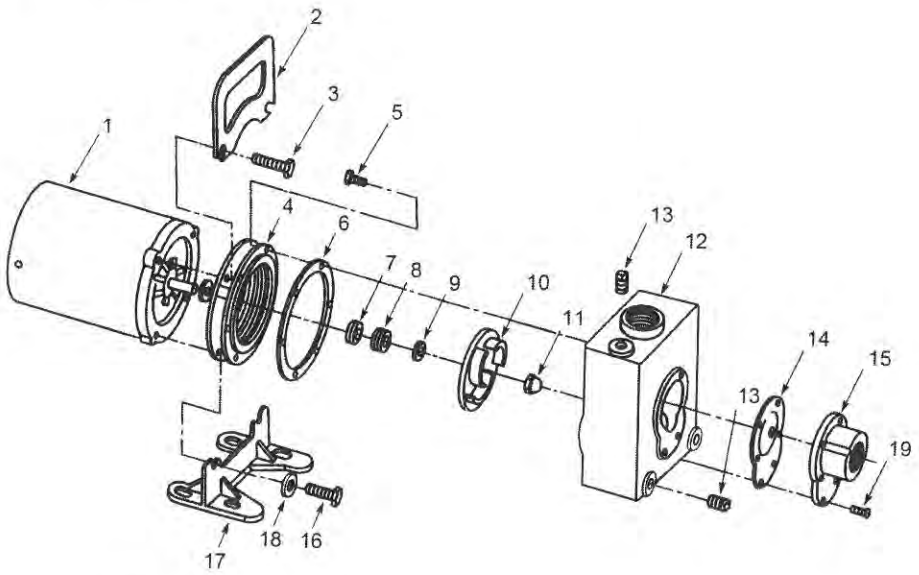

Figure 2 - Repair Parts Illustrations

Repair Parts List

Ref. No.	Description	Part Number for Models: 2762-95 (1-1/2HP) 2764-95 (1-1/2HP) 276B-95 (2HP) 276D-95 (2HP)	2761-95 (2HP) 2763-95 (2HP) 276A-95 (3HP) 276C-95 (3HP)	2767-95 (3HP) 2766-95 (3HP)	Qty
1	Motor - 1 Phase ODP	1626-012-00	1626-024-00	1626-026-00	1
	Motor - 3 Phase ODP	1626-016-00	1626-025-00	1626-027-00	1
	Motor - 1 Phase TEFC	1626-305-00	1626-306-00	-	1
	Motor - 3 Phase TEFC	1626-311-00	1626-312-00	-	1
2	Handle	1515-000-00	1515-000-00	1515-000-00	1
3	Fastener	Incl. w/Ref 4	Incl. w/Ref 4	Incl. w/Ref 4	2
4	Adapter Kit (includes Ref. Nos. 3, 4 and 5)	2820-030-95	2820-030-95	2820-030-95	1
5	Fastener	Incl. w/Ref 4	Incl. w/Ref 4	Incl. w/Ref 4	4
6	Casing Seal	Incl. w/Ref KIT	Incl. w/Ref KIT	Incl. w/Ref KIT	1
7 & 8	Shaft Seal Assembly - Buna-N	1640-161-90 & Incl. w/Ref KIT	1640-161-90 & Incl. w/Ref KIT	1640-161-90 & Incl. w/Ref KIT	1
	Shaft Seal Assembly - Viton	1640-161-91 & Incl. w/Ref KIT	1640-161-91 & Incl. w/Ref KIT	1640-161-91 & Incl. w/Ref KIT	1
9	Impeller Shim Set	1657-000-90	1657-000-90	1657-000-90	1
10	Impeller - 1 Phase	2820-011-09	2820-011-0B	1496-002-02	1
	Impeller - 3 Phase	2820-011-0A	2820-011-0C	1496-002-02	1
11	Impeller Fastener	1784-001-00	1784-001-00	1784-001-00	1
12	Casing Kit - Buna-N	2760-001-B5	2760-001-B5	2760-001-B5	1
	Casing Kit - Viton (includes Ref. Nos. 5, 13, 14 and 15)	2760-001-V5	2760-001-V5	2760-001-V5	1
13	Pipe Plug	*	*	*	3
14	Flapper Valve Assembly - Buna-N	1683-000-90 & Incl. w/Ref KIT	1683-000-90 & Incl. w/Ref KIT	1683-000-90 & Incl. w/Ref KIT	1
	Flapper Valve Assembly - Viton	1683-000-91 & Incl. w/Ref KIT	1683-000-91 & Incl. w/Ref KIT	1683-000-91 & Incl. w/Ref KIT	1
15	Suction Plate	1487-000-01	1487-000-01	1487-000-01	1
16	Fastener	*	*	*	2
17	Foot	1506-000-00	1506-000-00	1506-000-00	1
18	Washer	*	*	*	2
19	Fastener	*	*	*	4
KIT	Seal Kit - Buna-N (standard)	2760-304-95	2760-304-95	2760-304-95	1
	Seal Kit - Viton (optional) (includes Ref. Nos. 6, 7, 8 and 14)	2760-305-95	2760-305-95	2760-305-95	1

(*) Standard hardware item, available locally.

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General Information

SALES POLICY: AMT products are sold through our established Distributors. We do not sell direct to the consumer or organization not entitled to trade recognition. Therefore, possession of our catalogs and/or price list(s) does not infer an offer to sell.

MINIMUM ORDER: We appreciate your order, however, all orders are subject to a minimum $35.00 net invoice charge (excluding freight). This applies to all pump and parts purchase orders.

PRICES: Prices are subject to change without notice. All orders accepted are subject to prices in effect at time of shipment.

PAYMENT TERMS: Terms, upon establishment of credit, are Net 30 days. Past due accounts may be subject to a service charge of 1.5% per month. Domestic or assignable letter of credit is required for all export trade.

PAST DUE ACCOUNTS: AMT reserves the right to withhold open account shipments on any past due account. Invoices are considered past due after thirty (30) days. In the interest of sound business, all orders are subject to approval of the Credit Department.

SHIPPING INSTRUCTIONS: All shipments will be made F.O.B. the factory. Where instructions for shipment do not appear on the order, the shipment will be made according to our best judgment. Full risk of loss (including transportation delays and losses) shall pass to the customer upon delivery of the products to the carrier at the F.O.B. point. When loss or delay occurs, primary responsibility for tracing rests with the customer. When there is LOSS or APPARENT VISIBLE DAMAGE to a shipment, when tendered for delivery, *DO NOT* give the carrier a clear receipt. Note such damage on the carrier's delivery receipt and *HAVE THE DRIVER SIGN THE RECEIPT.*

PRODUCT REVISIONS: AMT reserves the right to discontinue, change or improve its products or any portions thereof without being obligated to provide such a change or improvement for units sold and/or shipped prior to such a change or improvement.

LEAD TIME: Products designated "Quick Ship Product", also referred to as "QSP" will normally be shipped within 24 hours of receipt of a non-cancellable purchase order. Only limited quantities of "QSP" pumps are available.

STANDARD LEAD TIME: Lead time is two weeks for all non "QSP" product. AMT reserves the right to revise lead times as required due to availability of materials and all other causes beyond our control.

VIP SHIPMENT: Select AMT and IPT branded pumps are available for next day shipment for non-QSP (Quick Ship Products) items and subjected to a specific model surcharge per unit noted in the respective price book. Requires calling for availability, confirmation and a non-cancellable purchase order or credit card payment prior to shipment. The expedited shipping charges are an additional cost added separately from the VIP charges per item. AMT reserves the right to revise lead times as required due to availability of materials and all other causes beyond our control. QSP quantities are limited as determined by AMT.

ALL purchase orders must be submitted via hard copy sent to AMT customer service department by fax, EDI or e-mail.

RETURN GOODS POLICY: Goods shall not be returned without a return goods authorization number (RGA) issued by AMT customer service. The RGA number must be listed on the packing list. Only current model and part numbers with a valid date code may be returned (within one year from date of purchase). **A 20% restocking and packaging charge will apply to all returns. All shipping charges must be pre-paid. No exceptions.**

ORDER CHANGES BY CUSTOMER: Orders in process may not be changed except with written consent and may be subject to special charges.

12 Month Limited Warranty

EXTENT AND DURATION OF LIMITED WARRANTY

Coverage: American Machine & Tool Company (herein "AMT") or IPT Pumps by Gorman-Rupp (herein "IPT") or Gorman-Rupp Industries Division of The Gorman-Rupp Company, Patterson, or the Gorman-Rupp Company (herein referred to as "G-R Unit") each individually warrants that its products and parts shall be free from defects in material ad workmanship for twelve (12) months from the date of purchase by the original end user when installation is made and maintenance is performed in accordance with G-R Unit's recommendations. Wear and tear resulting from use and items normally consumed in use are not covered.

EXCEPTIONS

(A) This Limited Warranty shall not apply to mechanical seals in AMT or IPT pumps and the following products and parts: engines, motors, trade accessories and all other products, components, parts and materials not manufactured by the G-R Units. These items may, however, be covered by the warranties of their respective manufacturers. (B) This warranty does not extend to or apply to any unit which has been repaired or altered at any place other than by a G-R Unit, or by persons not expressly approved by a G-R Unit to make repairs or alterations, nor to any unit the serial number, model number or identification of which has been removed, defaced or altered. (C) This warranty does not extend to any product manufactured by a G-R Unit, which has been subjected to mis-use, neglect, accident, improper installation, or use in violation of instructions furnished by a G-R Unit. (D) Pump Kits: This warranty does not extend to any product sold by a G-R Unit unassembled as a Pump Kit. Pump Kits are warranted against defects in material and workmanship for 60 days from the date of shipment from a G-R Unit. Any Pump Kit parts deemed defective by a G-R Unit will be replaced free of charge within 60 days of shipment. Pump Kits are not returnable for credit.

LIMITATIONS

THE G-R UNITS' SOLE AND EXCLUSIVE WARRANTY WITH RESPECT TO THEIR PRODUCTS AND PARTS IS THIS LIMITED WARRANTY. THIS LIMITED WARRANTY IS IN LIEU OF ALL OTHER EXPRESS AND/OR IMPLIED WARRANTIES, INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE.

EXCLUSIVE REMEDY AND DAMAGES

The sole and exclusive remedy for breach of this Warranty by a G-R Unit and the entire extent of its liability for such breach or for damages arising from the use of the products and parts covered under this Limited Warranty, shall be as follows:

1. **Repair or Replacement:** If inspection shows that any G-R Unit product or part covered under this Limited Warranty is defective in materials or workmanship, the G-R Unit shall repair or replace the defective or non-conforming product or part without charge, whichever the G-R Unit chooses. You must have properly maintained and used the product or part claimed to be defective in accordance with the maintenance schedule or manual, which comes with the product. No allowance will be made for labor, installation, removal, transportation or other charges incurred by you in connection with such repair or replacement.
2. To obtain the above remedy:
   - A. Immediately notify the G-R Unit upon discovery of the claimed defect in materials or workmanship and provide the serial number or date code of the product and/or part(s) or provide the G-R Unit with the invoice or bill of sale referencing the product by no later than the expiration date of the warranty period.
   - B. The G-R Unit will advise whether inspection will be necessary and how whether repair or replacement will be made. If inspection by the G-R Unit is necessary, the pump or defective part must be sent freight pre-paid to the G-R Unit. Return shipment will be F.O.B. the G-R Unit's plant.
   - C. **Return Goods Authorization Requirement:** No product will be accepted for return or replacement without the prior written authorization of the G-R Unit. Upon such authorization, and in accordance with instructions from the G-R Unit, the product will be returned to the G-R Unit, shipping charges prepaid by the Buyer.
3. **Damages:** The G-R Unit's liability for damages for breach of this Limited Warranty shall not exceed the amount of the purchase price of the product or part(s) in respect to which Such damages are claimed. **IN NO EVENT SHALL THE G-R UNITS BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES FOR BREACH OF THIS LIMITED WARRANTY.**

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you. This Limited Warranty gives you specific legal rights, and you may also have other rights, which vary from state to state.

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Please read and save this Repair Parts Manual. Read this manual and the General Operating Instructions carefully before attempting to assemble, install, operate or maintain the product described. Protect yourself and others by observing all safety information. The Safety Instructions are contained in the General Operating Instructions. Failure to comply with the safety instructions accompanying this product could result in personal injury and/or property damage! Retain instructions for future reference. AMT reserves the right to discontinue any model or change specifications at any time without incurring any obligation.

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Periodic maintenance and inspection is required on all pumps to ensure proper operation. Unit must be clear of debris and sediment. Inspect for leaks and loose bolts. Failure to do so voids warranty.

Electric Motor-Driven Pumps

Refer to Specific Information and Repair Parts Manual for product specific information.

SAFETY GUIDELINES

This manual contains information that is very important to know and understand. This information is provided for SAFETY and to PREVENT EQUIPMENT PROBLEMS. To help recognize this information, observe the following symbols:

⚠ DANGER

Danger indicates an imminently hazardous situation which, if not avoided, WILL result in death or serious injury.

⚠ WARNING

Warning indicates a potentially hazardous situation which, if not avoided, COULD result in death or serious injury.

⚠ CAUTION

Caution indicates a potentially hazardous situation which, if not avoided, MAY result in minor or moderate injury.

NOTE: ***Indicates important information that, if not followed, may cause damage to equipment.***

UNPACKING

When unpacking the unit, inspect carefully for any damage that may have occurred during transit. Check for loose, missing or damaged parts. (See pump exploded view and Repair Parts List.) **Do not attempt to assemble or operate pump if any parts are missing or damaged. Determine that all parts are properly installed.**

GENERAL SAFETY INFORMATION

1. Know the pump application, limitations, and potential hazards. Read all manuals included with this product carefully. Be thoroughly familiar with the pump and the proper use of the equipment.

⚠ WARNING

Pump should only be used with liquids compatible with pump component materials.

⚠ DANGER

Do not use to pump flammable or explosive fluids such as gasoline, fuel oil, kerosene, etc. Do not use in flammable and/or explosive atmospheres.

When pumping hazardous or dangerous materials, use only in room or area designated for that purpose. For your protection, always wear proper clothing, eye protection, etc. in case of any malfunction. For proper handling techniques and cautions, contact your chemical supplier, insurance company and local agencies (fire dept., etc.). Failure to comply with this warning could result in personal injury and/or property damage.

2. Make certain that the power source (engine) conforms to the requirements of your equipment.
3. Provide adequate protection and guarding around moving parts.
4. Disconnect power before servicing. If the power disconnect is out of sight, lock in the open position and tag it to prevent unexpected application of power. Failure to do so could result in fatal electric shock!
5. Release all pressure within the system before servicing any component.
6. Drain all liquids from the system before servicing.
7. Secure the discharge line before starting the pump. An unsecured discharge line will whip, possibly causing personal injury and/or property damage.
8. Check hoses for weak or worn condition before each use, making certain that all connections are secure.
9. Periodically inspect pump and system components. Perform routine maintenance as required (See Maintenance section).
10. Provide a means of pressure relief for pumps whose discharge line can be shut-off or obstructed.
11. **Personal Safety:**
    a. Wear safety glasses at all times when working with pumps.
    b. Wear a face shield and proper apparel when pumping hazardous chemicals.
    c. Keep work area clean, uncluttered and properly lighted; replace all unused tools and equipment.
    d. Keep visitors at a safe distance from the work area.
    e. Make workshop childproof – with padlocks, master switches, and by removing starter keys.
12. This unit is not waterproof and is not intended to be used in showers, saunas or other potentially wet locations. The motor is designed to be used in a clean dry location with access to an adequate supply of cooling air. Ambient temperature around the motor should not exceed 104°F (40°C). For outdoor installations, motor must be protected by a cover that does not block airflow to and around the motor. This unit is not weatherproof nor is it able to be submersed in water.
13. When wiring an electrically driven pump, follow all electrical and safety codes, as well as the most recent United States National Electrical Code (NEC) and the Occupational Safety and Health Act (OSHA).

⚠ WARNING

Risk of Electric shock!

Electric Motor-Driven Pumps

14. **THREE-PHASE MOTORS:** These units are for permanent installation using a power supply with a ground. To reduce the risk of electric shock, electric motor must have one of the following:
    a. Adequately grounded to a metal raceway system.
    b. Use of a separate grounding wire connected to bare metal on the motor frame or to the grounding screw located inside motor terminal box.
    c. By other suitable means.

    Refer to the most recent National Electrical Code (NEC) Article 250 (Grounding) for additional information. ALL WIRING SHOULD BE DONE BY A QUALIFIED ELECTRICIAN.

    On three-phase power, voltages on all three lines should be balanced within 1%. Unbalanced voltages cause motor overheating and poor performance.

⚠WARNING

Risk of Electric Shock! Never connect the green (or green and yellow) wire to a live terminal!

15. **SINGLE PHASE MOTORS:** These units can be wired for either portability with flexible 3-wire cord, or permanent installation using a supply with a ground. To reduce the risk of electric shock, the motor must be securely and adequately grounded! This can be accomplished by either (1) inserting plug (portable) directly into a properly installed and grounded 3-prong grounding type receptacle (as shown in Figure A for 110-120 volt, or Figure B for 220-240 volt) (2) permanently wiring the unit with a grounded, metal raceway system (3) using a separate ground wire connected to the bare metal of the motor frame or (4) other suitable means. The green (or green and yellow) conductor in the cord is the grounding wire.

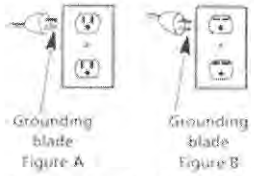

Figure 1 - Grounding Methods

Where a 2-prong wall receptacle is encountered, it must be replaced with a properly grounded 3-prong receptacle installed in accordance with the National Electrical Code, local codes and ordinances. To ensure a proper ground, the grounding means must be tested by a qualified electrician.

16. Use only 3-wire extension cords that have 3-prong grounding type plugs and 3-pole receptacles that accept the equipment plug.
17. All wiring should be performed by a qualified electrician.
18. Protect electrical cord from sharp objects, hot surfaces, oil and chemicals. Avoid kinking the cord. Replace or repair damaged or worn cords immediately.
19. Keep fingers and foreign objects away from ventilation and other openings. Do not insert any objects into the motor.
20. Use wire of adequate size to minimize voltage drop at the motor.
21. Disconnect power before servicing a motor or its load. If the power disconnect is out of sight, lock it in the open position and tag it to prevent unexpected application of power.
22. Do not touch an operating motor. Modern motors are designed to operate at high temperatures.

⚠WARNING

Do not handle a pump or pump motor with wet hands, when standing on a wet or damp surface or in water.

⚠WARNING

Specific single phase pump motors are equipped with an automatic resetting thermal protector and may restart unexpectedly. Protector tripping is an indication of motor overloading as a result of operating the pump at low heads (low discharge restriction), excessively high or low voltage, inadequate wiring, incorrect motor connections or a defective motor or pump. A motor equiped with a automatic thermal protection will be inidicated on the motor nameplate.

INSTALLATION

⚠WARNING

The pumps should not be used in flammable or explosive atmospheres. In order to safely use this product, familiarize yourself with this pump and also with the liquid (chemical, etc.) that is going to be pumped through the unit. This pump is not suitable for many liquids.

For installations where property damage might result from an inoperative or leaking pump due to power outages, discharge line blockage or any other reason, a backup system(s) should be used.

Failure to follow any warning can result in personal injury and/or property damage.

LOCATION

a. **Open Drip Proof Motor** - Clean dry locations with access to an adequate supply of cooling air.
b. **Totally Enclosed Motor** - Harsher environments where damp and dirty conditions may exist. Totally enclosed motors are not water proof.
c. Use only UL listed **Hazardous Location** motors for service in **Hazardous Locations** as defined in Article 500 of the NEC.
d. Temperature around the motor should not exceed 104°F (40°C). Minimum temperature is -20°F (29°C).
e. If the motor nameplate indicates "Air-Over, Cont. A.O.," etc., the motor must be mounted in the air stream of an air moving device.

1. Locate pump as close to the fluid source as possible, thus making the suction line short and direct as possible.

⚠ CAUTION

The unit should be placed where the motor and electrical components are protected from the weather and extremes of heat, cold and humidity.

2. Attach piping suction line to suction inlet and piping discharge line to discharge outlet. Avoid using looped section of pipe or fittings, which might permit air to ensure airtight pipe connections.

IMPORTANT: If plastic or fabric hose is used for the suction piping, it should be of a reinforced type so as not to collapse under suction. The suction piping should be one size larger than the discharge piping.

Electric Motor-Driven Pumps

3. Support the piping independently of the pump to avoid universal or excessive stresses on the pump casing, which would cause impeller misalignment and possible pump failure.
4. Install both a union and a gate valve (not furnished) on the discharge side of the pump for service convenience.

⚠ CAUTION

Do not use a globe or other restricting type of valve at the discharge. Globe valves seriously restrict the capacity of the pump; however, restricting the discharge of a centrifugal pump will not overload the drive motor.

5. **SELF-PRIMING PUMPS:** It is recommended that a foot valve be used on the suction line to assure quick priming and that a suitable suction strainer be attached to the suction line so that large pieces of foreign material are not drawn into the pump.
    a. Locate pump as close to the fluid source as possible making the suction line as short and direct as possible.

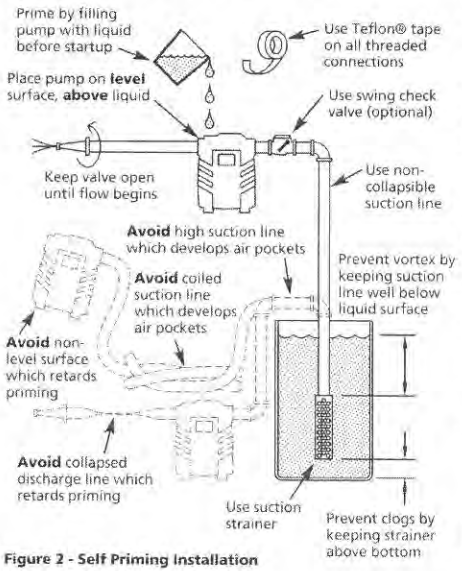

Figure 2 - Self Priming Installation

    b. The suction line should be positioned such that there is a continual upward slope from the fluid source to the pump. Avoid using loops or sections of pipe or fittings which might permit air to become trapped.
    c. Suction piping should be the same size as the discharge piping.

6. **WIRING:** For proper electrical connections, refer to the diagram located on the nameplate or inside the terminal of the motor. Make sure the connections are correct for the voltage being supplied to the motor. Connections should be made with flexible conduit to minimize vibration transmission.

    Whenever possible, the pump should be powered from a separate branch circuit of adequate capacity to keep voltage drop to a minimum during starting and running.

    Select the voltage to be used, either:
    a. Single phase - 115V or 230V
    b. Three phase - 230V or 460V

    Check motor wiring to verify which voltage the motor is currently wired for. If the wiring must be changed to conform to a specific voltage requirement, then the motor should be wired according to recommendations of wiring diagrams located on motor nameplate or wiring compartment cover. Make sure unit is properly grounded. A motor to be used with single phase power cannot be used with three phase power and vice versa. If unsure about the above information or the wiring diagrams, consult an electrician familiar with motor wiring.

⚠WARNING

A wrong connection can burn out the pump motor, cause an electrical short or produce an electrical shock. Failure to follow the above warning can result in property damage and/or personal injury. Always wire the motor with a three-wire system, ensuring that a ground wire runs to a good electrical ground such as a grounded water system or conduit. Also, ensure that a good electrical ground is provided at the supply end of the line. Connections should be made with flexible conduit to minimize vibration transmission.

7. Do not operate pump dry. Mechanical seal damage will result.
8. Install any auxiliary components (e.g. pressure switch, time).

OPERATION

SELF-PRIMING PUMPS

It is necessary to prime the pump before initial startup. Prime the pump by filling the casing with liquid through the top fill plug, the discharge port, or by installing a pipe tee at the discharge of the pump. (When installing a tee, use the horizontal leg of the tee as the pump discharge and place a pipe plug in the vertical leg. This procedure will help facilitate priming later.)

NON-PRIMING PUMPS

1. The casing and suction piping must be filled with liquid before the unit can begin pumping. In order to completely fill casing with liquid, entrapped air in casing must be vented. This is accomplished by momentarily loosening or removing the top drain plug located on the casing.

⚠ CAUTION

Do not run pump dry as permanent damage to the mechanical seal will result.

2. Activate the unit.

IMPORTANT: Proper Rotation- Power supply should be applied momentarily to the pump at first and the direction of rotation checked. When viewing the front of the pump, the motor shaft (impeller) should be rotating counterclockwise. If it is not, disconnect power and re-check wiring to motor. (See "Installation" section.) To change rotation on three phase models, interchange any two incoming line (power) leads. Other models, consult driver information that came with driver.

NOTE: Never shut off discharge or restrict suction flow while the pump is operating. It may take up to 5 minutes for a **SELF-PRIMING** pump to prime if

Electric Motor-Driven Pumps

long horizontal/ vertical lines are used. If pump has not picked up prime in 2 minutes, re-prime piping and casing after letting unit cool down for 5 minutes. Re-check all suction connections making sure pipe compound has sealed all connections. Initial priming may take 2 to 3 tries to prime successfully.

⚠ CAUTION

The proper Impeller (motor) rotation is CCW (counter clockwise) facing the front of the pump. Wrong rotation will give low performance, low head and could damage unit and/or injure personnel.

3. On initial start-up (after 15 minutes running time), check power consumption to be sure motor is not overloaded.
4. If motor is overloaded, install a valve on discharge to increase back pressure. Close the valve until pump motor is below full nameplate or within Service Factor (SF) amps.

MAINTENANCE

⚠WARNING

Make certain that the unit is disconnected from the power source before attempting to service or remove any components!

NOTE: Always flush pump thoroughly after use or if unit is not going to be used for any prolonged length of time to prevent crystallization and/or damage to seal and pump.

ROUTINE

1. Pump should be drained when subjected to freezing temperatures. A drain plug is provided on the pump casing.
2. Clean the suction line strainer at regular intervals.
3. Properly selected and installed electric motors are capable of operating for years with minimal maintenance. Periodically clean dirt accumulations from open-type motors, especially in and around vent openings, preferably by vacuuming (avoids imbedding dirt in windings).
4. Periodically check to see if electrical connections are tight.
5. Pump should be checked daily, weekly, monthly, etc. for proper operation. If anything has changed since unit was new, unit should be removed and repaired or replaced. Only qualified electricians or service personnel should attempt to repair this unit. Improper repair and/or assembly can cause an electrical shock hazard.

TROUBLESHOOTING CHART

Problem	Possible Cause(s)	Corrective Action
Motor will not start or run	1 Improperly wired.	1 Check wiring diagram on motor.
	2 Blown fuse or open circuit breaker.	2 Replace fuse or close circuit breaker after reason for overload has been determined and corrected.
	3 Loose or broken wiring.	3 Tighten connections, replace broken wiring.
	4 Stone or foreign object lodged in impeller.	4 Disassemble pump and remove foreign object.
	5 Motor shorted out.	5 Replace.
	6 Thermal overload has opened circuit.	6 Allow unit to cool. Restart after reason for overload has been determined.
	7 Voltage too low at motor terminals due to line drop.	7 Consult local power company. Increase wire size. Check for poor connections.
Motor runs slowly; will not get up to speed	1 Motor wired improperly.	1 Check and recheck wiring diagram on motor. Make internal wiring changes in wiring compartment.
	2 Capacitor burned out (single phase units only)	2 Replace capacitor.
	3 Voltage too low at motor terminals.	3 Increase wire size. Check for poor connections. Check for voltage unbalance (3 phase).
Motor overheats while running under load	1 Dirt blocking ventilation openings.	1 Clean Motor.
	2 Unbalanced supply voltage.	2 Check for faulty connections. Voltage on all three lines should be balanced within 1%. Excessive single phase loads.
	3 Faulty connection.	3 Clean, tighten, or replace.
	4 High or low voltage.	4 Check voltage at motor, should not be more than 10% above or below rated.
Pump will not prime	1 No priming water in casing.	1 Fill pump casing.
	2 Mechanical seal is leaking.	2 Replace (See Maintenance).
	3 Leak in suction line.	3 Use threaded sealant on piping, tighten, repair or replace.
	4 Discharge line is closed and priming air has nowhere to go.	4 Open.
	5 Suction line (or valve) is closed.	5 Open.
	6 Pipe union was used on suction side instead of discharge.	6 Remove union from suction side. Replace with single section of pipe.
	7 Pump is worn.	7 Replace worn parts.

TROUBLESHOOTING CHART (continued)

Problem	Possible Cause(s)	Corrective Action
Little or no discharge	1 Casing not filled with water.	1 Fill pump casing with liquid.
	2 Total head too high.	2 Shorten suction lift and/or discharge head.
	3 Suction head too high.	3 Lower suction head, install foot valve and prime.
	4 Impeller plugged.	4 Disassemble pump and clean impeller.
	5 Rotation incorrect.	5 Correct (See wiring diagram on motor).
	6 Hole or air leak in suction line.	6 Repair or replace suction line.
	7 Foot valve was too small.	7 Match foot valve to piping or install one size larger foot valve.
	8 Impeller damaged.	8 Replace.
	9 Foot valve or suction line not submerged deep enough in water.	9 Submerge lower in water.
	10 Suction piping too small.	10 Increase to pump inlet size or one size larger.
	11 Discharge piping too small.	11 Match to discharge outlet size on pump.
	12 Motor wired incorrectly.	12 Check wiring diagram.
	13 Casing gasket leaking.	13 Replace.
	14 Suction or discharge line valve closed.	14 Open.
	15 Single phase, new installation. Motor wired for 230V, etc. but supply is 115V, etc.	15 Check voltage of incoming power supply. Rewire as necessary.
	16 Mechanical seal is leaking.	16 Replace (See Maintenance).
Loss of suction	1 Air leak in suction line.	1 Use threaded sealant on piping, tighten, repair or replace.
	2 Suction lift too high.	2 Lower suction lift, install foot valve and prime.
	3 Clogged foot valve or strainer.	3 Clean.
Pump vibrates and/or makes excessive noise	1 Mounting plate or foundation not rigid enough.	1 Reinforce.
	2 Foreign material in pump.	2 Disassemble pump and clean.
	3 Impeller damaged.	3 Replace.
	4 Worn motor bearings.	4 Replace.
	5 Suction lift too high.	5 Decrease suction lift.
	6 Cavitation present.	6 Check suction line for proper size and be sure valve is open. Remove excessive lops in suction line. Install gate valve on discharge side of pump and reduce flow as necessary to match suction conditions available.
Pump leaks at shaft	1 Damaged or worn mechanical seal.	1 Replace (See Maintenance).
	2 Corrosion due to character of liquid pumped.	2 Discontinue pumping liquid and consult factory.
	3 Abrasive material in liquid causing an accumulation around the rotating assembly which results in faces opening up and allowing grit between them.	3 Pump not designed for abrasives. Discontinue use
	4 Liquid not compatible with seal.	4 Consult factory. Operational seal may be available.
	5 Temperature too high.	5 Lower liquid temperature below temperature rating of pump, See Specifications.
Pinholes in casting, drips around seal area	1 Cavitation caused by insufficient inlet pressure or suction head (NPSH).	1 Increase inlet pressure by adding a higher liquid level of fluid to source, increasing inlet pressure, or remove piping restrictions(valves, lops, etc.) in suction line.

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IPT PUMPS BY GORMAN-RUPP

General Information

SALES POLICY: AMT products are sold through our established Distributors. We do not sell direct to the consumer or organization not entitled to trade recognition. Therefore, possession of our catalogs and/or price list(s) does not infer an offer to sell.

MINIMUM ORDER: We appreciate your order, however, all orders are subject to a minimum $35.00 net invoice charge (excluding freight). This applies to all pump and parts purchase orders.

PRICES: Prices are subject to change without notice. All orders accepted are subject to prices in effect at time of shipment.

PAYMENT TERMS: Terms, upon establishment of credit, are Net 30 days. Past due accounts may be subject to a service charge of 1.5% per month. Domestic or assignable letter of credit is required for all export trade.

PAST DUE ACCOUNTS: AMT reserves the right to withhold open account shipments on any past due account. Invoices are considered past due after thirty (30) days. In the interest of sound business, all orders are subject to approval of the Credit Department.

SHIPPING INSTRUCTIONS: All shipments will be made F.O.B. the factory. Where instructions for shipment do not appear on the order, the shipment will be made according to our best judgment. Full risk of loss (including transportation delays and losses) shall pass to the customer upon delivery of the products to the carrier at the F.O.B. point. When loss or delay occurs, primary responsibility for tracing rests with the customer. When there is LOSS or APPARENT VISIBLE DAMAGE to a shipment, when tendered for delivery, *DO NOT* give the carrier a clear receipt. Note such damage on the carrier's delivery receipt and *HAVE THE DRIVER SIGN THE RECEIPT.*

PRODUCT REVISIONS: AMT reserves the right to discontinue, change or improve its products or any portions thereof without being obligated to provide such a change or improvement for units sold and/or shipped prior to such a change or improvement.

LEAD TIME: Products designated "Quick Ship Product", also referred to as "QSP" will normally be shipped within 24 hours of receipt of a non-cancellable purchase order. Only limited quantities of "QSP" pumps are available.

STANDARD LEAD TIME: Lead time is two weeks for all non "QSP" product. AMT reserves the right to revise lead times as required due to availability of materials and all other causes beyond our control.

VIP SHIPMENT: Select AMT and IPT branded pumps are available for next day shipment for non-QSP (Quick Ship Products) items and subjected to a specific model surcharge per unit noted in the respective price book. Requires calling for availability, confirmation and a non-cancellable purchase order or credit card payment prior to shipment. The expedited shipping charges are an additional cost added separately from the VIP charges per item. AMT reserves the right to revise lead times as required due to availability of materials and all other causes beyond our control. QSP quantities are limited as determined by AMT.

ALL purchase orders must be submitted via hard copy sent to AMT customer service department by fax, EDI or e-mail.

RETURN GOODS POLICY: Goods shall not be returned without a return goods authorization number (RGA) issued by AMT customer service. The RGA number must be listed on the packing list. Only current model and part numbers with a valid date code may be returned (within one year from date of purchase). **A 20% restocking and packaging charge will apply to all returns. All shipping charges must be pre-paid. No exceptions.**

ORDER CHANGES BY CUSTOMER: Orders in process may not be changed except with written consent and may be subject to special charges.

12 Month Limited Warranty

EXTENT AND DURATION OF LIMITED WARRANTY

Coverage: American Machine & Tool Company (herein "AMT") or IPT Pumps by Gorman-Rupp (herein "IPT") or Gorman-Rupp Industries Division of The Gorman-Rupp Company, Patterson, or the Gorman-Rupp Company (herein referred to as "G-R Unit") each individually warrants that its products and parts shall be free from defects in material ad workmanship for twelve (12) months from the date of purchase by the original end user when installation is made and maintenance is performed in accordance with G-R Unit's recommendations. Wear and tear resulting from use and items normally consumed in use are not covered.

EXCEPTIONS

(A) This Limited Warranty shall not apply to mechanical seals in AMT or IPT pumps and the following products and parts: engines, motors, trade accessories and all other products, components, parts and materials not manufactured by the G-R Units. These items may, however, be covered by the warranties of their respective manufacturers. (B) This warranty does not extend to or apply to any unit which has been repaired or altered at any place other than by a G-R Unit, or by persons not expressly approved by a G-R Unit to make repairs or alterations, nor to any unit the serial number, model number or identification of which has been removed, defaced or altered. (C) This warranty does not extend to any product manufactured by a G-R Unit, which has been subjected to mis-use, neglect, accident, improper installation, or use in violation of instructions furnished by a G-R Unit. (D) Pump Kits: This warranty does not extend to any product sold by a G-R Unit unassembled as a Pump Kit. Pump Kits are warranted against defects in material and workmanship for 60 days from the date of shipment from a G-R Unit. Any Pump Kit parts deemed defective by a G-R Unit will be replaced free of charge within 60 days of shipment. Pump Kits are not returnable for credit.

LIMITATIONS

THE G-R UNITS' SOLE AND EXCLUSIVE WARRANTY WITH RESPECT TO THEIR PRODUCTS AND PARTS IS THIS LIMITED WARRANTY. THIS LIMITED WARRANTY IS IN LIEU OF ALL OTHER EXPRESS AND/OR IMPLIED WARRANTIES, INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE.

EXCLUSIVE REMEDY AND DAMAGES

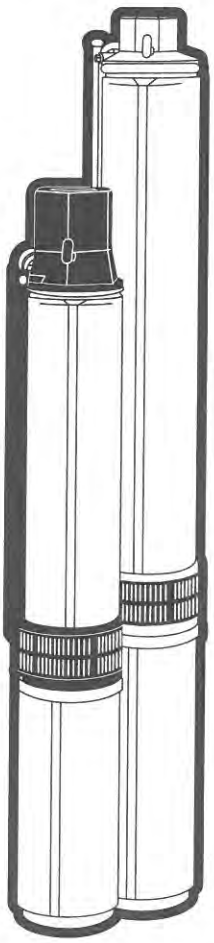
The sole and exclusive remedy for breach of this Warranty by a G-R Unit and the entire extent of its liability for such breach or for damages arising from the use of the products and parts covered under this Limited Warranty, shall be as follows:

1. **Repair or Replacement:** If inspection shows that any G-R Unit product or part covered under this Limited Warranty is defective in materials or workmanship, the G-R Unit shall repair or replace the defective or non-conforming product or part without charge, whichever the G-R Unit chooses. You must have properly maintained and used the product or part claimed to be defective in accordance with the maintenance schedule or manual, which comes with the product. No allowance will be made for labor, installation, removal, transportation or other charges incurred by you in connection with such repair or replacement.
2. To obtain the above remedy:
   - A. Immediately notify the G-R Unit upon discovery of the claimed defect in materials or workmanship and provide the serial number or date code of the product and/or part(s) or provide the G-R Unit with the invoice or bill of sale referencing the product by no later than the expiration date of the warranty period.
   - B. The G-R Unit will advise whether inspection will be necessary and how whether repair or replacement will be made. If inspection by the G-R Unit is necessary, the pump or defective part must be sent freight pre-paid to the G-R Unit. Return shipment will be F.O.B. the G-R Unit's plant.
   - C. **Return Goods Authorization Requirement:** No product will be accepted for return or replacement without the prior written authorization of the G-R Unit. Upon such authorization, and in accordance with instructions from the G-R Unit, the product will be returned to the G-R Unit, shipping charges prepaid by the Buyer.
3. **Damages:** The G-R Unit's liability for damages for breach of this Limited Warranty shall not exceed the amount of the purchase price of the product or part(s) in respect to which Such damages are claimed. **IN NO EVENT SHALL THE G-R UNITS BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES FOR BREACH OF THIS LIMITED WARRANTY.**

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you. This Limited Warranty gives you specific legal rights, and you may also have other rights, which vary from state to state.

Franklin Electric

4" and 6" SUBMERSIBLE PUMPS OWNER'S MANUAL



BEFORE INSTALLING PUMP, BE SURE TO READ THIS OWNER'S MANUAL CAREFULLY.

⚠CAUTION Fill pump with water before starting or pump will be damaged. The motor on this pump is guaranteed by the manufacturer. In event of failure it must be returned to an authorized service station for repairs. Motor warranty is void if repairs are not made by an authorized repair station.

INSPECT THE SHIPMENT

Examine the pump when it is received to be sure there has been no damage in shipping. Should any be evident, report it immediately to the dealer from whom the pump was purchased. Please check the pump package to see that it includes pump, motor, and motor leads (if your pump purchase includes a motor).

READ AND FOLLOW SAFETY INSTRUCTIONS

⚠ This is the safety alert symbol. When you see this symbol on your pump or in this manual, look for one of the following signal words and be alert to the potential for personal injury:

⚠DANGER warns about hazards that will cause serious personal injury, death or major property damage if ignored.

⚠WARNING warns about hazards that **can** cause serious personal injury, death or major property damage if ignored.

⚠CAUTION warns about hazards that **will** or **can** cause minor personal injury or major property damage if ignored.

The label **NOTICE** indicates special instructions, which are important but not related to hazards.

Carefully read and follow all safety instructions in this manual and on pump.

Keep safety labels in good condition.

Replace missing or damaged safety labels.

⚠WARNING



Hazardous voltage. Can shock, burn, or cause death.

Ground pump before connecting to power supply. Disconnect power before working on pump, motor or tank.

⚠WARNING Wire motor for correct voltage. See "Electrical" section of this manual and motor nameplate.

⚠WARNING Ground motor before connecting to power supply.

⚠WARNING Meet National Electrical Code, Canadian Electrical Code, and local codes for all wiring.

Follow wiring instructions in this manual when connecting motor to power lines.

106467101
Rev. 11
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⚠WARNING

IMPORTANT INFORMATION FOR INSTALLERS OF THIS EQUIPMENT!

THIS EQUIPMENT IS INTENDED FOR INSTALLATION BY TECHNICALLY QUALIFIED PERSONNEL. FAILURE TO INSTALL IT IN COMPLIANCE WITH NATIONAL AND LOCAL ELECTRICAL CODES, AND WITH FRANKLIN ELECTRIC RECOMMENDATIONS, MAY RESULT IN ELECTRICAL SHOCK OR FIRE HAZARD, UNSATISFACTORY PERFORMANCE, AND EQUIPMENT FAILURE. FRANKLIN INSTALLATION INFORMATION IS AVAILABLE FROM PUMP MANUFACTURERS AND DISTRIBUTORS, AND DIRECTLY FROM FRANKLIN ELECTRIC. CALL FRANKLIN TOLL FREE 800-348-2420 FOR INFORMATION. RETAIN THIS INFORMATION SHEET WITH THE EQUIPMENT FOR FUTURE REFERENCE.

⚠WARNING

SERIOUS OR FATAL ELECTRICAL SHOCK MAY RESULT FROM FAILURE TO CONNECT THE MOTOR, CONTROL ENCLOSURES, METAL PLUMBING, AND ALL OTHER METAL NEAR THE MOTOR OR CABLE, TO THE POWER SUPPLY GROUND TERMINAL USING WIRE NO SMALLER THAN MOTOR CABLE WIRES. TO REDUCE RISK OF ELECTRICAL SHOCK, DISCONNECT POWER BEFORE WORKING ON OR AROUND THE WATER SYSTEM. DO NOT USE MOTOR IN SWIMMING AREAS.

INSTALLATION RECORDS

It is good idea to keep an accurate record of your installation. Be sure to record the data below:

Purchased From:			
Date of Installation:			
Pump Model No.*			
Pump Date Code*			
Well Inside Dia.(in/mm):			
Depth of Well(ft/m):			
Depth of Water(ft/m):			
Pump Setting(ft/m):			
Drop Pipe Size:			
Wire Size(pump to control box):			
Wire Size(control box to power source):			
Horizontal Offset(between well & house):			
Make of Motor*			
Amps	**HP**	**Volts**	**Ph**
Make of Control Box			
HP		**Volts**	
Power Supply			
Volts		**HZ**	
Pressure Switch (PSI)			
Cut-in		**Cut-out**	

* This Information is on your pump or motor tag. It will help us identify your pump in case of later inquiries.

TEST RUNNING

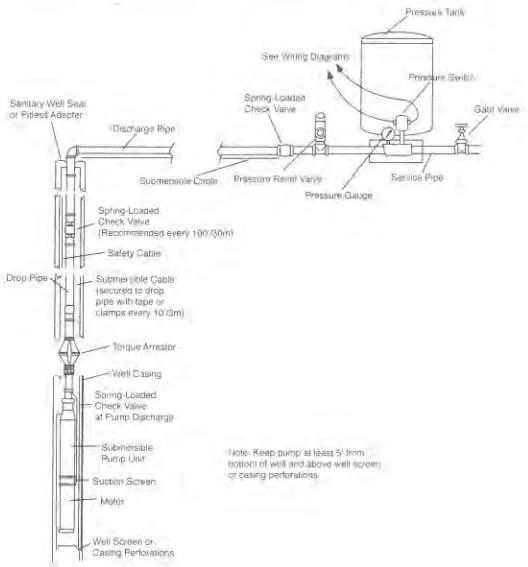
If test running pump before installation:

1. Insure that the power supply corresponds with that shown on the nameplate of the motor and control box. (if required).
2. Install pump and components appropriate for the test as shown in Fig. 1.
3. Make sure power supply is turned off and circuit breaker or disconnect switch is open. Make electrical connections appropriate to your motor as shown in Fig. 2, 3 or 4.
4. THREE-PHASE UNIT - A three-phase motor requires a magnetic starter equipped with quick-trip, ambient compensated heaters of correct size for the horsepower of the motor. To insure correct rotation of three-phase units, brace pump shell securely and apply power momentarily by snapping line switch quickly on and off.

If rotation is correct, reaction of the shell will be clockwise when viewed from pump discharge (that is, pump shaft will rotate counter clockwise). Interchange any two leads at magnetic starter to reverse rotation.

5. Run pump and motor unit for a few seconds to ensure that it is in working order.

FIGURE 1 - Installation Diagram



SUITABILITY OF WELL

Install the pump only in a well that has been properly developed. Water from an undeveloped well often contains an excessive amount of sand, dirt, and abrasives which can damage the pump. Check that the well is large enough to allow the pump to be set at the required depth. Do not set the pump below the casing perforations or well screen unless you make arrangements to ensure an adequate flow of water over the motor for cooling purposes. Determine the correct pump setting from the driller's record by taking into account the static water level and the drawdown at the proposed pumping rate. Keep the pump at least five feet from the bottom of a drilled well.

SPLICING THE POWER CABLE

Follow the instructions enclosed in the cable splicing kit you purchase.

DROP PIPE

Drop pipe is recommended for suspending submersible pumps into the well. Please refer to pipe manufacturer for recommendations on depth and pressure. Give special consideration to:

1. A safety cable to prevent loss of pump if pipe should break.

NOTICE: IT IS RECOMMENDED THAT STEEL CABLE BE USED FOR THE PURPOSES OF SECURING THE PUMP. 3/16" DIAMETER TO 1/4" DIAMETER BRAIDED STEEL CABLE IS SUFFICIENT TO SUPPORT MOST PUMP/MOTOR ASSEMBLIES. IT IS ALWAYS BEST TO CONFIRM THAT THE PUMP/MOTOR ASSEMBLY DOES NOT EXCEED THE MAXIMUM WEIGHT LIMIT OF THE CABLE SELECTED.

2. Torque arrestor just above pump to prevent chafing the cable when pump and pipe twist during the starting and stopping cycle. (See Figure 1)

Take great care to keep pipes clean and free from pebbles, scale and thread chips. Make sound, air-tight connections at all fittings. Pipe sealant is recommended.

CHECK VALVES

It is recommended that one or more check valves always be used in submersible pump installations. If the pump does not have a built-in check valve, an inline check valve should be installed in the discharge line within 25 feet of the pump and below the draw down level of the water supply. For deeper settings, check valves should be installed per the manufacturer's recommendations. More than one check valve is often needed, but more than the recommended number of check valves should not be used.

Swing type check valves are not acceptable and should never be used with submersible motors/pumps. Swing type check valves have a slower reaction time which can cause water hammer (see next page). Internal pump check valves or spring loaded check valves close quickly and help eliminate water hammer.

NOTE: Only positive sealing check valves should be used in submersible installations. Although drilling the check valve or using drain-back check valves may prevent back spinning, they create upthrust and water hammer problems.

Check valves are used to hold pressure in the system when the pump stops. They also prevent backspin, water hammer and upthrust. Any of these can lead to early pump or motor failure.

A. Backspin - With no check valve or a failed check valve, the water in the drop pipe and the water in the system can flow down the discharge pipe when the motor stops. This can cause the pump to rotate in a reverse direction. If the motor is started while it is backspinning,

an excessive force is placed across the pump-motor assembly that can cause impeller damage, motor or pump shaft breakage, excessive bearing wear, etc.

B. Upthrust - With no check valve, a leaking check valve, or drilled check valve, the unit starts under a zero head condition. This causes an uplifting or upthrust on the impeller-shaft assembly in the pump. This upward movement carries across the pump-motor coupling and creates an upthrust condition in the motor. Repeated upthrust can cause premature failure of both the pump and the motor.

C. Water Hammer - If the lowest check valve is more than 30 feet above the standing (lowest static) water level, or a lower check valve leaks and the check valve above holds, a vacuum is created in the discharge piping. On the next pump start, water moving at very high velocity fills the void and strikes the closed check valve and the stationary water in the pipe above it, causing a hydraulic shock. This shock can split pipes, break joints and damage the pump and/or motor. Water hammer can often be heard or felt. When discovered, the system should be shut down and the pump installer contacted to correct the problem.

REMOVABLE POPPET CHECK VALVE

4" submersible pumps with a 1-1/4" discharge are supplied with a spring-loaded REMOVABLE poppet style check valve assembly. The check valve can be removed from the pump discharge when the pump is installed in applications where drain back is desired.

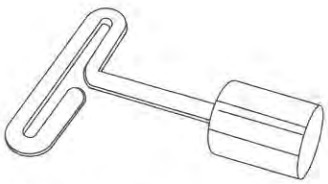
⚠WARNING Fluid draining back through the pump can cause the pump to rotate backwards. If pump/motor starts during this time; damage to the pump can occur.

The check valve can be removed with the use of the T-Handle Poppet Wrench(part no. 23498207), ordered separately, or, with standard needle nose pliers. The poppet assembly is left hand threaded and is removed by turning CLOCKWISE.

If reinstalling a Popppet Check Valve assembly, the assembly should be tightened to 15 inch-pounds.



Poppet Assembly



T-Handle Poppet Wrench

INSTALLATION OF PUMP, DROP PIPE, AND ASSOCIATED EQUIPMENT

Fig. 1 illustrates a typical well installation showing in-ground components. Franklin recommends the following procedure when installing the pump and drop pipe:

1. Prior to fastening the pump/motor assembly to the drop pipe, confirm that the motor's lead wires are securely housed under lead guard which was supplied with the pump. Fastening screws have been provided for use during the lead guard's installation.
2. Fasten the submersible cable to the drop pipe with clamps or appropriate tape every 10 ft. (3m) to prevent tangling and damage to the cable. The cable must remain slack when using plastic drop pipe to allow for stretching of pipe when installed in the well.
3. Take care not to scrape or pinch the submersible cable against the well casing.
4. Use an ohmmeter or megger to make insulation and continuity checks on the cable once the pump is installed. This locates any fault in the cable.
5. Make sure system check valves are installed properly. See previous sections of this manual for further information on check valve placement, type, and troubleshooting.
6. Install a torque arrestor just above the pump to prevent chafing the cable when pump and pipe twist during starting and stopping.
7. Attach a safety cable to pump to prevent loss of pump if pipe should break.

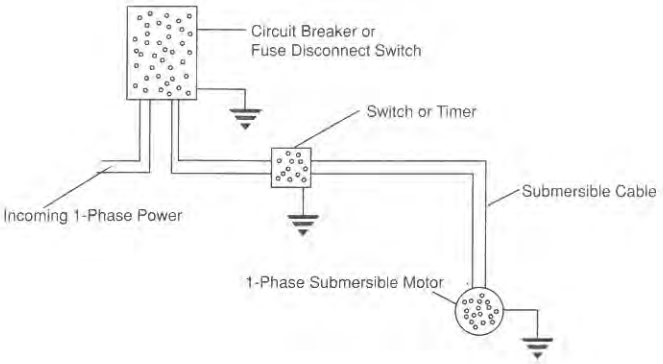
NOTICE: IT IS RECOMMENDED THAT STEEL CABLE BE USED FOR THE PURPOSES OF SECURING THE PUMP. 3/16" DIAMETER TO 1/4" DIAMETER BRAIDED STEEL CABLE IS SUFFICIENT TO SUPPORT MOST PUMP/MOTOR SYSTEMS. IT IS ALWAYS BEST TO CONFIRM THAT THE PUMP/MOTOR SYSTEM DOES NOT EXCEED THE MAXIMUM WEIGHT LIMIT OF THE CABLE SELECTED.

8. Place a sanitary well seal or pitless adapter with an approved cover plate over top of well per manufacturers recommendations.
9. Keep pump at least 5' (1.5m) from bottom of well and above well screen or casing perforations.

ELECTRICAL INFORMATION

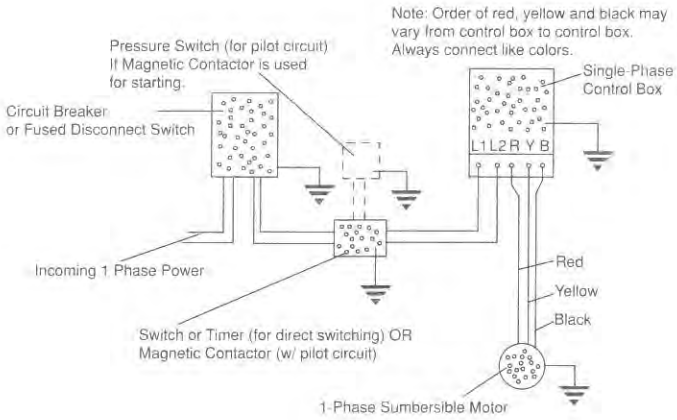
1. Employ a licensed electrician to perform the wiring. All wiring must be done in accordance with applicable national and local electrical codes.
2. Check that the power supply corresponds with the electrical rating of the submersible motor and the control box(if required). Make sure that the control box electrical rating matches the motor electrical rating.
3. Every installation requires a fused disconnect switch or circuit breaker.
4. Every installation must be grounded. There must be a reliable ground connection between the pump and the distribution panel. The motor lead incorporates a green grounding conductor.
5. Lightning arrestors are recommended for every installation. All stainless steel, single phase motors thru 5HP have built-in lightning arrestors. Any 6" motor or 4" 3-phase motor requires a separate lightning arrestor installed as close to the wellhead as possible. Install the arrestor in accordance with manufacturers recommendations. A lightning arrestor provides protection against induced voltage surges on
6. Mount the control box in an area protected from rain, snow, direct sunlight or other high temperatures as this may cause tripping of the overload protector. Also protect the control box from extreme cold (below 25°F/-32°C) as this may have adverse effects on starting capacitor.
7. A two-wire pump does not require a motor control box, since all electrical components are built inside the motor. Fig. 2 shows a typical wiring diagram for a two-wire installation.

FIGURE 2 - 2 WIRE, 1-Phase, 1/2 thru 1-1/2 HP Pump Wiring Diagram



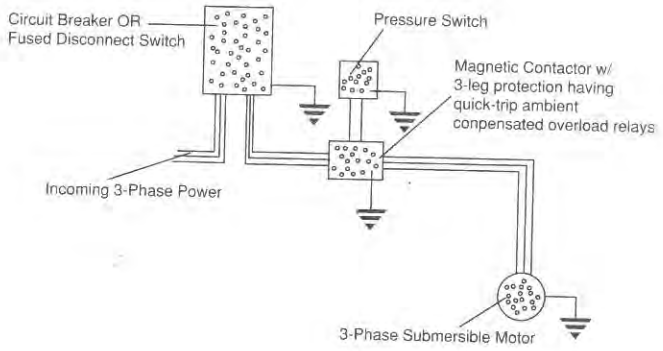
8. A three-wire, single-phase pump requires a motor control box incorporating overload relays. Fig. 3 shows a typical wiring diagram for a three-wire, single-phase installation. Note that a magnetic contactor must be used if the pressure switch electrical rating is not sufficient to handle the submersible motor electrical rating. The pressure switch would then be incorporated into a pilot circuit to control the magnetic contactor. Make the connections at the control box in accordance with the wiring diagram in the control box to avoid damage to the motor.

FIGURE 3 - 3-WIRE, 1-Phase, 1/2 thru 3 HP Pump Wiring Diagram



9. A three-phase pump does not require a motor control box . Fig. 4 shows a typical wiring diagram for a 3-wire, three-phase installation. A magnetic contractor with 3-leg protection having quick-trip ambient compensated overload relays must be used.

FIGURE 4 - 3-Wire, 3-Phase, 1-1/2 thru 50 HP Pump Wiring Diagram



10. Use an ohmeter to make continuity and insulation checks after the installation is completed.
11. Place the additional motor label with the pump label and place both in the disconnect switch or circuit breaker box for future reference.

WELL TEST

Check the pump and well performance before making the final connection to the discharge system.

1. Install a gate valve on the end of the pipe. Partially open the valve.
2. Start the pump.
3. Open valve gradually to give full flow.
4. If the discharge is not clear, let the pump run until water clears. If water does not clear in 30 minutes, stop the pump and take the necessary steps to correct the condition. After the water has appeared clear, check for sand by discharging into a clean bucket or suitable container.
5. Close valve until maximum required system flow rate is obtained (this should correspond to the cut-in pressure of the pressure switch). Ensure that the output of the pump at this setting is not greater than the yield of the well. This can be checked by monitoring the well drawdown level and ensuring that the level is stable at the maximum required system flow rate.

⚠CAUTION Never run pump unless it is completely submerged in water. If run without water, the pump and motor could be damaged. Note also that air drawn into the pump can cause an airlock under certain conditions.

LOW-YIELDING WELL

A low-yielding well exists when the output from the pump is greater than the yield of the well. It can reduce the water level to the suction screen so that a mixture of air and water enters the pump. Pumping may stop since the pump cannot generate pressure with insufficient water. In this case, the column of water already in the drop pipe holds the check valve closed and an airlock may develop inside the pump. Because the conditions ensure neither adequate lubrication of the pump nor proper cooling for the motor, damage can result if power is not cut off quickly. Use one or more of the following methods to correct and/or protect this installation.

1. Install additional length of drop pipe to place pump lower in well if possible.
2. Install a Franklin Pumptec or similar electronic drawdown sensor.
3. Install a floatless liquid level control. This device consists of an electrical relay activated by currents flowing through the ground-return circuits of electrodes hung in the well. The lower (STOP) electrode, just above the pump, ensures that the water level can never be pumped down to the suction screen. The upper (START) electrode, just below the lowest static water level, ensures that the pump can start again as soon as the well has recovered. A floatless liquid level control works in series with the pressure switch. Refer to the manufacturers instructions provided with control.
4. Install a flow control valve in the discharge line upstream from the pressure switch. This restricts the output from the pump without affecting the rate that water can be drawn from the pressure tank. Nevertheless, a heavy demand for water could empty the pressure tank, so a tank with a bonded diaphragm, air cell, or water bag is recommended.
5. Install a smaller pump to avoid over pumping the well. Have dealer size pump to the well yield.
6. Install a low-pressure cut-off switch. A low pressure cut off switch, or a pressure switch with such an arrangement built in, protects a shallow-well pump from losing its prime, but it does not always provide satisfactory protection to a submersible pump from the effects of over pumping the well. This is because it responds to a loss of pressure at the surface, which may occur after an air lock has formed inside the pump. We recommend either a floatless liquid level control or a flow control valve, in that order, in preference to a low-pressure cutoff switch as protection against over pumping.

DISCHARGE PLUMBING

Fig. 1 illustrates a typical well installation showing above ground components. Adhere to the following items when installing the discharge plumbing.

1. Install an above ground check valve upstream from the pressure switch.
2. Always install a pressure relief valve in the system. The relief valve should be capable of discharging the flow rate of the pump at the rated working pressure of the pressure tank. Locate the relief valve close to the pressure tank.
3. Install a pressure switch between the check valve and the pressure tank. Refer to Fig. 2, 3, or 4 for proper wiring connections of pressure switch.
4. Install a pressure tank as close as possible to the pressure switch. Refer to manufacturer's recommendations for installation.

TROUBLESHOOTING

1. PUMP FAILS TO START

a) Electrical trouble - call dealer or electrician.
b) Drawdown protection device has pump turned off.
c) Overload tripped.
d) Reset low pressure cutoff switch (if installed).

2. PUMP FAILS TO DELIVER WATER

a) Air lock in pump.
b) Clogged intake screen.
c) Insufficient well yield.

3. PUMP GIVES REDUCED OUTPUT

a) Insufficient well yield.
b) Worn pump.
c) Clogged intake screen.
d) Low voltage.
e) Incorrect rotation (3-phase only).

4. PUMP CYCLES TOO FREQUENTLY

a) Excessive pressure drop between pressure switch and pressure tank.
b) "Cut-in" pressure at pressure tank too high.
c) "Cut-out" pressure at pressure tank too low.
d) Waterlogged pressure tank.
e) Start and stop electrodes of floatless liquid level control set too close together.
f) Tank sized too small to meet system requirements.

5. OVERLOADS TRIP

a) Electrical trouble - call dealer or electrician.

6. PRESSURE SWITCH CYCLES RAPIDLY WHEN PUMP STARTS

a) Pressure switch too far from pressure tank.
b) Adjust air charge of tank to manufacturer's recommendations.

Limited Warranty Policy

Great Plains Industries, Inc. 5252 E. 36th Street North, Wichita, KS USA 67220-3205, hereby provides a limited warranty against defects in material and workmanship on all products manufactured by Great Plains Industries, Inc. This product includes a 1 year warranty. Manufacturer's sole obligation under the foregoing warranties will be limited to either, at Manufacturer's option, replacing or repairing defective Goods (subject to limitations hereinafter provided) or refunding the purchase price for such Goods theretofore paid by the Buyer, and Buyer's exclusive remedy for breach of any such warranties will be enforcement of such obligations of Manufacturer. The warranty shall extend to the purchaser of this product and to any person to whom such product is transferred during the warranty period.

The warranty period shall begin on the date of manufacture or on the date of purchase with an original sales receipt. This warranty shall not apply if:

A. the product has been altered or modified outside the warrantor's duly appointed representative;
B. the product has been subjected to neglect, misuse, abuse or damage or has been installed or operated other than in accordance with the manufacturer's operating instructions.

To make a claim against this warranty, contact the GPI Customer Service Department at 316-686-7361 or 888-996-3837. Or by mail at:

Great Plains Industries, Inc.
5252 E. 36th St. North
Wichita, KS, USA 67220-3205

The company shall, notify the customer to either send the product, transportation prepaid, to the company at its office in Wichita, Kansas, or to a duly authorized service center. The company shall perform all obligations imposed on it by the terms of this warranty within 60 days of receipt of the defective product.

GREAT PLAINS INDUSTRIES, INC., EXCLUDES LIABILITY UNDER THIS WARRANTY FOR DIRECT, INDIRECT, INCIDENTAL AND CONSEQUENTIAL DAMAGES INCURRED IN THE USE OR LOSS OF USE OF THE PRODUCT WARRANTED HEREUNDER.

The company herewith expressly disclaims any warranty of merchantability or fitness for any particular purpose other than for which it was designed.

This warranty gives you specific rights and you may also have other rights which vary from U.S. state to U.S. state.

Note: In compliance with MAGNUSON MOSS CONSUMER WARRANTY ACT – Part 702 (governs the resale availability of the warranty terms).

5252 East 36th Street North
Wichita, KS USA 67220-3205
316-686-7361 | FAX: 316-686-6746
888-996-3837 | www.GPImeters.net
GREAT PLAINS INDUSTRIES, INC.

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SAVE THESE INSTRUCTIONS

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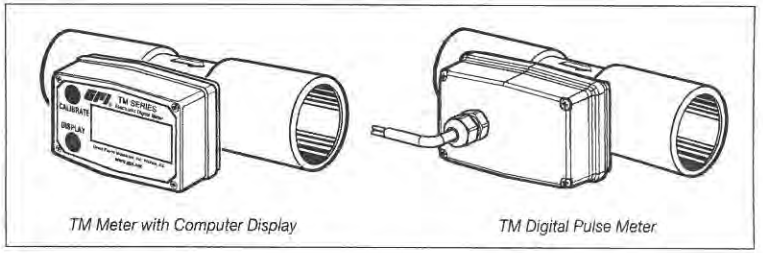
GREAT PLAINS INDUSTRIES, INC.

TM Series Electronic Water Meters CE

User Manual



TM Meter with Computer Display *TM Digital Pulse Meter*

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ENGLISH

IMPORTANT NOTICE

Use TM Series meters with water and other chemicals compatible with wetted components. Do not use to meter fuel or incompatible chemicals. TM Series meters are available with either a computer for local electronic display, or a conditioned signal output module to provide a digital signal to customer interfacing equipment. TM Series meters with computer display measure in gallons or litres. Refer to the Calibration Section for details.

These meters are not legal for trade applications.

TM Series meters are very sensitive to electric noise if operated within 1 to 2 inches of some electric motors or other sources of electronic noise.

INSTALLATION

Connections

Install your meter in-line either horizontally or vertically or at the end of the hose adjacent to the nozzle. Installation to metal connections is not recommended. Install as follows:

1. Plan to install turbine with a minimum straight pipe length as follows:
   - Upstream from the turbine, allow a minimum straight pipe length of 10 times the internal diameter of the turbine.
   - Downstream from the turbine, allow a minimum straight pipe length of 5 times the internal diameter of the turbine.
2. For Spigot (Pipe) End use only primer and solvents approved for PVC gluing.

   For NPT and BSP Fittings wrap all connections with 3 to 4 wraps of thread tape (optional to use pipe thread sealant). Make sure the tape does not intrude into the flow path.

3. Attach meter with arrow pointed in the direction of fluid flow.
4. For NPT and BSP Fittings - Hand tighten the meter at the housing ends. Do not use a wrench or similar tool to tighten. This can damage the housing.

⚠ WARNING

Compatibility of this product's material and the process fluid and/or environment should be considered prior to putting into service.

⚠ WARNING

Product should never be operated outside its published specifications for temperature or pressure. See specifications for your model.

⚠ WARNING

Make sure flow and pressure have been eliminated from process pipe prior to installing or removing product.

⚠ WARNING

Always use appropriate thread sealant or flange gaskets when connecting product to process piping.

⚠ CAUTION

To protect against leakage, seal all pipe threads with an appropriate sealing compound. Make sure the sealing compound does not intrude into the flow path.

NOTE: If connecting to new male pipe threads, burrs and curls can adversely affect accuracy. Correct the problem prior to turbine installation.

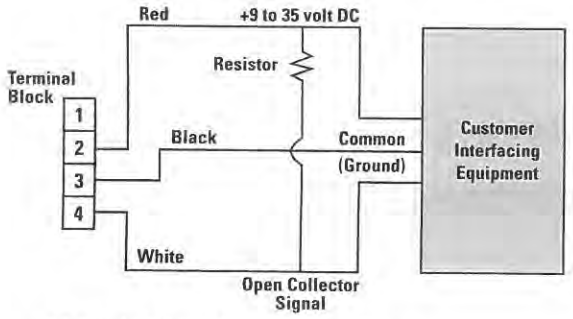
NOTE: Do not over tighten the flange bolts. This may cause the gasket to be compressed into the flow stream and may decrease the accuracy of the meter.

⚠ CAUTION

Installation near high electromagnetic fields and high current fields is not recommended and may result in inaccurate readings.

Wiring Diagram 1

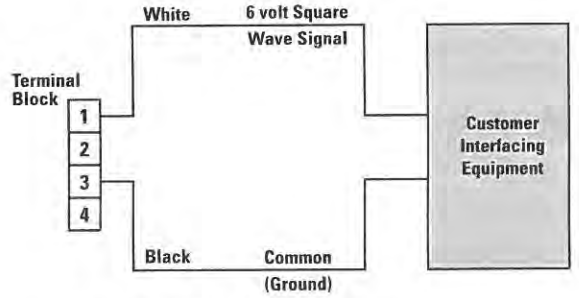
OPEN COLLECTOR SIGNAL OUTPUT



The terminal block is identified as follows:
Pin #1 6 volt square wave (not used)
Pin #2 +9 to 35 volt DC Input
Pin #3 Common Ground
Pin #4 Open Collector signal Output

Wiring Diagram 2

SQUARE WAVE OUTPUT



The terminal block is identified as follows:
Pin #1 6 volt square wave
Pin #2 +9 to 35 volt DC Input (not used)
Pin #3 Common Ground
Pin #4 Open Collector signal Output (not used)

Conditioned Signal Output Module Wiring

This conditioned signal output module can be wired to provide an open collector signal output or 6-volt square wave output.

Open Collector Signal Output

To achieve an open collector signal output, reference Wiring Diagram 1. The terminal block is located on the back side of the module. The module is factory assembled for open collector signal output. Please provide the (820 ohm minimum) resistor.

Ten feet (3 m) of cable is provided with the module. Trim it to desired length or extend it as necessary. Distances up to 5,000 feet (1,524 m) can be achieved for open collector signal output.

Square Wave Output

To achieve square wave output, reference Wiring Diagram 2 and use an Electronic Digital Meter Battery Kit (sold separately) for battery power. The terminal block and battery location are located on the back side of the module. Access as follows:

1. Remove the four Phillips-head screws from the front of the module and lift the module from the turbine.
2. To change terminal block connections, loosen the appropriate screws. Reconnect the wires in the proper positions and tighten the screws.
3. Install the batteries. Make sure the positive post is in the correct position.
4. Position the module on the turbine housing. To avoid moisture damage, make sure the seal is fully seated. Tighten the four screws on the front of the module.

Ten feet (3 m) of cable is provided with the module. Trim the cable to desired length or extend it as necessary.

Verify Meter Accuracy

Before using, check the meter's accuracy and verify calibration.

1. Make sure there is no air in the system by starting the flow until it runs steadily. Then, stop or divert the flow using a valve or nozzle.

2. Meter an exact known volume into an accurate container. For best results, meter with one continuous full stream.
3. Check the volume against the display or recording equipment. If the amount metered is accurate, further calibration is not necessary. If not, refer to the Calibration Section for further instructions.

OPERATION

Computer Display – Batch and Cumulative Totals

The computer maintains two totals. The Cumulative Total provides continuous measurement and cannot be manually reset. The Batch Total can be reset to measure flow during a single use. The Cumulative Total is labeled TOTAL 1, Batch Total is labeled TOTAL 2 BATCH.

When the Cumulative Total reaches a display reading of 999,999 the computer will highlight an X10 icon. This indicates to the operator that a zero must be added to the 6 digits shown. When the next rollover occurs, the computer will highlight an X100 icon. This indicates to the operator that two zeros must be added to the 6 digits shown.

Press the DISPLAY button briefly to switch between the TOTAL 1, TOTAL 2 BATCH and FLOWRATE. Press DISPLAY briefly to display the TOTAL 2 BATCH. Hold the DISPLAY button for 3 seconds to reset the Batch Total to zero.

When fluid is flowing through the meter, a small propeller icon is highlighted.

NOTE: Totalization counts total units without differentiating between gallons, litres or field calibrated units.

Flowrate Feature

To use this feature, press and release DISPLAY button until FLOWRATE icon appears. The factory set time base will be highlighted to the right of FLOWRATE (M = minutes, H = hours, D = days). When FLOWRATE is invoked, the display will be indicating rate of flow.

Activate the Meter

Computer is on continuously and always ready to perform. The computer is powered by field replaceable batteries. When display becomes dim, faded or the low battery message appears (see below), the batteries need to be replaced. Reference the Maintenance Section for details.

LobAtt

Factory and Field Calibration

All calibration information is visible to the user as icons on the top line of the display, above the numeric digits.

All units are configured with a "factory" calibration. Both gallons and litres are available ("GL" or "LT" will be displayed). While holding the CALIBRATE button, briefly press DISPLAY to toggle between gallons and litres. This factory calibration (indicated with FAC) is permanently programmed into the computer and is not user adjustable.

NOTE: Your computer may have other units of measure programmed into it. If so, holding the CALIBRATE button and momentarily pressing the DISPLAY button will toggle through all factory set units. Other possible units are: IGL (imperial gallon), QT (quart), CF (cubic feet), CM (cubic meter), BL (42 gal. barrel), CC (cubic centimeter) or OZ (ounce).

Switching between different units will not corrupt the Total's contents. For example, in GL mode, the computer totalizes 10.00 gallons, if the user switches to LT mode, the display will read 37.85 litres (the same volume, different unit).

The "field" calibration may be set by the user, and can be changed or modified at any time using the calibration procedure described in the Calibration Section. Totals or flowrate derived from the field calibration are invoked when the FAC icon is no longer visible on the top line of the display.

CALIBRATION

Verify Accuracy Before Beginning Field Calibration

For the most accurate results, dispense at a flowrate which best simulates your actual operating conditions. Avoid "dribbling" more fluid or repeatedly starting and stopping the flow. This can result in less accurate calibrations.

Make sure you meet the meter's minimum flowrate requirements:

TM Series Meters	
½ inch meter	1 GPM (3.8 LPM)
¾ inch meter	2 GPM (7.5 LPM)
1 inch meter	5 GPM (18.8 LPM)
1 ½ inch meter	10 GPM (37.5 LPM)
2 inch meter	20 GPM (75 LPM)

The use of a uniformly dependable, accurate calibration container is recommended for the most accurate results. Due to high flowrate, it is strongly recommended that calibration be completed with a combination of volume and weight using fine resolution scales.

For best results, the meter should be installed and purged of air before field calibration.

Field Calibration with Computer Display

Field Calibration and Factory Calibration are defined in the Operation Section. Factory calibration settings are programmed into each computer during manufacturing, using water at 70° F (21° C). Readings using the Factory Calibration (FAC) may not be accurate in some situations, for example, under extreme temperature conditions, non-standard plumbing configurations or with fluids other than water.

Field Calibration Procedures (Correction Factor Method)

1. To calibrate, press and hold the CALIBRATE and DISPLAY buttons for about 3 seconds until you see FLdCAL. Release both buttons and you will see CF - 00.0. You are now in the field calibration mode and values from -99.9% to +99.9% can be entered.
2. The +/– position appears either as an "underscore" character for plus, or as a "hyphen" character for minus. The DISPLAY button selects the position and the CALIBRATE button toggles this character.
3. The DISPLAY button can then be pushed to select the numeric positions. Press the CALIBRATE button to scroll from 0 to 9. Enter the percentage of change you want the display to correct. When satisfied with the value, press both CALIBRATE and DISPLAY buttons simultaneously. CALEnd will be displayed and unit will go back to normal operation, less the FAC (factory calibration) icon.
4. All enabled units-of-measure remain visible and selectable – the entered correction will be applied to all enabled units.
5. To return to factory calibration (FAC), press and hold both CALIBRATE and DISPLAY buttons for about 3 seconds until FAcCAL is displayed. Then release buttons. Unit should return to normal operation and FAC icon is visible.

Calibration with Conditioned Signal Output Module

The K-factor of your meter appears on the calibration report as the number of pulses per gallon. The factor is determined during production using water at 70° F (21° C). This K-factor may be used for "single point" calibration and provide acceptable accuracy. However, readings may not be accurate when using this calibration method in some situations. For example, extreme temperature conditions, non-standard plumbing configurations or with fluids other than water.

MAINTENANCE

Proper handling and care will extend the life and service of the meter.

Turbine Rotor

The meter is virtually maintenance-free. However, it is important the rotor moves freely. Keep the meter clean and free of contaminants.

If the rotor does not turn freely, apply a penetrating lubricant on the rotor, shaft and bearings. Remove any debris or deposits from the rotor using a soft brush or small probe. Be careful not to damage the turbine rotor or supports.

⚠ CAUTION

Blowing compressed air through the turbine assembly could damage the rotor.

⚠ CAUTION

Do not allow liquids to dry inside the turbine.

⚠ CAUTION

Handle the rotor carefully. Small scratches or nicks can affect accuracy.

Battery Replacement

The computer display is powered by two 3-volt lithium batteries which may be replaced while the meter is installed. When batteries are removed or lose power, the batch and cumulative totals and the field and factory calibrations are retained.

⚠ WARNING

(Battery) – Avoid mechanical or electrical abuse. Batteries may explode or cause burns, if disassembled, crushed or exposed to fire or temperatures in excess of 212°F (100°C). Do not short circuit or install with incorrect polarity. DO NOT INCINERATE.

⚠ CAUTION

Batteries should ONLY be replaced with P/N 113520-1 Kit (Includes two each P/N 902004-2 Batteries). Do not mix old with new. Do not use other brands or technologies.

Open battery cells should be disposed of in accordance with local regulations. Lithium batteries are best disposed of as a non-hazardous waste when fully or mostly discharged. EPA does not list or exempt Lithium as a hazardous waste. If waste lithium batteries are still fully charged or only partially discharged, they can be considered a reactive hazardous waste because of unconsumed lithium remaining in the battery. Such batteries may qualify as "Universal Waste" in many jurisdictions within the U.S. and thus can be shipped for disposal or recycling in accordance with Universal Waste requirements.

If the display becomes dim, blank or the low battery message appears (see below), replace the batteries as follows:

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1. Remove the four Phillips-head screws from the face of the meter and lift the faceplate from the turbine.
2. Remove the old batteries and clean any corrosion from the terminals.
3. Install new batteries. Make sure the positive post is in the correct position.
4. When the batteries are replaced, the faceplate will power ON. Check the display to ensure normal functions have resumed before assembling again.
5. Reseat batteries, if necessary, and position the faceplate on the turbine housing. To avoid moisture damage, make sure the seal is fully seated. Tighten the four screws on the faceplate.

SPECIFICATIONS

Inlet and Outlet:

Spigot (Pipe) End Models:

TM050/TM050-P	½ inch Schd. 80, Spigot (Pipe)
TM075/TM075-P	¾ inch Schd. 80, Spigot (Pipe)
TM100/TM100-P	1 inch Schd. 80, Spigot (Pipe)
TM150/TM150-P	1 ½ inch Schd. 80, Spigot (Pipe)
TM200/TM200-P	2 inch Schd. 80, Spigot (Pipe)

NPT Models:

TM050-N/TM050-N-P	½ inch NPT
TM075-N/TM075-N-P	¾ inch NPT
TM100-N/TM100-N-P	1 inch NPT
TM150-N/TM150-N-P	1 ½ inch NPT
TM200-N/TM200-N-P	2 inch NPT

BSP Models:

TM100-B/TM100-B-P	1 in. BSP
TM150-B/TM150-B-P	1 ½ in. BSP
TM200-B/TM200-B-P	2 in. BSP

Design Type: Turbine

Wetted Components:
Housing: PVC
Journal Bearings: Ceramic
Shaft: Tungsten Carbide
Rotor and Supports: PVDF
Retaining Washer: Stainless Steel

Max. Working Pressure:
225 PSIG @ 73° F
BSP: 150 PSIG @ 73° F

U.S. Measurement

Unit of Measure: Gallon

Flow Range:

½ inch	1 - 10 GPM
¾ inch	2 - 20 GPM
1 inch	5 - 50 GPM
1 ½ inch	10 - 100 GPM
2 inch	20 - 200 GPM

Accuracy with Computer: ± 3.0% of reading (Accuracy can be improved with field calibration)

Operating Temperature: +32° to +140° F (Do not allow fluid to freeze inside meter.)

Storage Temperature: –40° to +158° F

Product Weight:*

	Spigot (Pipe)	NPT	BSP
½ in.	.38 lbs.	.55 lbs.	N/A
¾ in.	.43 lbs.	.67 lbs.	N/A
1 in.	.49 lbs.	.84 lbs.	.84 lbs.
1 ½ in.	.66 lbs.	1.38 lbs.	1.47 lbs.
2 in.	.78 lbs.	1.78 lbs.	1.93 lbs.

Dimensions - Inches (W x H x L):**

	Without Fitting	With NPT Fitting
½"	2.1 x 2.5 x 4.3	2.1 x 2.7 x 6.0
¾"	2.1 x 2.7 x 4.4	2.1 x 2.9 x 6.1
1"	2.1 x 2.9 x 4.5	2.1 x 3.1 x 6.5
1 ½"	2.1 x 3.6 x 5.4	2.3 x 3.8 x 7.6
2"	2.4 x 4.1 x 5.5	3.5 x 4.4 x 7.9
	With BSP Fitting	
½"	N/A	
¾"	N/A	
1"	2.1 x 3.1 x 6.7	
1 ½"	2.2 x 3.7 x 7.6	
2"	2.7 x 4.2 x 7.8	

* Weight with computer display. Conditioned signal output module adds .30 lbs.

** Dimensions with computer display. Conditioned signal output module adds 1.1 inch to height.

Metric Measurement

Unit of Measure: Litre

Flow Range:

½ inch	3.8 - 38 LPM
¾ inch	7.6 - 76 LPM
1 inch	19 - 190 LPM
1 ½ inch	38 - 380 LPM
2 inch	76 - 760 LPM

Accuracy with Computer: ± 3.0% of reading (Accuracy can be improved with field calibration)

Operating Temperature: 0° to +60° C (Do not allow fluid to freeze inside meter.)

Storage Temperature: –40° to +70° C

Product Weight:*

	Spigot (Pipe)	NPT	BSP
½ inch	.172 kg	.249 kg	N/A
¾ inch	.195 kg	.304 kg	N/A
1 inch	.222 kg	.381 kg	.381 kg
1 ½ inch	.299 kg	.626 kg	.666 kg
2 inch	.354 kg	.807 kg	.875 kg

Dimensions - cm (W x H x L):**

	Without Fitting	With NPT Fitting
½"	5.3 x 6.4 x 10.9	5.3 x 6.9 x 15.2
¾"	5.3 x 6.9 x 11.2	5.3 x 7.3 x 15.5
1"	5.3 x 7.4 x 10.9	5.3 x 7.9 x 16.5
1 ½"	5.3 x 9.1 x 13.7	5.8 x 9.7 x 19.3
2"	6.1 x 10.4 x 14.0	8.9 x 11.2 x 20.0
	With BSP Fitting	
½"	N/A	
¾"	N/A	
1"	5.3 x 7.9 x 17.0	
1 ½"	5.6 x 9.4 x 19.3	
2"	6.9 x 10.7 x 19.8	

* Weight with computer display. Conditioned signal output module adds .14 kg.

** Dimensions with computer display. Conditioned signal output module adds 2.8 cm to height.

PARTS

The following replacement parts and accessories are available for the TM Series meters:

Part No.	Description
113435-1	Conditioned Signal Output Module
113520-1	Battery Replacement Kit
116000-1	Calibration Container, Large (5 gallon)
125508-03	½ inch, Turbine Assy Kit
125508-04	½ inch NPT, PVC Turbine Assy Kit
125510-03	¾ inch, Turbine Assy Kit
125510-04	¾ inch NPT, PVC Turbine Assy Kit
125512-03	1 inch, Turbine Assy Kit
125512-04	1 inch NPT, PVC Turbine Assy Kit
125514-03	1 ½ inch, Turbine Assy Kit
125514-04	1 ½ inch NPT, PVC Turbine Assy Kit
125516-03	2 inch, Turbine Assy Kit
125516-04	2 inch NPT, PVC Turbine Assy Kit
901002-52	Seal
125512-05	1 inch BSP, PVC Turbine Assy Kit
125514-05	1 ½ inch BSP, PVC Turbine Assy Kit
125516-05	2 inch BSP, PVC Turbine Assy Kit
Computer Kits:	
125509-03	½ inch, Computer Assy Kit
125511-03	¾ inch, Computer Assy Kit
125513-03	1 inch, Computer Assy Kit
125515-03	1 ½ inch, Computer Assy Kit
125517-03	2 inch, Computer Assy Kit

SERVICE

For warranty consideration, contact your local distributor. If you need further assistance, contact the GPI Customer Service Department at:

1-888-996-3837

You will need to:

- Provide information from the decal on your meter.
- Receive a Return Authorization number.
- Flush any fluid from the meter before shipping to the factory.

If possible leave customer installed fittings or ample length of bare pipe for reinstallation.

⚠ CAUTION

Do not return the meter without specific authority from the GPI Customer Service Department. Due to strict regulations governing transportation, handling, and disposal of hazardous or flammable liquids, GPI will not accept meters for rework unless they are completely free of liquid residue.

WEEE DIRECTIVE



The Waste Electrical and Electronic Equipment (WEEE) directive (2002/96/EC) was approved by the European Parliament and the Council of the European Union in 2003. This symbol indicates that this product contains electrical and electronic equipment that may include batteries, printed circuit boards, liquid crystal displays or other components that may be subject to local disposal regulations at your location. Please understand those regulations and dispose of this product in a responsible manner.

RoHS Compliant (2011/65/EU)

This product is in compliance with the RoHS Directive of the European Parliament and of the Council on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment.

Environmental Rating: IP65

ESPAÑOL

AVISO IMPORTANTE

Utilizar los medidores de los Series del TM con agua y otros productos químicos que son compatibles con los componentes que se exponen al líquido. No utilizar este medidor con combustible u otros productos qulmicos incompatibles. Los medidores de la serie de TM están dispon-ibles con una computadora para la visualiza-ción electrónica local, o un módulo de salida condicionado de la señal que proporcione una señal numérica al equipo de interconexión del cliente. Los medidores de las Series TM miden en galones o litros. Referirse a la sección de la calibración para mayores detalles.

Estos medidores no son legales para las aplicaciones comerciales.

Los medidores de las Series TM son muy sensibles a interferencia electrónica si funcionan a 1 o 2 pulgadas de algunos motores eléctricos o de otras fuentes del uso electrónico.

INSTALACIÓN

Conexiones

Instalar su medidor en línea, u horizontalmente, o verticalmente, o en el extremo de la manguera adyacente al inyector. No se recomienda la instalación a las conexiones de metal. Siga estos pasos para instalar:

1. Planee instalar la turbina con una longitud mínima de la pipa recta de esta manera:
   - Contra la corriente de la turbina, permita a una longitud mínima de la pipa recta de 10 veces el diámetro interno de la turbina.
   - Con la corriente de la turbina, permita una longitud mínima de la pipa recta de 5 veces el diámetro interno de la turbina.
2. Para Espita (Enchufo macho) Fin utilizar solamente los solventes aprobados para pegar PVC.

   Para conexiones NPT y BSP envuelva todas las conexiones con 3 a 4 vueltas de cinta para roscado (es opcional usar sellador para roscas de tubería). Compruebe que la cinta no interfiera con el paso del caudal.

Declaration of Conformity

Manufacturer's Name: Great Plains Industries, Inc.
Manufacturer's Address: 5252 East 36th Street North
Wichita, KS USA 67220-3205

Declares, that the product:

Product Name: TM Series Water Meter
Model Numbers:

TM050	TM200
TM075	TM300
TM100	TM400
TM150	

Model numbers may include the suffix "-N", "-B", "-F" or "-D" to indicate thread or flange type.

Conform to the following Standards:

EMC: EN 61000-6-2 (2005)
EN 61000-6-3 (2007)

Supplementary Information:
"The products comply with the requirements of the EMC Directive 2004/108/EC and RoHS 2 Directive 2011/65/EU." This product has insufficient internal volume size or pressure ratings to meet a pressure directive.
This product is not recommended for custody transfer or application where levying by consumption takes place.

I the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Signature: Victor Lukic

Full Name: Victor Lukic
Position: President
Great Plains Industries, Inc.
Place: Wichita, KS USA
January 2013

GPI®
5252 East 36th Street North
Wichita, KS USA 67220-3205
316-686-7361 | FAX: 316-686-6746
888-996-3837 | www.GPImeters.net
GREAT PLAINS INDUSTRIES, INC.

CE

Printed in USA 01/13

Rev. B 920737-01

G2 Series

Stainless Steel Industrial Meter (Rate & 2 Totals, 1 Resettable)



Our industrial grade electronic digital meters offer durable, compact, high precision fluid measurement systems at a fraction of the price you'd expect to pay for comparable systems with similar features and benefits.

FEATURES

- Battery operated.
- Flow ranges: 1-200 GPM (depending on size).
- Rugged construction.
- Designed for indoor/outdoor use.
- Digital display with large 1/2" tall digits.
- Maximum batch total of 999,999.
- Approximate battery life is 4,000 hours.
- Displays instantaneous flow rate & flow totals (one totalizer is resettable).
- Ability to field calibrate (standard).

TYPICAL APPLICATIONS

- Clean fluids (free of particulate).
- Fuel transfer pumps.
- Lubrication oil.
- Geothermal heating or cooling systems.
- Fertilizer trucks.
- Plant process fluid.
- Chemical feed lines.

MATERIALS OF CONSTRUCTION

Housing and Rings:
316 stainless steel.

Bearings:
Ceramic.

Shaft:
Tungsten carbide.

Rotor:
PVDF.

Signal Generator:
Ferrite.

G2 SERIES MODEL NUMBERING

Model Number: **G2** X X X X X

Size:
S05 = 1/2"
S07 = 3/4"
S10 = 1"
S15 = 1-1/2"
S20 = 2"

Fitting Type:
F = 150 lb. ANSI Flange*
I = ISO Female
N = NPT Female
T = Tri-Clamp
X = Electronics Only

Electronics (see page 158)

Calibration:
GM = Gallons / Minute
LM = Liters / Minute
XX = No Electronics

Packaging:
A = Turbine Only or Turbine with Display**
B = Turbine Only or Turbine with Display***
C = Turbine with Remote Transmitter with or without Turbine Mounted Display
D = 150 lb. ANSI Flange, Turbine with Local Display****
E = 150 lb. ANSI Flange, Turbine with Local Display***; 150 lb. ANSI Flange, Turbine with Remote Transmitter*

* S10, S15 and S20 only.
** S05, S07 and S10 only.
*** S15 and S20 only.
**** S10 only.

G2 Series

Stainless Steel Industrial Grade Meter

(NPT or tri-clamp fittings)

PRESSURE RATING

1500 PSI

TEMPERATURE RANGE

14˚F to 140˚F

ADDITIONAL SPECIFICATIONS

Repeatability:
± 0.1%.

WEIGHTS & SPECIFICATIONS

Size	Flow Range		Accuracy (% of Reading)	Typical K-Factor	Frequency Range	Strainer Size	Max. Flow		Wrench Flat Size	Wt. (lbs.)	Model No.
	GPM	LPM					GPM	LPM			
NPT											
1/2"	1-10	3.8-37.9	±2.0	2,500	42-420 Hz	55 mesh	15	56.8	1-1/16"	2.0	G2S05N09GMA
3/4"	2-20	7.6-75.7	±1.5	1,100	37-370 Hz	55 mesh	30	113.6	1-5/16"	2.3	G2S07N09GMA
1"	5-50	18.9-190	±1.5	565	47-470 Hz	28 mesh	75	284	1-5/8"	2.6	G2S10N09GMA
1-1/2"	10-100	38-380	±1.0	215	36-360 Hz	55 mesh	150	568	2-3/8"	4.2	G2S15N09GMB
2"	20-200	76-760	±1.0	100	33-330 Hz	28 mesh	300	1136	3"	6.6	G2S20N09GMB
Tri-Clamp											
3/4"	1-10	3.8-37.9	±2.0	2,500	42-420 Hz	55 mesh	15	56.8	-	2.5	G2S05T09GMA
1"	2-20	7.6-75.7	±1.5	1,100	37-370 Hz	55 mesh	30	113.6	-	2.9	G2S07T09GMA
1-1/2"	5-50	18.9-190	±1.5	565	47-470 Hz	28 mesh	75	284	-	3.2	G2S10T09GMA
2"	10-100	38-380	±1.0	215	36-360 Hz	55 mesh	150	568	-	4.8	G2S15T09GMB
2-1/2"	20-200	76-760	±1.0	100	33-330 Hz	28 mesh	300	1136	-	7.2	G2S20T09GMB

ELECTRONICS CHOICES

Turbine with Local Display
09 = Standard: 2 button display, field configurable (2 totals, 2 calibrations, rate).
19 = Vertical mount 2 button display, field configurable (2 totals, 2 calibrations, rate).

Pulse Output (Remote)
41 = Remote pulse out transmitter and sine wave pickup (standard remote sensor option).
43 = Remote pulse out transmitter and turbine mounted display (pulse out sensor option).

GG500 - Display with Pulse Output (Remote)
51 = Sine wave pickup (standard remote sensor option).
52 = Open collector pickup (conditioned signal sensor option).
53 = Turbine mounted display (pulse access sensor option).

GX500 - Display with 4-20 mA Output (Remote)
61 = Sine wave pickup (standard remote sensor option).
62 = Open collector pickup (conditioned signal sensor option).
63 = Turbine mounted display (pulse access sensor option).

GA500 - 4-20 mA Output (Remote)
71 = Sine wave pickup (standard remote sensor option).
72 = Open collector pickup (conditioned signal sensor option).
73 = Turbine mounted display (pulse access sensor option).

Turbine Only
XX = No electronics.

WILCLEAR® LACTATE CONCENTRATE

PROVEN ELECTRON DONOR EFFICIENCY AND DECHLORINATION KINETICS AT A LOW COST

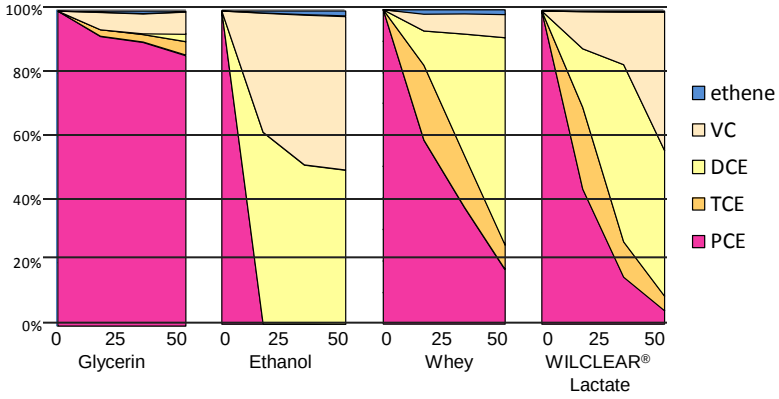
WILCLEAR® is a food grade 60% sodium or potassium lactate solution that has been deployed at U.S. Department of Energy sites and military installations, Superfund sites, mining sites, Brownfields, industrial sites, private chemical plants, and dry cleaners across North America and Europe. To date, WILCLEAR® has been used on over 250 projects in nearly every state in the US, including Hawaii and Alaska.

BENEFITS OF WILCLEAR®

- Provides carbon for rapid establishment of anaerobic conditions needed for reduction of nitrate, hexavalent chromium, perchlorate, and RDX.
- Miscibility in water and low viscosity allow for advective transport with groundwater; enhancing subsurface distribution and minimizing the number of injection points.
- Effective for both dissolved phase and DNAPL source area treatment.

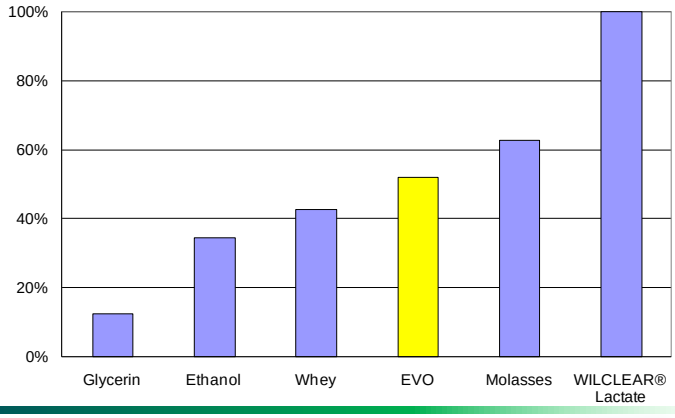
RAPID DECHLORINATION KINETICS

Microcosm studies comparing WILCLEAR® to other soluble donors show that while all four donors stimulate complete dechlorination of PCE to ethene, WILCLEAR® and ethanol have the fastest dechlorination kinetics.



GREATER DONOR EFFICIENCY

Efficiency (amount of contaminant remediated per unit donor added) should be considered when determining donor cost performance. Of the three donors that show both complete dechlorination and reasonable remediation rates, lactate has the best efficiency.



TYPICAL PROPERTIES

- WILCLEAR® sodium lactate (% wt/wt): 60 ± 1.2
- pH: 7 ± 1.0
- Viscosity: 110cP at 20ºC
- Specific gravity: 1.32 – 1.35
- Soluble in water
- Color: clear to light straw



JRW BIOREMEDIATION LLC

www.jrwbioremediation.com
(913)438-5544
info@jrwbiorem.com

Shuttle-Type Flow Switches
Series FS-200/400
Instruction Bulletin No. 45523 rev. R

Installation

Install FS-200 or FS-400 Series units in piping system using standard pipe fitting procedures. **Be careful to keep sealing compound out of the unit.** Be sure to observe direction of flow - marked **"IN"** and **"OUT"** on housing. **See chart below for port and wrench hex. sizes.**

Unless otherwise specified, standard FS-200 and FS-400 units are factory-calibrated with water. Factory calibrated FS-200 and FS-200 Adjustable units are installed horizontally, in line, with lead wires up. Factory calibrated FS-400 and FS-400 Adjustable units are installed vertically; lead wires up, as shown. All units can be installed in any orientation however slight calibration shifts can occur. Gems does not recommend lead wire down orientation as this may allow media debris to accumulate and prevent free shuttle movement under flow conditions. **150 micron filtration is suggested for use with all units.**

Specifications (FS-200 Series)

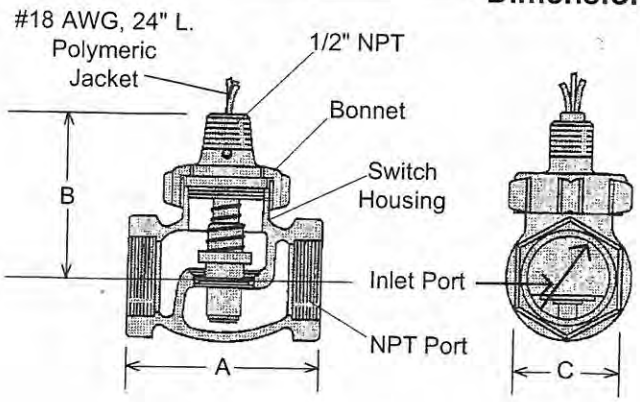
Wetted Materials	
Housing	
FS-200	Bronze or 316 Stainless Steel
FS-200 Adj.	Bronze
Shuttle	Teflon®
Bonnet	Bronze or Stainless Steel
Spring	316 Stainless Steel
Other Wetted Parts	Viton®, Ceramic
Pressure Rating	
Operating	400 PSIG @ 100°F (37.8°C)
Proof	800 PSIG @ 100°F (37.8°C)
Operating Temperature	
FS-200	-20°F to +300°F (-29°C to +148.9°C)
FS-200 Adj.	-20°F to +200°F (-29°C to +93.3°C)
Repeatability	1% Maximum Deviation
Set Point Accuracy	±10%
Set Point Differential	15% Maximum
Switch*	SPDT, 20 VA
Electrical Termination	No. 18 AWG, 24" L., Polymeric Lead Wires

Note: Bonnet and shuttle assembly should be removed from unit during welding or brazing.

(See bonnet assembly removal under "Maintenance" on back of sheet.)

***See "Electrical Data" on inside pages**

Dimensions (FS-200 Series)



Model	Port Size NPT	"A" Dim.	"B" Dim.	"C" Dim. (HEX)
FS-200 and FS-200 Adjustable	1"	3-1/4"	3"	1-25/32"
	1-1/4"	4"	3-3/16"	2-3/16"
	1-1/4" SS	4-1/2"	3-3/16"	2-3/16"
	1-1/2"	4-1/2"	3-1/2"	2-1/2"
	2"	5-3/8"	4"	3-3/32"
	2-1/2"	6-5/16"	4-1/2"	3-5/8"
	3"	7-3/8"	5-5/32"	4-3/8"

Adjustable versions available in 1" port sizes only.

Specifications (FS-400 Series) . . .

Wetted Materials	
Housing	Bronze
Shuttle	Delrin®
Spring	316 Stainless Steel
O-Ring	Viton®
Other Wetted Parts	Ceramic
Pressure Rating, Max.	
Operating	400 PSI @ 100°F (+37.8°C)
Proof	800 PSI @ 100°F (+37.8°C)
Operating Temperature	-20°F to +180°F (-29°C to +82.2°C)
Repeatability	1% Maximum Deviation
Set Point Accuracy	±10%
Set Point Differential	15% Maximum
Switch*	SPDT, 20 VA
Inlet/Outlet Ports	3/4" NPT
Electrical Termination	No. 18 AWG, 24" L., Polymeric Lead Wires

***See "Electrical Data" below.**

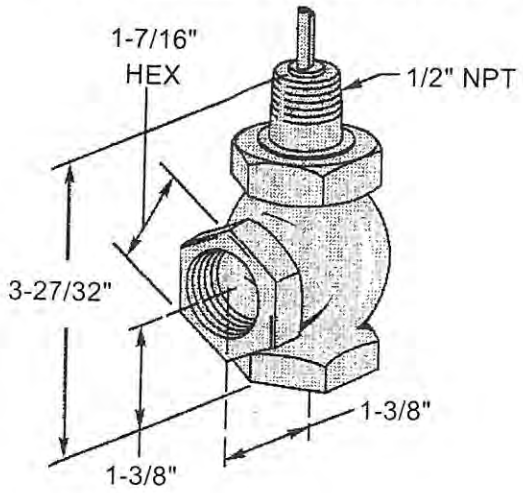
CE This product is suitable for Class I and Class II applications only, per the requirements of standard EN60730 and any additional specific requirements for a particular application or medium being sensed. Class I compliance of metal bodied units requires a ground connection between the metal body and the earthing system of the installation. Class I compliance of plastic bodied units in contact with a conductive medium requires that the medium be effectively earthed so as to provide an earthed barrier between the unit and accessible areas. For Class III compliance, a supply at safety extra-low voltage (SELV) must be provided. Please consult the Factory for compliance information on specific part numbers.

Electrical Data

Switch Ratings - Maximum Resistive Load

VA	Volts	Amps AC	Amps DC
10 General Use	0-50	.2	.13
	120	.08	N.A.
	100	N.A.	.3
20 Pilot Duty	0-30	.4	.3
	120	.17	.13
	240	.08	.06
50 General Use	0-50	0.5	0.5
	120	.4	.4
	240	.2	.2

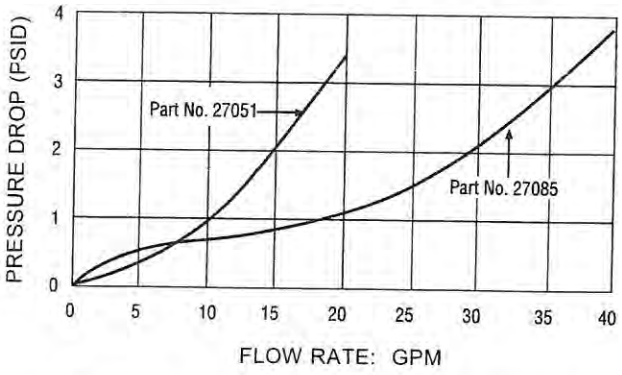
Dimensions (FS-400 Series)



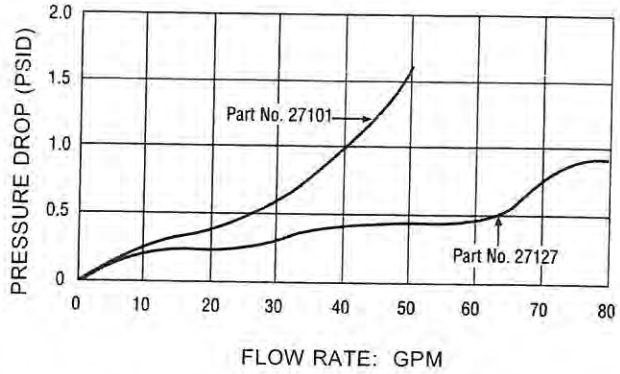
Pressure Drop Charts - Typical

FS-200 Series

1" NPT and 1-1/2" NPT Ports

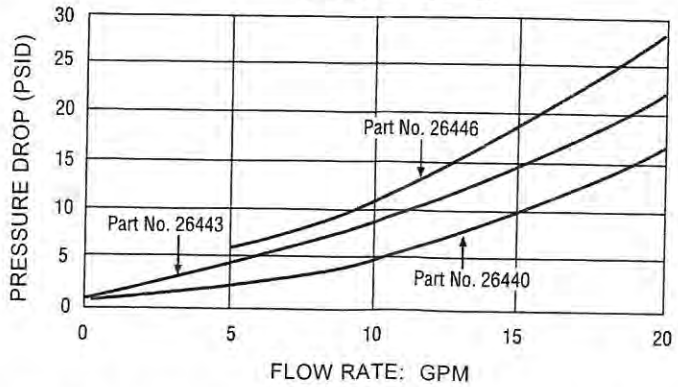


2" NPT and 3" NPT Ports



Note: Tests conducted with units in horizontal position (lead wires up) with water at +70°F (21°C).

FS-400 Series



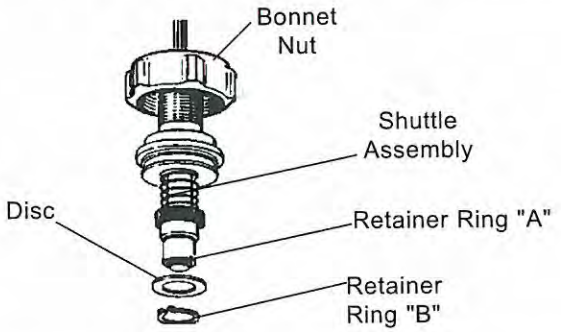
Note: Tests conducted with units in vertical position (lead wires up) with water at +70°F (21°C).

Electrical Connection . . .

Lead wires and 1/2" NPT or junction box with 1/2" NPT.

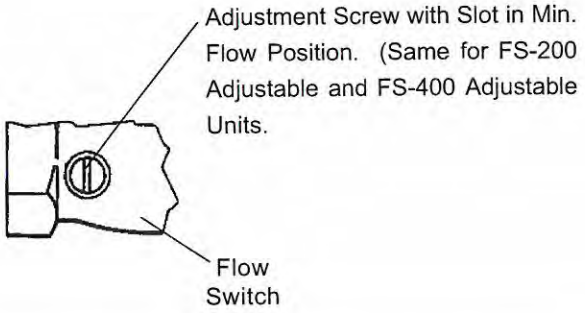
Maintenance . . .

Occasional cleaning when excessive contamination is present in the liquid is the only maintenance normally required. With system shut-down and no liquid in piping, remove bonnet nut to disassemble unit for cleaning. **It is not necessary to remove unit body from the system.** Remove retainer ring "A" for complete shuttle disassembly. Remove ring "B" to disassemble disc only.



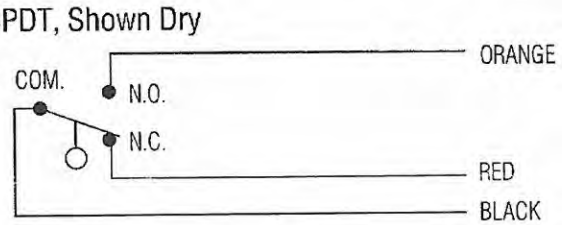
Flow Setting Adjustment . . .
(FS-200/400Adjustable and FS-400 Units.)

Standard units are normally supplied with adjustment set at "minimum flow" - adjustment screw slot (and vane within unit) in vertical position, as shown below. Adjustment may be made with unit on test stand or installed in system. With liquid flowing at desired rate, adjust screw in side of housing until unit just actuates. (Switch closes or opens, as desired.)



Typical Wiring Diagram . . .

FS-200/400 Series
(Fixed & Adjustable)



Important Points!

Product must be maintained and installed in strict accordance with the National Electrical Code and GEMS technical brochure and instruction bulletin. Failure to observe this warning could result in serious injuries or damages.

An appropriate explosion-proof enclosure or intrinsically safe interface device must be used for hazardous area applications involving such things as *(but not limited to)* ignitable mixtures, combustible dust and flammable materials.

*** Warning: To prevent ignition of flammable or combustible atmospheres, disconnect power before servicing.

Pressure and temperature limitations shown on individual catalog pages and drawings for the specified flow switches must not be exceeded. These pressures and temperatures take into consideration possible system surge pressures/temperatures and their frequencies.

Selection of materials for compatibility with the media is critical to the life and operation of GEMS flow switches. Take care in the proper selection of materials of construction; particularly wetted materials.

Life expectancy of switch contacts varies with applications. Contact GEMS if life cycle testing is required.

Ambient temperature changes do affect switch set points, since the specific gravity of a liquid can vary with temperature.

Flow switches have been designed to resist shock and vibration; however, shock and vibration should be minimized.

Liquid media containing particulate and/or debris should be filtered to ensure proper operation of GEMS products.

Electrical entries and mounting points may require liquid/vapor sealing if located in an enclosed tank.

Flow switches must not be field repaired.

Physical damage sustained by the product may render it unserviceable.

Gems Sensors Inc.
One Cowles Road
Plainville, CT
06062.1198

tel 860.747.3000
fax 860.747.4244

P/N 45523
Rev. R

TWISTIICLEAN

Installation Instructions for: 3/4-inch Model T2C-075
1-inch Model T2C-100
1 1/2-inch Model T2C-150

Installation and Operation Guide

Pre-Installation Checklist

A. Select a good filter location:
- ☐ Install on the pressure (outlet) side of any pumps and pressure tanks
- ☐ In a vertical position with Purge Exit pointing down
- ☐ Away from extreme weather conditions to protect from freezing
- ☐ At least 12 inches away from walls or obstructions, so top handle can be twisted
- ☐ Allow enough clearance beneath the unit to:
  - (a) attach a purge drain hose to the Purge Exit (recommended)
  - (b) remove the clear bowl assembly, to allow replacement of element as needed

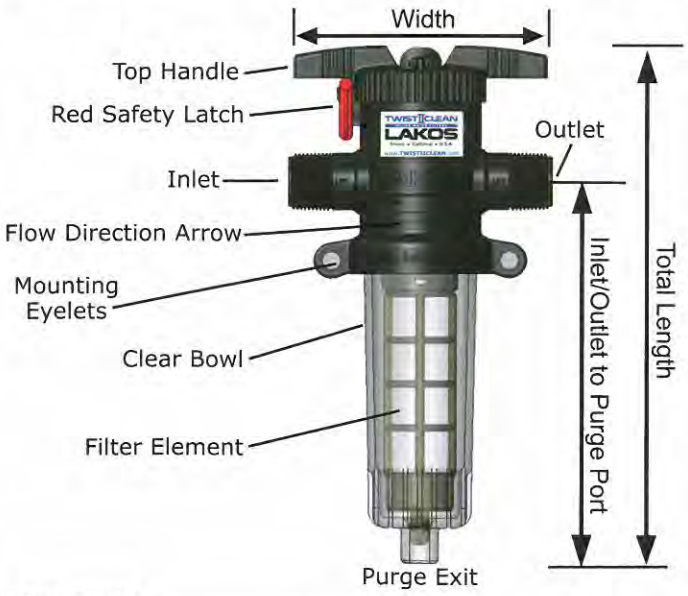
B. As a sunny outdoor installation might lead to algae growth inside the clear bowl and affect the operation of your TWISTIICLEAN, an optional Sun Shield is available.

Maximum Flow Ranges:
- T2C-075 ¾" Inlet/Outlet: 0 to 25 US gpm (0 to 5.7 m³/hr)
- T2C-100 1" Inlet/Outlet: 0 to 39 US gpm (0 to 8.9 m³/hr)
- T2C-150 1 ½" Inlet/Outlet: 0 to 78 US gpm (0 to 17.7 m³/hr)

Maximum Pressure:
- 100 psi at 73°F (6.9 bar at 38°C)

Temperature Range:
- 32°F - 120°F (0°C - 49°C)

Mesh Sizes:
- 30 Mesh (600 Micron) Element (Brown)
- 60 Mesh (250 Micron) Element (White)
- 100 Mesh (150 Micron) Element (Gray)
- 140 Mesh (105 Micron) Element (Black)
- 200 Mesh (74 Micron) Element (Blue)



Dimensions

Model	Inlet/Outlet	Purge	Total Length	Length (Inlet/Outlet to Purge Port)	Width (inlet/outlet)
T2C-075	¾" MPT	½" MPT	11¾"	8¾"	6"
T2C-100	1" MPT	½" MPT	11¾"	8¾"	6"
T2C-150	1½ MPT	¾" MPT	15¼"	11¾"	7½"

Installation In 7 Easy Steps

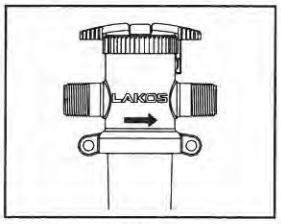


Fig A

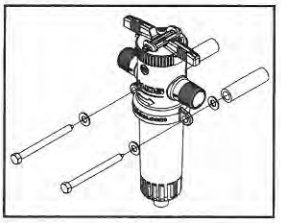


Fig B

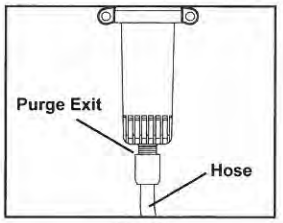


Fig C

1. Remove the TWISTIICLEAN from its box. Check to make sure the box also contains a small dispenser of Teflon tape and two slip/threaded adapters for use if needed.
2. Be sure the clear bowl is securely tightened (hand tighten only). The unit is shipped with the bowl loose. Lift the red safety latch and rotate the top handle a few times to make sure it will rotate ¼ clockwise turn.
3. Prepare the piping manifold to install TWISTIICLEAN. Select the best fittings for your installation, using slip or threaded fittings as desired. Notice the direction of water flow through the unit -- a flow direction arrow is molded into the side of the unit. (Fig A).
4. Use proper PVC solvents and follow gluing instructions on solvent container. Do not spill solvent on any part of the TWISTIICLEAN unit.
5. Mounting eyelets provide for a more stable installation (Fig B). Stabilizer bolts are recommended for long term stability of your TWISTIICLEAN. Use ⅜" Hex Lag Screws plus washers and PVC pipe to connect to a secure surface. These parts are NOT supplied with your TWISTIICLEAN.
6. Once installed, test by turning water supply on slowly, allowing water to feed through the unit. Check for leaks. After lifting the safety latch, twist the top handle with a ¼ clockwise turn to re-direct the flow for cleaning. This should lift the screen element inside the bowl and release flush water through the Purge Exit at the bottom of the unit. Twist the handle back to its "run" position, lower the safety latch and check for leaks.
7. Attach a flush drain hose (if necessary) to direct the purged particle matter and excess water to a drain or other desired area for discharge (Fig C).



SUN SHIELD

Optional Accessories

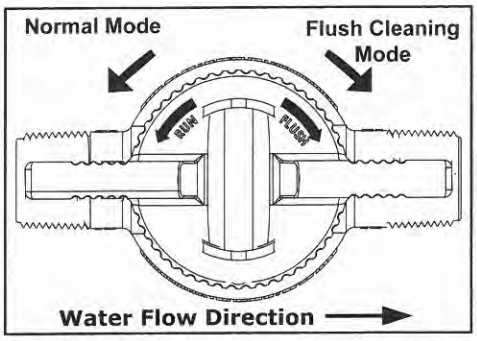
Sun Shield For Outdoor Installations

Black neoprene woven cover, slips over bowl to prevent growth of algae and other organics.

Model Size	Sun Shield Part Number
T2C-075 (¾") T2C-100 (1")	131355
T2C-150 (1-½")	132240

Using Your TWISTIICLEAN

TWISTIICLEAN removes sand and organics as the water passes through the filter element. Periodic cleaning is necessary to optimize filter performance, reduce the pressure loss and prolong the product life. When the filter element looks like it is filled with debris, it should be cleaned. Just a gentle 1/4 clockwise TWIST of the top handle begins the patented reverse flushing action. In just a few seconds, all debris are backwashed off the filter element and flushed out the bottom of the Purge Exit port. BE SURE TO RAISE THE SAFETY LATCH BEFORE TWISTING THE HANDLE AND LOWER IT AFTER FLUSHING.





For proper purging of your TWISTIICLEAN, lift the red safety latch prior to twisting the handle.

Maintenance and Troubleshooting

If for any reason the filter element does not clean completely during the normal Twist to Clean operation, manual cleaning may be needed. In this case, remove the bowl and clean the element with a soft nylon brush, brushing and running water across element.

Caution: If the filter bowl is to be removed, all water flow must be shut off going to the filter.

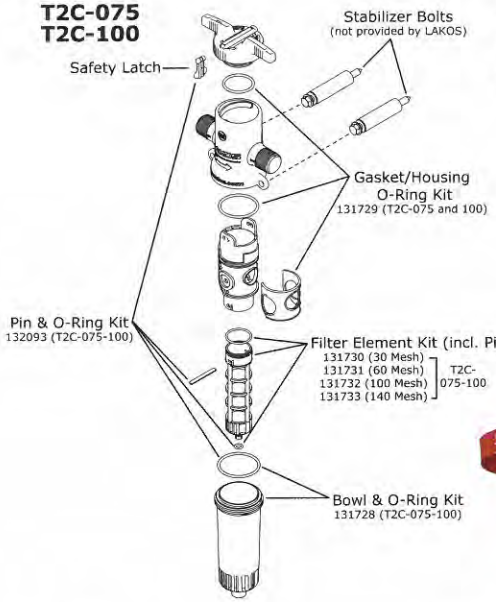
Safety Notes:

Despite the ease of installation and operation of the LAKOS TWISTIICLEAN product, certain precautions should be taken.

1. Lubricate "O" rings with NSF approved silicon grease only - Dow 111 is recommended.
2. Do not overtighten the threaded connections. Do not tighten more than a 1/4 turn past finger tight. Hand tighten the bowl, do not use tools.
3. Do not use wrenches on plastic filter parts. Use of tools on filter will void warranty.
4. For threaded connections, use the PTFE sealant tape provided with product.
5. Filter components that have "O" rings do not require thread sealant.
6. Remove clear bowl if the filter is to be installed using any solvent welding. This will prevent solvent damage to the clear bowl.
7. This filter is designed for use with water only. Other chemicals or components can damage the filter components. Evaluate all chemicals for proper usage with the filter.
8. Protect unit from freezing, as you would with any other water supply lines.
9. Follow all local and state codes, laws, and regulations when installing any filter.
10. If removal of the screen element is necessary, take care not to damage the element or the components that hold the element in place. The T2C-150 model has latching clips that hold the element in place. Do not spread the clips more than necessary to remove the element.

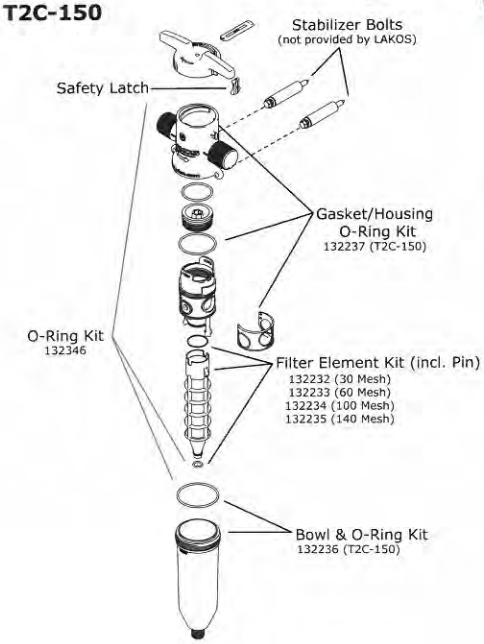
TWISTIICLEAN Exploded View and Spare Parts

T2C-075
T2C-100





T2C-150



Limited Warranty

The LAKOS TWISTIICLEAN is warranted to be free of material or workmanship defects for at least one year from delivery date.

If a fault develops, notify us, giving a complete description of the alleged malfunction. Include the model number(s), date of delivery and operating conditions of subject product(s). We will subsequently review this information and, at our option, supply you with either servicing data or shipping instruction and returned materials authorization. Upon prepaid receipt of subject product(s) at the instructed destination, we will then either repair or replace such product(s), at our option, and if determined to be a warranted defect, we will perform any products, damages or injuries resulting from misuse, neglect, normal expected wear, chemically-caused corrosion, improper installation or operation contrary to factory recommendation. Nor does it cover equipment that has been modifed, tampered with or altered without authorization. No other extended liabilities are stated or implied and this warranty in no event covers incidental or consequential damages, injuries or costs resulting from any such defective product(s).

TWISTIICLEAN
INLINE WATER FILTERS
LAKOS
www.TWISTIICLEAN.com

40271-419-04
06/2005
Lexington, KY, USA

Replaces 40271-419-04 dated 03/2005

Instruction Bulletin

QO® and Homeline® Load Centers

Class 1100

Retain for future use.

ENGLISH

INTRODUCTION

This bulletin contains instructions for the installation and operation of QO® and Homeline® load centers.

⚠ DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E.
- This equipment must only be installed and serviced by qualified electrical personnel.
- Turn off all power supplying this equipment before working on or inside equipment.
- Always use a properly rated voltage sensing device to confirm power is off.
- Replace all devices, doors and covers before turning on power to this equipment.
- Do not allow petroleum-based paints, solvents, or sprays to contact the nonmetallic parts of this product.
- Before starting a wiring installation or addition, consult a local building or electrical inspector for current National Electrical Code requirements. Local codes vary, but are adopted and enforced to promote safe electrical installations. A permit may be needed to do electrical work, and some codes may require an inspection of the electrical work.
- This equipment may not be suitable for use in corrosive environments present in agricultural buildings. See NEC 547 or CEC 2–400.

Failure to follow these instructions will result in death or serious injury.

PREPARATION

1. Determine the wiring or conduit requirements for the main and branch circuits, as required by local electrical codes.
2. Select the proper cable clamp, or use other approved methods for securing the cable or conduit to the enclosure.
3. Remove the appropriate knockouts required for installation of cable clamps or conduit (Table 1). To remove the knockouts, see Figure 1.

Table 1: Bolt-On Conduit Hubs for Outdoor Load Centers

Conduit	Hub No.
3/4 in.	B-075
1 in.	B-100
1-1/4 in.	B-125
1-1/2 in.	B-150
2 in.	B-200
2-1/2 in.	B-250

Figure 1: Removing the Knockouts



ENCLOSURE MOUNTING

Surface Mounting (Indoor or Outdoor)

Fasten the enclosure to the wall with screws or nails. Use all of the pre-cut holes in the back of the enclosure. See Figure 2.

Flush Mounting (Indoor Enclosure Only)

1. Remove the small mounting knockouts on the side of the enclosure. See Figure 3.
2. Position the load center so the front edge of the enclosure is flush with the finished wall.
3. Nail or screw through the small knockouts on the enclosure sides. See Figure 2.

Figure 2: Surface Mounting

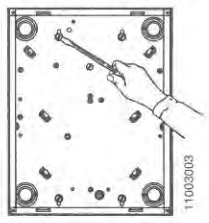
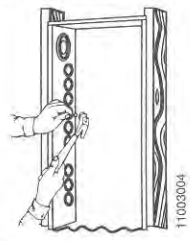


Figure 3: Flush Mounting



MAIN CIRCUIT BREAKER OR MAIN LUG WIRING

1. Pull the conductors into the enclosure. Use approved wire clamps, conduit bushings, or other approved methods to secure the conductor to the enclosure and prevent damage to the conductor insulation.
2. Connect the main and neutral wires.
   a. Install the main and neutral wires according to the load center wiring diagram.
   b. Connect the service ground, equipment grounding wire, or both as required by the local electrical code.
   c. Torque each connection to the value specified on the load center wiring diagram attached to the enclosure.
3. If required by the local code, install the enclosed green neutral bonding screw through the hole in the neutral bar. Thread the screw into the hole in the enclosure and torque to the value specified on the card shipped with the bonding screw.

BRANCH CIRCUIT BREAKER INSTALLATION AND REMOVAL

⚠ WARNING

HAZARD OF EQUIPMENT DAMAGE

This equipment is designed and tested by Square D® to performance levels which exceed Underwriter's Laboratories (UL) standards and Mexican Official Standards (NOM) listing.

Use only Square D circuit breakers and accessories.

Failure to follow this instruction can result in death or serious injury.

Standard Branch Circuit Breakers—Installation

1. Determine the wiring or conduit requirements for the branch circuit.
2. Turn OFF (O) circuit breaker.

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3. Install the wire terminal end of the circuit breaker to the mounting rail and push inward until the plug-on jaw fully engages the bus bar connector. Keep the bottom of the circuit breaker case against the mounting rail.
4. Remove the wire insulation from the branch wire as required. Install the branch wire into the load terminal of the branch circuit breaker.
5. Torque each branch circuit breaker connection to the value specified on the circuit breaker.
6. Torque each neutral and ground connection to the value specified on the load center circuit breaker.

Removal

1. Turn OFF (O) the circuit breaker. Remove the wires.
2. To disconnect the plug-on jaw from the connector and mounting rail, pull the circuit breaker outward until it disengages from the mounting rail. See Figure 4 or Figure 5 depending on the circuit breaker type.

Figure 4: QO Branch Circuit Breaker

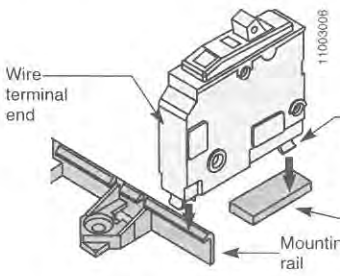
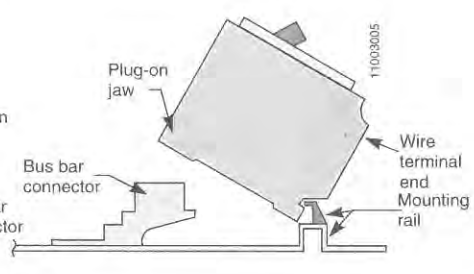


Figure 5: Homeline Branch Circuit Breaker



Tandem Branch Circuit Breakers—Installation

Install QOT and HOMT tandem-type circuit breakers only in single-phase load centers. Refer to the wiring diagram on the load center for the installation location.

1. Determine the wiring or conduit requirements for the branch circuit.
2. Turn OFF (O) the circuit breaker.
3. Hold the tandem circuit breaker at 30°–45° angle.
4. Install the wire terminal end of the circuit breaker into the mounting rail.
5. Rotate the circuit breaker inward until the plug-on jaw fully engages the bus bar connector. Keep the bottom of the circuit breaker case against the mounting rail.
6. Remove the wire insulation from the branch wire as required. Install the branch wire into the load terminal of the branch circuit breaker.
7. Torque each branch circuit breaker connection to the value specified on the circuit breaker.
8. Torque each neutral and ground connection to the value specified on the load center wiring diagram attached to the enclosure.

Removal

1. Turn OFF (O) the circuit breaker.
2. To disconnect the plug-on jaw from the connector, pull the circuit breaker outward until it disengages from the mounting rail. See Figure 6 or Figure 7, depending on the circuit breaker type.

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ENGLISH

Figure 6: QO Tandem Circuit Breaker

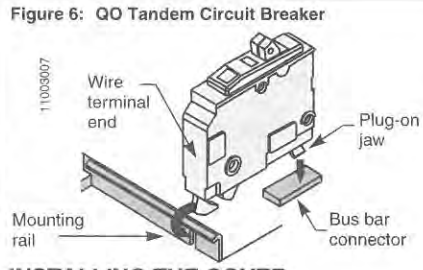
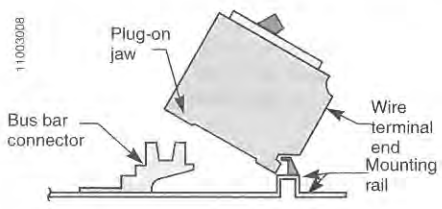


Figure 7: Homeline Tandem Circuit Breaker



INSTALLING THE COVER



Figure 8: Removing Twistouts

1. Remove the cover twistouts.
   a. Remove only enough twistouts to match the number of circuit breakers being installed.
   b. Twist out with pliers at the center of the twistout. See Figure 8.
   c. Close all unused open spaces in the cover using filler plates as listed on the cover directory label.
2. Attach the Spanish translation label, if supplied with the load center, to the rear of the cover. See Figure 9.
3. Identify the branch circuits on the directory label.
4. If the load center is used as service equipment, apply the "Service Disconnect" label to the part of the cover nearest the main circuit breaker handle. If the load center is not used as service equipment, apply the "Main" label to the part of the cover nearest the main circuit breaker handle.
5. Install the cover using the screws provided.

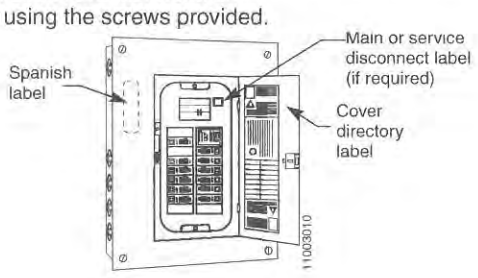


Figure 9: Label Locations

ENERGIZING THE LOAD CENTER

1. Before energizing the load center, turn off the main and all branch circuit breakers.
2. After power is turned on to the load center, first turn on the main circuit breaker and then turn on the branch circuit breakers.

Schneider Electric USA
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Lexington, KY 40511 USA
1-888-SquareD (1-888-778-2733)
www.us.SquareD.com

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

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United TRAILERS

Owner's Manual



BUILT FOR THE United TRAILERS LONG HAUL

25TH ANNIVERSARY



United TRAILERS

Owner's Manual

⚠ WARNING

This manual contains safety information and instructions for your trailer.

You must read this manual before loading or towing your trailer.

You must follow all safety precautions and instructions.

Contact Information

Address: *United Trailers*
19985 County Road 8
Bristol, Indiana 46507

Toll Free : *(800) 637-2592*
Phone : *(574) 848-7088*
Main Fax : *(574) 848-4643*
Parts Dept. Fax : *(574) 848-1815*
E-mail : *Sales@united-trailers.com*
Parts : *Parts@united-trailers.com*
Web site : *www.united-trailers.com*

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1 Safety Information

1.1 Safety Alert Symbols and Signal Words

Loss of control of the trailer or trailer/tow vehicle combination can result in death or serious injury. The most common causes for loss of control of the trailer are:

- Driving too fast for the conditions.
  (Maximum speed when towing a trailer is 60 mph).
- Overloading the trailer.
- Loading the trailer unevenly.
- Trailer improperly coupled to the hitch.
- Inadequate tow vehicle.
- Inadequate towing hitch.
- Improperly adjusted brakes.
- Not maintaining proper tire pressure.
- Not keeping lug nuts tight.
- Not properly maintaining the trailer structure.

An owner's manual that provides general trailer information cannot cover all of the specific details necessary for the proper combination of every trailer and tow vehicle. Therefore, you must read, understand and follow the instructions given by the tow vehicle manufacturer as well as the instructions in this manual.

Our trailers are built with components produced by various manufacturers. Some of these items have separate instruction manuals. Where this manual indicates that you should read another manual, and you do not have that manual, please call United Trailers at 1-800-637-2592 for a free copy.

The safety information in this manual is denoted by the safety alert symbol: ⚠

The level of risk is indicated by the following signal words:

⚠ Danger

DANGER – Immediate hazards that WILL result in severe personal injury or death if the warning is ignored.

⚠ WARNING

WARNING – Hazards or unsafe practices that COULD result in severe personal injury or death if the warning is ignored.

⚠ Caution

CAUTION – Hazards or unsafe practices that could result in minor or moderate injury if the warning is ignored.

1.2 MAJOR HAZARDS

Driving Too Fast

With ideal road conditions, the maximum speed when safely towing a trailer is 60 mph. If you drive too fast, the trailer tires will overheat and possibly blowout. As your speed increases, you are more likely to suddenly lose control. Never exceed 60 mph while towing the trailer.

⚠ WARNING

Driving too fast for conditions can result in loss of control and cause death or serious injury.

Decrease your speed as road, weather and lighting conditions deteriorate.

Failure to Adjust Handling While Towing a Trailer

- When towing a trailer, you will have decreased acceleration, increased stopping distance, and increased turning radius. This means you must make wider turns to keep from hitting curbs, vehicles, and anything else that is on the inside corner. In addition, you will need a longer distance to pass, due to slower acceleration and increased length. See Section 1.3 (Trailer Towing Guide) on page 17.
- Be alert for slippery conditions. You are more likely to be affected by slippery road surfaces when driving a tow vehicle with a trailer, than driving a tow vehicle without a trailer.
- Anticipate the trailer "swaying." Swaying is the trailer reaction to the air pressure wave caused by passing trucks and busses. Continued pulling of the trailer provides a stabilizing force to correct swaying. Do not apply the tow vehicle brakes to correct trailer swaying.
- Check rearview mirrors frequently to observe the trailer and traffic.
- Use lower gear when driving down steep or long grades. Use the engine and transmission as a brake. Do not ride the brakes, as they can overheat and become ineffective.
- Be aware of your trailer height, especially when approaching roofed areas and around trees.

Trailer Not Properly Coupled to the Hitch

It is critical that the trailer be securely coupled to the hitch and that the safety chains are correctly attached. Uncoupling while towing may result in death or serious injury.

⚠ WARNING

Proper selection and condition of the coupler and hitch are essential to safely towing your trailer. A loss of coupling may result in death or serious injury.

Be sure the hitch load rating is equal to or greater than the load rating of the coupler.

Be sure the hitch size matches the coupler size.

Observe the hitch for wear, corrosion and cracks before coupling.

Replace worn, corroded or cracked hitch components before coupling the trailer to the tow vehicle.

Be sure the hitch components are tight before coupling the trailer to the tow vehicle.

⚠ WARNING

An improperly coupled trailer can result in death or serious injury.

Do not move the trailer until:

- The coupler is secured and locked to the correct ball size.
- The safety chains are secured to the tow vehicle.
- The trailer jack(s) are fully retracted.

Do not tow the trailer on the road until:

- Tires and wheels are checked.
- The trailer brakes are checked.
- The breakaway switch is connected to the tow vehicle.
- The load is secured to the trailer.
- The trailer lights are connected and checked and lug nuts tightened.

Incorrect Use of Safety Chains

If your trailer comes loose from the hitch for any reason, we have provided safety chains so that control of the trailer can be maintained.

⚠ WARNING

Improper rigging of the safety chains can result in loss of control of the trailer and tow vehicle, leading to death or serious injury, if the trailer uncouples from the tow vehicle.

Fasten chains to frame of tow vehicle. Do not fasten chains to any part of the hitch unless the hitch has holes or loops specifically for that purpose.

Cross chains underneath hitch and coupler with enough slack to permit turning and to hold tongue up, if the trailer comes loose.

Incorrect Use of Breakaway Brake

Your trailer may be equipped with a breakaway brake system that can apply the brakes on your trailer if your trailer comes loose from the hitch. The safety chains and breakaway brake system must be in good condition and properly rigged to be effective. The breakaway brake system must not be used as a substitute for a parking brake.

⚠ WARNING

An ineffective or inoperative breakaway brake system can result in a runaway trailer, leading to death or serious injury if the coupler or hitch fails.

The breakaway cable must be connected to the tow vehicle and NOT to any part of the hitch.

Before towing the trailer, test the function of the breakaway brake system. If the breakaway brake system is not working, do not tow the trailer. Have it repaired or replaced by a qualified professional.

Mismatch of Trailer and Hitch

⚠ Danger

Use of a hitch with a load rating less than the load rating of the trailer can result in loss of control and may lead to death or serious injury.

Use of a tow vehicle with a towing capacity less than the load rating of the trailer can result in loss of control and may lead to death or serious injury.

Be sure your hitch and tow vehicle are rated for the Gross Vehicle Weight Rating (GVWR) of your trailer.

Unsafe Tires, Lug Nuts or Wheels

Trailer tires and wheels are more likely to fail than car tires and wheels because they carry a heavier load. Therefore, it is essential to inspect the trailer tires before each tow.

If a tire has a bald spot, bulge, cuts, is showing any cords, or is cracked replace the tire before towing. If a tire has uneven tread wear, take the trailer to a dealer service center for diagnosis. Tire imbalance, axle misalignment, incorrect inflation, overloading, or unevenly loading the trailer can cause uneven tread wear.

Tires with too little tread will not provide adequate tracking on wet roadways and can result in loss of control, leading to death or serious injury.

Improper tire pressure causes an unstable trailer and can result in a tire blowout and loss of control. Therefore, before each tow you must also check the tire pressure. Tire pressure must be checked when tires are cold. NOTE: Trailer tires will be inflated to higher pressures than passenger vehicle tires.

⚠ WARNING

Improper tire pressure can result in a blowout and loss of control, which can lead to death or serious injury.

Be sure tires are inflated to pressure indicated on sidewall before towing trailer.

Since trailer wheels and lug nuts (or bolts) are subjected to greater side loads than automobile wheels, they are more prone to loosen. Before each tow, check to make sure they are tight.

⚠ WARNING

Metal creep between the wheel rim and lug nuts will cause rim to loosen and could result in a wheel coming off, leading to death or serious injury.

Tighten lug nuts before each tow.

The proper tightness (torque) for lug nuts is listed in Section 7 (Inspection Service & Maintenance) on page 77. Use a torque wrench to tighten the lug nuts. If you do not have a torque wrench, use a lug wrench from your tow vehicle and tighten the nuts as much as you can. Then have a service garage or trailer dealer tighten the lug nuts to the proper torque.

⚠ WARNING

Lug nuts are prone to loosen after initial installation, which can lead to death or serious injury.

Check lug nuts for tightness on a new trailer or when wheel(s) have been remounted after the first 10, 25 and 50 miles of driving and before each tow thereafter. Failure to perform this check can result in a wheel parting from the trailer and a crash, leading to death or serious injury.

Be sure lug nuts are tight before each tow.

Overload

The total weight of the load you put in the trailer, plus the empty weight of the trailer, must not exceed the trailer's Gross Vehicle Weight Rating (GVWR). If you do not know the empty weight of the trailer, you must weigh it at a commercial scale. In addition, you must distribute the load in the trailer so that the load on any tire or axle does not exceed the tire load rating or the Gross Axle Weight Rating (GAWR).

⚠ WARNING

An overloaded trailer can result in loss of control of the trailer, leading to death or serious injury.

Do not exceed the trailer Gross Vehicle Weight Rating (GVWR) or an axle Gross Axle Weight Rating (GAWR).

Do not load a trailer so that the weight on any tire exceeds its rating.

Unsafe Load Distribution

Uneven load distribution can cause tire, wheel, axle or structural failure. Load the trailer properly with the weight evenly distributed from side-to-side and a proper proportion of the weight supported by the hitch.

Check to be sure that no axle is overloaded.

See Section 4 (Loading The Trailer) on page 63 for further information.

⚠ WARNING

Improper tongue weight (load distribution) can result in loss of control of the trailer, leading to death or serious injury.

Make certain that tongue weight is within the allowable range.

Be sure to:

Distribute the load front-to-rear to provide proper tongue weight. (See table on p. 10)

Distribute the load evenly, side-to-side, to avoid tire overload.

Keep the center of gravity low.

In the following table, the second column notes the recommended percentage of Gross Vehicle Weight (GVW) that the tongue of the trailer should support. The Gross Vehicle Weight Rating (GVWR) of your trailer is located on the Certification Label that is mounted on the lower roadside front of the trailer body.

For example, a trailer with a gooseneck hitch and a loaded weight of 12,000 pounds should have 20-25%, or 2,400 to 3,000 pounds, on the tongue. This practice is accepted by many trailer manufacturers.

Tongue Weight as a Percentage of Loaded Trailer Weight

Type of Hitch	Percentage
Ball Hitch (or Bumper Hitch)	10–15%
Gooseneck Hitch	20–25%
Fifth Wheel Hitch	

Towing stability also depends on keeping the center of gravity as low as possible. Load heavy items on the floor over the axles, but do not exceed the Gross Axle Weight Rating (GAWR). Be sure to maintain even side-to-side weight distribution and proper tongue weight.

Shifting Cargo

Since the trailer "ride" can be bumpy and rough, you must secure your cargo so that it does not shift while the trailer is being towed. See Section 4.2 (Securing The Cargo) on page 65 for further information.

⚠ WARNING

Shifting cargo can result in loss of control of the trailer and can lead to death or serious injury.

Tie down all loads with proper sized fasteners, ropes, straps, etc.

⚠ WARNING

If the door opens, your cargo may be ejected onto the road, resulting in death or serious injury to other drivers.

Use a linchpin, padlock, or lock the RV lock to prevent the door latch from opening.

Always secure the door latch after closing.

Inappropriate Cargo

Your trailer may be designed for specific cargo. If your trailer is designed for specific cargo, only carry that cargo in the trailer. A utility trailer must not be used to carry certain items, such as people, containers of hazardous substances or containers of flammable substances.

⚠ WARNING

Do not transport people inside the trailer, even if it has living quarters. The transport of people puts their lives at risk and may be illegal.

⚠ WARNING

Do not transport flammable, explosive, poisonous or other dangerous materials in your trailer.

Inoperable Brakes, Lights or Mirrors

Be sure that the electric brakes and all of the lights on your trailer are functioning properly before towing your trailer. A multi-pin electrical connector controls electric brakes and lights. Check the trailer lights by turning on your tow vehicle lights. Check the trailer brake lights by having someone step on the tow vehicle brake pedal while you look at the trailer lights. Do the same thing to check the turn signal lights.
If your trailer has electric brakes, your tow vehicle must have an electric brake controller (not supplied by United Trailers) that sends power to the trailer brakes. Before towing the trailer, you must operate the brake controller while trying to pull the trailer in order to confirm that the electric brakes operate. While towing the trailer at less than 5 mph, manually operate the electric brake controller in the tow vehicle cab. You should feel the operation of the trailer brakes.

⚠ WARNING

Improper electrical connection between the tow vehicle and the trailer will result in inoperable lights and electric brakes which can lead to a collision.

Before each tow:

Check that the taillights, brake lights and turn signals work.

Check that the electric brakes work by operating the brake controller inside the tow vehicle.

Standard side mirrors usually do not provide adequate visibility for viewing traffic to the sides and rear of a towed trailer. You must provide mirrors that allow you to safely observe approaching traffic.

Hazards From Modifying Your Trailer

Altering your trailer can damage essential safety items. Even driving a nail or screw can damage an electrical circuit, LP gas line or other feature of the trailer.

Before making any alteration to your trailer, contact your dealer or United Trailers at 1-800-637-2592 and describe the alteration you are considering. Alteration of the trailer structure or modification of mechanical, electrical, plumbing, heating or other systems on your trailer must be performed only by qualified professionals who are familiar with the system as installed.

The United Trailers warranty does not extend to equipment which has been modified, repaired or altered in any way without the express written consent of United Trailers.

Hazards from Accessories

Section 6 (Accessories) on page 69 of this manual contains information about optional accessories that may be on your trailer. Read and follow all of these instructions before operating the accessories.

Generator

If your trailer is equipped with a generator, you must follow the generator manufacturer's instructions. You must also have one or more carbon monoxide detectors in the trailer's accommodation spaces.

Carbon monoxide is an odorless gas that can cause death. You must have an operating carbon monoxide detector inside the accommodation spaces of your trailer. Be certain exhaust from a running generator does not accumulate in or around your trailer by situations such as:

- Being drawn in by fans or ventilators operated in a trailer.
- A prevailing wind.
- Being trapped between your trailer and other trailers, vehicles, buildings, snow banks or other nearby objects

⚠ WARNING

Operating generators can lead to death or serious injury by:

Carbon monoxide

Fire and explosion

Electrocution

Have a working carbon monoxide detector in the accommodation spaces before operating a generator.

Do not refuel a running generator or refuel near ignition sources.

Shore Power

"Shore Power" is the name given to connecting your trailer to a source of electrical power using an extension cord specifically designed for that purpose.

⚠ WARNING

Shore power poses a risk of death due to electrocution or fire.

Always use an electrical cord specifically designed for a shore power connection. Never use an ordinary extension cord.

Always connect the electrical cord to a grounded source of shore power.

Do not remove the third (ground) prong from the shore power plug.

Connect only to a source of proper voltage.

Make certain polarity is correct.

Do not overload electrical circuits.

Always replace fuses or circuit breakers with correct rating.

Always inspect the cord for defects before using.

LP Gas Fuel System

⚠ Danger

You can die or be brain damaged by carbon monoxide.

Make certain the exhaust from LP appliances is directed to the outdoors.

Have a working carbon monoxide detector in the accommodation spaces of your trailer before operating any LP gas appliance.

Do not operate portable grills or stoves inside the trailer.

⚠ WARNING

Risk of death due to fire or explosion.

Only connect an LP gas system to a supply of LP gas, NOT natural gas.

Do not store LP gas tanks inside the trailer.

Only fill an LP gas tank 80% full.

Only fill the tank with LP gas (propane).

Overfilled tanks can release gas and cause an explosion.

⚠ WARNING

Risk of fire or explosion.

If LP gas is detected by smell or by the LP gas detector:

- Do not touch electrical switches.
- Extinguish flames and pilot lights.
- Open doors for ventilation.
- Shut off LP gas supply at the LP tank.
- Leave the area until odor clears.

Correct the source of LP gas leakage before using LP appliances.

Do not use a flame to locate the source of an LP gas leak.

⚠ WARNING

Risk of fire or explosion.

Never attempt to thaw an LP gas regulator. Seek a qualified service technician to fix.

Do not remove the regulator cover or attempt to service the LP gas regulator.

1.2.5 REPORTING SAFETY DEFECTS

If you believe that your vehicle has a defect that could cause a crash, injury or death, you should immediately inform the National Highway Traffic Safety Administration (NHTSA) in addition to notifying United Trailers at 1-800-637-2592.

If NHTSA receives similar complaints, it may open an investigation. If it finds that a safety defect exists in a group of vehicles, it may order a recall and remedy campaign. However, NHTSA cannot become involved in individual problems between you, your dealer, or United Trailers.

To contact NHTSA, you may either call the Vehicle Safety Hotline toll-free at 1-888-327-4236 (TTY: 1-800-424-9153), go to http://www.safercar.gov; or write to:

Administrator
NHTSA
1200 New Jersey Avenue S.E.
Washington, DC 20590

You can also obtain other information about motor vehicle safety from http://www.safercar.gov.

Call 1-800-637-2592 to reach United Trailers.

1.3 TRAILER TOWING GUIDE

- Driving a vehicle with a trailer in tow is vastly different from driving the same vehicle without a trailer in tow. It takes longer to get up t speed. You need more room to turn and pass, and more distance t stop when towing a trailer. You will need to spend time adjusting t the different feel and maneuverability of the tow vehicle with a loaded trailer. Because of the significant differences in all aspects of maneuverability when towing a trailer, the hazards and risks of injury are also much greater than when driving without a trailer. Y are responsible for keeping your vehicle and trailer in control, and for all the damage that is caused if you lose control of your vehicle and trailer.
- Find an open area with little or no traffic for your first practice. Before you start towing the trailer, you must follow all of the instructions for inspection, testing, loading and coupling. Adjust th mirrors so you can see the trailer as well as the area to the rear.
- Drive slowly at first, 5 mph or so, and turn the wheel to get the feel of how the tow vehicle and trailer combination responds. Next, make some right and left hand turns. Watch in your side mirrors t see how the trailer follows the tow vehicle. Note that turning with a trailer attached requires more room.
- Stop the rig a few times from speeds no greater than 10 mph. Not the effect that the trailer brakes have when they are the only brake used. When properly adjusted, the trailer brakes will come on just before the tow vehicle brakes.
- It will take practice to learn how to back up with a trailer attached. Take it slow. Before backing up, get out of the tow vehicle and loo behind the trailer to make sure that there are no obstacles. If you place your hands at the bottom of the steering wheel, and with the tow vehicle in reverse, move your hands to the right (counter-clockwise), the rear of the trailer moves to the right. Conversely, rotating the steering wheel to the left (clockwise) with your hands a the bottom of the wheel, the trailer moves to the left. Be careful n to allow the trailer to turn too much, because it may hit the tow vehicle. To straighten the rig out, simply pull forward.

1.4 SAFE TRAILER TOWING GUIDELINES

- Recheck the load tie downs to make sure the load will not shift during towing.
- Before towing, check coupling, safety chains, safety brake, tires, wheels and lights.
- Check the breakaway battery. Make sure it is fully charged.
- Check the lug nuts or bolts for tightness.
- Check coupler tightness after towing 50 miles.
- Adjust the brake controller to engage the trailer brakes before the tow vehicle brakes. Your dealer can assist you by making this adjustment.
- Use your mirrors to verify that you have room to change lanes or pull into traffic.
- Use your turn signals well in advance.
- Allow plenty of stopping distance for your trailer and tow vehicle.
- Do not drive so fast that the trailer begins to sway due to speed. Never drive faster than 60 mph.
- Allow plenty of room for passing. A rule of thumb is that the passing distance with a trailer is 4 times the passing distance without a trailer.
- Shift your automatic transmission into a lower gear for city driving (check tow vehicle Owner's Manual).
- Use lower gears for climbing and descending grades.
- Do not ride the brakes while descending grades; they may get so hot that they stop working. Then you will potentially have a runaway tow vehicle and trailer.
- Slow down for bumps in the road. Take your foot off the brake when crossing the bump.
- Do not brake while in a curve unless absolutely necessary. Instead, slow down before you enter the curve and power through the curve. The towing vehicle will then remain in control of the trailer.
- Do not apply the tow vehicle brakes to correct extreme trailer swaying. Continued pulling of the trailer, and even slight acceleration, or carefully applying the trailer brakes (using the electronic brake controller) will provide a stabilizing force.

- Make regular stops to confirm:
  - The coupler is secure to the hitch and is locked.
  - Electrical connections are made.
  - There is appropriate slack in the safety chains.
  - There is appropriate slack in the breakaway switch pull-pin cable.
  - The tires are not visibly low on pressure.
  - The cargo is secure and in good condition.

1.5 Safety Warning Labels on Your Trailer

Check your United Trailer for warning and instruction labels. If you hav any questions regarding the labels, call United Trailers at 1-800-637-2592.

⚠ WARNING

To protect you and others against death or serious injury, all labels tha apply to your trailer must be on the trailer and must be legible.

Call United Trailers at 1-800-637-2592 for free replacement labels.

You will need to provide us with the number shown at the bottom of the label(s) in order for us to send the correct one(s). If there is no numbe on the label, a description of the label and the text on the label will b necessary.

2 Tire Safety Information

This portion of the User's Manual contains tire safety information as required by 49 CFR 575.6.

Section 2.1 contains "Steps for Determining Correct Load Limit – Trailer".

Section 2.2 contains "Steps for Determining Correct Load Limit – Tow Vehicle".

Section 2.3 contains a Glossary of Tire Terminology

Section 2.4 contains information from the NHTSA brochure entitled "Tire Safety – Everything Rides On It". This brochure, as well as the preceding subsections, describes the following items:

- Tire labeling, including a description and explanation of each marking on the tires, and information about the DOT Tire Identification Number (TIN).
- Recommended tire inflation pressure, including a description and explanation of:
  A. Cold inflation pressure.
  B. Vehicle Placard and location on the vehicle.
  C. Adverse safety consequences of under inflation (including tire failure).
  D. Measuring and adjusting air pressure for proper inflation.
- Tire Care, including maintenance and safety practices.
- Vehicle load limits, including a description and explanation of the following items:
  A. Locating and understanding the load limit information, total load capacity, and cargo capacity.
  B. Calculating total and cargo capacities with varying seating configurations including quantitative examples showing / illustrating how the vehicles cargo and luggage capacity decreases as combined number and size of occupants' increases. This item is also discussed in Section 3.
  C. Determining compatibility of tire and vehicle load capabilities.
  D. Adverse safety consequences of overloading on handling and stopping on tires.

2.1 STEPS FOR DETERMINING CORRECT LOAD LIMIT – TRAILER

Determining the load limits of a trailer includes more than understandi the load limits of the tires alone. On all trailers there is a Federal certification/VIN label that is located on the forward half of the left (roa side of the trailer. This certification/VIN label will indicate the trailer's Gross Vehicle Weight Rating (GVWR). This is the most weight the full loaded trailer can weigh. It will also provide the Gross Axle Weight Rating (GAWR). This is the most weight a particular axle can carry. If there are multiple axles, the GAWR of each axle will be provided.

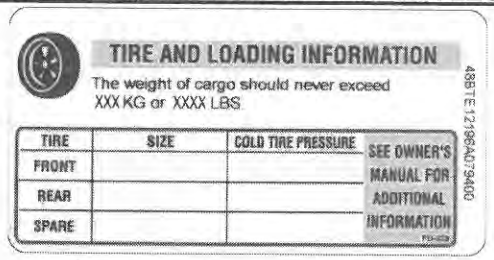
If your trailer has a GVWR of 10,000 pounds or less, there is a vehicle placard located in the same location as the certification label describe above. This placard provides tire and loading information. In addition, this placard will show a statement regarding maximum cargo capacity. Cargo can be added to the trailer, up to the maximum weight specifie on the placard. The combined weight of the cargo is provided as a single number. In any case, remember: the total weight of a fully loade trailer cannot exceed the stated GVWR.

For trailers with living quarters installed, the weight of water and propane also need to be considered. The weight of fully filled propane containers is considered part of the weight of the trailer before it is loaded with cargo, and is not considered part of the disposable cargo load. Water however, is a disposable cargo weight and is treated as such. If there is a fresh water storage tank of 100 gallons, this tank when filled would weigh about 800 pounds. If more cargo is being transported, water can be off-loaded to keep the total amount of cargo added to the vehicle within the limits of the GVWR so as not to overlo the vehicle. Understanding this flexibility will allow you, the owner, to make choices that fit your travel needs.

When loading your cargo, be sure it is distributed evenly to prevent overloading front to back and side to side. Heavy items should be placed low and as close to the axle positions as reasonable. Too man items on one side may overload a tire. The best way to know the actu weight of the vehicle is to weigh it at a public scale. Talk to your deale to discuss the weighing methods needed to capture the various weigh related to the trailer.

Excessive loads and/or underinflation cause tire overloading and, as a result, abnormal tire flexing occurs. This situation can generate an excessive amount of heat within the tire. Excessive heat may lead to tire failure. It is the air pressure that enables a tire to support the load, so proper inflation is critical. The proper air pressure may be found on the certification/VIN label and/or on the Tire Placard. This value should never exceed the maximum cold inflation pressure stamped on the tire.

TRAILERS 10,000 POUNDS GVWR OR LESS



Tire and Loading Information Placard – Figure 1-1

1. Locate the statement, "The weight of cargo should never exceed XXX kg or XXXX lbs.," on your vehicle's placard. See figure 1-1.
2. This figure equals the available amount of cargo load capacity.
3. Determine the combined weight of cargo being loaded on the vehicle. That weight may not exceed the available cargo load capacity.

The trailer's placard refers to the Tire Information Placard attached adjacent o or near the trailer's VIN (Certification) label at the left front of the trailer.

2.2 TRAILERS OVER 10,000 POUNDS GVWR

Note: These trailers are not required to have a tire information placard on the vehicle

1. Determine the empty weight of your trailer by weighing the trailer using a public scale or other means. This step does not have to be repeated.
2. Locate the GVWR (Gross Vehicle Weight Rating) of the trailer on your trailer's VIN (Certification) label.
3. Subtract the empty weight of your trailer from the GVWR stated on the VIN label. That weight may not exceed the available cargo load capacity.

2.3 Steps for Determining Correct Load Limit – Tow Vehicle

1. Locate the statement, "The combined weight of occupants and cargo should never exceed XXXX lbs.," on your vehicle's placard.
2. Determine the combined weight of the driver and passengers who will be riding in your vehicle.
3. Subtract the combined weight of the driver and passengers from XXX kilograms or XXXX pounds.
4. The resulting figure equals the available amount of cargo capacity. For example, if the "XXXX" amount equals 1400 lbs. and there will be five 150 lb. passengers in your vehicle, the amount of available cargo capacity is 650 lbs. (1400-750 (5 x 150) = 650 lbs.).
5. Determine the combined weight of cargo being loaded on the vehicle. That weight may not safely exceed the available cargo capacity calculated in Step #4.
6. If your vehicle will be towing a trailer, load from your trailer will be transferred to your vehicle. Consult the tow vehicle's manual to determine how this weight transfer reduces the available cargo capacity of your vehicle.

2.4 Glossary of Tire Terminology

Bias ply tire
A pneumatic tire in which the ply cords that extend to the beads are laid at alternate angles substantially less than 90 degrees to the centerline of the tread.

Cold inflation pressure
The pressure in the tire before you drive.

Curb weight
The weight of a motor vehicle with standard equipment including the maximum capacity of fuel, oil, and coolant, and, if so equipped, air conditioning and additional weight optional engine.

Gross Axle Weight Rating
The maximum weight that any axle can support, as published on the Certification / VIN label on the front left side of the trailer.

Gross Vehicle Weight Rating
The maximum weight of the fully loaded trailer, as published on the Certification/VIN label.

Hitch Weight
The downward force exerted on the hitch by the trailer coupler.

Light truck (LT) tire
A tire designated by its manufacturer as primarily intended for use on lightweight trucks or multipurpose passenger vehicles.

Load rating
The maximum load that a tire is rated to carry for a given inflation pressure.

Radial ply tire
A pneumatic tire in which the ply cords that extend to the beads are laid at substantially 90 degrees to the centerline of the tread.

Recommended inflation pressure
This is the inflation pressure provided by the vehicle manufacturer on the Tire Information label and on the Certification / VIN tag.

PSI (Pounds per Square Inch)
Recommended tire pressure.

Special Trailer (ST) tire
The "ST" is an indication the tire is for trailer use only.

Treadwear indicators (TWI)
The projections within the principal grooves designed to give a visual indication of the degrees of wear of the tread.

2.5 Tire Safety – Everything Rides On It

The National Traffic Safety Administration (NHTSA) has published a brochure (DOT HS 809 361) that discusses all aspects of Tire Safety, required by CFR 575.6. This brochure is reproduced in part below. It can be obtained and downloaded from NHTSA, free of charge, from th following web site:

http://www.nhtsa.dot.gov/cars/rules/TireSafety/ridesonit/tires_index.htr

Studies of tire safety show that maintaining proper tire pressure, observing tire and vehicle load limits (not carrying more weight in your vehicle than your tires or vehicle can safely handle), avoiding road hazards, and inspecting tires for cuts, slashes, and other irregularities are the most important things you can do to avoid tire failure, such as tread separation or blowout and flat tires. These actions, along with other care and maintenance activities, can also:

- Improve vehicle handling
- Help protect you and others from avoidable breakdowns and accidents
- Improve fuel economy
- Increase the life of your tires.

This booklet presents a comprehensive overview of tire safety, includi information on the following topics:

- Basic tire maintenance
- Uniform Tire Quality Grading System
- Fundamental characteristics of tires
- Tire safety tips.

Use this information to make tire safety a regular part of your vehicle maintenance routine. Recognize that the time you spend is minimal compared with the inconvenience and safety consequences of a flat ti or other tire failure.

.6 Safety First–Basic Tire Maintenance

Properly maintained tires improve the steering, stopping, traction, and load-carrying capability of your vehicle. Underinflated tires and overloaded vehicles are a major cause of tire failure. Therefore, as mentioned above, to avoid flat tires and other types of tire failure, you should maintain proper tire pressure, observe tire and vehicle load limits, avoid road hazards, and regularly inspect your tires.

.7 Finding Your Vehicle's Recommended Tire Pressure and Load Limits

Tire information placards and vehicle certification labels contain information on tires and load limits. These labels indicate the vehicle manufacturer's information including:

- Recommended tire size
- Recommended tire inflation pressure
- Vehicle capacity weight (VCW–the maximum occupant and cargo weight a vehicle is designed to carry)
- Front and rear gross axle weight ratings (GAWR– the maximum weight the axle systems are designed to carry).

Both placards and certification labels are permanently attached to the trailer near the left front.

2.8 Understanding Tire Pressure and Load Limits

Tire inflation pressure is the level of air in the tire that provides it with load-carrying capacity and affects the overall performance of the vehicle. The tire inflation pressure is a number that indicates the amou of air pressure– measured in pounds per square inch (psi)–a tire requires to be properly inflated. (You will also find this number on the vehicle information placard expressed in kilopascals (kPa), which is th metric measure used internationally.)

Manufacturers of passenger vehicles and light trucks determine this number based on the vehicle's design load limit, that is, the greatest amount of weight a vehicle can safely carry and the vehicle's tire size. The proper tire pressure for your vehicle is referred to as the "recommended cold inflation pressure." (As you will read below, it is difficult to obtain the recommended tire pressure if your tires are not cold.)

Because tires are designed to be used on more than one type of vehicle, tire manufacturers list the "maximum permissible inflation pressure" on the tire sidewall. This number is the greatest amount of a pressure that should ever be put in the tire under normal driving conditions.

2.9 Checking Tire Pressure

It is important to check your vehicle's tire pressure at least once a mo for the following reasons:

- Most tires may naturally lose air over time.
- Tires can lose air suddenly if you drive over a pothole or other object or if you strike the curb when parking.
- With radial tires, it is usually not possible to determine underinflati by visual inspection.

For convenience, purchase a tire pressure gauge to keep in your vehicle. Gauges can be purchased at tire dealerships, auto supply stores, and other retail outlets.

The recommended tire inflation pressure that vehicle manufacturers provide reflects the proper psi when a tire is cold. The term cold does not relate to the outside temperature. Rather, a cold tire is one that ha not been driven on for at least three hours. When you drive, your tires get warmer, causing the air pressure within them to increase. Therefo to get an accurate tire pressure reading, you must measure tire pressure when the tires are cold or compensate for the extra pressure warm tires.

2.10 Steps for Maintaining Proper Tire Pressure

- Step 1: Locate the recommended tire pressure on the vehicle's tire information placard, certification label, or in the owner's manual.
- Step 2: Record the tire pressure of all tires.
- Step 3: If the tire pressure is too high in any of the tires, slowly release air by gently pressing on the tire valve stem with the edge of your tire gauge until you get to the correct pressure.
- Step 4: If the tire pressure is too low, note the difference between the measured tire pressure and the correct tire pressure. These "missing" pounds of pressure are what you will need to add.
- Step 5: At a service station, add the missing pounds of air pressure to each tire that is underinflated.
- Step 6: Check all the tires to make sure they have the same air pressure.

2.11 Tire Size

To maintain tire safety, purchase new tires that are the same size as the vehicle's original tires or another size recommended by the manufacturer. Look at the tire information placard, the owner's manual, or the sidewall of the tire you are replacing to find this information. If you have any doubt about the correct size to choose, consult with the tire dealer.

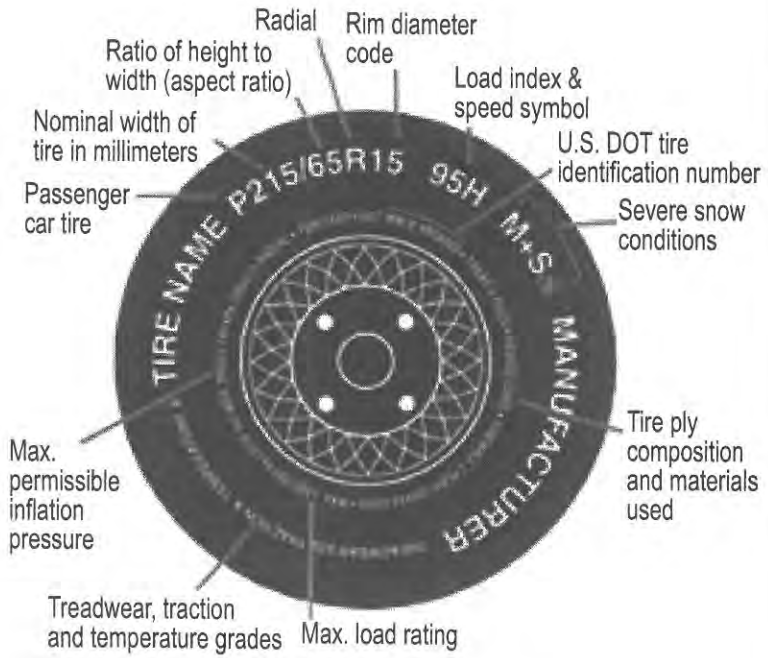
2.12 Tire Repair

The proper repair of a punctured tire requires a patch for the hole and a patch for the area inside the tire that surrounds the puncture hole. Punctures through the tread can be repaired if they are not too large, but punctures to the sidewall should not be repaired. Tires must be removed from the rim to be properly inspected before being patched.

2.13 TIRE FUNDAMENTALS

Federal law requires tire manufacturers to place standardized information on the sidewall of all tires. This information identifies and describes the fundamental characteristics of the tire and also provides tire identification number for safety standard certification and in case o a recall.

Please refer to the diagram below.
NOTE: This is a passenger tire example.



P
The "P" indicates the tire is for passenger vehicles.

Next number
This three-digit number gives the width in millimeters of the tire from sidewall edge to sidewall edge. In general, the larger the number, the wider the tire.

Next number
This two-digit number, known as the aspect ratio, gives the tire's ratio of height to width. Numbers of 70 or lower indicate a short sidewall for improved steering response and better overall handling on dry pavement.

R
The "R" stands for radial. Radial ply construction of tires has been the industry standard for the past 20 years.

Next number
This two-digit number is the wheel or rim diameter in inches. If you change your wheel size, you will have to purchase new tires to match the new wheel diameter.

Next number
This two- or three-digit number is the tire's load index. It is a measurement of how much weight each tire can support. You may find this information in your owner's manual. If not, contact a local tire dealer. Note: You may not find this information on all tires because it is not required by law.

M+S
The "M+S" or "M/S" indicates that the tire has some mud and snow capability. Most radial tires have these markings; hence, they have some mud and snow capability.

Speed Rating
The speed rating denotes the speed at which a tire is designed to be driven for extended periods of time. Please remember, no trailer is to be hauled at speeds exceeding 60MPH.

U.S. DOT Tire Identification Number
This begins with the letters "DOT" and indicates that the tire meets all federal standards. The next two numbers or letters are the plant code where it was manufactured, and the last four numbers represent the week and year the tire was built. For example, the numbers 3197 mea the 31st week of 1997. The other numbers are marketing codes used the manufacturer's discretion. This information is used to contact consumers if a tire defect requires a recall.

Tire Ply Composition and Materials Used
The number of plies indicates the number of layers of rubber-coated fabric in the tire. In general, the greater the number of plies, the more weight a tire can support. Tire manufacturers also must indicate the materials in the tire, which include steel, nylon, polyester, and others.

Maximum Load Rating
This number indicates the maximum load in kilograms and pounds tha can be carried by the tire.

Maximum Permissible Inflation Pressure
This number is the greatest amount of air pressure that should ever b put in the tire under normal driving conditions.

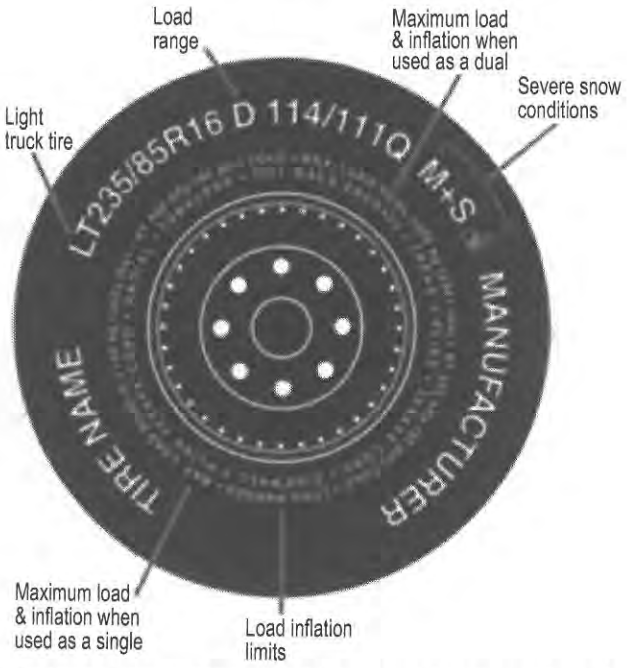
Treadwear Number
This number indicates the tire's wear rate. The higher the treadwear number is, the longer it should take for the tread to wear down. For example, a tire graded 400 should last twice as long as a tire graded 200.

Traction Letter
This letter indicates a tire's ability to stop on wet pavement. A higher graded tire should allow you to stop your car on wet roads in a shorte distance than a tire with a lower grade. Traction is graded from highes to lowest as "AA","A", "B", and "C".

Temperature Letter
This letter indicates a tire's resistance to heat. The temperature grade for a tire that is inflated properly and not overloaded. Excessive speed underinflation or excessive loading, either separately or in combinatio can cause heat build-up and possible tire failure. From highest to lowest, a tire's resistance to heat is graded as "A", "B", or "C".

Additional Information on Light Truck Tires

Please refer to the following diagram.



Tires for light trucks have other markings besides those found on the sidewalls of passenger tires.

LT
The "LT" indicates the tire is for light trucks or trailers.

ST
An "ST" is an indication the tire is for trailer use only.

Max. Load Dual kg (lbs) at kPa (psi) Cold
This information indicates the maximum load and tire pressure when the tire is used as a dual, that is, when four tires are put on each rear axle (a total of six or more tires on the vehicle).

Max. Load Single kg (lbs) at kPa (psi) Cold
This information indicates the maximum load and tire pressure when the tire is used as a single.

Load Range
This information identifies the tire's load-carrying capabilities and its inflation limits.

2.14 Tire Safety Tips

Preventing Tire Damage

- Slow down if you have to go over a pothole or other object in the road.
- Do not run over curbs or other foreign objects in the roadway, an try not to strike the curb when parking.

Tire Safety Checklist

- Check tire pressure regularly (at least once a month), including th spare.
- Inspect tires for uneven wear patterns on the tread, cracks, foreig objects, or other signs of wear or trauma.
- Remove bits of glass and foreign objects wedged in the tread.
- Make sure your tire valves have valve caps.
- Check tire pressure before going on a long trip.
- Do not overload your vehicle. Check the Tire Information and Loading Placard or User's Manual for the maximum recommend load for the vehicle.

3 Coupling to the Tow Vehicle

3.1 Use an Adequate Tow Vehicle and Hitch

If the vehicle or hitch is not properly matched to the Gross Vehicle Weight Rating (GVWR) of your trailer, you can cause an accident that could lead to death or serious injury. If you already have a tow vehicle, know your vehicle's tow rating and make certain the trailer's rated capacity is less than or equal to the tow vehicle's rated towing capacity. If you already have (or plan to buy) a trailer, make certain that the tow rating of the tow vehicle is equal to or greater than that of the trailer.

⚠ Danger

Use of a hitch with a load rating less than the load rating of the trailer can result in loss of control and may lead to death or serious injury.

Use of a tow vehicle with a towing capacity less than the load rating of the trailer can result in loss of control, and may lead to death or serious injury.

Be sure your hitch and tow vehicle are rated for the Gross Vehicle Weight Rating (GVWR) of your trailer.

Also, make sure the combined weight of the tow vehicle and trailer does not exceed the tow vehicle manufacturer's recommended Gross Combined Weight Rating.

Trailer Information

The Certification Label is the silver label on the roadside lower front s of the body.



Certification Label

The Certification Label contains the following information for the use your trailer:

- **VIN:** Vehicle Identification Number.
- **GAWR:** (Gross Axle Weight Rating) The maximum weight that axle can support, as published on the Certification/VIN label on front left side of the trailer.
- **GVWR:** (Gross Vehicle Weight Rating) The maximum weight o the fully loaded trailer, as published on the Certification/VIN labe

.2 Other Important Tow Vehicle Considerations

When equipping a vehicle to tow your trailer, ask the vehicle dealer for advice on how to outfit the towing vehicle. Discuss the following information and equipment with the vehicle dealer.

verall Carrying and Towing Capacity of Tow Vehicle

Vehicle manufacturers will provide you with the maximum capacities of their various models.

owing Hitch

The towing hitch attached to your tow vehicle must have a capacity equal to or greater than the load rating of the trailer you intend to tow. The hitch capacity must also be matched to the tow vehicle capacity. Only a qualified professional can provide and install the proper hitch on your tow vehicle.

uspension System

Load equalizing bars, sway control bars, shock absorbers, heavy-duty springs, heavy-duty tires and other suspension components must be able to sufficiently serve the size and weight of the trailer that is going to be towed.

rake Controller

The brake controller is installed in the tow vehicle. It is essential in the operation of electric brake equipped trailers. The brake controller is not the same as the safety breakaway system that is installed on the trailer.

ide View Mirror

Depending on the width of your trailer, it may be necessary to use extended mirrors. Check with your dealer for mirror requirements. Some states prohibit extended mirrors on a tow vehicle, except while towing.

eavy-Duty Flasher

A heavy-duty flasher is an electrical component that may be required when your trailer turn signal lights are attached to the tow vehicle flasher circuit.

Electrical Connector

An electrical connector connects the light and brake systems on the trailer to the light and brake controls on the towing vehicle.

Heavy-Duty Engine Oil Cooling System

The tow vehicle engine works harder when a trailer is being towed. Depending on the size of the trailer, you may need to install a separate engine oil cooler. Inadequate cooling may result in sudden engine failure. Ask the tow vehicle dealer if it is necessary to install a heavy-duty cooling system.

Automatic Transmission Oil Cooler

The automatic transmission of a towing vehicle handles more load when a trailer is being towed. Inadequate cooling will shorten transmission life and may result in sudden transmission failure. Ask the tow vehicle dealer if it is necessary to install a separate oil cooler for the automatic transmission.

Emergency Flares and Emergency Triangle Reflectors

It is wise to carry these warning devices even if you are not towing a trailer. It is particularly important to have these when towing a trailer because the hazard flashers of your towing vehicle will not operate for as long a period of time when the battery is running both the trailer lights and tow vehicle lights.

3.3 Coupling and Uncoupling the Trailer

A secure coupling (or fastening) of the trailer to the tow vehicle is essential. A loss of coupling may result in death or serious injury. Therefore, you must understand and follow all of the instructions for coupling.

After coupling the trailer to the tow vehicle, the trailer must be level while being towed.

The following parts are involved in making a secure coupling between the trailer and tow vehicle:

- **Coupler** -- A device on the tongue of the trailer that connects to the hitch on the tow vehicle.
- **Hitch** -- A device on the tow vehicle that supports the weight of the trailer tongue and pulls the trailer. The coupler attaches to the hitch.
- **Safety chains** -- If the coupler connection comes loose, the safety chains can keep the trailer attached to the tow vehicle. With properly rigged safety chains, it is possible to keep the tongue of the trailer from digging into the road pavement, even if the coupler-to-hitch connection comes apart.
- **Trailer lighting and braking connector** -- A device that connects electrical power from the tow vehicle to the trailer. Electricity is used to turn on brake lights, running lights, and turn signals as required. In addition, if your trailer has a separate braking system, the electrical connector will also supply power to the brakes from the tow vehicle.
- **Breakaway switch** -- If the coupler connection comes loose, the breakaway switch can actuate emergency electrical brakes on the trailer. The breakaway switch must be rigged to the tow vehicle with appropriate slack that will activate the switch if the coupler connection comes loose. The breakaway system is fitted with a battery charger that draws power from the tow vehicle. If the electrical system on your tow vehicle does not provide power to the breakaway battery, you must periodically charge the battery to keep the breakaway system in working order.
- **Jack** -- A device on the trailer that is used to raise and lower the coupler. The jack is sometimes called the "landing gear".

⚠ WARNING

An improperly coupled trailer can result in death or serious injury.

Do not move the trailer until:

The coupler is secured and locked to the correct ball size.

The safety chains are secured to the tow vehicle.

The trailer jack(s) is fully retracted.

Do not tow the trailer on the road until:

Tires and wheels are checked.

The trailer brakes are checked.

The breakaway switch is connected to the tow vehicle.

The load is secured to the trailer.

The trailer lights are connected and checked and lug nuts tightened.

Various Coupler Designs

Trailers are produced with a variety of coupler devices. One of the sections below may pertain to your trailer.

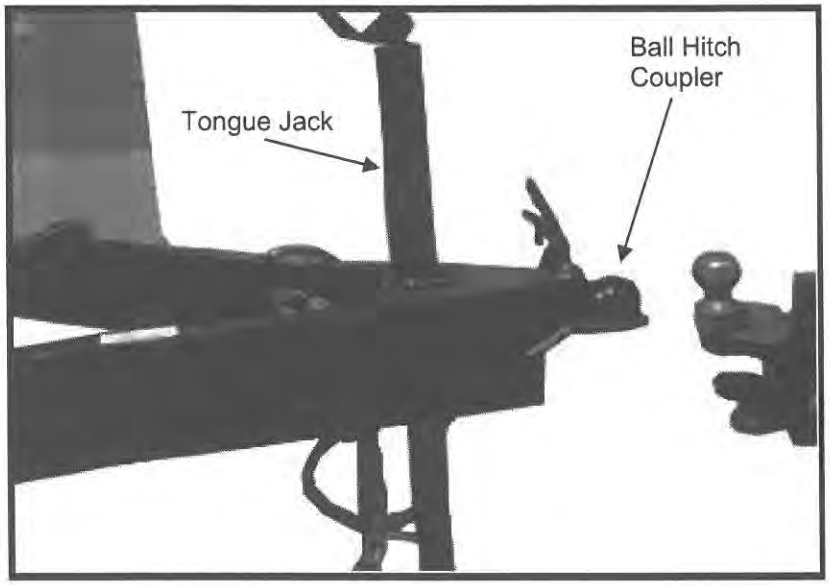
- Ball Hitch Coupler (Section 3.4) page 39
- Gooseneck Hitch Coupler (Section 3.5) page 45
- Fifth Wheel Hitch Coupler (Section 3.6) page 55

If the coupler on your trailer does not resemble one of the couplers shown in the figures, see the coupler instructions. If you do not have coupler instructions, call United Trailers at 1-800-637-2592 for a free copy.

3.4 TRAILER WITH BALL HITCH COUPLER

A Ball Hitch coupler connects to a ball that is located on, or under, the rear bumper of tow vehicle. This system of coupling a trailer to a tow vehicle is sometimes referred to as "bumper pull."

A Ball Hitch trailer may be fitted with a tongue jack that can raise and lower the coupler. The tongue jack is mounted to the A-frame (front, or tongue) part of the trailer. By rotating the jack handle clockwise, the jack will extend and raise the tongue of the trailer.



We have installed a Ball Hitch coupler that is suitable for the size and weight of the trailer. The load rating of the coupler and the necessary ball size are listed on the trailer coupler. You must provide a hitch and ball for your tow vehicle, where the load rating of the hitch and ball is equal to or greater than that of your trailer. The ball size must be the same as the coupler size. If the hitch ball is too small, too large, is underrated, is loose or is worn, the trailer can come loose from the tow vehicle, and may cause death or serious injury.

The tow vehicle, hitch, and ball must have a rated towing capacity equal to or greater than the trailer Gross Vehicle Weight Rating (GVWR).

Before coupling the trailer to the tow vehicle

Be sure the size and rating of hitch ball match the size and rating of the coupler. Hitch balls and couplers are marked with their size and rating.

⚠ WARNING

Coupler-to-hitch mismatch can result in uncoupling, leading to death or serious injury.

Be sure the LOAD RATING of the hitch ball is equal or greater than the load rating of the coupler.

Be sure the SIZE of the hitch ball matches the size of the coupler.

- Wipe the hitch ball clean and inspect it visually and by feel for flat spots, cracks and pits.
- Rock the ball to make sure it is tight to the hitch, and visually check that the hitch ball nut is solid against the lock washer and hitch frame.
- Wipe the inside and outside of the coupler clean and inspect it visually for cracks and deformations. Feel the inside of the coupler for worn spots and pits.
- Be sure the coupler is tight to the tongue of the trailer. All coupler fasteners must be visibly solid against the trailer frame.

⚠ WARNING

A worn, cracked or corroded hitch ball can fail while towing, and may result in death or serious injury.

Before coupling trailer, inspect the hitch ball for wear, corrosion and cracks.

Replace a worn or damaged hitch ball.

A loose hitch ball nut can result in uncoupling, leading to death or serious injury.

Be sure the hitch ball is tight to the hitch before coupling the trailer.

Prepare the coupler and hitch

- Lubricate the hitch ball and the inside of the coupler with a thin layer of automotive bearing grease.
- If your trailer is equipped with a jack, raise the coupler above the ball height.
- Open the coupler locking mechanism. Ball couplers have a locking mechanism with an internal moving piece and an outside handle.
- In the open position, the coupler is able to drop fully onto the hitch ball.
- See the coupler instructions for details of placing the coupler in the "open" position.
- Slowly back up the tow vehicle so that the hitch ball is near the coupler or aligned under the coupler, if the trailer jack has raised the coupler.

Couple the trailer to the tow vehicle

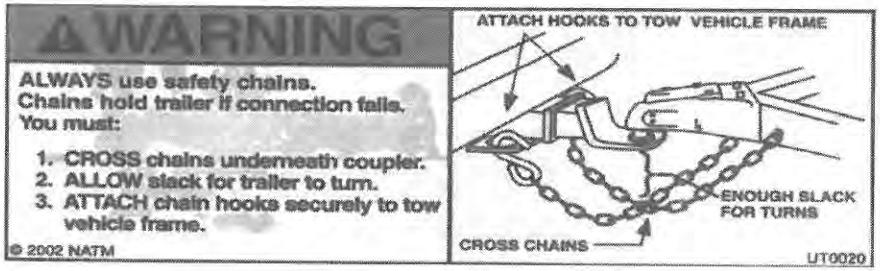
- Raise the bottom surface of the coupler to be slightly above the top of the hitch ball. Use the trailer jack, if provided.
- If your trailer does not have a jack, you will have to lift the coupler manually and place it over the ball.
- If you have a jack, lower the trailer until the coupler fully engages the hitch ball. If the coupler does not line up with the hitch ball, adjust the position of the tow vehicle.
- Engage the coupler locking mechanism. The locking mechanism securely holds the coupler to the hitch ball.
- Insert a pin or lock through the hole in the locking mechanism.
- Be sure the coupler is all the way on the hitch ball and the locking mechanism is engaged. A properly engaged locking mechanism will allow the coupler to raise the rear of the tow vehicle. Using the trailer jack, test to see that you can raise the rear of the tow vehicle by 1 inch after the coupler is locked to the hitch.
- Lower the trailer so that its entire tongue weight is held by the hitch and continue cranking the jack to its fully retracted position.

If the coupler cannot be secured to the hitch ball, do not tow the trailer. Call United Trailers at 1-800-637-2592 or your dealer for assistance.

Rig the safety chains

- Visually inspect the safety chains and hooks for wear or damage. Replace worn or damaged safety chains and hooks before towing.
- Rig the safety chains so that they have enough slack to permit tight turns, but do not hang too close to the road. If the trailer should uncouple, the safety chains hold the tongue above the road.
- Rig the safety chains so that they cross underneath the coupler.
- Hook to the holes provided in the hitch system. Do not attach them to an interchangeable part of the hitch assembly.

Safety Chain Arrangement Ball Hitch Trailer



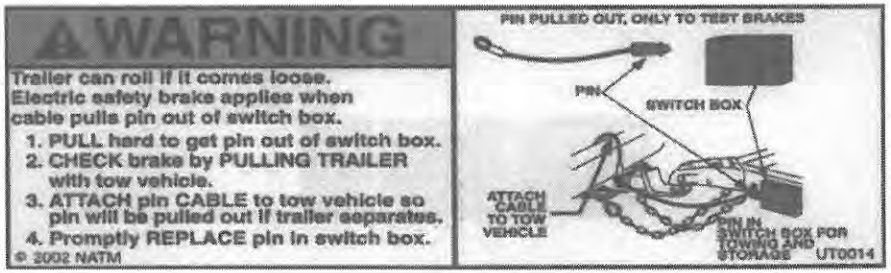
Attach and test electric breakaway brake system

If the coupler or hitch fails, a properly connected and working breakaway brake system will apply electric brakes on the trailer. The safety chains will keep the tow vehicle attached and, as the brakes are applied at the trailer's axles, the trailer/tow vehicle combination will come to a controlled stop.

The breakaway brake system includes a battery and a switch with a pull pin. Read and follow the instructions here as well as the instructions that have been prepared by the breakaway brake controller manufacturer. If you do not have these instructions, call United Trailers at 1-800-637-2592 for a free copy.

The breakaway system is fitted with a battery charger that draws power from the tow vehicle. If the electrical system on your tow vehicle does not provide power to the breakaway battery, you must periodically charge the battery to keep the breakaway system in working order.

Breakaway System Battery Ball Hitch Trailer



- Connect the pull pin cable to the tow vehicle so that the pull pin will be pulled out before all of the slack in the safety chains is taken up. Do not connect the pull pin cable to a safety chain or to the hitch ball or hitch ball assembly. This would keep the breakaway brake system from operating when it is needed.
- Remove the pull pin from the switch and test tow the trailer at less than 5 mph. You should feel the trailer resisting being towed, but the wheels will not necessarily be locked. If the brakes do not function, do not tow the trailer until brakeaway system or the brakes are repaired.
- Immediately replace the pull pin. The breakaway system battery discharges rapidly when the pull pin is removed.

⚠ WARNING

An ineffective breakaway brake system can result in a runaway trailer, leading to death or serious injury if the coupler or ball hitch fails.

Connect the breakaway cable to the tow vehicle and NOT to the hitch, ball or support.

Before towing the trailer, test the function of the breakaway brake system. If the breakaway brake system is not working, do not tow the trailer. Have it serviced or repaired.

Do not tow the trailer with the breakaway brake system ON because the brakes will overheat which can result in permanent brake failure.

⚠ WARNING

Failure to replace the pull pin will prevent the brakes from working, leading to loss of control, serious injury or death.

If you do not use your trailer for three or more months:

- Charge the battery as needed.

Connect the electrical cables

Connect the trailer lights to the tow vehicle's electrical system using the electrical connectors.

Check all lights for proper operation:

- Clearance Lights -- Turn on tow vehicle headlights.
- Brake Lights -- Step on tow vehicle brake pedal.
- Turn Signals -- Operate tow vehicle directional signal lever.
- Backup Lights -- Put tow vehicle gear shift into reverse.

Check electric brakes for proper operation

If your trailer has electric brakes, your tow vehicle must have an electric brake controller that sends power to the trailer brakes. Before towing the trailer on the road, you must operate the brake controller while trying to pull the trailer in order to confirm that the electric brakes operate. While towing the trailer at less than 5 mph, manually operate the electric brake controller in the tow vehicle cab. You should feel the operation of the trailer brakes.

⚠ WARNING

Improper electrical connection between the tow vehicle and the trailer will result in inoperable lights and electric brakes and can lead to a collision.

Before each tow:

Check that the taillights, brake lights and turn signals work.

Check that the electric brakes work by operating the brake controller inside the tow vehicle.

Uncoupling the Ball Hitch Trailer with Tongue Jack

Follow these steps to uncouple your ball hitch trailer from the tow vehicle:

- Block tires to prevent the trailer from rolling.
- Disconnect the electrical connector.
- Disconnect the breakaway system cable. Promptly replace the pull pin in the switch.
- Disconnect the safety chains from the tow vehicle.
- Unlock the coupler.
- Rotate the jack handle/crank clockwise. This will slowly extend the jack and transfer the weight of the trailer tongue to the jack.

3.5 Trailer with Gooseneck Coupler & Drop Leg Jack(s)

A gooseneck coupler on the trailer connects to a gooseneck ball that you must have installed in the bed of the tow vehicle. This system of coupling a trailer permits the tow vehicle to turn sharper than permitted by a bumper hitch system. A gooseneck coupler consists of a tube with a gooseneck ball receiver at the bottom.

Trailer with gooseneck coupler



We have installed a gooseneck ball receiver that is suitable for the size and weight of the trailer. The load rating of the coupler and the necessary ball size are listed on the gooseneck.

You must provide a gooseneck ball and support structure that is marked with a rating that meets or exceeds the Gross Vehicle Weight Rating (GVWR) of your trailer and matches the size of the gooseneck ball receiver. If the gooseneck ball is too small, is underrated, is loose or is worn, the trailer can come loose from the tow vehicle, and may lead to death or serious injury.

The tow vehicle, support structure and gooseneck ball must have a rated towing capacity equal to or greater than the trailer Gross Vehicle Weight Rating (GVWR).

It is essential that the gooseneck ball be the same size as the gooseneck ball receiver.

The gooseneck ball size and load rating (capacity) are marked on the ball; the hitch capacity is marked on the hitch.

⚠ WARNING

Coupler-to-hitch mismatch can result in uncoupling, leading to death or serious injury.

Be sure the LOAD RATING of the hitch ball is equal or greater than the load rating of the coupler.

Be sure the SIZE of the hitch ball matches the size of the coupler.

The height of the ball receiver on the trailer must be adjusted to match the height of the gooseneck ball on your tow vehicle, so that:

- There is clearance between the bottom of the trailer and the sides of the tow vehicle bed.
- The trailer is level and allows equal weight distribution on all axles.

The gooseneck height adjustment bolts, which have a "cup" that makes a gripping impression into the gooseneck tube, must be tight so that the trailer does not drop to a lower position. Do not over-tighten because the tube can become deformed.

Gooseneck Ball Receiver and Height Adjustment



⚠ WARNING

Improper gooseneck height adjustment can result in overloaded tires, blowout and loss of control, leading to death or serious injury.

Adjust the gooseneck receiver so that the loaded trailer is level.

A trailer having a gooseneck hitch will have drop leg jack(s) for raising and lowering the gooseneck ball receiver. Because we use several drop leg jack mechanisms, the general instructions below may vary slightly from the jack manufacturer's instructions. If the jack on your trailer does not resemble the jack shown in the figures, follow the instructions provided by the jack manufacturer. If you do not have these instructions, call United Trailers at 1-800-637-2592 for a free copy.

Drop Leg Jack Mechanism



Before attempting to tow the trailer:

- Be sure the size and rating of the gooseneck ball match the size and rating of the receiver. Gooseneck balls and receivers are marked with their size and ratings.
- Wipe the gooseneck ball clean and inspect it visually and feel for flat spots, cracks and pits.

⚠ WARNING

A worn, cracked or corroded gooseneck ball can fail while towing, and may result in death or serious injury.

Before coupling the trailer, inspect the gooseneck ball for wear, corrosion and cracks. Replace a worn or damaged gooseneck ball.

- Rock the ball to make sure it is tight to the ball support and visually check that the gooseneck ball nut is solid against the lock washer and ball support frame.

⚠ WARNING

A loose gooseneck ball can result in uncoupling, leading to death or serious injury.

Be sure the gooseneck ball nut is tight before coupling the trailer.

- Wipe the inside and outside of the receiver clean and inspect it visually for cracks. Feel the inside of the receiver for worn spots and pits. If any of these conditions exist, have the receiver replaced before coupling the trailer.
- Lubricate the inside of the gooseneck ball receiver with automotive bearing grease.
- Be sure the receiver is tight to the trailer. All receiver fasteners must be visibly solid against the trailer frame.
- Release the jack handle or crank from its holder.
- Make certain the ground beneath the jack foot is firm enough to support the tongue weight.
- Rotate the handle/crank clockwise to raise the bottom surface of the gooseneck to be above the top of the gooseneck ball.

Prepare the ball receiver and gooseneck ball

Release the lock on the gooseneck ball receiver. Move the spring-loaded lock to the OPEN position that allows the gooseneck ball to enter the receiver (see "Gooseneck Ball Receiver and Height Adjustment" figure).

Slowly back up the tow vehicle so that the gooseneck ball is aligned under the gooseneck ball receiver.

⚠ WARNING

If the trailer drops during coupling, death or serious injury may result.

There must be no one under the trailer or coupler before or during the coupling operation.

Couple the trailer to the tow vehicle

- Rotate the jack handle counter-clockwise. This will retract the jack causing the gooseneck ball receiver to drop down so it can fully engage the gooseneck ball and transfer the weight of the trailer tongue to the towing vehicle hitch. If the receiver does not line up with the ball, raise the receiver again and adjust the position of the tow vehicle. Then lower the receiver over the ball. When the drop leg base is no longer resting on the ground, the towing vehicle hitch is holding all of the weight of the trailer tongue.
- Close the lock plate on the gooseneck ball receiver.
- Move the spring-loaded lock plate pin to the CLOSED position. Be sure the locking pin is holding the lock plate.
- Be sure the receiver is all the way on the gooseneck ball and the lock plate is engaged. A properly engaged locking mechanism will allow the coupler to raise the rear of the tow vehicle. Using the trailer jack(s), test to see that you can raise the rear of the tow vehicle by 1 inch.

⚠ Notice

Overloading can damage the drop leg jack. Do not use the drop leg jack to raise the tow vehicle more than 1 inch.

If the gooseneck ball cannot be secured to the receiver, do not tow the trailer. Call United Trailers at 1-800-637-2592 or your dealer for assistance.

After testing to see that the receiver is properly secured and locked to the ball, retract the jack(s) to the fully retracted position.

Return the drop legs to their upper positions. The drop legs are held in the lowered position with a plunger pin. Rotating the plunger pin while pulling it outward will cause it to come out of engagement with the drop leg and the leg can be raised.

⚠ Caution

Keep your feet and hands clear of the drop legs and drop leg bases when releasing the drop legs.

Always wear shoes or boots while performing this operation.

Rig the safety chains

- Visually inspect the safety chains and hooks for wear or damage. Replace worn or damaged safety chains and hooks before towing. Rig the safety chains so that they attach to the safety chain receivers on the hitch. If you are not certain of the hitch provisions for receiving safety chains, contact

the hitch manufacturer or installer. Do NOT attach the safety chains to the gooseneck ball or its support.

- Rig the safety chains so they have sufficient slack to permit turning, but not too much slack – the safety chains must keep the gooseneck on the tow vehicle bed if the trailer uncouples.

⚠ WARNING

Improper rigging of the safety chains can result in loss of control of the trailer and tow vehicle, leading to death or serious injury if the trailer uncouples from the tow vehicle.

Fasten safety chains to safety chain receivers on the hitch, not to the ball.

Have sufficient slack to permit turning and to keep the gooseneck on the bed of trailer if the trailer comes loose.

Attach and test the breakaway brake system

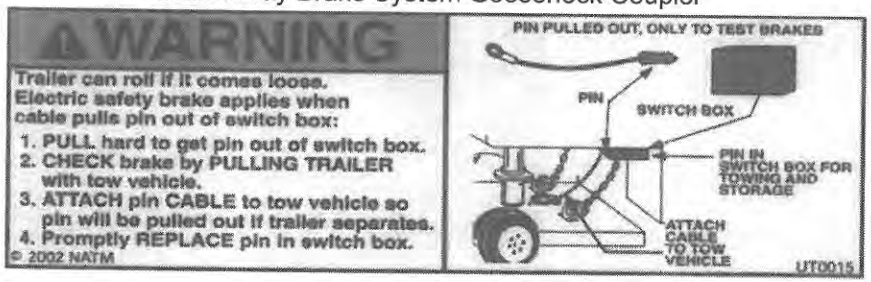
If the coupler or hitch fails, a properly connected and working breakaway system will apply electric brakes on the trailer. The safety chains will keep the tow vehicle attached and as the brakes are applied at the trailer's axles, the trailer/tow vehicle combination will come to a controlled stop.

The breakaway system includes a battery and a switch with a pull pin.

Read and follow the instructions here as well as the instructions that have been prepared by the breakaway system manufacturer. If you do not have these instructions, call United Trailers at 1-800-637-2592 for a free copy.

The breakaway brake system may be fitted with a charger that draws power from the tow vehicle. If the electrical system on your tow vehicle does not provide power to the breakaway battery you must periodically charge the battery on the trailer to keep the breakaway system in working order.

Breakaway Brake System Gooseneck Coupler



- Visually inspect the breakaway system for broken parts.
- Connect the pull pin cable to the tow vehicle so that the pull pin will be pulled out before all of the slack in the safety chains is taken up. Do not connect the pull pin cable to a safety chain or a safety chain receiver or to the gooseneck ball or its support. This would keep the breakaway brake system from operating when it is needed. Contact the hitch manufacturer or installer if you are not certain of the hitch provisions for breakaway system connection
- Remove the pull pin from the switch and test tow the trailer at less than 5 mph. You should feel the trailer resisting being towed, but the wheels will not necessarily be locked.
- Immediately replace the pull pin. The breakaway system battery discharges rapidly when the pull pin is removed.

⚠ WARNING

An ineffective or inoperative breakaway brake system can result in a runaway trailer leading to death or serious injury if the coupler or hitch fails.

Connect the breakaway cable to the tow vehicle and NOT to the safety chain, safety chain receiver, gooseneck ball or gooseneck ball support.

Test the function of the breakaway brake system before towing the trailer. Do not tow the trailer if the breakaway brake system is not working. Have it serviced or repaired.

Do not tow the trailer with the breakaway brake system ON because the brakes will overheat which can result in permanent brake failure.

⚠ WARNING

Failure to replace the pull pin will prevent brakes from working, leading to loss of control, serious injury or death.

If you do not use your trailer for three or more months:

- Charge the battery as needed.

Replace the breakaway brake battery at intervals recommended by the battery manufacturer's instructions.

Connect the electrical cables

Connect the trailer lights to the tow vehicle's electrical system using the electrical connectors.

Check all lights for proper operation

- Clearance Lights – Turn on tow vehicle headlights.
- Brake Lights -- Step on tow vehicle brake pedal.
- Turn Signals -- Operate tow vehicle directional signal lever.
- Backup Lights -- Put tow vehicle gear shift into reverse.

Check electric brakes for proper operation

If your trailer has electric brakes, your tow vehicle must have an electric brake controller that sends power to the trailer brakes. Before towing the trailer on the road, you must operate the brake controller while trying to pull the trailer in order to confirm that the electric brakes operate. While towing the trailer at less than 5 mph, manually operate the electric brake controller in the tow vehicle cab. You should feel the operation of the trailer brakes.

⚠ WARNING

Improper electrical connection between the tow vehicle and the trailer will result in inoperable lights and electric brakes and can lead to a collision.

Before each tow:

Check that the clearance lights, taillights, brake lights and turn signals work.

Check that the electric brakes work by operating the brake controller inside the tow vehicle.

Uncoupling the Gooseneck Trailer with Drop Leg Jack

Follow these steps to uncouple your gooseneck hitch trailer from the tow vehicle:

- Block the trailer tires to prevent the trailer from rolling.
- Disconnect the electrical connector.
- Disconnect the breakaway switch cable. Promptly replace the pin in the switch.
- Disconnect the safety chains from the tow vehicle.
- Move the spring-loaded gooseneck receiver lock plate-locking pin to the OPEN position.
- Rotate the lock plate to a position that permits the gooseneck ball to exit the receiver.
- Before releasing drop leg jack, make certain ground surface below jack base will support the trailer tongue load.
- Rotate the drop leg plunger pin handle so that the plunger pin is released from the drop leg.
- The drop leg will drop to the desired lowered position.
- Rotate the plunger pin handle so that the plunger pin is attempting to engage the drop leg.
- Slowly raise the drop leg. The plunger pin will engage a hole in the drop leg.
- Release the handle/crank from its holder and engage it with the jackshaft.
- Rotate the handle/crank from its hold and engage it with the jackshaft.
- Rotate the handle/crank clockwise to slowly extend the jack and transfer the weight of the trailer tongue to the jack.

⚠ Caution

Keep your feet and hands clear of the drop legs and drop leg bases when releasing the drop legs.

Always wear shoes or boots while performing this operation.

- Be sure the plunger pin is fully engaged. Push it in by hand if necessary. The loop part of the plunger pin handle must be touching the plunger pin housing.
- If your trailer has more than one drop leg jack, lower them to the same level, following the above instructions.

⚠ Notice

If the drop legs are not set at the same level, one of the drop leg jacks can be overloaded and can be damaged.

- On two speed jacks, pushing the handle shaft toward the gearbox shifts the gearbox into high-speed mode. When the drop leg base contacts the ground, shift the gearbox into low speed mode by pulling out on the handle shaft until it locks into low gear.

⚠ Notice

Do not use high speed to lift the trailer because the drop leg jack mechanism can be damaged.

High speed is used only to rapidly move the drop leg base into contact with the ground.

- Continue to extend the jack(s), making sure that the ground is providing stable and level support for the trailer.
- After the jack(s) are extended and the gooseneck ball receiver is well clear of the gooseneck ball, disengage the handle from its shaft and return to its holder to permit driving the tow vehicle away.

3.6 Trailer with Fifth Wheel Coupler & Drop Leg Jack(s)

A fifth wheel king pin on the trailer connects to a fifth wheel coupler that you must have installed in the bed of the tow vehicle.

A fifth wheel coupler includes a flat load-bearing plate with a slot, and a mechanism inside the slot that "grips" the king pin.

We have installed a fifth wheel king pin that is suitable for the size and weight of the trailer. You must provide a fifth wheel hitch that is rated for the Gross Vehicle Weight Rating (GVWR) of your trailer.

Trailer with Fifth Wheel Coupler



Before attempting to tow the trailer

- Be sure the size and rating of the fifth wheel and king pin match.
- Wipe the king pin clean and inspect it visually and by feel for flat spots, cracks and pits. Check the condition of the king pin mounting in the bed of the tow vehicle.

⚠ WARNING

A worn, bent, cracked or corroded king pin can fail while towing and may result in death or serious injury.

Before coupling the trailer, inspect the king pin and king pin plate for wear, bending, cracks or corrosion. Replace a worn or damaged king pin.

- Be sure the fifth wheel mechanism operates freely.
- Lubricate the fifth wheel plate surface with a light coat of lithium-base, waterproof grease.
- Be sure the fifth wheel and king pin fasteners are tight and any welds are solid.

⚠ WARNING

A loose fifth wheel or king pin can result in uncoupling, leading to death or serious injury.

Be sure the fifth wheel and king pin are tight before coupling the trailer.

- Be sure the brake line, electrical line, and any other lines are clear of the coupling area.
- Be sure the locks are open.
- Block the trailer wheels, front and rear.
- Make certain that trailer fifth wheel plate is slightly above the king pin plate on the tow vehicle.
- Back tow vehicle up close to the trailer, centering the king pin in the slot of the fifth wheel.
- STOP before engaging the coupling.

⚠ WARNING

If the trailer drops during coupling, death or serious injury may result.

There must be no one under the trailer or coupler before or during the coupling operation.

- Adjust the height of the trailer using the jack so that the fifth wheel plate just touches the king pin plate.
- Slowly back up the tow vehicle, keeping the king pin centered in the slot of the fifth wheel. Continue backing up until the fifth wheel locks firmly on the king pin.
- Attempt to pull forward as an initial test of the closing of the fifth wheel locks.

⚠ WARNING

An improperly coupled fifth wheel can come loose, resulting in death or serious injury.

Do not tow the trailer until all of the visual checks have been performed:

Adjustment nut against fifth wheel.

Secondary lock behind yoke.

Fifth wheel against king pin plate.

Drop Leg Mechanism



Raise the Drop Leg Jack(s)

A trailer having a fifth wheel coupler will be outfitted with one or two drop leg jacks for raising and lowering the fifth wheel coupler. Because we use several drop leg jack mechanisms, the general instructions below may vary slightly from the jack manufacturer's instructions. If the trailer jack on your trailer does not resemble the jack shown in the figures, follow the jack instructions provided by the jack manufacturer. If you do not have these instructions, call United Trailers at 1-800-637-2592 for a free copy.

- Rotate the jack handle counter-clockwise. This will slowly retract the jack and transfer the weight of the trailer tongue to the towing vehicle. When the drop leg base is no longer resting on the ground, the towing vehicle hitch is holding all of the weight of the trailer tongue. Continue retracting the jack to its fully retracted position.
- Return the drop legs to their upper positions. The drop legs are held in the lowered position with a plunger pin. Rotating the plunger pin while pulling it outward about ¾ inch will cause it to come out of the engagement with the drop leg and the leg can be raised.
- Remove the trailer wheel blocks.

⚠ Caution

Keep your feet and hands clear of the drop legs and drop leg bases when releasing the drop legs.

Always wear shoes or boots while performing this operation.

Attach and test the breakaway brake system



Fifth Wheel Breakaway System

If the coupler fails, a properly connected and working breakaway system will apply electric brakes on the trailer. The breakaway system includes a battery and a switch with a pull pin. Read and follow the instructions here as well as the instructions that have been prepared by the breakaway system manufacturer. If you do not have these instructions, call United Trailers at 1-800-637-2592 for a free copy.

The breakaway system may be fitted with a charger that draws power from the tow vehicle. If the electrical system on your tow vehicle does not provide power to the breakaway brake battery, you must periodically charge the battery to keep the breakaway brake system in working order.

- Visually inspect the breakaway system for broken parts.
- Connect the pull pin cable to the tow vehicle. Do not connect to king pin or its support.
- Remove the pull pin from the switch and test tow the trailer at less than 5 mph. You should feel the trailer resisting being towed, but the wheels will not necessarily be locked.
- Immediately replace the pull pin. The breakaway brake system battery discharges rapidly when the pull pin is removed.

Do not tow the trailer with the breakaway brake system ON because the brakes will overheat which can result in permanent brake failure.

⚠ WARNING

An ineffective breakaway brake system can result in a runaway trailer leading to death or serious injury if the coupler fails.

Connect the breakaway cable to the tow vehicle and NOT to the king pin or its support.

Before towing the trailer, test the function of the breakaway brake system. If the breakaway brake system is not working, do not tow the trailer. Have it serviced or repaired.

⚠ WARNING

Failure to replace the pull pin will prevent brakes from working, leading to loss of control, serious injury or death.

If you do not use your trailer for three or more months:

- Charge the battery as needed.

Replace the breakaway brake battery at intervals recommended by the battery manufacturer.

Connect the electrical cables

Connect the trailer lights to the tow vehicle's electrical system using the electrical connectors. Check all lights for proper operation:

- Clearance Lights -- Turn on tow vehicle headlights.
- Brake Lights -- Step on tow vehicle brake pedal.
- Turn Signals -- Operate tow vehicle directional signal lever.
- Backup Light -- Put tow vehicle gear shift into reverse.

Check brakes for proper operation. While towing the trailer at less than 5 mph, manually operate the electric brake controller in the tow vehicle cab. You should feel the operation of the trailer brakes.

⚠ WARNING

Improper electrical connection between the tow vehicle and the trailer will result in inoperable lights and electric brakes and can lead to collision.

Before each tow:

Check that the clearance lights, taillights, brake lights and turn signals work.

Check that the electric brakes work by operating the brake controller inside the tow vehicle.

Uncoupling the Fifth Wheel Trailer with Drop Leg Jack(s)

Follow these steps to uncouple your fifth wheel hitch trailer from your tow vehicle:

- Block the trailer tires.
- Disconnect the electrical connector.
- Disconnect the breakaway brake switch cable. Promptly replace the pin in the switch.
- Make certain that ground surface below jack base will support trailer tongue load.
- Rotate the drop leg plunger pin handle so that the plunger pin is released from the drop leg.
- The drop leg will now drop to the ground.

⚠ Caution

Keep your feet and hands clear of the drop legs and drop leg bases when releasing the drop legs.

Always wear shoes or boots while performing this operation.

- Rotate the plunger pin handle so that the plunger pin is attempting to engage the drop leg.
- Slowly raise the drop leg to the desired position. The plunger pin will engage a hole in the drop leg.

- Be sure the plunger pin is fully engaged. Push it in by hand if necessary. The bent part of the plunger pin handle must be touching the plunger pin housing.

If your trailer has two drop leg jacks, lower them both to the same level, following the above instructions.

⚠ Notice

If the drop legs are not set at the same level, one of the drop leg jacks can be overloaded and can be damaged.

- Release the handle/crank from its holder and engage it with the jackshaft.
- Rotate the handle/crank clockwise to slowly extend the jack and transfer the weight of the trailer tongue to the jack.
- On two speed jacks, pushing the handle shaft toward the gearbox can perform rapid extension. This shifts the gearbox into a high-speed mode.
- When the drop leg base contacts the ground, shift the gearbox into low speed mode by pulling out on the handle shaft until it locks into low gear.

⚠ Notice

Do not use high speed to lift the trailer because the drop leg jack mechanism can be damaged.

High speed is used only to rapidly move the drop leg base into contact with the ground.

- Continue to extend the jack(s), making sure that the ground is providing stable and level support for the trailer.
- Turn the crank two or three turns to take some of the weight off the coupling. Do not raise the fifth wheel off the king pin plate.
- After the jack(s) are extended enough to permit driving the tow vehicle away, disengage the jack handle from its shaft and return it to its holder. Do NOT drive the tow vehicle yet!

Open the fifth wheel locks by:

- Pulling the release handle, or
- Using a separate pipe release handle to engage the solid stud on the secondary lock.

Slowly drive the tow vehicle away from the trailer.

4 LOADING THE TRAILER

Improper trailer loading causes many accidents and deaths. To safely load a trailer, you must consider:

- Overall load weight;
- Load weight distribution;
- Proper tongue weight; and
- Securing the load properly.

To determine that you have loaded the trailer within it's rating you must consider the distribution of weight, as well as the total weight of the trailer and its contents. The trailer axles carry most of the total weight of the trailer and its contents (Gross Vehicle Weight, or "GVW"). The remainder of the total weight is carried by the tow vehicle hitch. It is essential for safe towing that the trailer tongue and tow vehicle hitch carry the proper amount of the loaded trailer weight, otherwise the trailer can suddenly sway wildly at towing speed. Read the "Tongue Weight" section below.

The load distribution must be such that no component part of the trailer is loaded beyond its rating. This means that you must consider the rating of the tires, wheels and axles. For tandem and triple axle trailers, you must make sure that the front-to-rear load distribution does not result in overloading any axle.

⚠ WARNING

Do not transport flammable, explosive, poisonous or other dangerous materials in your trailer.

Towing stability also depends on keeping the center of gravity as low as possible. Load heavy items on the floor over the axles. When loading additional items, be sure to maintain even side-to-side weight distribution and proper tongue weight. The total weight of the trailer and its contents must never exceed the total weight rating of the trailer (Gross Vehicle Weight Rating, or "GVWR").

⚠ WARNING

An overloaded trailer can result in loss of control of the trailer, leading to death or serious injury.

Do not exceed the trailer Gross Vehicle Weight Rating (GVWR) or an axle Gross Axle Weight Rating (GAWR).

Do not load a trailer so that the weight on any tire exceeds its rating.

4.1 TONGUE WEIGHT

It is critical to have a portion of the trailer load carried by the tow vehicle. The trailer tongue must exert a downward force on the hitch. This is necessary for two reasons:

1. To be able to maintain control of the tow vehicle/trailer system.
2. To insure that the trailer axle(s) do not exceed their Gross Axle Weight Rating (GAWR).

Too much weight behind the axles of the trailer can cause the tongue to exert an upward pull on the hitch. The rear wheels of the tow vehicle will lose traction and will cause loss of control.

Too little tongue weight can cause the trailer to become unstable at high speeds. Too much tongue weight can cause loss of steering control.

In the following table, the second column notes the recommended percentage of total weight (GVW) that the tongue of the trailer should support. The GVW of your trailer is located on the Certification Label that is mounted on the lower roadside front of the trailer body.

For example, a trailer with a gooseneck hitch and a loaded weight of 12,000 pounds should have 20 - 25%, or 2,400 to 3,000 pounds, on the tongue.

Tongue Weight as a Percentage of Loaded Trailer Weight	
Type of Hitch	**Percentage**
Ball Hitch (or Bumper Hitch)	10–15%
Gooseneck Hitch	20–25%
Fifth Wheel Hitch	

4 LOADING THE TRAILER

Improper trailer loading causes many accidents and deaths. To safely load a trailer, you must consider:

- Overall load weight;
- Load weight distribution;
- Proper tongue weight; and
- Securing the load properly.

To determine that you have loaded the trailer within it's rating you must consider the distribution of weight, as well as the total weight of the trailer and its contents. The trailer axles carry most of the total weight of the trailer and its contents (Gross Vehicle Weight, or "GVW"). The remainder of the total weight is carried by the tow vehicle hitch. It is essential for safe towing that the trailer tongue and tow vehicle hitch carry the proper amount of the loaded trailer weight, otherwise the trailer can suddenly sway wildly at towing speed. Read the "Tongue Weight" section below.

The load distribution must be such that no component part of the trailer is loaded beyond its rating. This means that you must consider the rating of the tires, wheels and axles. For tandem and triple axle trailers, you must make sure that the front-to-rear load distribution does not result in overloading any axle.

⚠ WARNING

Do not transport flammable, explosive, poisonous or other dangerous materials in your trailer.

Towing stability also depends on keeping the center of gravity as low as possible. Load heavy items on the floor over the axles. When loading additional items, be sure to maintain even side-to-side weight distribution and proper tongue weight. The total weight of the trailer and its contents must never exceed the total weight rating of the trailer (Gross Vehicle Weight Rating, or "GVWR").

⚠ WARNING

An overloaded trailer can result in loss of control of the trailer, leading to death or serious injury.

Do not exceed the trailer Gross Vehicle Weight Rating (GVWR) or an axle Gross Axle Weight Rating (GAWR).

Do not load a trailer so that the weight on any tire exceeds its rating.

4.1 TONGUE WEIGHT

It is critical to have a portion of the trailer load carried by the tow vehicle. The trailer tongue must exert a downward force on the hitch. This is necessary for two reasons:

1. To be able to maintain control of the tow vehicle/trailer system.
2. To insure that the trailer axle(s) do not exceed their Gross Axle Weight Rating (GAWR).

Too much weight behind the axles of the trailer can cause the tongue to exert an upward pull on the hitch. The rear wheels of the tow vehicle will lose traction and will cause loss of control.

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For example, a trailer with a gooseneck hitch and a loaded weight of 12,000 pounds should have 20 - 25%, or 2,400 to 3,000 pounds, on the tongue.

Tongue Weight as a Percentage of Loaded Trailer Weight	
Type of Hitch	**Percentage**
Ball Hitch (or Bumper Hitch)	10–15%
Gooseneck Hitch	20–25%
Fifth Wheel Hitch	

⚠ WARNING

Improper tongue weight (load distribution) can result in loss of control of the trailer, leading to death or serious injury.

Make certain that tongue weight is within the allowable range.

Be sure to:

Distribute the load front-to-rear to provide proper tongue weight (see table on page 64);

Distribute the load evenly, side-to-side, to avoid tire overload; and

Keep the center of gravity low.

Checking Tongue Weight

The tow vehicle and trailer must be on level ground to check the tongue weight.

If you know the weight on your tow vehicle axles when you are not towing a trailer, the trailer tongue weight can be determined with the use of a truck axle scale.

4.2 SECURING THE CARGO

Before loading cargo into your enclosed trailer, inspect the interior of the trailer.

Enclosed trailers may be fitted with "D"-ring hold-downs, and/or a track system that can be used to secure the cargo. Inspect the "D"-rings and track system for looseness or signs of bending before loading the cargo onto the trailer.

⚠ WARNING

Damaged or loose "D"-rings can break, allowing cargo to become loose inside the trailer. Loose cargo can shift the center of gravity and result in loss of control of the trailer.

Inspect "D"-rings, and test them for looseness before loading cargo.

Do not use a damaged or loose "D"-ring to secure cargo.

Since the trailer "ride" can be bumpy and rough, you must secure your cargo so that it does not shift while the trailer is being towed.

⚠ WARNING

Shifting cargo can result in loss of control of the trailer and can lead to death or serious injury.

Tie down all loads with proper sized fasteners, ropes, straps, etc.

4.3 DROP RAMP DOOR OPERATION

Enclosed trailers may be fitted with a drop ramp door. The weight of the drop ramp door is partially supported by a spring and cable counterbalance assembly. If out of adjustment or worn out, it will not provide the expected assistance for raising and lowering the drop ramp door.

⚠ WARNING

A spring and cable counterbalance can inflict serious injury if it breaks or if incorrectly adjusted.

Inspect the cable and cable ends each time the door is operated.

Do not attempt to service the counterbalance. Take the trailer to a qualified professional for service.

- Carefully lower the drop ramp to the ground.
- Load the cargo up the drop ramp and into the trailer.
- Secure the cargo to the trailer using appropriate straps, chains or tensioning devices.
- Close the drop ramp door and secure the trailer door catch using a linchpin or other locking device, so that the door cannot open while the trailer is being towed.

⚠ WARNING

If the door opens, your cargo may be ejected onto the road, resulting in death or serious injury to other drivers.

Always secure the door latch after closing. Place a linchpin in the catch.

5 Checking the Trailer Before & During Each Tow

5.1 Pre-tow Checklist

Before towing, double-check all of these items:

- Tires, wheels, and lug nuts.
- Coupler secured and locked
  (See Section 3.3 Coupling and Uncoupling the Trailer).
- Safety chains properly rigged to tow vehicle, not to hitch or ball
  (See Section 3.3 Coupling to the Tow Vehicle)
- Test of lights: Tail, Stop, Turn and Backup.
- Safety breakaway switch cable fastened to tow vehicle, not to safety chains (See Section 3 Coupling to the Tow Vehicle).
- Cargo properly loaded, balanced and tied down with a proper proportion of the weight on the tongue of the trailer.
  (See Section 4 Loading the Trailer).
- Doors and gates latched and secured.

Synchronizing The Brake Systems

Trailer brakes are designed to work with the brakes on the tow vehicle. Do not use either brake system alone to stop the combined tow vehicle and trailer.

⚠ WARNING

If trailer and tow vehicle brakes do not work properly together, death or serious injury can occur.

Road test the brakes in a safe area at no more than 30 mph before each tow.

5.2 Check During Trip

After each 50 miles, stop and check the following items:

- Coupler secured.
- Safety chains are fastened and not dragging.
- Cargo secured.

Retighten Lug Nuts at First 10, 25 & 50 Miles

Wheel lugs can shift and settle quickly after being initial assembly and must be checked after the first 10, 25 and 50 miles of driving. Failure to perform this check may result in a wheel coming loose from the trailer, causing a crash leading to death or serious injury.

⚠ WARNING

Lug nuts are prone to loosen after initial installation, which can lead to death or serious injury.

Check lug nuts for tightness on a new trailer or when wheel(s) have been remounted after the first 10, 25 and 50 miles of driving.

6 ACCESSORIES

This chapter provides some basic information for the safe operation of several accessories. For many accessories, such as generators and LP appliances, the manufacturer of the accessory has also provided instructions. You must read and follow these instructions before using the accessory. If you are uncertain whether you have all of the instructions, call United Trailers at 1-800-637-2592 before operating the accessory. The following accessories are described in this section:

- Generators
- Accessory Battery
- "Shore Power" connections which provide power by plugging the trailer into an external source of electrical power
- LP Gas Appliances
- Vending or Accessory Doors
- Electric-powered Landing Gear

Many accessories introduce the risk of fire. If you have an accessory on your trailer that uses electricity or fuel, make sure you have a fire extinguisher charged and ready before operating the accessory. Check the fire extinguisher at least once a month. If the fire extinguisher is discharged even partially, it must be recharged. Follow the fire extinguisher manufacturer's instructions for recharging the extinguisher after use. Fire extinguishers are an optional accessory, and will be supplied when ordered from United Trailers.

6.1 GENERATORS

If your trailer is equipped with a generator, you must follow the generator manufacturer's instructions in their manual.

Carbon monoxide is an odorless gas that can cause death. You must have an operating carbon monoxide detector inside the accommodation spaces of your trailer. Be certain exhaust from a running generator does not accumulate in or around your trailer by situations such as:

- Being drawn in by fans or ventilators operated in a trailer.
- Prevailing wind.
- Being trapped between your trailer and other trailers, vehicles, buildings, snow banks or other nearby objects.

⚠ WARNING

Operating generators can lead to death or serious injury by:

Carbon Monoxide

Fire and Explosion

Electrocution

Have a working carbon monoxide detector in the accommodation spaces before operating a generator.

Do not refuel a running generator or refuel near ignition sources.

Before starting the generator, check fuel and oil levels. The generator may have to run for two or three minutes before it allows drawing electricity from it. Read the generator instruction manual. If you do not have the generator instruction manual, call United Trailers at 1-800-637-2592 for a free copy.

6.2 ACCESSORY BATTERY

Your trailer may be outfitted with an accessory battery that operates lighting, electric landing gear, or other accessories. An accessory battery may be kept charged by the tow vehicle, a generator or shore power with converter.

6.3 SHORE POWER

Shore power is the delivery of electrical power from another source to a power inlet on your trailer. To connect your trailer to this source, you must have a shore power cord, specifically designed for this use. DO NOT USE AN ORDINARY EXTENSION CORD. The trailer end of this cord is connected to an electrical box on the trailer. This box contains circuit breakers and/or Ground-Fault Interrupter (GFI) circuit breakers. It may include a power converter to change the shore power (usually 110-volt alternating current) into 12-volt direct current.

Do not assume that a shore power supply is correctly wired. Shore power may have reverse polarity or it may not have the safety ground. Before connecting your trailer, test the shore power by using a polarity and ground tester that can be purchased at an electronics store.

If you have GFI protection, you must periodically test the outlets by pressing the "TEST" button located on the GFI-equipped device.

⚠ WARNING

Shore power poses a risk of death due to electrocution or fire.

Always use an electrical cord specifically designed for shore power connection. Never use an ordinary extension cord.

Always connect the electrical cord to a grounded source of shore power.

Do not remove the "third prong" from the shore power plug.

Connect only to source of proper voltage.

Make certain polarity is correct.

Do not overload electrical circuits.

Always replace fuses or circuit breakers with correct rating.

6.4 LP Gas Fuel System

LP gas systems are installed to operate a variety of appliances, such as stoves, refrigerators, heating units and electrical generators. The exhaust fumes from burning LP gas contain carbon monoxide. Carbon monoxide gas is odorless and can cause death or serious brain injury if inhaled. The exhaust from LP appliances must be directed to the outdoors. You must have an operating carbon monoxide detector in the accommodation space of your trailer.

⚠ Danger

You can die or be brain damaged by carbon monoxide.

Make certain the exhaust from LP appliances is directed to the outdoors.

Have a working carbon monoxide detector in the accommodation spaces of your trailer before operating any LP gas appliance.

Do not operate portable grills or stoves inside the trailer.

When used for the first time, or after a period of storage, the LP gas lines will be full of air and must be purged before the appliances will stay lit. Have the LP gas lines purged by a qualified professional.

An LP gas system is designed to operate with a supply of LP gas only, NOT natural gas. A natural gas supply is unsafe for the system's pressure regulation devices.

⚠ WARNING

Risk of death due to fire or explosion.

Only connect an LP gas system to a supply of LP gas, NOT natural gas.

Do not store LP gas tanks inside the trailer.

Only fill an LP gas tank 80% full.

Only fill the tank with LP gas (propane).

Overfilled tanks can release gas and cause an explosion.

Keep the shutoff valve on your LP gas tank closed at all times, except when you are operating an LP gas appliance. Before opening the LP shutoff valve, turn off all LP gas appliances. If an appliance is on when you open the shutoff valve, LP gas will accumulate in the trailer, which can result in an explosion.

Do not use a wrench to open or close the shutoff valve. If the shutoff does not completely stop the flow of LP gas when it is hand-tightened, replace the shutoff valve.

LP gas leaks can result in fire or explosion. If your trailer is equipped with an LP gas system, it must also be equipped with an LP gas detector. The LP gas detector will be located near the floor to detect the heavier-than-air LP gas. If a leak is suspected, use a soapy water solution to search for the leak. Do not use a solution that contains ammonia or chlorine (common in window and other household cleaning compounds), because those chemicals will cause LP piping corrosion.

⚠ WARNING

Risk of fire or explosion.

If LP gas is detected by smell or by the LP gas detector:

Do not touch electrical switches.

Extinguish flames and pilot lights.

Open doors for ventilation.

Shut off LP gas supply at the LP tank.

Leave the area until odor clears.

Correct the source of LP gas leakage before using LP appliances.

Do not use a flame to locate the source of an LP gas leak.

Keep the regulator for the LP gas system that is located near the LP gas tank covered with a guard to protect it from road debris. LP gas is prohibited on some roadways, bridges and tunnels. Check a map and with Departments of Transportation (or with the AAA) for travel routes that do not have such restrictions.

LP Gas System Troubleshooting

If your LP gas appliances do not stay lit, it might be because your LP gas system is contaminated with air or moisture. Many LP gas vendors have facilities to purge the air from an LP gas system.

If your LP gas system is not providing gas, even when the shutoff valve is open, it might be because the LP gas regulator has frozen water in it, or you may be out of gas.

⚠ WARNING

Risk of fire or explosion.

Never attempt to thaw an LP gas regulator. Seek a qualified service technician to fix.

Do not remove the regulator cover or attempt to service the LP gas regulator.

7 INSPECTION, SERVICE & MAINTENANCE

7.1 INSPECTION, SERVICE & MAINTENANCE GUIDELINES

You must inspect, maintain and service your trailer regularly to insure safe operation and keep the warranty intact. If you cannot or are unable to perform this inspection, have your dealer do it. Throughout this manual are many instructions to insure your safety while you are using your trailer.

The following is a short list of maintenance items you should follow to keep your trailer in top condition:

- Once a year, check the roof sealant for cracks or tears that could have occurred while driving. Tree branches have been known to damage the sealant on the roof. Reseal with the original sealant if possible. If your dealer does not have the sealant, call United Trailers at 1-800-637-2592.
- Always check the battery in the breakaway system, and any other batteries that are in your trailer to make sure your trailer functions properly.
- Check the axle manufacturer's guide for your trailer and follow the instructions on how to maintain your axles and keep them in proper working condition.
- Inspect your tires before every trip for proper air inflation and damage of any kind. Check the lug nuts for proper torque.
- Inspect your coupler, safety chains, and jack to make sure they are in proper working condition.
- Make sure all running lights, clearance lights, tail and brake lights are in working order.
- Inspect all parts of the steel frame for any structural failure.
- Inspect all bolts and fasteners that may apply to your trailer.

7.2 Inspection and Service Warnings

The following warnings apply to service and inspections:

⚠ WARNING

Worn or broken suspension parts can cause loss of control and injury may result.

Have trailer professionally inspected annually and after any impact.

⚠ WARNING

Never crawl under your trailer unless it is on firm and level ground and resting on properly placed and secured jack stands.

⚠ WARNING

Broken or damaged fasteners or welds can cause injury or damage to trailer and contents.

Inspect for and repair all damaged parts at least once a year.

⚠ WARNING

Improper weld repair will lead to early failure of the trailer structure and can cause serious injury or death.

Do not repair cracked or broken welds unless you have the proper skills and equipment. If not, have the welds repaired by a qualified professional.

⚠ WARNING

If electric breakaway brakes do not operate when trailer is uncoupled from the tow vehicle, death or serious injury can occur.

Check emergency breakaway brake system before each tow.

⚠ WARNING

Improper operating taillights, stoplights and turn signals can cause collisions.

Check all lights before each tow.

⚠ WARNING

Worn, damaged or under-inflated tires can cause loss of control, resulting in damage, serious injury and possibly death.

Inspect tires before each tow.

⚠ WARNING

Lug nuts are prone to loosen after initial installation, which can lead to death or serious injury.

Check lug nuts for tightness on a new trailer or when wheel(s) have been remounted after the first 10, 25 and 50 miles of driving.

⚠ WARNING

Metal creep between the wheel rim and lug nuts will cause rim to loosen and could result in a wheel coming off, leading to death or serious injury.

Tighten lug nuts before each tow.

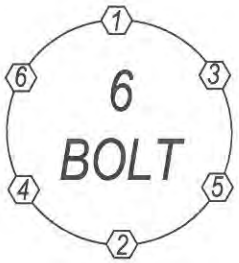
Even though these inspections sound simple, a qualified professional should do them. This could be United Trailers, your dealer who you purchased the trailer from, or an authorized repair facility. Always call ahead for an appointment. This inspection may not be free, but it is well worth the money spent to insure your safety and the safety of others on the road.

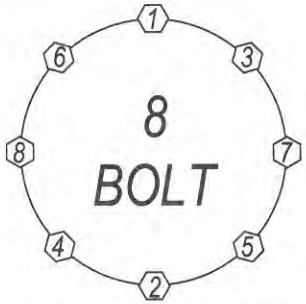
If at any time you have questions that have not been answered in this manual, please feel free to contact the United Trailers service department. They will be more than happy to answer any questions you may have. Call 1-800-637-2592 and ask for the service department.

Lug Nut Tightening Sequence

Tighten the lug nuts to the proper torque for the axle size on your trailer to prevent wheels from coming loose. Use a torque wrench to tighten the fasteners. If you do not have a torque wrench, tighten the fasteners with a lug wrench as much as you can, then have a service garage or dealer tighten the lug nuts to the proper torque. Over-tightening will result in breaking the studs or permanently deforming the mounting stud holes in the wheels.





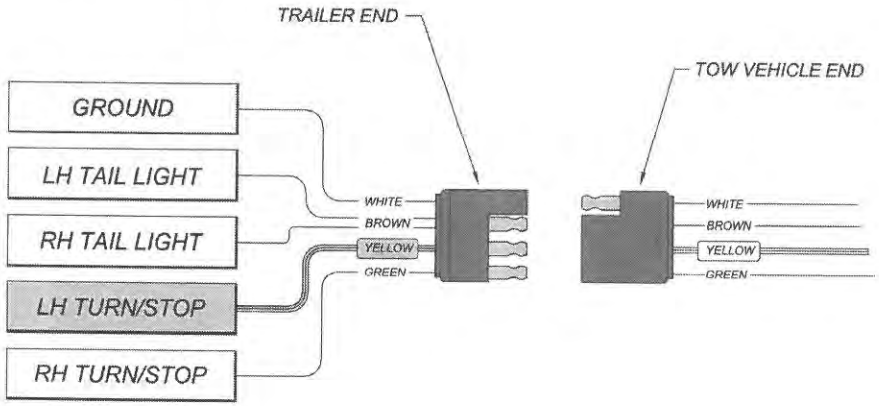


Lug Nut Torque – Steel Wheels		
Axle Rating Pounds	**Stud Size**	**Torque Foot-pounds**
3,000	½ inch	90-120
3,500	½ inch	90-120
5,200	½ inch	90-120
6,000	9/16 inch	140-170
7,000	9/16 inch	140-170
8,000	5/8 inch	275-325

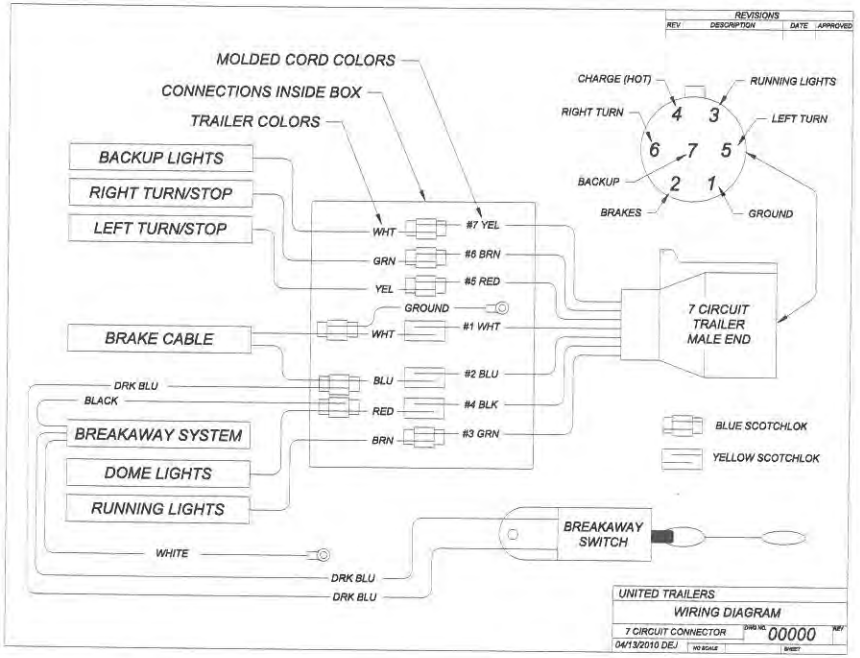
Lug Nut Torque – Aluminum Wheels		
Rim Size	**Stud Size**	**Torque Foot-pounds**
15 inch (5 or 6 hole)	½ inch	90-120
16 inch (8 hole)	9/16 inch	120-140
17.5 inch (8 hole)	5/8 inch Alcoa	140-160

8 Wiring Diagrams

4-Way Connector



7-Way Connector



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BUILT FOR THE United TRAILERS 25TH ANNIVERSARY LONG HAUL

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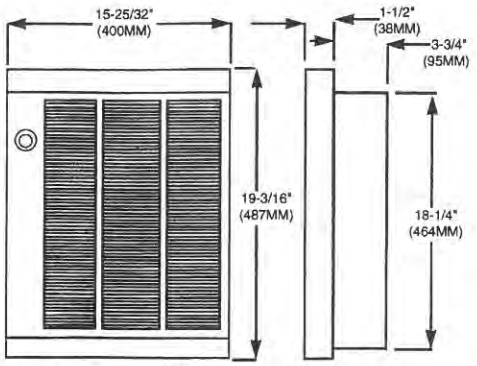


Installation, Operation & Maintenance Instructions

Specifications

MODEL #	VOLTS	PH	WATTS	BTU/HR	AMPS	WIRE SIZE
FRA1512	120	1	1500	5,118	12.5	12 AWG
FRA1812	120	1	1800	6,142	15	10 AWG
FRA3027B	277	1	3000/1500	10,239/5120	10.8/5.4	12 AWG
FRA4020B	208	1	4000/2000	13,652/6826	19.2/9.6	10 AWG
FRA40203B	208	3	4000	13,652	11.1	14 AWG
FRA4024B	240/208	1	4000/3000 2000/1500	13,652/10,239 6826/5120	16.7/14.45 8.3/7.2	10 AWG 12 AWG
FRA40243B	240/208	3	4000/3000	13,652/10,239	9.7	14 AWG
FRA4027B	277/240	1	4000/3000 2000/1500	13,652/10,239 6826/5120	14.4/12.5 7.2/6.3	12 AWG
FRA4820B	208	1	4800	16,382	23.1	10 AWG
FRA48203B	208	3	4800	16,382	13.4	12 AWG
FRA4824B	240/208	1	4800/3600	16,382/12,287	20.0/17.3	10 AWG
FRA48243B	240	3	4800	16,382	11.6	14 AWG
FRA4827B	277/240	1	4800/3600	16,382/12,287	17.3/15.0	10 AWG

IMPORTANT INSTRUCTIONS

WARNING

WHEN USING ELECTRIC APPLIANCES, BASIC PRECAUTIONS SHOULD ALWAYS BE FOLLOWED TO REDUCE THE RISK OF FIRE, ELECTRIC SHOCK, AND INJURY TO PERSONS, INCLUDING THE FOLLOWING:

1. Read all instructions before installing or using this heater.
2. This heater is hot when in use. To avoid burns, do not let bare skin touch hot surfaces. Keep combustible materials, such as furniture, pillows, bedding, papers, clothes, etc. and curtains at least 3 feet (0.9 m) from the front of the heater.
3. Extreme caution is necessary when any heater is used by or near children or invalids and whenever the heater is left operating and unattended.
4. Do not operate any heater after it malfunctions. Disconnect power at service panel and have heater inspected by a reputable electrician before using.
5. Do not use outdoors.
6. To disconnect heater, turn controls to off, and turn off power to heater circuit at main disconnect panel.
7. Do not insert or allow foreign objects to enter any ventilation or exhaust opening as this may cause an electric shock, fire, or damage to the heater.
8. To prevent a possible fire, do not block air intake or exhaust in any manner.
9. A heater has hot and arcing or sparking parts inside. Do not use it in areas where gasoline, paint, or flammable liquids are used or stored.
10. Use this heater only as described in this manual. Any other use not recommended by the manufacturer may cause fire, electric shock, or injury to persons.
11. This heater is intended for comfort heating applications and not intended for use in special environments. Do not use in damp or wet locations such as marine or greenhouse or in areas where corrosive or chemical agents are present.
12. When installing, see INSTALLATION INSTRUCTIONS for additional warnings and precautions.
13. For safe and efficient operation, and to extend the life of your heater, keep your heater clean - See MAINTENANCE INSTRUCTIONS.

SAVE THESE INSTRUCTIONS

INSTALLATION INSTRUCTIONS

⚠ WARNING ⚠

To prevent a possible fire, injury to persons or damage to the heater, adhere to the following:

1. Disconnect all power coming to heater at main service panel before wiring or servicing.
2. All wiring procedures and connections must be in accordance with the National and Local Codes having jurisdiction and the heater must be grounded.
3. Power supply must enter back box through the knockouts. See also TOP marking on the back box for proper orientation.
4. Verify the power supply voltage coming to heater matches the ratings as shown on the heater nameplate.

CAUTION: ENERGIZING HEATER AT A VOLTAGE GREATER THAN THE VOLTAGE PRINTED ON THE NAMEPLATE WILL DAMAGE THE HEATER AND VOID THE WARRANTY AND COULD CAUSE A FIRE.

5. **CAUTION** - High temperature, risk of fire, keep electrical cords, drapery, furnishings, and other combustibles at least 3 feet (0.9 m) from front of heater. Do not install heater behind doors, below towel racks, or in an area where it is subject to being blocked by furniture, curtains or storage materials. Hot air from the heater may damage certain fabrics and plastics.
6. To reduce the risk of fire, do not store or use gasoline or other flammable vapors and liquids in the vicinity of the heater.
7. This heater is to be mounted only using back box and may be installed with the back box recessed or surface mounted as described within this manual.
8. The following minimum clearances must be maintained:

   Bottom of heater to floor - 8" (203 mm) - optimum height is 18" to 24".

   Sides of heater to adjacent wall - 8" (203 mm) - optimum minimum 12" (305 mm).

   Top of heater to ceiling - 36" (915 mm).
9. Do not operate the heater without the grille installed.
10. Do not use this heater for dry out as the paint, plaster, sawdust and drywall sanding dust will permanently damage the heater and must be kept out of the heater.

NOTE: This heater has a continuous fan-only feature. See page 4, **Operating Instructions**, step #4 for details.

Installation of Back Box in New Construction

1. Place the back box between two 16" (406 mm) center-to-center wall studs at the desired mounting height but no closer than 8" (203 mm) to adjacent wall or floor.

NOTE: If wall studs are spaced greater than 16" on center, additional framing supports may be necessary.

2. Align back box such that the bottom and sides will be flush with finished wall surface (top flange of back box should protrude approximately 1/2" (12.7 mm) from finished wall surface).
3. Secure the back box in position with wood screws or nails as shown in Figure 1.

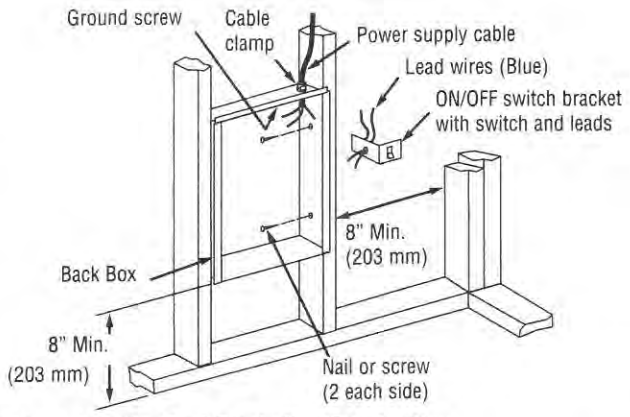


Figure 1 - Locating Back Box in New Construction

4. Run a power supply cable into the knockout area in the upper right hand corner of the back box. All wiring must be in accordance with National and Local Electrical Codes. Refer to Specifications, page 1 for correct wire size.

NOTE: Wire compartment volume - 119 in^3 (1950 cm^3).

5. Remove ON/OFF switch bracket by loosening two screws on the right side.
6. Install a cable clamp in the knockout in the top of the back box.
7. Insert power supply cable through cable clamp, allowing at least 6" (152 mm) of leads to extend inside the back box. Connect the blue lead wires of ON/OFF switch to the supply wire leads using wire connectors (see Wiring Diagrams, pages 3 & 4).

NOTE: If power supply is provided by standard non-metallic sheathed cable (Romex) and the supply voltage is 240 or 208 volts (two power wires), the white wire color must be changed using black electrical tape to comply with the NEC. White is only allowed for a Neutral conductor.

8. Ground the back box by connecting the supply ground lead wire to the green ground screw located in the inside top of the back box.
9. Secure ON/OFF switch bracket in place by tightening screws.

Installation of Back Box in Existing Construction

1. Provide a wall opening 14-1/2" (362 mm) wide by 18-1/2" (470 mm) high at the desired mounting height, but no closer than 8" (203 mm) to adjacent wall or floor. (See Figure 2.)

NOTE: Locate so at least one side of opening is at wall stud.

2. Run a power supply cable into the area above the top of the wall opening. All wiring must be in accordance with National and Local electrical codes. Refer to Specifications, page 1 for correct wire size.

NOTE: Wiring Compartment Volume - 119 in3 (1950 cm3).

3. Remove ON/OFF switch bracket by loosening the two screws on the right side.
4. Install a cable clamp in the knockout in the top of wall back box.
5. Insert power supply cable through cable clamp, allowing approximately 6" (152 mm) of cable length to remain inside the back box to facilitate connections.

NOTE: If power supply is provided by standard non-metallic sheathed cable (Romex) and the supply voltage is 240 or 208 volts (two power wires), the white wire color must be changed using black electrical tape to comply with the NEC. White is only allowed for a Neutral conductor.

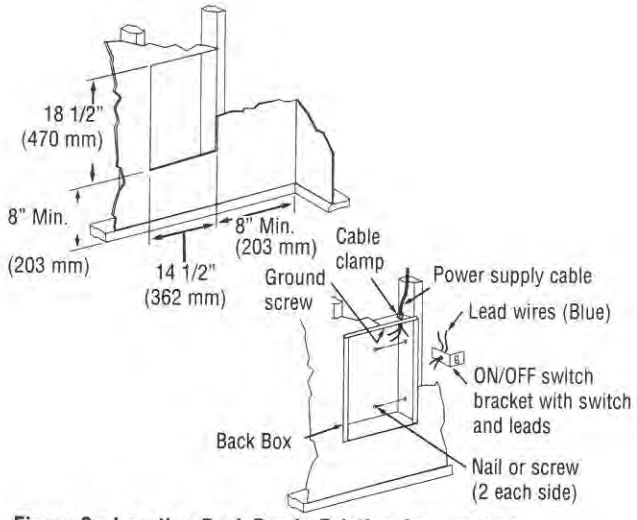


Figure 2 - Locating Back Box in Existing Construction

6. Place the back box into wall opening flush with finished wall surface on bottom and sides of box. (Top flange of backbox should protrude approximately 1/2" or 12.7 mm from finished wall surface).
7. Secure the back box in place with wood screws or nails.
8. Connect the power supply wires to the blue wires of the ON/OFF switch using wire connectors (see Wiring Diagrams, pages 3 & 4)
9. Ground the back box connecting the supply ground lead wire to the green ground screw located in the inside top of the back box.
10. Secure ON/OFF switch bracket in place by tightening screws.

Installation of Back Box With Surface Mounting Frame

See Figure 3

1. Secure back box to wall with knockouts in upper right hand corner using screws and anchors.
2. Hang the surface-mounting frame on the back box. Ensure that the back edge of the surface-mounting frame is flush against the wall.

NOTE: If heater is located in a high traffic area where it may be subjected to vandalism or abuse, take extreme care to see that the box is firmly attached to the wall.

3. Run a power supply cable into the area of the upper right corner of the mounting frame. Arrangement of wiring to this point must be in accordance with National and Local codes. Refer to Specifications page 1 for proper wire size.

NOTE: Wiring Compartment Volume - 119 in^3 (1950 cm^3).

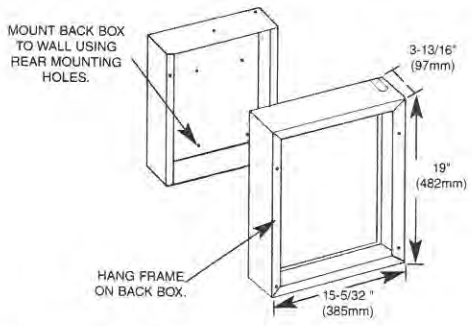


Figure 3: Optional Surface Mounting Frame Installation

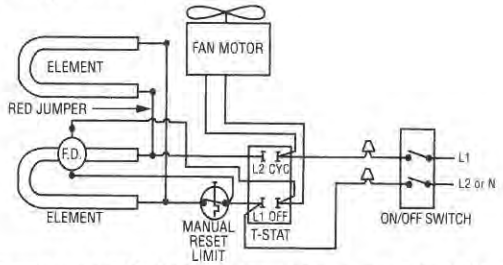
NOTE: If the wiring is to run through the wall, cut a hole in the area of the top of the wall box. Run the supply wire through this hole. Then remove the "knockout" from the top of the box and proceed to Step 5.

4. Remove the knockout on the top side of the frame.
5. Remove ON/OFF switch bracket by loosening the two screws on the right side.
6. Feed the power supply cable through the frame allowing 6" (152 mm) of lead to remain inside the back box.

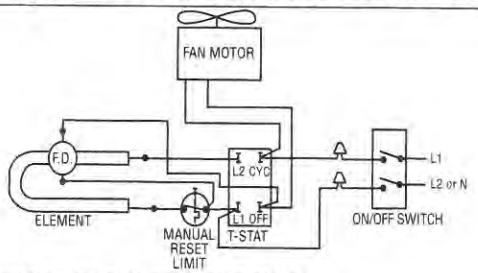
NOTE: If power supply is provided by standard non-metallic sheathed cable (Romex) and the supply voltage is 240 or 208 volts (two power wires), the white wire color must be changed using black electrical tape to comply with the NEC. White is only allowed for a Neutral conductor.

7. Secure the power supply cable to the back box (using cable clamp, connector, or other suitable strain relief) allowing 6" (152 mm) of lead to remain inside the back box.
8. Connect supply wires to blue wires of ON/OFF switch using wiring connectors (see Wiring Diagrams, page 3 &4).
9. Ground the back box by connecting the supply ground lead-wire to the green ground screw located in the inside top of the back box.
10. Secure ON/OFF switch bracket in place.

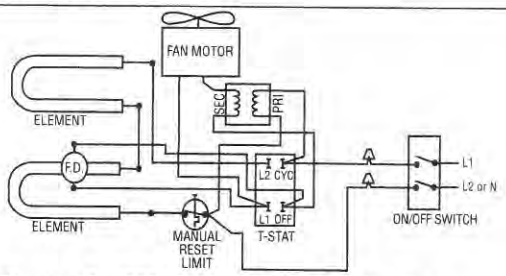
Wiring Diagrams



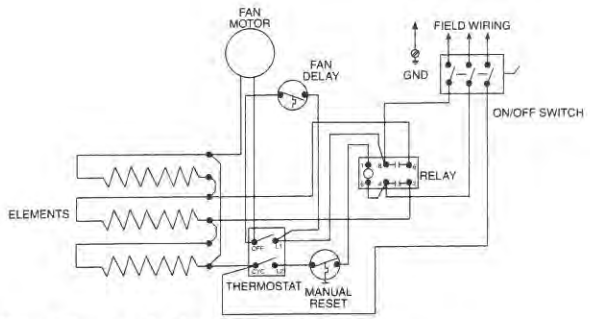
Wiring Diagram 1: 1500, 1800, 4800, 4000, & 3000 Watt Heaters
120V, 208V, 240V, OR 277V (Full wattage heaters can be converted to half wattage by removing the red jumper wire connecting the top and bottom element terminals.) See wiring No. 5 for 4800W, 208V, 1phase.
NOTE: Wattage conversion not applicable to FRA1512 and FRA1812



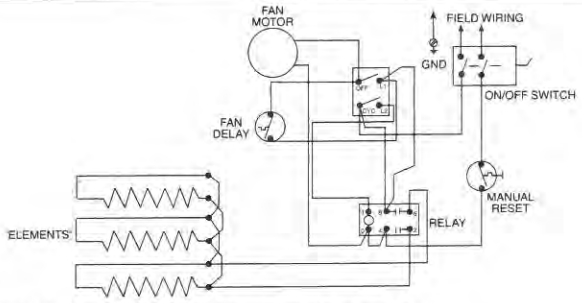
Wiring Diagram 2: 2000 & 1500 Watt Heaters
208V, 240V, OR 277V



Wiring Diagram 3: 4800, 4000, & 3000 Watt Heaters
347V, 600V



Wiring Diagram 4: Three Phase Heaters



Wiring Diagram 5 : 4800 Watt Heater, Single Phase
208V

Installation of Heater Assembly and Grille

After back box is completely installed and no further construction dirt is expected, clean debris from back box, remove heater assembly from its carton, then refer to Figure 4 and proceed as follows:

1. Insert the heater assembly into wall housing, placing the four mounting holes (with key-hole slots) over the screws in the housing. Tighten all screws securely.
2. If surface-mounting frame is used, ensure that the frame is even with all four heater assembly tabs before tightening screws.
3. Connect the two ON/OFF switch wires to the thermostat leads using wirenuts (see wiring diagram). After connection, push wires back into the opening.
4. Turn thermostat to the extreme counterclockwise position.
5. Push ON/OFF switch into ON position.
6. Install (2) plastic covers on back box as follows: (See Fig. 4)

NOTE: Top plastic cover must have Warning Label visible when installed.

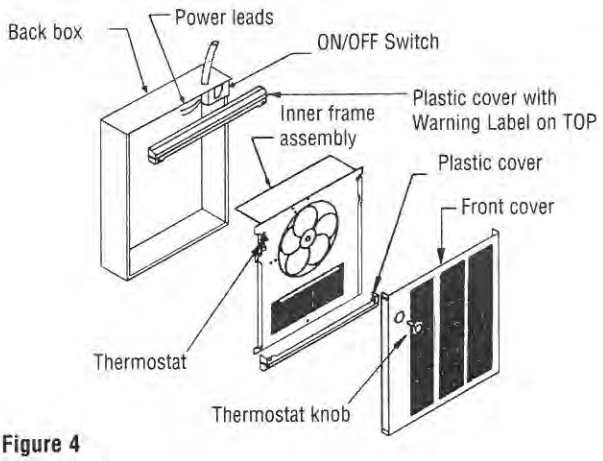


Figure 4

- TOP - Align the screw bosses on the back of the plastic cover with the second hole down from the top of the back box and attach it with the two screws provided.
- BOTTOM - Align the screw bosses on the back of the other plastic cover with holes at the bottom of the back box that are just above the fan deck mounting screws and attach it with two screws provided.

7. Install the front cover by hooking the (2) tabs on the one side then rotating the front cover into place making sure that all four tabs are snapped onto the front cover.
8. Fit the thermostat knob onto the thermostat shaft and push into place.

OPERATING INSTRUCTIONS

1. Heater must be properly installed before operation.
2. Rotate the thermostat knob fully clockwise. This should energize the heating elements and fan causing warm air to flow from the hot air discharge at the openings in the bottom of the grille.

NOTE: There will be a short delay from the time the unit is turned on until the fan engages. This is to allow the elements time to warm up. The fan will also continue to run once the unit is turned off to allow the elements time to cool.

3. After the operation check, rotate the thermostat knob to the desired position to obtain room comfort.
4. For continuous fan-only operation (elements will not be energized) rotate thermostat knob where indicator dot on knob is aligned with fan.

NOTE: For best results, the heater should be left "ON" constantly during the heating season because the thermostat, when properly set, will maintain the desired temperature.

How To Reset Manual Thermal Limit Safety Control:

Your heater is equipped with a manual reset thermal limit safety control that will automatically turn the heater off to prevent a fire if the heater overheats. This control is located on the fan panel assembly between the element and fan blade and marked "**RESET**". The red reset button can be seen through the front grille when the heater is installed. To reset, allow the heater to cool, then push the red button that is visible through the hole in the fan panel. The heater should immediately return to normal operation.

⚠ WARNING ⚠

DO NOT TAMPER WITH OR BYPASS ANY SAFETY LIMITS INSIDE HEATER.

CAUTION ⚠

CAUTION - DO NOT CONTINUE TO ATTEMPT TO USE THE HEATER IF THE SAFETY CONTROL REPEATEDLY OPERATES AFTER BEING RESET. TO DO SO COULD PERMANENTLY DAMAGE THE HEATER OR CREATE A FIRE OR SAFETY HAZARD.

MAINTENANCE INSTRUCTIONS

It is important to keep this heater clean. Your heater will give you years of service and comfort with only minimum care. To assure efficient operation follow the simple instructions below.

⚠ WARNING ⚠

ALL SERVICING BEYOND SIMPLE CLEANING THAT REQUIRES DISASSEMBLY SHOULD BE PERFORMED BY QUALIFIED SERVICE PERSONNEL.

⚠ WARNING ⚠

TO REDUCE RISK OF FIRE AND ELECTRIC SHOCK OR INJURY, DISCONNECT ALL POWER COMING TO HEATER AT MAIN SERVICE PANEL AND CHECK THAT THE ELEMENT IS COOL BEFORE SERVICING OR PERFORMING MAINTENANCE.

User Cleaning Instructions:

1. After the heater has cooled, a vacuum cleaner with brush attachment may be used to remove dust and lint from exterior surfaces of the heater including the grille openings.
2. With a damp cloth, wipe dust and lint from grille and exterior surfaces.
3. Return power to heater and check to make sure it is operating properly.

Maintenance Cleaning Instructions:

(To be performed only by Qualified Service Personnel)

At least annually, the heater should be cleaned and serviced by a qualified service person to assure safe and efficient operation. This should include the removal of the grille and, as necessary the heater from the backbox to clean residue from the unit. After completing the cleaning and servicing, the heater should be fully reassembled and checked for proper operation.

Marley Engineered Products

Cat. No. SM, S1, S2, SMSB, S1SB, and S2SB Surface Mounting Frame and Semi-Recessed Sleeves

PLEASE READ AND FOLLOW THESE DIRECTIONS. LEAVE INSTALLATION INSTRUCTIONS FOR USER TO READ. ALL WIRING MUST CONFORM TO NATIONAL AND LOCAL ELECTRICAL CODES.

⚠ WARNING ⚠

PERSONAL INJURY OR DEATH CAN RESULT FROM ELECTRICAL SHOCK. DISCONNECT ALL POWER TO HEATER AT MAIN SERVICE PANEL DURING INSTALLATION AND DURING SERVICE OR MAINTENANCE OF HEATER.

Installation of Back Box with Cat.No. SM or SMSB - Surface Mounting Frame (See Figure 1)

1. Secure back box to wall (with knockouts in upper right hand corner) using screws and anchors.
2. Power Supply Wiring.
   a. Run a power supply cable into the area to the upper right hand corner of the mounting frame shown in figure 1.

NOTE: If the wiring is to run through the wall, cut a hole in the wall in the area of the top of the back box. Run the supply wire through this hole. Then remove the "knockout" from the top of the box and proceed to step C.

   b. If surface conduit is used, remove the "knockout" on the top side of the back box and "U" shaped knockout in sur face frame at top and install conduit to box using appropriate conduit connector.
   c. Secure the frame in position over the box with the screws provided as shown in figure 1.

NOTE: Install screws loosely.

   d. Remove disconnect switch bracket by loosening the two screws on the right side.
   e. Feed the power supply cable into back box allowing 6 inches of lead to remain inside for connections.
   f. Secure the power supply cable to the back box using cable clamp, connector, or other suitable strain relief.
   g. Connect supply wires to blue wires of disconnect switch using wire nuts.
   h. Ground the back box by connecting the supply ground leadwire to the green ground screw located in the back box.

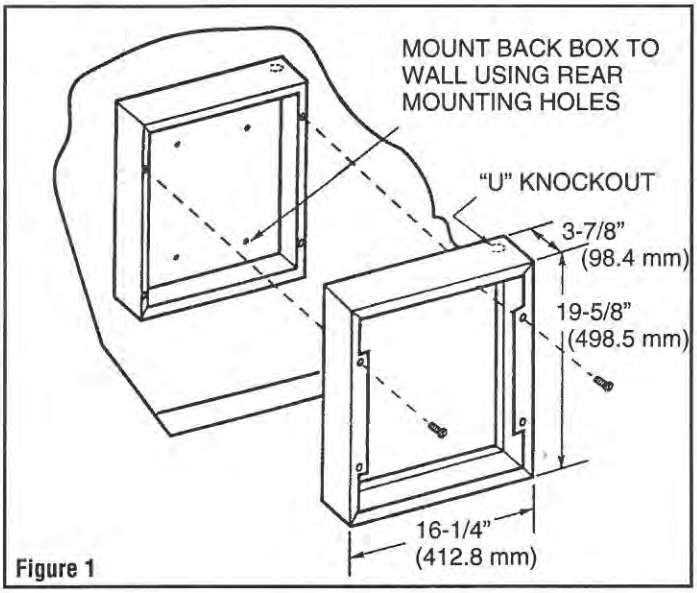


Figure 1

   i. Feed (two) black leads from switch through rolled edge hole in bracket and secure disconnect switch bracket in place by tightening screws.
   j. Set fan deck on surface mounting frame aligning the top two keyholes with screws installed in Step C. Tighten top two screws and install two screws in top of bottom two keyholes, continue with heater installation as described in unit installation instructions.

To Install S1, S1SB, S2, or S2SB

Provide opening in wall 14-1/2" Wide x 18-1/2" high. Depth must be a minimum of 2-3/4" for use with S1/S1SB or 1-3/4" for use with S2/S2SB.

SAVE THESE INSTRUCTIONS

Installation of Back Box

Refer to "Installation of Back Box in Existing Construction" in heater instruction sheet.

1. When using the S1/S1SB, the front edge of the back box must extend 1" beyond the finished wall surface. When using the S2/S2SB, the front edge of the back box must extend 2" beyond the finished wall surface. See Figure 2.
2. Fasten back box into wall opening using mounting holes provided. Knockouts in back and side should be in upper right hand corner. Knockouts in bottom of box should not be used.

Installation of Semi-Recessed Sleeve

1. Position sleeve over back box.
2. To complete heater installation, follow the heater installation instruction packed with heater.

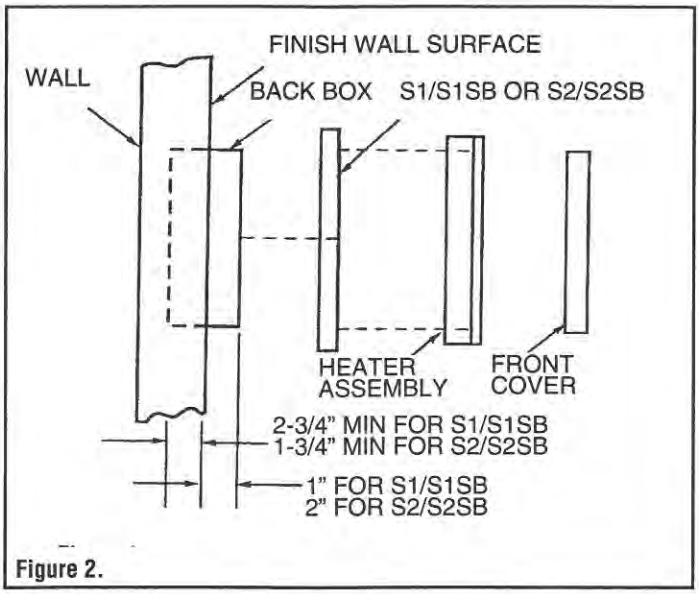


Figure 2.

LIMITED WARRANTY

All products covered by this instruction sheet are warranted against defects in workmanship and materials for one year from date of installation. This warranty does not apply to damage from accident, misuse, or alteration; nor where the connected voltage is more than 5% above the nameplate voltage; nor to equipment improperly installed or wired or maintained in violation of this instruction sheet. All claims for warranty work must be accompanied by proof of the date of installation.

The customer shall be responsible for all costs incurred in the removal or reinstallation of products, including labor costs, and shipping costs incurred to return products to a Marley Engineered Products Service Center, and we will repair or replace, at our option, at no charge to you with return freight paid by Marley. It is agreed that such repair or replacement is the exclusive remedy available from Marley Engineered Products.

THE ABOVE WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED, AND ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE WHICH EXCEED THE AFORESAID EXPRESSED WARRANTIES ARE HEREBY DISCLAIMED AND EXCLUDED FROM THIS AGREEMENT. MARLEY ENGINEERED PRODUCTS SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES ARISING WITH RESPECT TO THE PRODUCT, WHETHER BASED UPON NEGLIGENCE, TORT, STRICT LIABILITY, OR CONTRACT.

Some states do not allow the exclusion on limitation of incidental or consequential damages, so the above exclusion or limitation may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state.

For the address of your nearest authorized service center, contact Marley Engineered Products, 470 Beauty Spot Road East, Bennettsville, SC 29512 USA. Merchandise returned to the factory must be accompanied by a return authorization and service identification tag, both available from the above location. When requesting return authorization, include all catalog numbers shown on the products.

HOW TO OBTAIN WARRANTY SERVICE AND WARRANTY PARTS PLUS GENERAL INFORMATION

1. Warranty Service or Parts **1-800-642-4328**
2. Purchase Replacement Parts **1-800-654-3545**
3. General Product Information **www.marleymep.com**

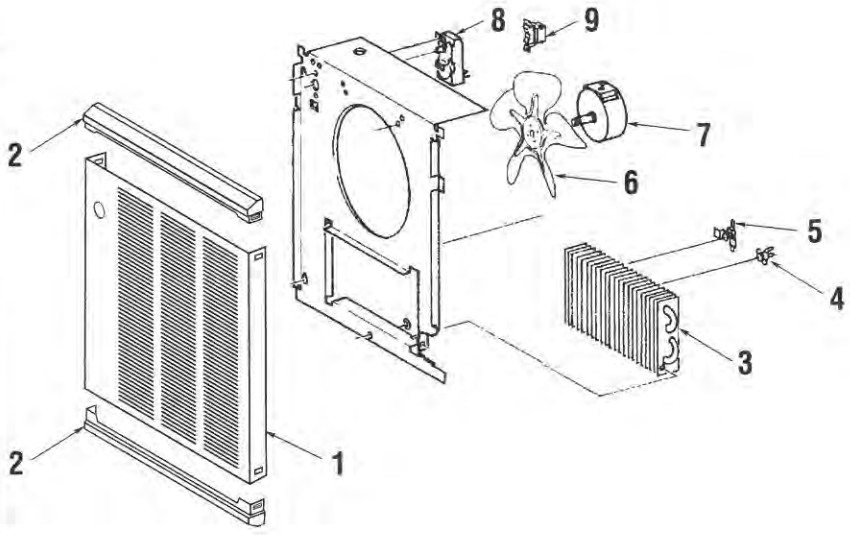
Note: When obtaining service always have the following:
1. Model number of the product
2. Date of manufacture
3. Part number or description

Marley Engineered Products

470 Beauty Spot Rd. East
Bennettsville, SC 29512 USA

Replacement Parts

Key No.	Description	Part Number
–	Parts Bag: (4) Wire Nuts (4) #6 Screws Thermostat Knob Plug Button	1205-2020-000
1	Front Cover	1402-2241-001
2	Plastic Cover	1402-2120-000
3	Element: 120V/1500W 120V/1800W 208V/2000W 208V/4000W 208V/4800W 240V/2000W 240V/4000W 240V/4800W 277V/1500W 277V/2000W 277V/4000W 277V/4800W	302012828 302012827 302015801 302012807 1802-2075-801 302015802 302012808 302012810 302015806 302015803 302012809 302012811
4	Manual Reset	4520-2027-000
5	Fan Delay	410074000
6	Fan Blade	490030103
7	Motor: 120V 208V 240V 277V	3900-2010-003 3900-2010-000 3900-2010-001 3900-2010-001
8	Thermostat	5813-2059-000
9	Disconnect Disconnect (4820B)	410170001 5216-2020-000



LIMITED WARRANTY

All products manufactured by Marley Engineered Products are warranted against defects in workmanship and materials for one year from date of installation, except heating elements which are warranted against defects in workmanship and materials for five years from date of installation. This warranty does not apply to damage from accident, misuse, or alteration; nor where the connected voltage is more than 5% above the nameplate voltage; nor to equipment improperly installed or wired or maintained in violation of the product's installation instructions. All claims for warranty work must be accompanied by proof of the date of installation.

The customer shall be responsible for all costs incurred in the removal or reinstallation of products, including labor costs, and shipping costs incurred to return products to Marley Engineered Products Service Center. Within the limitations of this warranty, inoperative units should be returned to the nearest Marley authorized service center or the Marley Engineered Products Service Center, and we will repair or replace, at our option, at no charge to you with return freight paid by Marley. It is agreed that such repair or replacement is the exclusive remedy available from Marley Engineered Products.

THE ABOVE WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED, AND ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE WHICH EXCEED THE AFORESAID EXPRESSED WARRANTIES ARE HEREBY DISCLAIMED AND EXCLUDED FROM THIS AGREEMENT. MARLEY ENGINEERED PRODUCTS SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES ARISING WITH RESPECT TO THE PRODUCT, WHETHER BASED UPON NEGLIGENCE, TORT, STRICT LIABILITY, OR CONTRACT.

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above exclusion or limitation may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

For the address of your nearest authorized service center, contact Marley Engineered Products in Bennettsville, SC, at 1-800-642-4328. Merchandise returned to the factory must be accompanied by a return authorization and service identification tag, both available from Marley Engineered Products. When requesting return authorization, include all catalog numbers shown on the products.

HOW TO OBTAIN WARRANTY SERVICE AND WARRANTY PARTS PLUS GENERAL INFORMATION

1. Warranty Service or Parts **1-800-642-4328**
2. Purchase Replacement Parts **1-800-654-3545**
3. General Product Information **www.marleymep.com**

Note: When obtaining service always have the following:
1. Model number of the product
2. Date of manufacture
3. Part number or description

Marley
Engineered Products
470 Beauty Spot Rd. East
Bennettsville, SC 29512 USA

SOP-17: HOLLOW STEM AUGER AND PERCUSSION/DIRECT PUSH / ROTORY SONIC DRILLING METHODS

1.0 Purpose

This standard operating procedure (SOP) provides guidance for selecting and implementing the proper drilling methods for collecting subsurface soil, soil gas, and groundwater samples and for installing groundwater monitoring wells using hollow stem auger (HSA) and percussion/direct push system (DPS) and rotary sonic (RS) drilling.

In addition to selecting the proper type of drilling technology, drilling activities should conform to state regulations and be supervised by a qualified geologist or engineer. Either the drilling contractor or IEC will obtain all permits, applications, and other documents required by state and local authorities. In addition, the following general guidelines should be thoroughly considered during planning and implementation of all drilling investigations:

- Review background information for the investigation area. This includes identifying and understanding the type(s) of contaminant(s) released, the manner of release, and the affected media.
- Select the proper drilling technology and drill rig. Drilling activities should conform to Federal and State regulations.
- Coordinate boring locations with the Agency before drilling begins.
- Determine the inside diameter of the soil borehole needed to accomplish the drilling objectives and provide adequate sample volume.
- Before mobilization to each boring location, determine that the location is free of subsurface or overhead utilities according to the procedures described in *SOP for Utility Clearance for Intrusive Operations*.
- Take appropriate precautions during drilling to avoid introducing contaminants into the borehole.
- Drill boreholes in areas of reported minor anticipated contamination by first progressing toward areas of increasing contamination. Under ideal conditions, upgradient areas without contamination should be drilled first.
- When drilling boreholes through more than one water-bearing zone or aquifer, measures will be employed to prevent cross-connection or cross-contamination of the zones or aquifers, such as using telescoped casing.
- Before mobilization to each boring location, decontaminate the drill rig and all drilling equipment placed into the borehole by steam cleaning, using high-pressure hot water, or similar methods according to *SOP for Equipment Decontamination Procedures*. The drill rig must not leak any fluids that may enter the borehole or contaminate equipment placed in the borehole.
- Avoid using drilling mud, synthetic drilling fluids, or petroleum- or metal-based pipe joint compounds and other potential contaminants unless necessary. If their use is necessary, drilling fluids must not introduce or mask contaminants. Provide material safety data sheets (MSDSs) for all drilling fluids proposed for downhole use before field work and describe procedures for containment and disposal of fluid in the project work plan. If it is necessary to add drilling mud to the borehole during drilling to stabilize the hole or control down-hole fluid losses, use only high-yield sodium bentonite clay free of organic polymer additives.
- If it is necessary to add water to the borehole during drilling to control flowing and heaving soils, use only potable water from a documented clean source. All potable water volume added to a borehole must be

developed from the well. If potable water is added to the borehole, an equal volume of water must be developed from the borehole in addition to the standard well development volume.

- To the extent practical, restore the site to its pre-investigation conditions.
- Record all information pertinent to documenting the above requirements in the field log book and the Soil Boring Log Datasheet according to *SOP for Note Taking and Field Log Books*.

2.0 Scope

This SOP focuses on the most commonly used drilling tasks and applications anticipated at DuPont EC and should be used in conjunction with other project SOPs in Appendix H, Field Standard Operating Procedures, including the following:

- *SOP- Note Taking and Field Log Books*
- *SOP- Site Reconnaissance, Preparation, and Restoration*
- *SOP- Utility Clearance for Intrusive Operations*
- *SOP- Boring Log Completion, Soil Classification, and Logging*
- *SOP- Discrete Surface and Subsurface Soil Sampling*
- *SOP-, Monitoring Well/Piezometer Installation*
- *SOP- Equipment Decontamination Procedures*
- *SOP- Well Decommissioning and Abandonment*

Should field tasks and procedures be added to a project that is not included in this SOP, they must be defined in a Worksheet, Field Standard Operation Procedures and/or the Project-specific Health and Safety Plan (HASP), before implementation. Changes to field procedures and/or equipment should be implemented and documented according to *SOP- Field Procedure Change Management.*

4.0 Drilling Methods and Equipment

4.1 Hollow Stem Auger Drilling

Hollow Stem Auger (HSA) drilling methods are a form of rotating auger drilling, consisting of continuous-casing, segmented auger sections with screw-flights that are rotated into the subsurface under downward pressure. The auger section is typically equipped with a drill bit and cutting teeth. Drill cuttings are brought to the surface by a conveyor action created by the rotating screw flights and drill bit. The auger sections maintain borehole stability even in unconsolidated material. Generally, HSA drilling is limited to depths less than 150 feet where lithology is unconsolidated. Multiple auger sections are connected in series to create a “drill string” with clamping pins or screw fittings. HSA drilling usually requires a larger drill rig than is used with DPS drilling, and the entire rig can stand between 20 and 40 feet high, requiring high overhead clearance.

At sites where groundwater is relatively shallow (less than 50 feet) and DPS drilling is not feasible because of lithology (fill, cobbles and boulders are present), or where a larger- diameter boring is required, it is common to use HSA

drilling. *SOP for, Attachment 1: Geoprobe 6712 Features and Specifications* further discusses the capabilities of the Geoprobe 6712 drill rig, which is typical equipment for HSA drilling.

In situ soils may be sampled through the center of the HSA drill stem. An advantage of HSA drilling is that the auger sections can be left in place to hold the borehole open and reduce slough in unconsolidated soils.

HSAs are specified by the internal diameter of the hollow stem, not by the size of the hole they drill. Augers with a minimum inner diameter (I.D.) of 4-1/4 inches will be required to install a 2-inch monitoring well, to give clearance around the well for filter pack sand and bentonite seals. It is preferable to use a larger inner-diameter auger (5 or 6 inches) to install a 2-inch monitoring well; however, the benefits should be weighed against the additional investigation-derived waste (IDW) volumes that will be generated. If a 4-inch monitoring well is required, the inner auger diameter must be 6 to 8 inches.

Boreholes should be advanced using pre-cleaned and decontaminated augers and sampling equipment, according to *SOP- Equipment Decontamination Procedures*. Boreholes that are not converted to wells should be abandoned according to *SOP- Well Decommissioning and Abandonment*.

4.2 Percussion/Direct Push System Drilling

Percussion/Direct Push System (DPS) drilling technologies involve a category of drilling equipment that hydraulically pushes or drives small-diameter, hollow steel rods into the subsurface without rotating the drill rods. Some drill rigs may be "combo rigs," capable of conducting both direct push and rotating HSA drilling operations, such as the abovementioned Geoprobe 6712 drilling rig. DPS drilling uses a combination of a hydraulically powered percussion hammer, a downward hydraulic push, and the weight of the vehicle on which the system is mounted to drive rods into the subsurface. DPS methods push a continuous tube sampler into the subsurface by laterally displacing soil to make a path for the sampler, producing minimal drill cuttings. DPS drilling is commonly used for shallow applications (less than 50 feet); however, depending on the lithologic conditions, it may be used as deep as 120 feet. *Attachment 2: Geoprobe® Model 66 Series Features and Specifications* further discusses the capabilities of the Geoprobe® 6610DT drilling rig.

DPS technology is typically limited to unconsolidated formations that are relatively free of cobbles or boulders. Refusal may occur if there are too many cobbles, boulders, or other consolidated formation materials. However, since DPS drilling is relatively fast, refusal at a desired location because of cobbles may be mitigated by abandoning the hole, moving to a nearby location, and re-drilling.

DPS boreholes generally cannot be sampled deeper than the water table because unconsolidated materials cave in once the drive rods are removed. However, caving may be mitigated by advancing a casing with an inner drill rod used for sampling, allowing for sampling and well installation far below the water table.

Outside diameters of samplers and boring tools generally range from 0.75 to 3.5 inches. If installation of monitoring wells is planned, the inside diameter of the boring should typically range between 1.5 and 3.5 inches (for 1- to 2-inch wells).

DPS technologies provide the following advantages over conventional drilling methods:

- Minimal ground disturbance, with a small-diameter boring that is easy to abandon
- No cuttings, which eliminates the need for handling, containerizing, sampling, and disposing of potentially contaminated IDW (unless samples are brought to the surface)
- Faster boring advancement
- Faster monitoring well installation if small-diameter wells (0.75 to 1 inch in diameter) with pre-packed screens are installed

Boreholes should be completed using pre-cleaned and decontaminated drive points, rods, and sampling equipment according to *SOP for Equipment Decontamination Procedures*. Boreholes that are not converted to wells should be abandoned according to *SOP- Well Decommissioning and Abandonment*.

4.3 Rotary Sonic System Drilling

At first glance, a SONIC drill rig looks very much like a conventional air or mud rotary drill rig. The biggest difference is in the drill head, which is slightly larger than a standard rotary head. The head contains the mechanism necessary for rotary motion, as well as an oscillator, which causes a high frequency force to be superimposed on the drill string. The drill bit is physically vibrating up and down in addition to being pushed down and rotated. These three combined forces allow drilling -to proceed rapidly through most geological formations including most types of rock.

In overburden, the vibratory action causes the surrounding soil particles to fluidize, thereby allowing effortless penetration. In rock, the drill bit causes fractures at the rock face, creating rock dust and small rock particles, which facilitates advancement of the drill bit. In many instances the drilling and coring of rock and earth can be accomplished without the use of any drilling fluid whatsoever. This is an important requirement for environmental drilling projects. Compressed air, drill mud, or plain water can be utilized to remove the cuttings and speed up the operation further, depending on the application that the machine is used for.

The oscillator is driven by a hydraulic motor and uses out of balance weights to generate high sinusoidal forces that are transmitted to the drill bit. An air spring is also incorporated in order to confine the alternating forces to the drill string. The frequency can be varied to suit operation conditions and is generally between 50 and 160 hertz (cycles per second). As a comparison, ordinary household current in many countries alternates at 60 hertz. This frequency range falls within the lower range of sound vibrations that the human ear is capable of hearing. Thus the term "SONIC DRILL" has been applied to this class of rotary-vibratory drilling machine.

Continuous, relatively undisturbed samples can be obtained through virtually any formation. Conventional sampling tools can be employed as attachments (i.e., hydropunch, split spoon, shelby tube, etc.). No mud, air, water, or other circulating medium is required. The sonic method can drill easily at any angle through formations such as rock, sand, clay permafrost, or glacial till.

5.0 Drilling and Sampling Procedures

5.1 Drilling Subcontractor Responsibilities

Increased consciousness and vigilant oversight of drilling activities are critical, to reduce the risk of injury to workers involved with drilling. Safe work requires that good communication is maintained between the driller and the Field Geologist during drilling activities. Encourage the driller to notify the Field Geologist routinely of the depth(s) at which changes in drilling rates become evident and immediately of any other drilling observations that may indicate subsurface obstructions or utilities.

At a minimum, the following activities should be conducted as part of the drilling program:

- Conduct a project kickoff meeting. Describe tasks to be conducted and a tentative schedule for the project at the beginning. As the project progresses, discuss the remaining tasks and revised schedule with the drill crew daily. Communicate progress and issues with the PM.
- Conduct a health and safety tailgate meeting using a IEC pre-task safety plan.
- Review or have the drill rig operator discuss the task-specific activities identified in the driller subcontractor Job Hazard Analysis (JHA).

- Wear proper PPE at all times.
- Visit the site and drilling locations with the driller to identify all potential site hazards and obstacle before mobilization and setup.
- Obtain underground and overhead utility clearance and verify that the drilling location has been cleared according to *SOP for, Utility Clearance for Intrusive Operations.* Maintain proper clearance with aboveground utilities and obstructions.
- Set up proper traffic controls if working in an area where there are traffic hazards, according to *SOP-XX, Site Reconnaissance, Preparation, and Restoration*.
- Establish an exclusion zone using barriers, flagging tape, or other methods to prevent unauthorized access to the drilling location according to the HASP.
- Inspect the drill rig for leaking lines or other hazards and have the driller test safety switches and demonstrate that they work. No fluids should leak from the rig.
- Verify that all personnel working around the drill rig are properly trained and instructed, familiar with drill rig operation, and understand the task to be performed.
- Identify the locations of the fire extinguisher(s) and first aid kit(s) and verify that they are readily available for use.
- Maintain good housekeeping on and around the rig at all times.
- Complete *Attachment 3: Drilling Self Assessment Checklist* according to requirements in the HASP.
- Establish a staging area for storing IDW and decontaminating augers and sampling equipment.
- Establish a core logging and sample collection area at a safe location within sight of the drill rig.
- Place sampling equipment and soil recovered from the subsurface on plastic sheeting or similar dedicated material to avoid potentially contaminating the ground surface.
- Carefully log any downtime that occurs because of subcontractor equipment failure, weather, site access, or other issues, and any time where IEC is causing a delay in field activities, in the field log book, according to *SOP for Field Documentation.*

5.1 Hollow Stem Auger Drilling

Stage the drill rig over the desired drilling location and attach the first auger section. Rotate the auger so that soil cuttings are brought to the surface. The driller's helper will use a shovel to scoop cuttings into a pile near the borehole as they emerge at the surface. As the auger section is drilled into the subsurface, add new auger sections to achieve greater depths. Along the way, leave auger sections in place while a spilt-spoon sampler, open- barrel sampler, or similar tool is used to collect a sample.

Collect lithologic samples at intervals specified in the site-specific sampling plans. Soil cuttings seen at the surface represent a blend of material from the borehole and the current auger depth, so logging or sampling cuttings is of limited use. In addition, soil cuttings seen at the surface have to travel the length of the auger flights to reach the surface, so these cuttings do not correlate exactly with the lithology that the auger is currently drilling through. The best indication of lithology, when not sampling, is to carefully examine the rate in which the auger is advancing. There is commonly a discernable sound when the drilling rate changes. Note changes in lithology and drilling rate on the Soil Boring Log Datasheet (within the *SOP for Boring Log Completion, Soil Classification and Logging*).

A split-spoon sampler is typically used to collect representative soil samples at depth during HSA drilling. A split-spoon sampler is a soil coring device that consists of a length of carbon or stainless-steel tubing split longitudinally and equipped with a sample shoe and a drive head. These are available in a variety of lengths and diameters and are typically advanced by blows of a hammer dropped from a drill rig mast. The soil sample is contained within the split-spoon sampler as it is advanced into the ground. Depending on the sampling purpose, separate liners made out of plastic, stainless-steel, or brass may also be used within the split spoon to collect soil samples.

When sampling using HSA drilling, advance the drill string to the desired sample depth. Attach a split-spoon sampler to the end of a series of drive rods and lower it down the center of the hollow auger sections (drill string). Hammer the split-spoon sampler ahead of the drill string to collect a relatively undisturbed, representative soil sample. Depending on the size of split spoon employed, 18 to 24 inches of soil typically should be recovered in advance of the drill bit. Remove the sampler from the borehole and open it to expose the soil for examination and sampling. The Field Geologist will examine the lithologic sample. The sample will be logged for lithology as described in *SOP for Boring Log Completion, Soil Classification, and Logging*. Decontaminate the entire split-spoon sampler and sample shoe between each sample retrieval depth, according to *SOP for Equipment Decontamination Procedures*. Once the sample is collected, advance the drill string to the top of the next desired sampling depth. Reinstall the decontaminated split-spoon sampler on the HSA drill string to collect another split-spoon sample.

Problems with split-spoon sampler soil recovery are encountered when unconsolidated, non-cohesive soils fall out of the end of the split spoon upon retrieval and when large gravel lodges in the end of the sampler, preventing further soil from entering the sampler during

advancement. Both issues may result in less than full sample recovery. Note the percentage recovered, and what portion of the sample is missing, on the Soil Boring Log Datasheet as described in *SOP for Boring Log Completion, Soil Classification, and Logging.*

A Standard Penetration Test (SPT) can be completed during advancement of the split- spoon sampler into the in situ formation, to evaluate the relative density of unconsolidated soil. To complete the SPT, drive the split-spoon sampler into the formation using a hammer mounted on the drill rig. Repeatedly raise and drop the hammer over a 30-inch height until the entire length of the split-spoon sampler is driven into the formation over the discrete sampling interval or there is sampler refusal. Record the number of blows necessary to drive the sampler every 6-inch interval on the Soil Boring Log Datasheet (see *SOP for Boring Log Completion, Soil Classification, and Logging.*-). Also record the weight of the hammer used on the Soil Boring Log Datasheet.

Upon reaching total borehole depth, remove the drill string from the borehole by withdrawing and disconnecting each auger section. Before advancing another soil boring, decontaminate all used auger sections, drive rods, drill bits, and split spoons according to *SOP for Equipment Decontamination Procedures.*

5.2 Direct Push System Drilling

Stage the drill rig over the desired drilling location and advance a solid-point drive string to the top of the desired discrete sample interval. When the desired sampling depth is achieved, withdraw the center rods and solid-drive tip from the probe drive string (outer drive casing) and lower a sampling tool (for example, a Geoprobe® DT325 Dual Tube Sampling System sampler with polyvinyl chloride [PVC] liners) down the inside probe drive string to the end of the cutting shoe. Hydraulically push the probe drive string and sampler down through the discrete sample interval to obtain an undisturbed sample of the soil formation.

Once the probe drive string and sampler are fully advanced, withdraw the sampler and center rods from the probe drive string and remove the recovered soil core in the PVC liner from the sampler. After the soil core is removed, the solid-point drive point can be either reinserted and driven to another desired discrete sample interval or another sampler with a PVC liner can be lowered down the inside of the probe drive string to the end of the cutting shoe to conduct continuous-core soil sampling. *Attachment 4: Geoprobe® DT325 Dual Tube Sampling System SOP* further

describes this method and associated tools. Soil sampling using DPS drilling may be conducted from the surface until groundwater is encountered or until sample recovery becomes poor as specified in the site-specific sampling plans.

After soil core recovery, extract the PVC liner encasing the soil core from the sampler's sample sheath and cut open the PVC liner to expose the core. The Field Geologist will examine the soil core for lithology. The soil core will be sampled according to *SOP for Discrete Surface and Subsurface Soil Sampling*. Decontaminate the sample collection equipment between each sample depth, according to *in SOP for Boring Log Completion, Soil Classification, and Logging.*

Problems with sampler soil recovery are encountered when unconsolidated, non-cohesive soils fall out of sampler upon retrieval and when large gravel lodges in the end of the sampler, preventing further soil from entering the sampler during advancement. Both issues may result in less than full sample recovery. Note the percentage recovered, and what portion of the sample is missing, on the Soil Boring Log Datasheet as described in *SOP for Boring Log Completion, Soil Classification, and Logging.*

To install a well, install an expendable cutting shoe on the probe drive string. Install the well through the probe drive string upon reaching the desired total depth. Push out the expendable cutting shoe and withdraw the probe drive string. Construct the resulting well with sand and bentonite according to *SOP for Monitoring Well/Piezometer Installation*.

5.3 Rotary Sonic System Drilling

The vibrasonic drilling technique, referred to as "Core and Case", involves advancing a core barrel with an inner string and over casing with an outer string, which prevents borehole collapse during core barrel retrieval. The over casing is only needed if the borehole does not remain open. The core barrels are available in single wall for dry coring, dual wall for hard rock sampling with water/air/drilling mud, and are also available with clear lexan liners. Typically, drilling involves a 3 m (10 ft) long, 115 mm OD core barrel and optional 1.5 m (5 ft) and 3 m (10 ft) long, 165 mm OD outer casings, although smaller rigs may use shorter core barrels. The core barrel is fitted with a bit and, if necessary, a core catcher. For drilling to depths of less than 2.4 m (8 ft) depth, the core barrel is connected directly to the vibrasonic drill head. For deeper boreholes core barrel extensions are added between the drill head and the core barrel. Advancement is achieved by a combination of variable, high frequency vertical vibrations, variable rotation, and/or downward pressure. The first run can reach a depth of 2.4 m (8 ft). Beyond that depth borehole advancement is achieved in intervals of up to 3 m (10 ft). Boreholes can also be advanced by plugging the core barrel and displacing soil as the core barrel is advanced until a target depth is reached, at which point the plug can be removed and the core collected. This technique is useful for installing monitoring wells only (without soil sampling), or to advance the borehole to the top of a zone of interest.

If water is used during vibrasonic drilling, a hydrovac unit can be deployed to collect excess water and sediment as it leaves the borehole. This is usually required if contamination is expected, or where drilling takes place in an area where waste cannot be left on ground surface.

Excess soil is typically produced during borehole advancement. Drill cuttings should be stockpiled and placed in drums or soil bags for later characterization and/or disposal. If placed in drums or soil bags, the containers should be labeled. Labels should as a minimum include the client's name, the date, and a list of boreholes from which the cuttings originated. Soil bags should be placed on pallets, particularly where ground freezing is of concern, for ease of removal. The location and number of drums/soil bags used should be recorded in field notes. In certain circumstances, cuttings may be returned to the borehole as backfill; however, this is only to occur with cuttings that are not contaminated and are of a granular nature suitable for use as backfill. Appropriate cuttings should only be used as borehole backfill material with the approval of the project manager and the client.

Ensure that the amount of water used during drilling is recorded, as this volume will have to be removed during well development. Otherwise the borehole may be backfilled, typically with bentonite/grout, although intervals of clean

sand may be acceptable as site-specific conditions or client preferences warrant. If the borehole extends below the water table, the use of bentonite pellets or grout through the saturated interval is recommended to ensure a good seal and to prevent bridging. Bentonite chips may also be placed in the borehole using a tremmie pipe, to limit the possibility of bridging. In areas where recontamination may occur, it is recommended that the borehole be backfilled to near ground surface with bentonite or grout. In accordance with the Groundwater Protection Regulation (GPR) a surface seal of bentonite or grout, at least 1 m thick if possible, should be placed at the ground surface of the drill hole to minimize infiltration of surface water to the drill hole. Cuttings represent a preferential vertical pathway, and contaminated cuttings placed in a borehole could result in groundwater contamination. Cuttings used as backfill in drill holes often consolidate or settle with time and can create a safety hazard to pedestrian traffic at the ground surface from the re-formed hole if the drill hole is not properly completed near the ground surface. As such, in areas of pedestrian traffic, the drill hole should be completed with a concrete plug at the ground surface.

5.4 Heaving and Flowing Soils

The reported presence of heaving and flowing soils within the saturated zone exist at the DuPont EC site. When encountered, use appropriate drilling techniques to minimize potential impacts; these includes using drilling fluids or a drill-stem plug. Minimize the use of drilling fluids if possible. However, when necessary, it is permissible to add potable water from a documented, clean source and/or drilling mud to the borehole to control heaving and flowing soils as long as identification of the saturated zones during drilling is not compromised and the drilling fluid can be removed during development so that representative water levels can be obtained. All drilling fluid volume added to a borehole must be developed from the well. If potable water is added to the borehole, develop an equal volume of water from the borehole, in addition to the standard well development volume. If a drill-stem plug is used, slowly release the plug from the end of the drill-string while at total borehole depth.

6.0 Records

Record all field activities in the Field Notebook and/or Soil Boring Log Datasheet according to *SOP- Note Taking and Field Log Books*. Log all borings lithologically according to *SOP for Boring Log Completion, Soil Classification, and Logging*.

8.0 References

American Society for Testing Materials (ASTM). 2008. *Standard Practice for Using Hollow- Stem Augers for Geotechnical Exploration and Soil Sampling*. ASTM Standard D 6151, ASTM International, West Conshohocken, PA.

American Society for Testing Materials (ASTM). 2005. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations*. ASTM Standard D 6282-98, ASTM International, West Conshohocken, PA.

American Society for Testing Materials (ASTM). 2004. Standard Guide for Use of Hollow- Stem Augers for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices. ASTM Standard D 5784, ASTM International, West Conshohocken, PA.

American Society for Testing Materials (ASTM). 2010. Standard Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices. ASTM Standard D6914 / D6914M, ASTM International, West Conshohocken, PA.

Kejr, Inc. 2009. *Geoprobe® Download Literature.*

Kejr, Inc. 2009. *Geoprobe® Machines: Model 6712.*

Kejr, Inc. 2009. *Geoprobe® Machines: Model 6610DT.*

Kejr, Inc. 2009. Geoprobe® Machines: Model 8140LS.

Kejr, Inc. 2005. *Geoprobe® Tools: DT325 Dual Tube Sampling System.*

7.0 Definitions

Auger section: a segment of hollow auger outer casing with helices (flights) welded around the exterior that conveys soil cuttings from the drill bit to the surface when rotated.

Borehole: the downward hole in the subsurface lithology created by drilling activities.

Combo drill rig: drill rigs capable of conducting both DPS and rotating HSA drilling operations.

Cutting shoe: the cutting end of a DPS drill string.

Direct Push System (DPS): a drilling technology that hydraulically pushes or drives small diameter, hollow steel rods into the subsurface without rotating the drill rods.

Down time: non-productive time on the part of the drilling contractor or their subcontractors related to scheduling, breakdown, or other operational delays

Drill bit: the cutting end of a drill string that typically has cutting teeth.

Drill string: multiple auger or casing sections connected in series with a drill bit or cutting shoe connected at the driving end of the drill string.

Heaving or Flowing Soils: loose medium- and fined-grained soils in a confined, water- bearing zone or aquifer that tend to rise up into the drill stem when the unit confining the aquifer is breached by the drill bit. This happens because the water in the aquifer has a pressure head great enough to cause upward flow into the drill stem with enough velocity to overcome the weight of the sand, creating a quicksand condition and carrying sand into the drill stem. Usually associated with hollow stem auger drilling.

Hollow Stem Auger (HSA): a form of rotating auger, consisting of continuous-casing, segmented auger sections with helices (screw-flights) that are rotated into the subsurface under downward pressure.

Investigation-derived waste (IDW): any contaminated waste generated during investigation activities, including wash water, purge water, personal protective equipment, sampling tools and supplies, and soil cuttings.

Probe drive string: the outer casing and drive string used during DPS drilling.

Sample shoe: a retaining device, typically made of polyethylene, that allows soils to enter a sampler but does not allow them to exit through the end of the sampler.

Solid-point drive point: a solid point placed within the open, hollow end of a DPS cutting shoe so that soil may not push up and into the probe drive string.

Split- spoon sampler: a soil coring device that consists of a length of carbon or stainless-steel tubing split longitudinally and equipped with a sample shoe and a drive head.

Standard Penetration Test (SPT): a soil test used to evaluate the relative density of unconsolidated soil by counting the number of times a weighted hammer is repeatedly raised and dropped over a 30-inch height for every 6 inches of soil penetration.

Unconsolidated formation: a subsurface soil formation that is unstable or loose with a low ability to remain cohesive without retainment. Soils that easily slough or erode back into an open borehole without an outer casing to keep the borehole open.

8.0 Attachments

Attachment 1: *Geoprobe Model 6712 Features and Specifications*

Attachment 2: *Geoprobe® Model 66 Series Features and Specifications*

Attachment 3: *Drilling Self Assessment Checklist*

Attachment 4: *Geoprobe® DT325 Dual Tube Sampling System SOP*

Attachment 4: *Geoprobe® 8140LS Features and Specifications*

GEOPROBE®

6712DT ... Strong Direct Push Features in a Modular, Easy-to-Use Machine



The three components of the 6712DT are air lifted via helicopter in Alaska and then 15 minutes later, the 'pieces' are ready for work.

6712DT MACHINE OPTIONS

Machine Modules

222719	Side Shifting Drill Mast
212598	Drill Mast
222720	Lightweight Undercarriage
212597	Standard Undercarriage

Augerhead

213942	GA2500 2-Speed Augerhead

Automatic Drop Hammer

213894	DH100 Automatic Drop Hammer, 140 lb.
217074	DH100 Automatic Drop Hammer, Mounting Kit
221820	Automatic Drop Hammer, 170 lb. Expansion Kit
210126	Automatic Drop Hammer, 65 kg Expansion Kit

Mast / Winch

214078	Hydraulic Winch and Mast

Water / Mud Pumps

217391	Moyno® 2L4 Pump & Mount

Hydraulic Extruder

222613	60 in. Hydraulic Extruder - Helper Side
217396	Extruder w/ 2L4 Mounting Kit

Rod Racks

212306	Locking Side Mount Rod Rack
209257	Side Mount Rod Rack
211734	Side Rack Mount Blank
217744	Drop Rack Suitcase Weight

Toolboxes

220333	48 in. Toolbox

Model 6712DT Specifications

Stroke	66 in.	1,676 mm
Weight (w/o Auger Head & Mast & Winch)	5,900 lb.	2,682 kg
Weight (w/ Auger Head & Mast & Winch)	6,480 lb.	2,946 kg
Width	52 in.	1,321 mm
Length (folded)	115 in.	2,921 mm
Height (folded)	83 in.	2,108 mm
Height (unfolded)	153.5 in.	3,899 mm
Foot Travel	30 in.	762 mm
Extension	15.75 in.	400 mm
Down Force	36,800 lb.	164 kN
Retraction Force	49,000 lb.	218 kN
Hydraulic Pressure (system)	2,500/3,400 psi	172/234 bar
Hydraulic Flow Rate (system)	24 gpm	90 Lpm
Hammer System	GH63	
Percussion Rate	32 Hz	
Torque (hammer motor)	560 ft. lb.	759 N•M
Rotation Rate (hammer motor)	200 rpm (bi-directional)	
Fuel Capacity (diesel)	14 gal	53 L
Engine (diesel)	Kubota, 4-cylinder turbo	
Engine Power	44.2 hp	33 Kw
Rear Blade Travel	29 in.	737 mm
Travel Speed	0-2.5 mph	0-4 kph
Surface Load @ 5,900 lb.	4.3lb/in2	0.3 kg/cm2
Surface Load @ 6,480 lb.	4.7lb/in2	0.33 kg/cm2
Winch Rating	2,500 lb	1,136 kg
Winch Speed	0-110 fpm	0-33.5 m/min

Augerhead Specifications		
Torque (high torque/low speed)	2,500 ft. lb.	3389 N•m
Torque (low torque/high speed)	1,250 ft. lb.	1694 N•m
Hex adapter	1-5/8 in.	41 mm
Rotation speed (low speed/high torque)	0-70 rpm	
Rotation speed (high speed/low torque)	0-150 rpm	

6712DT

Limited Access

- **Modular Machine Design (3 Sections) Assembles in 15 min.**
- **Pick Weight Under 2,500 lb per Component**
- **Reliable Geoprobe® GH63 Percussion Hammer**
- **Single Speed Bi-directional Hammer Rotation**
- **Two-Speed Augerhead, 2,500 ft/lb (optional)**
- **Simple Hydraulic Design**
- **Rear Blade Assembly for Tooling Transport and Machine Stabilization**

Geoprobe® Tooling Run with 6712DT

60-in. Direct Push Tooling

- Probe Rod Sizes: 3.75 in., 3.5 in., 3.25 in., 2.25 in., 1.5 in., 1.25 in.
- Direct Image® Tooling
- Macro Core® MC5 Soil Sampling
- DT22 Soil Sampling
- DT325 / DT35 / DT375 Dual Tube Soil Sampling
- SP22 Groundwater Sampling
- SP16 Groundwater Sampling
- 2.0 in., 1.5 in., 1.0 in., 0.75-in. Prepacked Monitoring Well Installations



Driving into a residential garage with a 7-ft. overhead door clearance.



With barely 0.5 in. to spare on each side, the 6712DT goes where no rig has gone before!

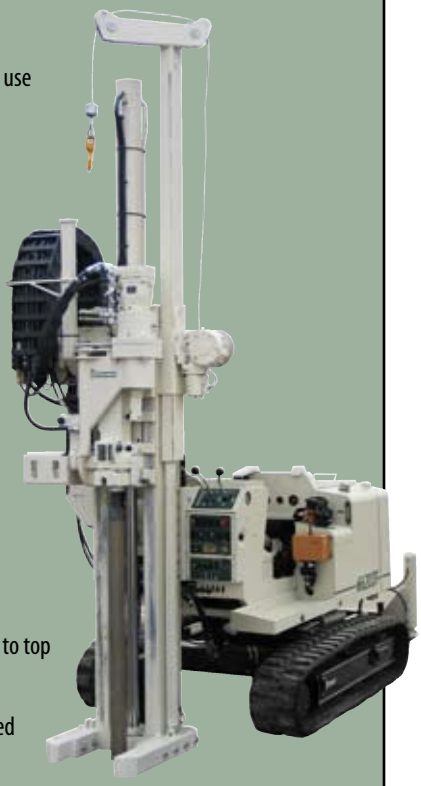


Set up inside a building with 9.5-ft. overhead clearance prior to drilling a 4-in. diameter SVE well using standard 5-ft. long, 6.25-in. ID HSA.

Geoprobe Systems®
1-785-825-1842
geoprobe.com

Genuine Geoprobe® model 6620DT

- 66 in. (1676 mm) probe cylinder stroke allows use of 60 in. (1,524 mm) probe rods
- Over 20 ton pulling capacity for today's larger sampling tools and deeper depths
- Equipped with the powerful GH62 Hammer
- Heavy Duty Undercarriage has a wider track that carries more weight, adds more torque, reduces ground pressure and handles greater tool weight
- Wireless remote control
- Built-in rotary spindle for concrete drilling, augering, and anchoring
- Equipped with a hydraulic winch for handling augers and tripping dual tube sampling tools
- Two-speed probe cylinder cycles from bottom to top in less than 5 seconds
- Powered by a four-cylinder, 54 Hp, liquid-cooled Kubota turbo diesel engine
- Hydraulic movement in all three axes allows easy probe alignment with tool string
- Auxiliary hydraulic ports provide power for remote equipment



Model 6620DT Specifications

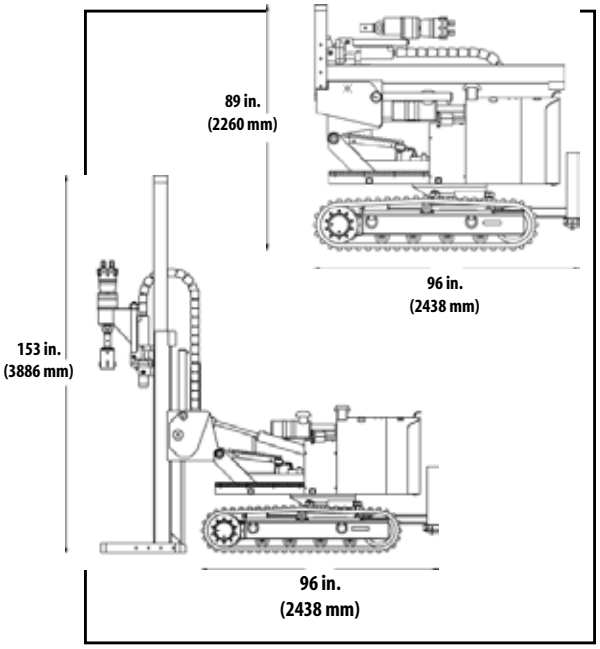
Stroke	66 in.	1676 mm
Weight	6,900 lb.	3130 kg
Width	60 in.	1524 mm
Length (folded)	96 in.	2438 mm
Height (folded)	89 in.	2260 mm
Height (unfolded)	153 in.	3886 mm
Lateral Movement (side-to-side)	33 in.	838 mm
Foot Travel	39 in.	991 mm
Extension	15 in.	381 mm
Down Force	35,000 lb.	160 kN
Retraction Force	47,000 lb.	214 kN
Hydraulic Pressure (system)	2,450 psi	169 bar
Hydraulic Flow Rate (system)	30 gpm	114 Lpm
Hammer System		GH62
Percussion Rate		32 Hz
Torque (hammer motor)	560 ft. lb.	759 N•M
Rotation Rate (hammer motor)		240 rpm (bi-directional)
Fuel Capacity (diesel)	15 gal	57 L
Engine (diesel)		Kubota, 4-cylinder turbo
Engine Power	54 hp	40 Kw
Outrigger Extension	16 in.	406 mm
Travel Speed	0-4.5 mph	0-7.2 kph
Surface Load	3.7lb/in^2	0.26 kg/cm^2
Winch Rating	2,350 lb	1,067 kg
Winch Speed	0-110 fpm	0-34 m/min

Augerhead Specifications

Torque (high torque/low speed)	3,000 ft. lb.	4067 N•M
Torque (low torque/high speed)	1,500 ft. lb.	2034 N•M
Hex adapter	1-5/8 in.	41 mm
Rotation speed (low speed/high torque)		0-105 rpm
Rotation speed (high speed/low torque)		0-150 rpm



Wireless Remote Control



Geoprobe® Systems



We have developed this **E-specs** document to allow you the ability to quickly compare the features and capabilities of various probe machines offered by Geoprobe Systems® ... the direct push innovators. Unit and tooling specifications are subject to change without notice. If you are interested in a specific Geoprobe® direct push system, please call us at **1-800-436-7762** for a formal, specialized quotation which includes all the details required for purchasing your Geoprobe® system.

Geoprobe® Systems

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1-800-436-7762
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Geoprobe Direct Push Machine
Inspection Form: 3230 & 3200 Series

Company Name: Location: Date of Inspection:

Equipment Information				Crew Information	Job Information
Unit Number	Current Hours	Next Service Hour	Unit Serial #	Supervisor:	Job Name:

Inspector: Geoprobe Model #

POWERTRAIN	Y	N	NA	Comments
Engine oil level add |----------| full				
Engine coolant level add |----------| full				
Fan Belt condition & proper tension				
Air filter cover secure, orientated correctly				
Fuel lines condition, leak free, secure				
Wiring secure, condition, frays, corrosion, etc				
Radiator cleanliness				
Hydraulic oil cooler clean				
Battery clean and secure				
Fuse and relay box clean, secure, closed				
Master disconnect secure, clean, functioning				
Hyd. oil level unit folded btm |----------| top				
Hyd. fill cap installed & secured				
Hyd. drain plug cap in place				
Fuel cap installed				
MACHINE CHASSIS				
Tracks' condition and correct tension				
Grease chassis as required or ~100hrs				
Inspect Hyd cylinders for leaks				
Hyd lines overall condition and free of leaks				
Hyd manifolds for security, leaks, damage				
Emergency Stops condition & operation				
Fire Extinguisher secure, charged, exp date				
Strobe light operation				
Wiring secure, condition, corrosion, etc				
Check for loose or missing fasteners				
Frame for damage, cracks, etc				
DRILL MAST				
Slides adjusted, secure, lubricated				
Hydraulics free of leaks and secure				
Check for loose or missing fasteners				
Oscillation Cylinder Bolts condition & secure				
Pull latch security and condition				
Electrical harness security & condition				

CONTROL PANEL	Y	N	NA	Comments
Swing Arm security, latches, fasteners				
Hyd hose, fittings, routing, leak free				
Electrical harness security & condition				
Manual levers neutral and secure				
Cleanliness				
Joysticks, switches, etc condition & secure				
Operator presence bar & spring				
Enable switch operation and condition				
Overlay condition and readability				
Panel retention bolts in place and secure				
System display condition				
System display alarms, warnings, cautions				
WINCH SYSTEM				
Winch assemblies secure				
Winch Fluid Level (ISO 46 Hyd Oil)				
Winch drum tensioners secure & not bent				
Wire Ropes condition, secure, lay on drum				
Wire rope safety hooks condition & ops				
Wire rope quick attach condition				
Mast sheaves secured rotating freely				
Mast cylinder upper roll pins installed				
REMOTE SYSTEMS				
Wireless TX condition, batteries, operation				
Wireless RX security, condition, operation				
Tether Remote – cable, box, condition				
Remote E-stop functionality				
COMBO HEAD				
4-Speed Head oil (sight glass w/ head level)				
4-Speed Head case vent in place				
Head Clamp arms grease ~200hrs				
Hyd hoses for condition, leaks, security				
Fasteners for security				
Moyno, Bean, or Hose Pump				
GH70 hammer Nitrogen Charge ery 30 days				

ACCESSORIES	Y	N	NA	Comments
Breakout table free of damage & secure				
Extruder installation correct and secure				
Pressure washer instl correct and secure				
Racks, Trays, & etc instl correct & secure				
Safety cage, condition, operation				
Moyno, Bean, or Hose Pump				
ADH hyd. hoses, cylinder, linkages secure				

MACHINE DISCREPANCIES	SAFETY CRITICAL *(y/n)*	CORRECTIVE ACTION

FIELD / UNIT NOTES

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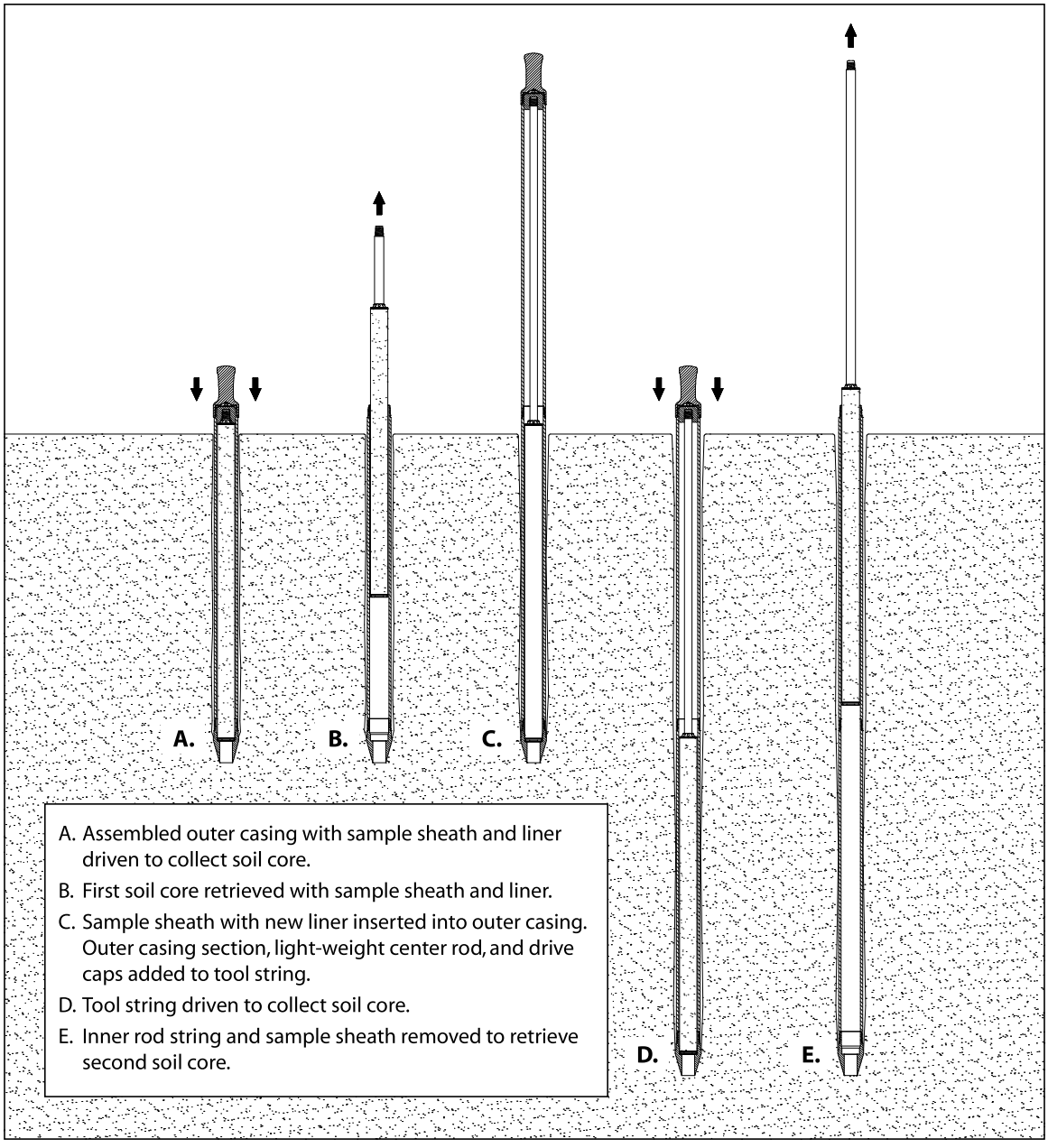
GEOPROBE® DT325 DUAL TUBE SAMPLING SYSTEM

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3138

PREPARED: November, 2006
REVISED: January, 2011



Collecting soil cores with the DT325 Dual Tube Sampling System.



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**Geoprobe® Prepacked Screens are manufactured under
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1.0 Objective

The objective of this procedure is to collect a representative soil sample at depth through an enclosed casing and recover it for visual inspection and/or chemical analysis.

2.0 Background

2.1 Definitions

Geoprobe®*: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and testing, soil conductivity and contaminant logging, grouting, and materials injection.

**Geoprobe® and Geoprobe Systems® are registered trademarks of Kejr, Inc., Salina, Kansas.*

DT325 Dual Tube Sampling System: A direct push system for collecting continuous core samples of unconsolidated materials from within a sealed casing of Geoprobe® 3.25-inch (83 mm) OD probe rods. Samples are collected and retrieved within a sample sheath and liner that is threaded onto the leading end of a string of Geoprobe® 1.25-inch (32 mm) OD light-weight center rods and inserted to the bottom of the outer casing. Collected samples measure up to approximately 2,600 ml in volume in the form of a 1.85-inch x 59-inch (47 mm x 1499 mm) core when using common equipment options.

Liner: A 2.1-inch (53 mm) OD thin-walled, PVC tube that is placed within a steel sheath and then inserted into the outer casing on the leading end of the inner rod string for the purpose of containing and retrieving core samples. Liners are available in two configurations; a simple open tube or a tube with a core catcher permanently attached to the leading end. Nominal liner lengths include 1 meter, 48 inches, and 60 inches.

***Nominal liner length identifies the length of tools with which the liner is used. The actual end-to-end lengths of the various DT325 liners will differ from the specified nominal lengths.*

Core Catcher: A dome-shaped device positioned at the leading end of a liner to prevent loss of collected soil during retrieval of the liner and soil core. Flexible fingers at the top of the core catcher are pushed outward by soil entering the liner during advancement of the tool string. As the filled liner is subsequently retrieved, the fingers of the core catcher move back inward, effectively closing off the end of the liner and limiting soil loss. The core catcher designed for the DT325 system is permanently fused to the liner.

2.2 Discussion

Dual tube sampling gets its name from the fact that two sets of probe rods are used to retrieve continuous soil core samples from the subsurface. One set of rods is driven into the ground as an outer casing (Fig. 2.1). These rods receive the driving force from the hammer and provide a sealed casing through which soil samples may be recovered. The second, smaller set of rods are placed inside the outer casing with a sample liner attached to the leading end of the rod string (Fig. 2.1). These smaller rods hold the liner in place as the outer casing is driven to fill the liner with soil. The inner rods are then retracted to retrieve the full liner.

Standard Geoprobe® 3.25-inch OD probe rods provide the outer casing for the DT325 Dual Tube Soil Sampling System. A cutting shoe is threaded into the leading end of the rod string. When driven into the subsurface, the cutting shoe shears a 1.75- or 1.85-inch OD soil core (depending on cutting shoe option) which is collected inside the casing in a PVC liner.

The second set of rods in the DT325 dual tube system are Geoprobe® 1.25-inch OD light-weight center rods. A sample sheath with PVC liner is attached to the end of these smaller rods and then inserted into the casing. The 1.25-inch light-weight center rods hold the sample sheath tight against the cutting shoe as the outer casing is driven to collect the soil core. Once filled with soil, the sample sheath and liner are removed from the bottom of the outer casing by lifting out the 1.25-inch center rod string.

The outer, 3.25-inch probe rods provide a cased hole through which to sample. The main advantage of sampling through a cased hole is that there is no side slough to contend with. In addition, the outer casing effectively seals the probe hole when sampling through perched water tables. These factors mean that sample cross-contamination is eliminated. The DT325 sampling system is therefore ideal for continuous coring in both saturated and unsaturated zones.

Solid Drive Tip

A Solid Drive Tip (28509 or 27763) can be placed on the leading end of the inner 1.25-inch rod string in place of a sample sheath and liner (Fig. 2.2). When installed in the outer casing, the drive tip firmly seats within the cutting shoe and effectively seals the tool string as it is driven into the subsurface. This enables the operator to advance the outer casing to the bottom of a pre-cored hole or through undisturbed soil to reach the top of the sampling interval.

Grouting

The DT325 system allows bottom-up grouting through the primary tool string. This means that a cement or bentonite grout mix can be pumped through the outer casing as it is withdrawn from the ground. This is in contrast to most other soil samplers which require driving a second set of tools back down the probe hole in order to deliver the grout mix.

Monitoring Well Installation

An expendable cutting shoe enables the operator to install a Geoprobe® prepacked screen monitoring well through the outer casing of the DT325 Dual Tube System. After the collection of continuous soil cores to the desired depth, prepacked screens can be inserted to the bottom of the outer casing on the leading end of a PVC riser string. The well is finished, complete with grout barrier, bentonite well seal, and a high-solids bentonite slurry/neat cement grout, during retrieval of the outer casing.

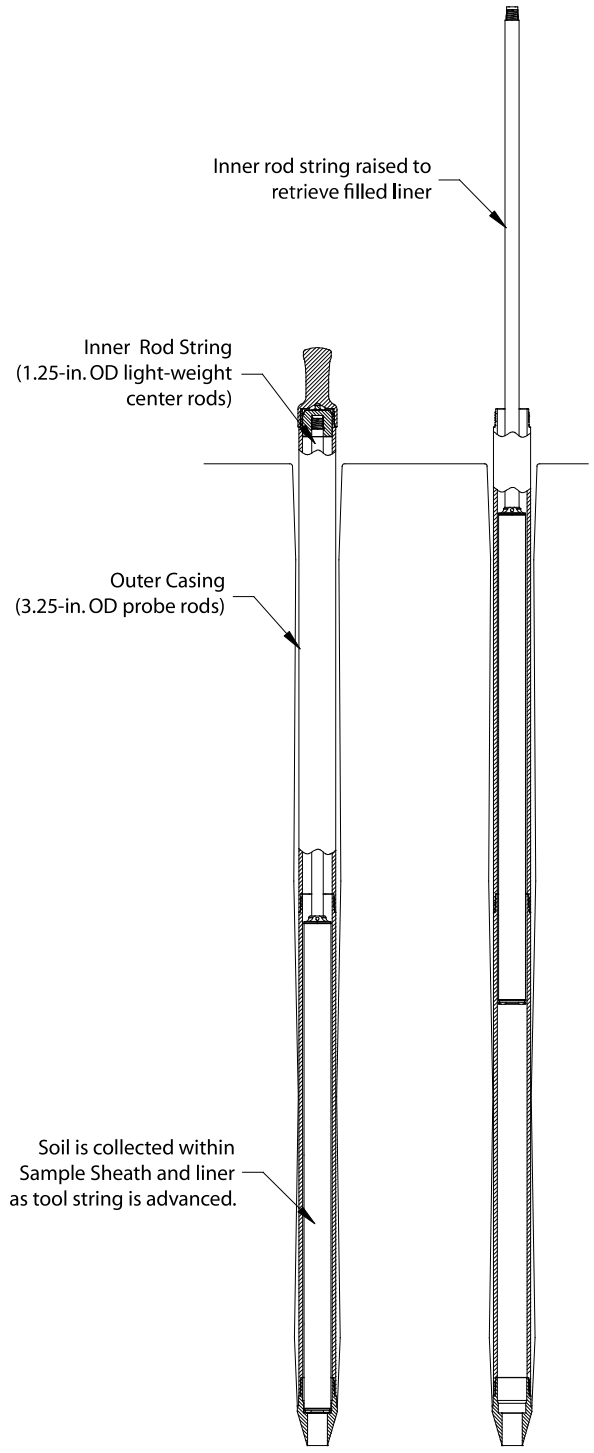

Figure 2.1
Outer casing driven with sample sheath and liner.

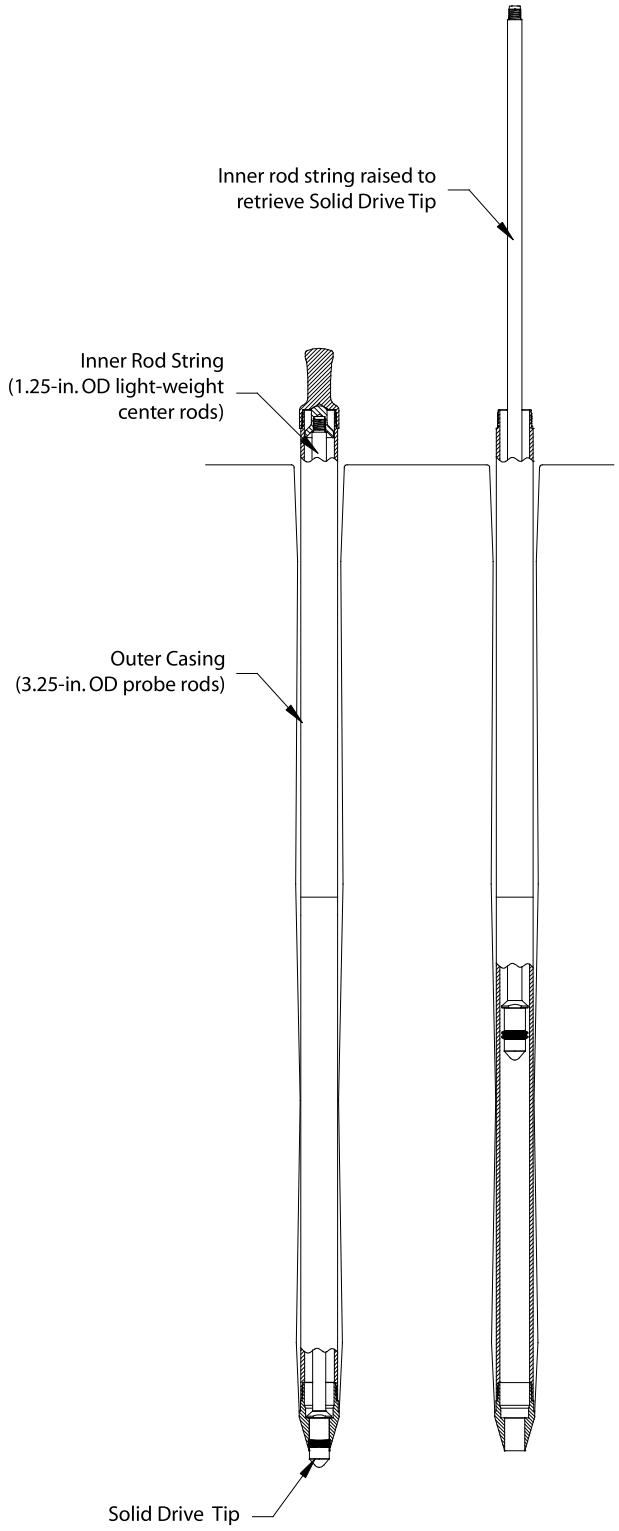

Figure 2.2
Outer casing driven with solid drive tip.

3.0 Tools and Equipment

The following equipment is required to operate the DT325 Dual Tube Sampling System. Refer to Figure 3.1 for identification of the specified parts.

DT325 Sampler Parts*	Quantity	Part Number
DT325 Sheath Drive Head	-1-	10212
DT325 Sample Sheath, 72-in. length	-1-	26805
DT325 Sample Sheath, 60-in. length	-1-	26719
DT325 Sample Sheath, 48-in. length	-1-	27711
DT325 Sample Sheath, 1-m length	-1-	27712
DT325 Centering Drive Cap, 1.25-in. rods	-1-	12943
DT325 Buffering Centering Drive Cap, 1.25-in rods	-1-	37708
DT325 Cutting Shoe, standard, 1.85-in. ID	-1-	28508
DT325 Cutting Shoe, optional, 1.75-in. ID	-1-	26720
DT325 Expendable Cutting Shoe Holder	-1-	28339
DT325 Expendable Cutting Shoe, 1.75-in. ID	-1-	28341
DT325 Solid Drive Tip, for standard (28508) cutting shoe	-1-	28509
DT325 Solid Drive Tip, for optional cutting shoe (28341) and expendable cutting shoe (26720)	-1-	27763
Replacement O-rings, for DT325 solid drive tips (28509 and 27763), pkg. of 25	Variable	13942
DT325 Liner Retainer	-1-	26718
O-rings, for DT325 liner retainer (26718), pkg. of 25	Variable	28379
DT325 Liner Retainer, without O-ring groove	-1-	39011
DT325 Liner Retainer Wrench	-1-	27838

DT325 Liners and Accessories	Quantity	Part Number
DT325 Liner Spacer	Variable	29609
DT325 Liner Spacer Head	-1-	29358
DT325 PVC Liner, 60-in. length, box of 43	Variable	DT3260K
DT325 PVC Liner, 48-in. length, box of 43	Variable	DT3248K
DT325 PVC Liner, 1-m length, box of 43	Variable	DT3239K
DT325 PVC Liner with Core Catcher, 60-in. length, box of 43	Variable	27813
DT325 PVC Liner with Core Catcher, 48-in. length, box of 43	Variable	27814
DT325 PVC Liner with Core Catcher, 1-m length, box of 43	Variable	27815
DT325 Vinyl End Caps, pkg. of 84 (42 pair)	Variable	17762
DT325 Liner Cutter	-1-	26155
Universal Liner Holder	-1-	22734

Probe Rods and Accessories*	Quantity	Part Number
GH60 Threadless Drive Cap, 3.25-in. rods**	-1-	9742
Pull Cap, 3.25-in. rods	-1-	13257
Rod Grip Handle, GH60 Hammer, 3.25-in. rods	-1-	9757
Probe Rod, 3.25-in. OD x 60-in. length	Variable	9040
Probe Rod, 3.25-in. OD x 48-in. length	Variable	10594
Probe Rod, 3.25-in. OD x 1-m length	Variable	13925
Replacement O-rings, for 3.25-in. probe rods, pkg. of 25	Variable	9960
Pull Cap, 1.25-in. rods	-1-	AT1204
Rod Grip Handle, GH60 Hammer, 1.5-in. and 1.25-in. rods	-1-	15554
Light-Weight Center Rod, 1.25-in. OD x 60-in. Length***	Variable	27600
Light-Weight Center Rod, 1.25-in. OD x 48-in. Length***	Variable	21900
Light-Weight Center Rod, 1.25-in. OD x 1-meter Length***	Variable	32318
1.25-inch Leaf Puller	-1-	31499
Adjustable Rod Clamp	-1-	27216

Optional Accessories	Quantity	Part Number
DT325 Adapter for Hydraulic Liner Extruder	-1-	24959
DT325 Plunger for Hydraulic Liner Extruder	-1-	23977
Rod Wiper Donuts, 3.25-in. Rods	-1-	27194
Rod Wiper Weldment	-1-	23633

* Select DT325 Sample Sheath and liner lengths to match length of probe rods.
** A 3.25-inch probe rod drive cap is also available for use with GH40 Series hammers.
*** 1.25-inch OD probe rods may be substituted for Light-Weight Center Rods.

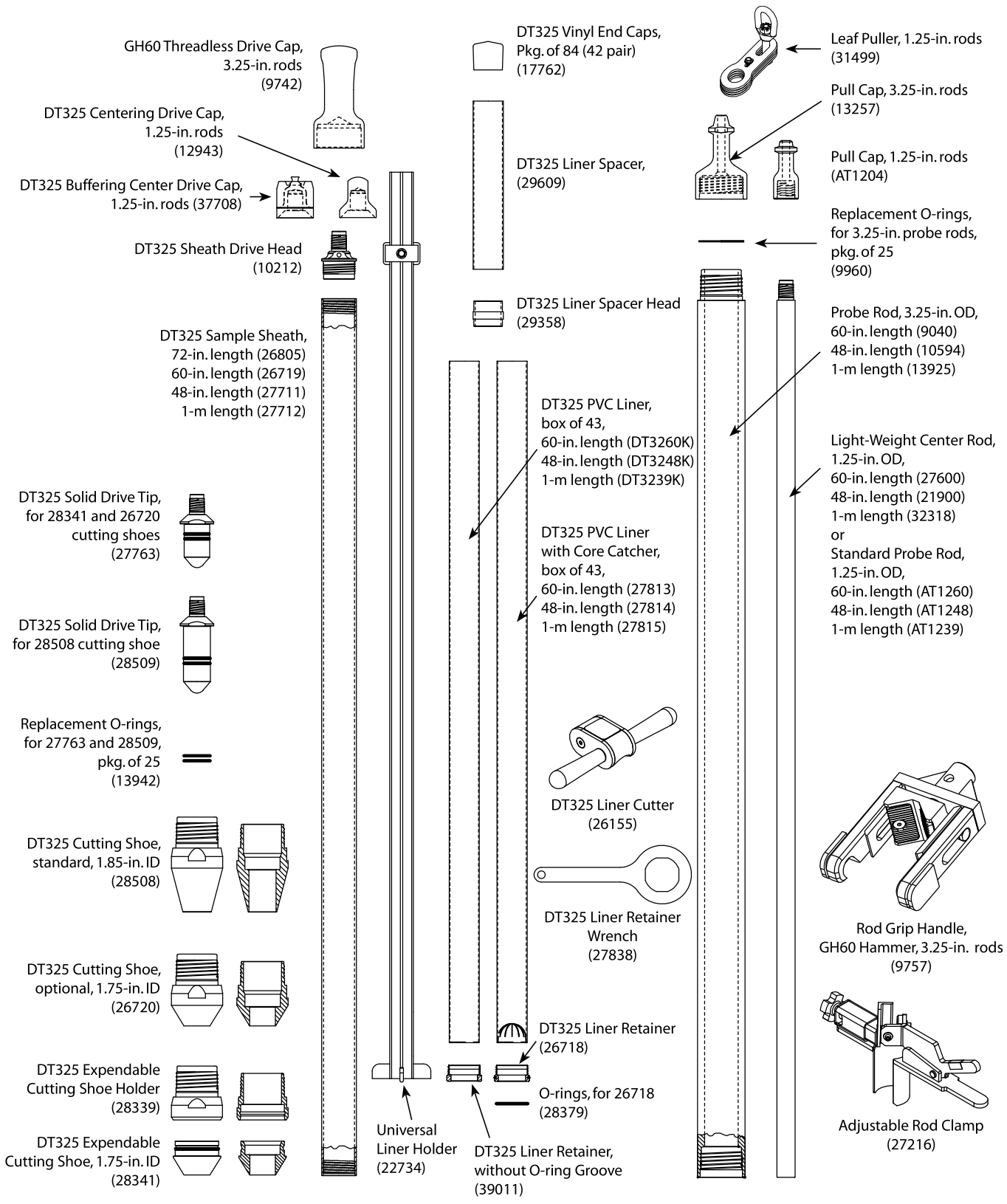

Figure 3.1
DT325 parts and accessories.

3.1 Tool Options

This section identifies the specific tool options available for use with the DT325 Dual Tube System. Refer to Figure 3.1 for illustrations of the specified parts.

Probe Rods

Standard Geoprobe® 3.25-inch (83-mm) OD probe rods are utilized for the outer casing of the DT325 Sampling System. Nominal rod lengths include 1 meter, 48 inches, and 60 inches. The specific length of rods may be selected by the operator and will determine the length of tooling for the rest of the DT325 system.

1.25-inch Light-Weight Center Rods

1.25-inch Light-weight center rods (1.25-inch / 32-mm OD) are recommended for the inner rod string of the DT325 system when utilizing an outer casing of 48- or 60-inch long rods. Choose the light-weight rod length that matches the length of rods used for the outer casing (48-inch light-weight rods with 48-inch outer casing, etc.).

A weight reduction of up to 64% is provided by the 1.25-inch light-weight center rods over standard 1.25-inch probe rods. As a result, considerably less energy is expended when retrieving the light-weight center rods from within the outer casing during operation of the DT325 Dual Tube System.

Sample Sheaths

A steel sample sheath supports the weight of the inner rods to protect the sample liner from damage while advancing the DT325 tool string. The liner is placed within the sheath and secured with a drive head at the top of the sheath and a liner retainer at the bottom. The assembled sheath with liner is inserted to the bottom of the outer casing on the leading end of the inner rod string (light-weight rods). After advancing the entire tool string one sample interval, the inner rods and sample sheath are retrieved to recover the soil core.

Sample sheaths are available in nominal lengths of 1 meter, 48 inches, 60 inches, and 72 inches. Sample sheath length is generally matched to the length of the probe rods selected for the outer casing. However, a DT325 Liner Spacer (29609) and DT325 Liner Spacer Head (29358) allow use of 48-inch liners with a 60-inch Sample Sheath (26719) and 60-inch liners with a 72-inch Sample Sheath (26805).

Sample Liners

Sample liners are made of a heavy-duty clear PVC for convenient inspection of the soil sample. Liners are available either as a simple, open tube or with an intergral core catcher. Utilize the core catcher liners when sampling flowing sands, noncohesive soils, extremely dry soils, or any other materials that fall from the liner during retrieval.

Nominal liner lengths include 1 meter, 48 inches, and 60 inches with an OD of 2.1 inches (53 mm). Under "normal" sampling conditions, liner length should correspond to the length of probe rods used for the outer casing. Certain sampling conditions can cause over-filled liners which may lead to problems removing the liner and soil core from the sample sheath. For these special conditions, utilize a Liner Spacer (29609) and DT325 Liner Spacer Head (29358) to provide additional room above the liner for the excess soil (Fig. 3.2). The liner spacer and liner spacer head must be used with either a 48-inch liner in a 60-inch Sample Sheath (26719) or a 60-inch liner in a 72-inch Sampler Sheath (26805). With the tool string only advanced the length of the liner, the liner spacer remains free to accept excess soil that may otherwise overfill the liner.

Cutting Shoes

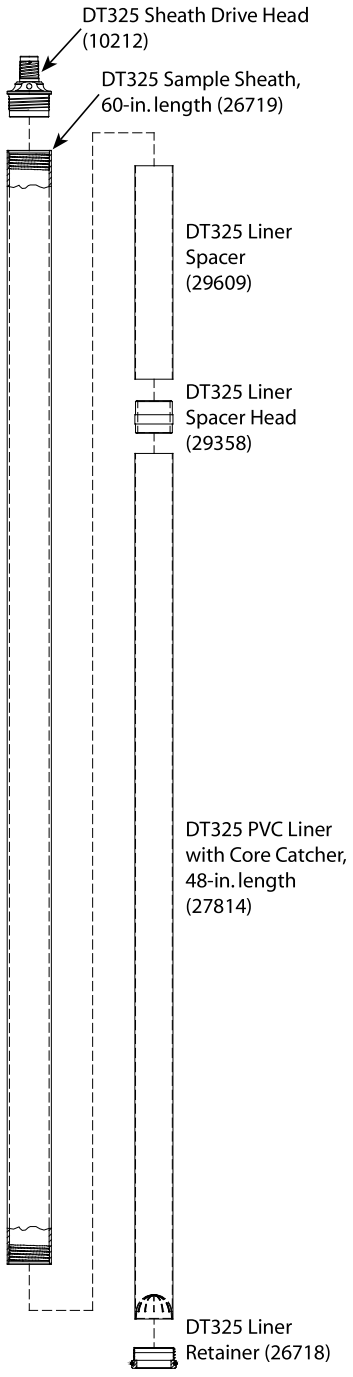

Figure 3.2
Common tooling configuration for use of DT325 Liner Spacer.

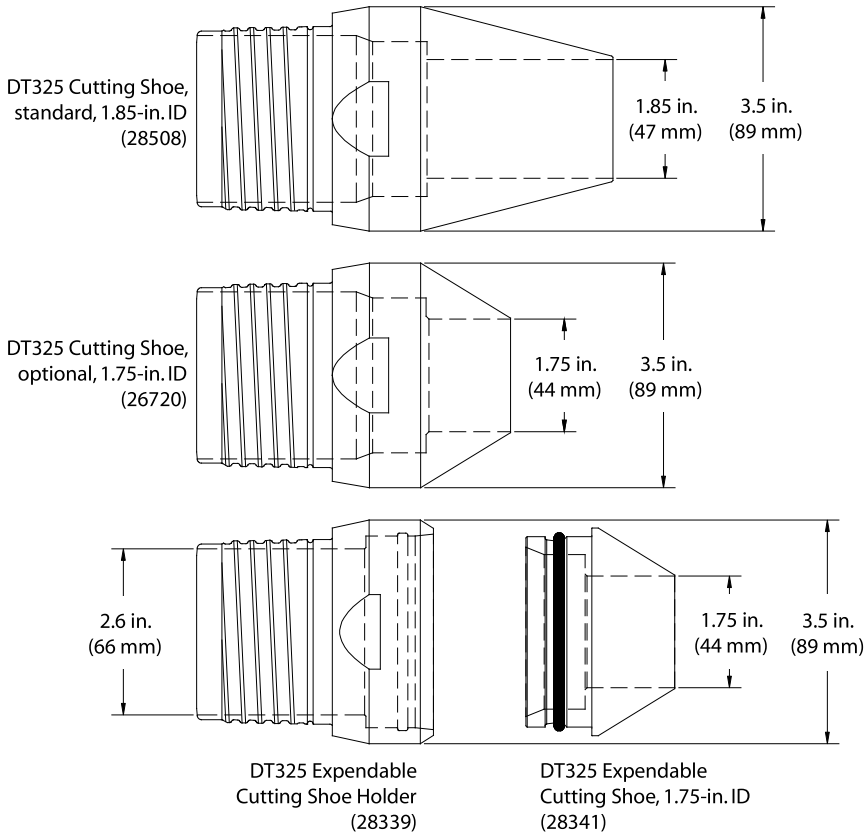

Figure 3.3
Cutting shoe options for the DT325 Dual Tube Sampling System.

Three cutting shoes are available for use with the DT325 Dual Tube System (Fig. 3.3). The DT325 Standard Cutting Shoe (28508) and DT325 Optional Cutting Shoe (26720) thread into the leading end of the 3.25-inch probe rods and are recovered after sampling. Dimensions for the standard cutting shoe are 1.85 inches (47 mm) ID and 3.5 inches (89 mm) OD. The optional cutting shoe also has an OD of 3.5 inches (89 mm), but the ID is only 1.75 inches (44 mm). The standard cutting shoe is ideal for sampling plastic clays and saturated sands while the optional cutting shoe is designed for use in formations where a smaller-diameter soil core is beneficial to sample recovery.

The DT325 sampling system may also employ an expendable cutting shoe (Fig. 3.3). In this arrangement, a DT325 Expendable Cutting Shoe Holder (28339) is threaded into the leading end of the outer casing. A DT325 Expendable Cutting Shoe (28341) is then inserted into the holder. Upon completion of soil sampling, the outer casing is withdrawn slightly. The expendable cutting shoe is knocked from the holder, leaving an open casing through which a prepacked screen monitoring well may be installed. Dimensions for the expendable cutting shoe are the same as the optional cutting shoe (ID = 1.75 in. (44 mm) and OD = 3.5 in. (89 mm)).

4.0 Operation

4.1 Decontamination

Before and after each use, thoroughly clean all parts of the soil sampling system according to project requirements. Parts should also be inspected for wear or damage at this time. During sampling, a clean new liner is used for each soil core.

4.2 Operational Overview

The DT325 Soil Sampling System is designed to collect continuous soil cores. Sampling may begin either from ground surface or a predetermined depth below ground. Once sampling begins, consecutive soil cores are removed as the outer casing is advanced to greater depths

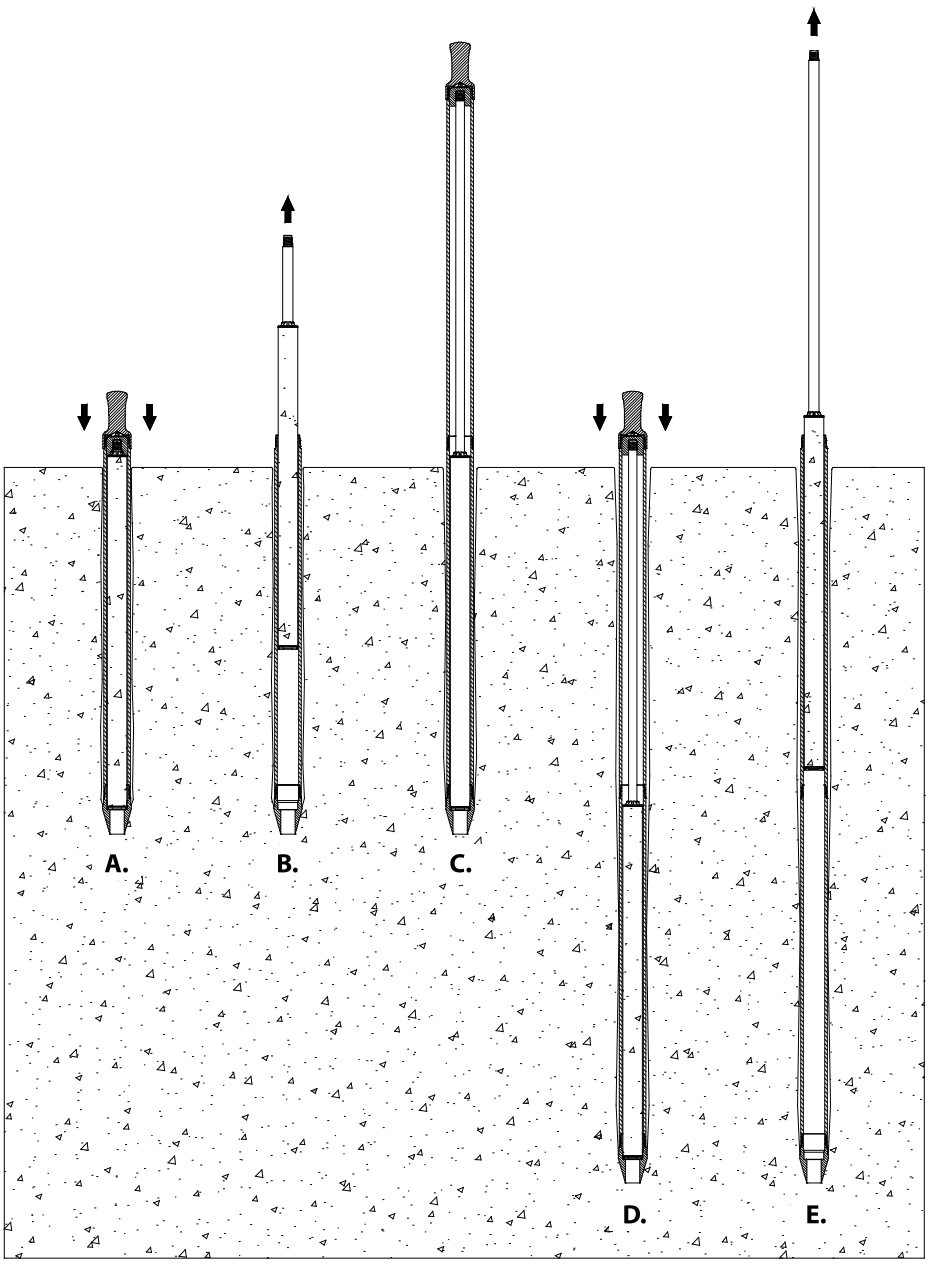

Figure 4.1
Continuous core sampling from ground surface with the DT325 system.

When sampling is to begin at the ground surface, the first soil core is generally collected using a liner with core catcher to maximize sample recovery (Fig. 4.1-A). This is especially true when the first core is composed of dry, loose soil. Upon retrieval of the first liner and soil core (Fig. 4.1-B), a new liner is loaded into the sample sheath and inserted to the bottom of the outer casing on the end of an inner rod. A section of outer casing is added to the tool string (Fig. 4.1-C) and the entire tool string is driven to fill the liner with soil (Fig. 4.1-D). The sample sheath and filled liner are removed from the outer casing to retrieve the second soil core (Fig. 4.1-E). A new liner is placed in the sample sheath and the process is repeated for the entire sampling interval.

When the sampling interval begins at some depth below ground surface, a DT325 Solid Drive Tip is installed in the outer casing and the entire assembly is driven from ground surface directly through undisturbed soil using the DT325 Centering Drive Cap (12943) (Fig. 4.2-A). This enables the operator to reach the top of the sampling interval without stopping to remove unwanted soil cores. Once the interval is reached, the solid drive tip is removed (Fig 4.2-B) and sampling continues using the Buffering Center Drive Cap (37708) as described in the preceding paragraphs (Fig. 4.2-C, Fig. 4.2-D, and Fig. 4.2-E).

Specific instructions for assembly and operation of the DT325 Sampling System are given in the following sections.

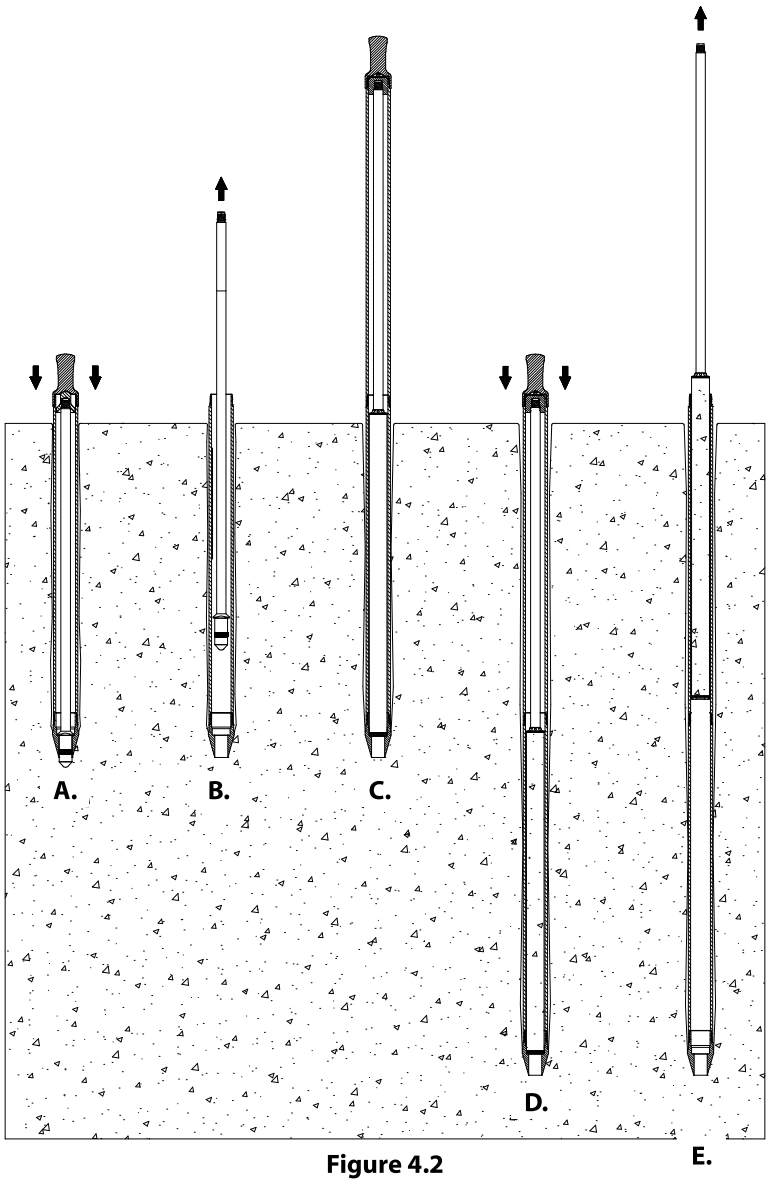

Figure 4.2
Using a solid drive tip to advance the DT325 outer casing through undisturbed soil before collecing soil cores.

4.3 Assembling and Driving the Outer Casing Using a DT325 Solid Drive Tip

A solid drive tip enables the operator to advance the outer casing to the bottom of a pre-cored hole or through undisturbed soil to reach the top of the sampling interval. The outer casing is assembled first, followed by the 1.25-in. light-weight center rod system with a solid drive tip. Step by step instructions are listed below.

1. When using a DT325 Standard (28508) or Optional (26720) Cutting Shoe, install an O-ring (9960) at the base of the theads as shown in Figure 4.3. If using an expendable cutting shoe, install an O-ring (9960) on the DT325 Expendable Cutting Shoe Holder (28339) and one o-ring (6834) on the DT325 Expendable Cutting Shoe (28341).

2. Thread the DT325 Cutting Shoe or DT325 Expendable Point Holder onto the leading end of a 3.25-inch OD Probe Rod. Completely tighten the cutting shoe or cutting shoe holder using a pipe wrench.

3. Install an O-ring (13942) in both grooves of the DT325 Solid Drive Point (27763 or 28509).

4. Thread the solid drive point into the female end of a 1.25-inch light-weight center rod.

5. Lubricate the O-rings on the solid drive point with a small amount of deionized water. Insert the point and probe rod into the outer casing until the point partially extends from the bottom of the cutting shoe.

6. Place a DT325 Centering Drive Cap (12943) on top of the 1.25-inch light-weight center rod and a GH60 Threadless Drive Cap (9742) onto the 3.25-inch probe rod (outer casing) as shown in Figure 4.5.

7. Raise the probe unit hammer assembly to its highest position by fully extending the probe cylinder.

8. Position the assembled outer casing section directly under the hammer with the cutting shoe centered between the toes of the probe foot. The assembled outer casing section should now be parallel to the probe derrick. Step back from the unit and visually check sampler alignment. A magnetic level can be placed on the assembly to check level.

9. Apply static weight and hammer percussion to advance the assembled outer casing until the drive head reaches the ground surface.

   NOTE: Activate hammer percussion whenever collecting soil. Percussion helps shear the soil at the leading end of the sampler so that it moves into the sample tube for increased recovery.

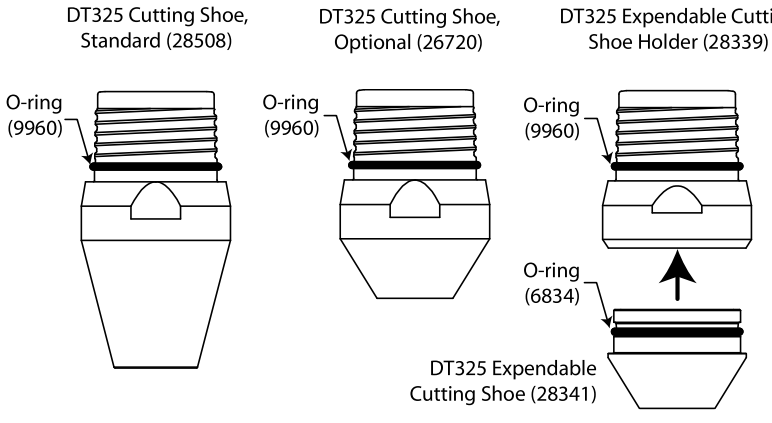

Figure 4.3
DT325 Cutting Shoes Utilize O-ring Seals

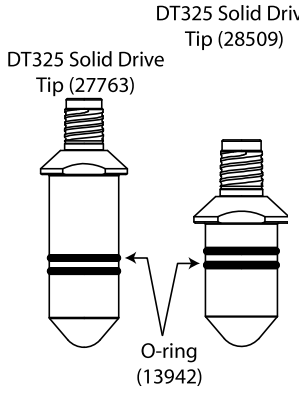

Figure 4.4
Solid Drive Points Utilize Two O-rings

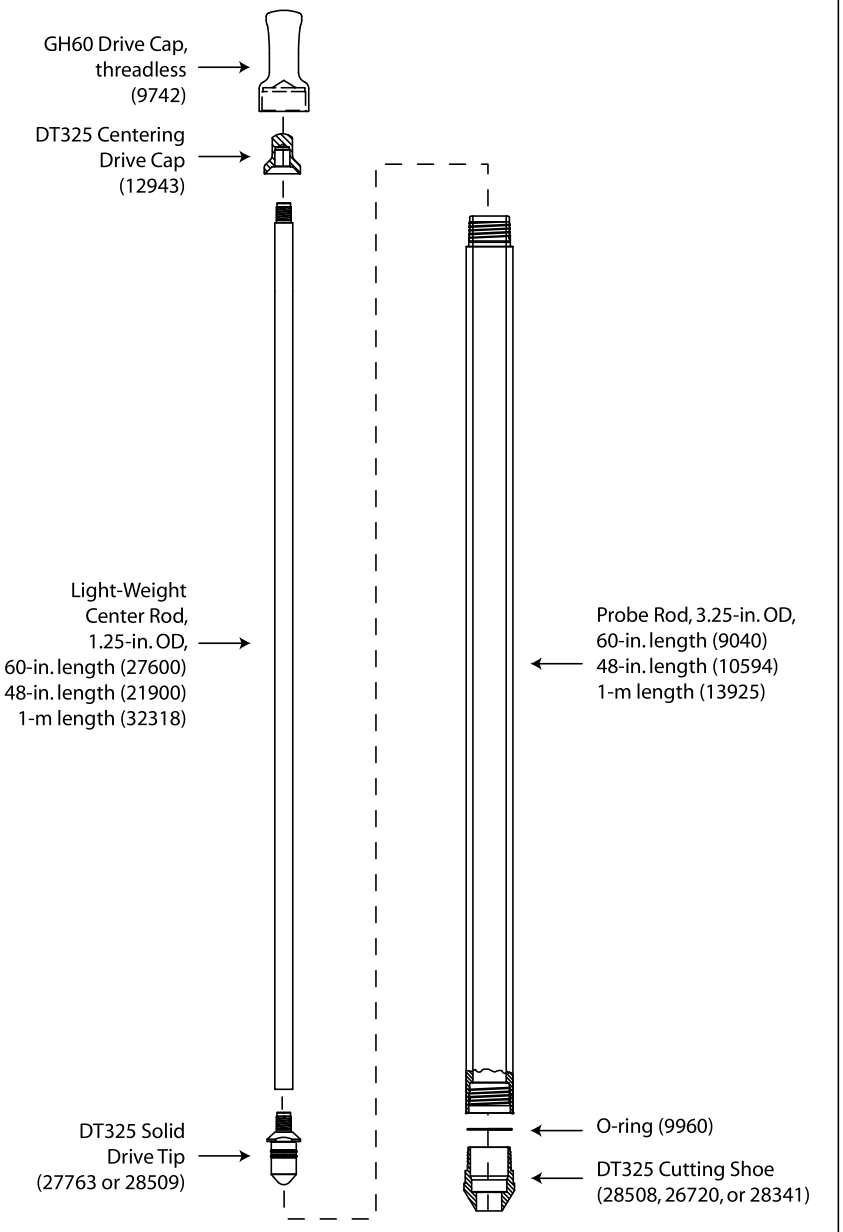

Figure 4.5
Assembly Using the DT325 Solid Drive Tip

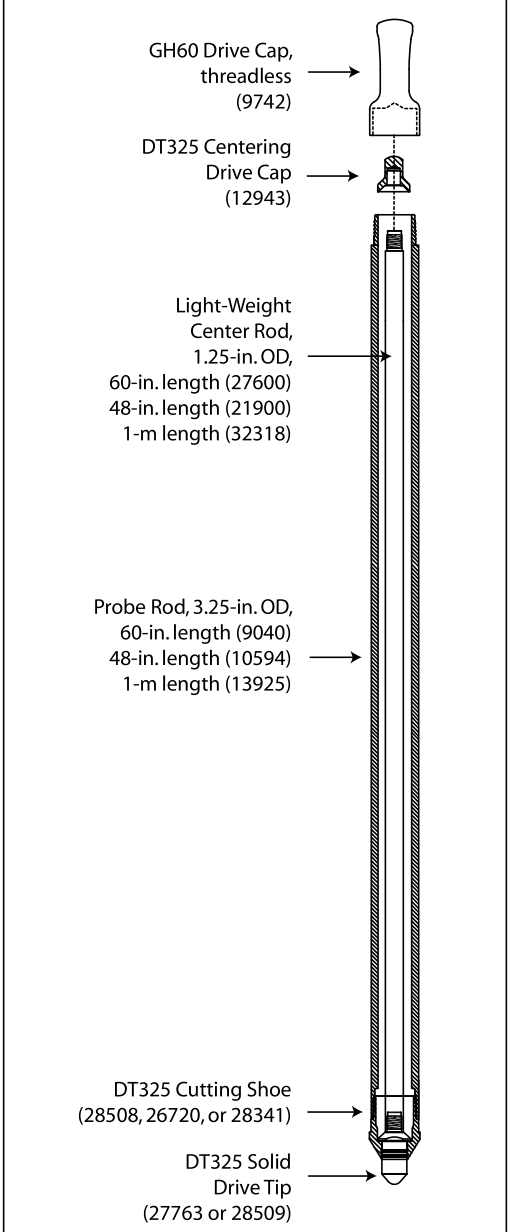

Figure 4.6
Completed Assembly

10. Raise the hammer assembly a few feet and retract the unit to provide access to the top of the outer casing assembly.

11. Remove the centering drive cap and 3.25-inch drive cap.

12. Add additional 1.25-inch light-weight center rods and 3.25-in. probe rods until the sampling interval is reached. At this point, the inner rods can be removed and an assembled sample sheath can be added (See Section 4.4)

4.4 Assembling the Sample Sheath

The sample sheath is used to support the weight of the 1.25-inch light-weight center rods and to protect the liner from damage while advancing the DT325 tool string. The process of assembling the sheath to collect soil samples is given below.

1. Place an O-ring onto the DT325 Liner Retainer. Note: No O-ring is needed for retainer 39011.
2. Slide the retainer ring onto the leading end of the liner. (Fig. 4.7).
3. Place the liner and retainer ring into either end of the sampler sheath (Fig. 4.8).
4. Thread the retainer ring onto the sample sheath. If the tools are clean, it should easily thread on easily by hand (Fig. 4.9).
5. On the opposite end of the sheath, thread on the DT325 Sheath Drive Head. The drive head will connect the sheath to the 1.25-inch light-weight center rods.



Figure 4.7. The retainer ring is placed on the end of the liner.



Figure 4.8. The liner and spacer ring are slid into the sample sheath.



Figure 4.9. Tighten the retainer ring by hand.

The sample sheath is now ready for soil core collection (Section 4.5).

4.5 Soil Core Collection

This section describes collection of continuous soil core samples from within the sealed outer casing of the DT325 Dual Tube Sampling System. The procedure is written for a sampling series that begins at the ground surface. Refer to Figure 4.10 for an illustration of the assembled sampler.

1. When using a DT325 Standard (28508) or Optional (26720) Cutting Shoe, install an O-ring (9960) at the base of the theads as shown in Figure 4.3. If using an expendable cutting shoe, install an O-ring (9960) on the DT325 Expendable Cutting Shoe Holder (28339) and one o-rings (6834) on the DT325 Expendable Cutting Shoe (28341).
2. Thread the DT325 Cutting Shoe or DT325 Expendable Point Holder onto the leading end of a 3.25-inch OD Probe Rod (Fig. 4.11). Completely tighten the cutting shoe or cutting shoe holder using a pipe wrench.
3. Insert the sample sheath assembly into the 3.25-inch OD probe rod.

4. Place a DT325 Buffering Centering Drive Cap (37708) on top of the DT325 Drive Head (Fig. 4.12) and a GH60 Threadless Drive Cap (9742) onto the 3.25-inch probe rod (outer casing, Fig. 4.13).

5. Raise the hydraulic hammer to its highest position by fully extending the probe cylinder.

6. Position the DT325 Sampler directly under the hammer with the cutting shoe centered between the toes of the probe foot (Fig. 4.14). The sampler should now be parallel to the probe derrick. Step back from the unit and visually check sampler alignment. A magnetic level can be placed on the assembly to check level.

7. Apply static weight and hammer percussion to advance the sampler unit until the drive head reaches the ground surface.

   NOTE: Activate hammer percussion whenever collecting soil. Percussion helps shear the soil at the leading end of the sampler so that it moves into the sample tube for increased recovery.

8. Raise the hammer assembly a few feet and retract the unit to provide access to the top of the sampler.

9. Remove the drive cap and thread an additional 1.25-inch light-weight center rod onto the center string. Place the adjustable rod clamp on the top of the 3.25-inch rods to keep the center rods from falling when they are removed (Fig. 4.15).

10. Pull up the 1.25-inch light-weight center rod string along with the sample tube (Fig. 4.16). When available, the 1.25-in. Leaf Puller can be used with overhead winch.

    To sample consecutive soil cores, advance a clean sample sheath and liner down the previously opened hole to the top of the next sampling interval. Add 1.25-inch light-weight center rods as the sample sheath is lowered into the opened hole. An additional 1.25-inch light-weight center rod and 3.25-inch probe rod should be added. Drive the tool string the length of the sampler to collect the next soil core. Proceed to Section 4.6 for instructions on recovering the soil core from the sample sheath.

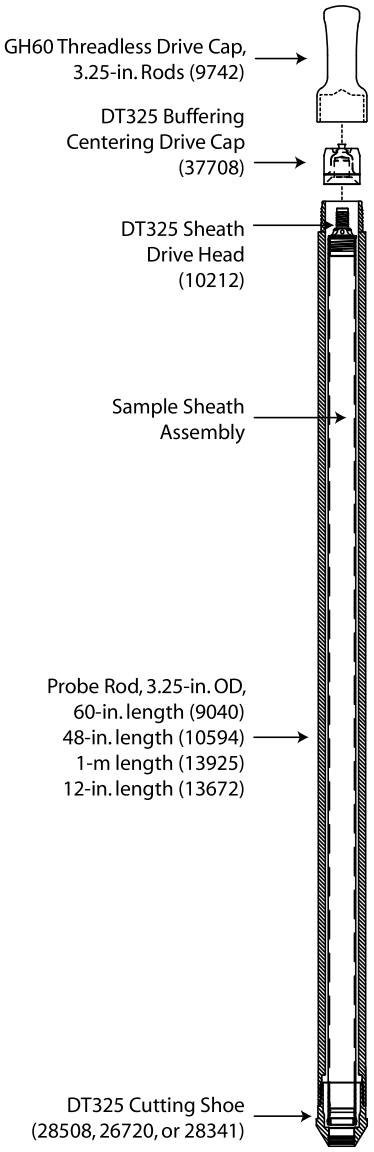

Figure 4.10
Assembled DT325 Sampler



Figure 4.11. The cutting shoe is threaded onto the 3.25-inch probe rod.



Figure 4.12. A DT325 Buffering Centering Drive Cap (37708) is placed on the DT325 Drive Head.



Figure 4.13. Place the threadless drive cap on the 3.25-inch probe rod.



Figure 4.14. The probe rod should be centered between the toes of the probe foot.



Figure 4.15. The adjustable rod clamp can be used when retrieving the sample.



Figure 4.16. The 1.25-inch light-weight center rods are pulled along with the sample tube.

4.6 Removing Filled Liner from the Sample Sheath

Place the sample tube into the vise. The liner retainer wrench can be used to remove the DT325 Liner Retainer and liner from the sample sheath. If possible, the retainer can be removed by hand (Fig. 4.17). The wrench can be used to gently knock off the retainer if necessary (Fig. 4.17). With the retainer removed, the liner and core can be withdrawn from the sample tube. A Hydraulic Liner Extruder is also available for mounting on your machine to remove liners (Fig. 4.19).



Figure 4.17. The retainer is removed from the sheath, either by hand or with the retainer wrench. Gently tap the retainer with the wrench to remove it from the liner.



Figure 4.18. The Hydraulic Liner Extruder helps remove the liner.

4.7 Removing a Section of Liner with a DT325 Liner Cutter

The liner and core can be placed on the Universal Liner Holder. Use the DT325 Liner Cutter to safely expose the sample. Begin the cut at the opposite end of the core catcher (Fig. 4.19). It is a little thinner plastic, which makes it easier to begin the cut. Using both hands, smoothly pull the cutter through the liner. The slit liner can be removed and the core is exposed (Fig. 4.20).



Figure 4.19. The DT325 Liner Cutter is used to safely make a longitudinal cut on the sample.

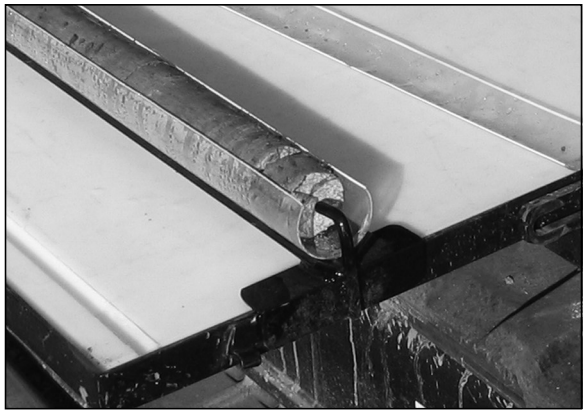

Figure 4.20. The core is exposed by the DT325 Liner Cutter.

4.8 Dual Tube Soil Sampling Tips

Saturated sands are the most difficult formations to sample with the DT325 system. Saturated conditions place positive pressure on the soil outside of the outer casing. When sampling in noncohesive formations (e.g. sands) below the water table, it may be necessary to add water to the outer casing to prevent formation heave. Adding water to the probe rods puts a positive head on the system and may keep formation material from flowing into the rods as the liner and soil sample are retracted. If a small amount of formation material is still drawn into the outer casing as the soil core is retrieved, the material may be displaced by slightly raising the outer casing while lowering the next new liner to depth. Water must be maintained within the outer casing during this process to overcome the hydraulic head imparted by the formation fluid. When retrieving, pull back the sample slowly.

DT325 core catcher liners will help considerably with sample recovery in non-cohesive soils and other materials that do not fill the liner diameter. Core catcher liners are not recommended for cohesive or extruding soils as the core catchers may actually inhibit soil movement into the liner. Also, using a shorter sample interval may improve sample recovery by minimizing wall friction as the material is sampled.

Certain soils have a tendency to exhibit plastic flow or extrusion characteristics. Allowing additional space for these materials will increase the speed of sampling because less time is spent cleaning overfilled sample sheaths. This will also yield a more representative sample. Using a sheath that is a foot or two longer than the sampling interval or using a shorter sample interval (under driving) can create a buffer zone. The DT325 Liner Spacer and Spacer Head were designed for these situations.

Some clay materials will extrude during sampling. Under these conditions, using a shorter sample interval (24-inch liners) may improve sample recovery by minimizing the wall friction as the material is sampled.

It is recommended that an O-ring be used on the liner retainer when sampling in clays. If an O-ring is not used, clay may build up between the sample sheath and the outer casing. It is not necessary to use retainer o-rings in saturated sands and anytime water is present.

It may be helpful to mark the first 1.25-inch light-weight center rod attached to the sheath as an indicator that the sheath is next in line.

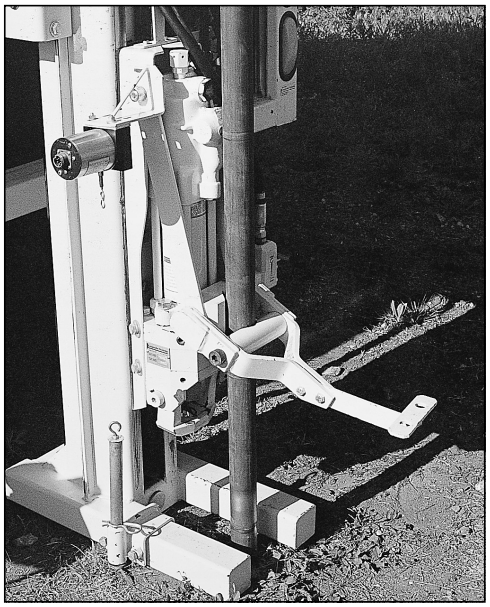

Figure 4.21. Outer casing may be retrieved with a pull cap or rod grip pull system if the probe hole is sealed with granular bentonite.



Figure 4.22. A grout machine and flexible tubing allow bottom-up grouting as the outer casing is retrieved.

4.9 Outer Casing Retrieval

The outer casing of the DT325 Dual Tube System may be retrieved in one of three ways:

1. Casing pulled then probe hole sealed from ground surface with granular bentonite.

   The outer casing may be pulled from the ground with the probe machine and a Pull Cap (13257) or a Rod Grip Pull System (for GH40 Hammers [12235] or for GH60 Hammers [44688]) if the probe hole is to be sealed with granular bentonite from the ground surface (Fig. 4.21). This method is used for shallow probe holes in stable formations only. Such conditions allow the entire probe hole to be sealed with granular bentonite.

2. Casing pulled with probe hole sealed from bottom-up during retrieval.

   Bottom-up grouting should be performed during casing retrieval in unstable formations where side slough is probable. Such conditions create void spaces in the probe hole if granular bentonite is installed from the ground surface. (Fig. 4.22)

3. Casing pulled with Geoprobe Prepacked Screen Well installed during retrieval.

   The final option is to install a 2.5-inch OD Geoprobe® Prepacked Screen Monitoring Well in the probe hole during retrieval of the outer casing. A DT325 Expendable Cutting Shoe Holder (28339) and a DT325 Expendable Cutting Shoe (28341) allow the operator to collect continuous soil cores as the outer casing is driven to depth.

   When sampling is complete, the outer rods are raised a few inches, and the expendable cutting shoe is deployed from the holder. This leaves an open casing through which a set of prepacked screens is lowered on the leading end of a PVC riser string. The well is finished, complete with grout barrier, bentonite well seal, and a high-solids bentonite slurry/neat cement grout, during retrieval of the outer casing.



Figure 4.23. Geoprobe® prepacked screens may be installed through the outer casing when an expendable cutting shoe is used.

Refer to Geoprobe® 1.0-in. x 2.5-in. OD and 1.5-in. x 2.5-in. OD Prepacked Screen Monitoring Wells Standard Operating Procedure (Geoprobe® Technical Bulletin No. 992500) for specific information on well installation.

5.0 References

Geoprobe Systems®, 2003. *Tools Catalog, V. 6.*

Geoprobe Systems®, 2005. *Standard Operating Procedure. Geoprobe@ Pneumatic Slug Test Kit. Technical Bulletin No. 19344.*

Geoprobe Systems®, 2010. *Standard Operating Procedure. 1.0-in. x 2.5-in. OD and 1.5-in. x 2.5-in. OD Prepacked Screen Monitoring Wells. Geoprobe® Technical Bulletin No. 992500.*

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.

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Sonic Head

222919	GV4 High Speed Coring Head Drive

Automatic Drop Hammer

213902	DH104 Automatic Drop Hammer, 140 lb. no Mounting Kit
213903	DH104 Mounting Kit
216826	Automatic Drop Hammer 340 lb. Expansion Kit
217067	Automatic Drop Hammer 300 lb. Expansion Kit
221820	Automatic Drop Hammer 170 lb. Expansion Kit
210126	Automatic Drop Hammer 65 kg Expansion Kit

Rotational Safety Cage

215322	Safety Cage, compatible w/ Rod Handler
215025	Safety Cage

Rod Handler

212069	Rod Handling System
213555	Casing Stand Assembly

Control System

207870	LCD Display Heater Kit
211806	Head Feed Down Control Kit

Water / Mud Pumps

210991	SPX40 Pump & Mount
212398	Hose Reel Kit
209925	Moyno® 3L6 with Table - Operator Side

Air Compressor

218584	Air Line Oiler Kit

Toolboxes

212954	53 in. Toolbox
220333	48 in. Toolbox
207214	20 in. Toolbox

Model 8140LS Specifications

TRACK PLATFORM / UNDERCARRIAGE		
Width	85 in	2,159 mm
Length (transport)	298 in	7,569 mm
Length (deployed, lateral fully retracted)	185 in	4,699 mm
Length (deployed, lateral fully retracted, rod handler deployed)	270 in	6,858 mm
Height (normal transport)	114 in	2,896 mm
Height (deployed; winch mast up)	298 in	7,569 mm
Height (min standard working height)	NA	
Extension (fore and aft)	11 in	279 mm
Lateral (side to side)	NA	
Drill Mast Dump	NA	
Base Unit Weight	22,900 lb	10,387 kg
Head Travel	157 in	3,988 mm
Head Crowd/Pull Force	20,000 lb	89 kN
Head Feed Carriage	Comp. slides	
Head Feed Pressure Control (w.o.b)	Optional	
Head Sideshift	26 in	660 mm
Head tilt out	25 deg	
Outrigger travel	26 in	660 mm
Engine	CAT C4.4 Tier 3 Flex	
Engine Rated Power	142 hp	106 kW
Fuel Capacity	40 gal	151 L
Max angle drilling ability off vertical	NA	
Approach/departure angle in transport	24 deg	
Ground Speed	1.5 mph	2.4 km/hr
Electronic Controls	V1	
Sonic head	GV4	

HP LIMITED PUMP		
Max pressure	4,000 psi	275.8 bar
Max flow	100 gpm	379 L/min

HYDROSTATIC PUMP	
Max pressure	NA
Max flow	NA

Max oscillator speed	130 Hz	
Dynamic force @ max oscillator speed	33,000 lbf	146.8 kN
Rotation (high torque/low speed)	4,000 ft-lbf @ 80 rpm	5,423 N•m
Rotation (low torque/high speed)	2,500 ft-lbf @ 120 rpm	3,390 N•m @ 120 rpm

STANDARD WINCH		
Line pull	2,000 lbf	809 kN
Line speed	110 fpm	33.5 m/min

TRIPLEX WATER PUMP		
Max pressure	1,000 psi	69 bar
Max flow	25 gpm	95 L/min

DOUBLE WRENCH BREAKOUT		
Clamp force	0 to 21,000 lbf	0 to 93.4 kN
Breakout torque	13,500 ft-lbf	18,303 N•m
Casing size compatible	2 to 12 in	51 to 305 mm
Vertical travel	9 in	229 mm

Geoprobe® Tooling Run with 8150LS

- Casing Sizes: 10 in., 8 in., 6 in., 4.5 in.
- SDT60 and SDT45 Weighted Wire Line Sampling
- SDT60 and SDT45 Sonic Sampling
- 8 x 10, 6 x 8, 4 x 6 Sonic Sampling
- DT22 Soil Sampling
- SP60 Groundwater Sampling
- DH104 Auto Hammer for SPT

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SOP-18: BORING LOG COMPLETION, SOIL CLASSIFICATION, AND LOGGING

1.0 Purpose

The purpose of this standard operating procedure (SOP) is to establish the methodology to be used by IEC field technicians and subcontractors to classify and record soil lithology, and complete Soil Boring Log Datasheets and Test Pit Log Datasheets with pertinent geological, geotechnical, physical, and chemical field observations of the soil. Adherence to a standard format for recording data will help streamline project efforts and allow a consistent presentation of subsurface data.

Attachment 1: Soil Boring Log Datasheet is intended for use in the field during drilling, sampling, soil classification, and soil boring/test pit logging activities. The purpose of the *Soil Boring Log Datasheet* is to clearly document the findings of the drilling and test pit excavation activities. Complete datasheets according to *SOP for Field Documentation Books* and retain in the project files.

Complete the Soil Boring Log Datasheets and Test Pit Log Datasheets in the field according to the procedures outlined below. If completed by hand, fill datasheets out neatly and completely. Datasheets may also be filled out electronically in the field. For geotechnical needs, it is important to check field classifications against laboratory test results. Corrections should be noted in red, initialed, and dated on the datasheet.

2.0 Scope

This procedure applies to field geologists, field personnel, and subcontractors who oversee the advancement of soil borings and excavation of test pits, classify soil, and prepare lithologic logs describing those borings and test pits on projects and tasks. All personnel new to the project who will be involved in such activities must be trained in the protocols described in this SOP by a competent person with program-specific experience.

3.0 Procedure for Lithological Logs

This section covers several aspects of the soil characterization: instructions for completing soil boring and test pit logs, field classification of soil, and standard penetration test procedures. *Attachment 1: Soil Boring Log Datasheet* indicate the information required for observation and logging of soils. The heading information should be completed on each log sheet, and the technical items in each column must be addressed in the field. Field personnel should review completed logs for accuracy, clarity, and thoroughness. It is important that information be correctly recorded on both the sample container and the datasheets. The information required in each column is discussed in more detail below.

3.1 Heading Information

Complete the heading block with all available information. If the item requested is not applicable (NA), then record NA in that box. The heading block portion of the soil boring field forms contains general information regarding the soil boring or test pit. Record the following information in the heading block for each soil boring or test pit as appropriate.

Project Number. Use the standard six-digit project number and appropriate point numbers.

Boring/Test Pit Number. Enter the boring or test pit number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site (See *SOP for Sample Identification and Nomenclature*). Number the sheets consecutively for each boring. If rock core log sheets are also used, continue the consecutive numbering.

Project. Fill in the name of the project or client.

Location. Identify the area of concern, building, or other landmark the boring or test pit is associated with. Also indicate the stationing, coordinates, mileposts, or similar project layout information, if available. Indicate the position of the boring to that system using modifiers such as approximate or estimated, as appropriate. If this information is not available, identify the client facility (for example,) and provide a brief description of location. Record swing-tie information if valuable and/or necessary.

Elevation. Enter the estimated elevation. If it is estimated from a topographic map, or if it is roughly determined using a hand level, use the modifier approximate. It is important to tie the boring elevation to a recoverable reference point (such as a fire hydrant or floor slab) if no other elevation data are available. Such points can be picked up later in a site survey and boring elevations can be determined. In the event that no survey is done, the relative boring elevation with respect to pertinent project facilities will be known, at the least.

Drilling/Test Pitting Contractor. Enter the name of the drilling or test pit excavation subcontractor, and the city and state where the company is based.

Drilling/Test Pitting Method and Equipment. Identify the drilling method (such as hollow- stem auger [HAS] or direct-push system [DPS], or other), drilling equipment (such as CME- 75, Geoprobe 6620D), bit size and type, and drilling fluid (if used). Information on the test pit excavation equipment (such as Caterpillar 303C excavator) should also be included.

Water Level and Date. Enter the depth below ground surface (bgs) to the static water level in the borehole, if encountered. If multiple water level measurements are taken for the boring, this field should list the last or most representative measurement. Frequent water measurements are recommended to capture differences between water-bearing zones, and to capture the stable water level. Record the information in the Comments column. If free water is not encountered during drilling, or cannot be detected because of the drilling method, make a note of this information. Generally, water levels should be measured each morning before resuming drilling and at the completion of each boring. Record the date and time of day (for such things as tides or river stage) of each water level measurement.

Date of Start and Finish. Enter the dates and times the boring was begun and completed.

Logger. Enter the first initial and full last name of the geologist or engineering recording the soil log.

3.2 Technical Data

Depth Below Surface. This column refers to the depth bgs. Depths should typically be recorded in feet, unless very shallow soil borings are expected. The scale of the log may be adjusted as needed by the Field Geologist for the best and most accurate representation of the data. Depth intervals should be recorded at consistent depths (such as 10, 15, 20, 25 feet; or 0.5, 1.0, 1.5, 2.0 feet). Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. The sample interval refers to the depth interval that each lithologic sample is collected using a split spoon or core sampler. The depth interval that each lithologic sample is collected from should be recorded in the

Interval column corresponding to where it was collected. Draw horizontal lines at the top and bottom depth of each sample interval.

These lines should extend to the soil description column. For a very short sample interval, the bottom line can be lowered after the interval column to provide room for writing the information. Enter the depth at the top and bottom of the sample interval.

Sample Recovery. The recovery column shows the amount of sample recovered per lithologic sample attempt. The lithologic sample recovery should be recorded as the length in inches of sample recovered. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value (the sum of the blows in the last two 6-inch penetration intervals) if the standard penetration test is being used with a hollow-stem auger drill rig. A typical standard penetration test involving successive blow counts of 2, 3, and 4 is recorded as 2-3-4 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of more than 6 but less than 12 inches, with a blow count of 100, or a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50'4. In order for the standard penetration test to be useful, the hammer weight and split-spoon size must be recorded. See Geotechnical ASTM Standards utilized for the project presented in the CMI Work Plan.

Soil Description. Soil classification should follow the format described in Section 5.3, Field Classification of Soil. The Soil Description column is completed using the standard Unified Soil Classification System (USCS) Group Symbol code that corresponds to the lithology encountered. An entry should be made at each lithological change or at the top of a new page if the same lithology is encountered. The Field Geologist should determine and record the correct USCS group symbol classification according to Section 5.3. Lithologic descriptions must be determined before the assignment of the appropriate group symbol.

Comments. Include pertinent observations including soil core or soil headspace photoionization detector (PID) readings, analytical samples collected with identification (ID) and depths, changes in drilling difficulty, equipment malfunctions, any driller observations and comments, and any other valuable observations. The driller will be instructed to alert the geologist when changes in drilling are encountered. Such information should be attributed to the driller and recorded in this column.

Others specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Rod chatter, rod drops, and depth of occurrence
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Drilling interval through a boulder
- Depth of piezometers and the results of in situ tests

Soil core PID screening results or headspace screening results for volatile organic compounds (VOCs), collected according to procedures outlined in *SOP for Organic Vapor Monitoring and Air Monitoring*, should be recorded in the Comments column. The specific PID reading depth should also be recorded.

3.3 Field Classification of Soil

This section describes the format for the field classification of soil. In general, the approach and format for classifying soils should conform to the most current version of the American Society for Testing and Materials (ASTM) standard ASTM D2488, *Visual-Manual Procedure for Description and Identification of Soils*.

The USCS is based on numerical values of certain soil properties measured by laboratory tests (ASTM D2487). It is possible, however, to estimate these values in the field reasonably accurately with visual-manual procedures (ASTM D2488). Also, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field. Corrections and additions to the field classification can be provided, when necessary, through laboratory testing of the soil samples.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities between consecutive samples, rather than differences, should be stressed.

Soil descriptions must be recorded in the Soil Description column for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D2488 Group Name) with appropriate modifiers
2. Group symbol
3. Color
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D2488. Examples of soil descriptions are provided in Table 1.

Table 1. Example Soil Descriptions.

- POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size FAT CLAY (CH), dark gray, moist, stiff
- SILT (ML), light greenish gray, wet, very loose, some mica
- WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, sub-angular gravel to 0.6 inches max POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense
- ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica
- SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, sub-rounded gravel to 1.2 inches max
- INTERLAYERED SILT (60%) AND CLAY (40%): SILT WITH SAND (ML), medium greenish gray, moist, non-plastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick
- SILTY SAND WITH GRAVEL FILL(SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inch maximum, very few small particles of coal
- SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff
- WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

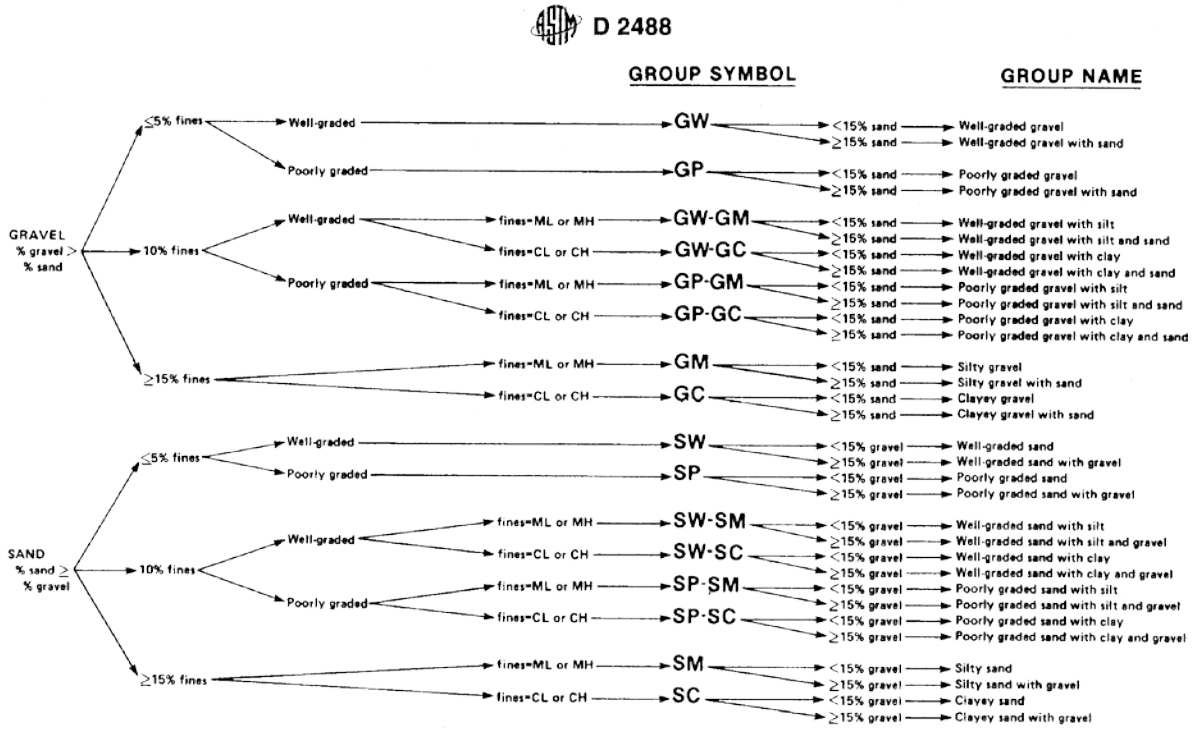
3.3.1 Soil Name

The basic name of a soil should be identical to the ASTM D2488 Group Name, based on visual estimates of gradation and plasticity, and should be capitalized. The only acceptable soil names are those listed in Figures 3 and 4, from ASTM D2488.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15% gravel, 55% sand, and 30% fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10% gravel, 30% sand, and 60% fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15%. The Group Symbol is (ML).

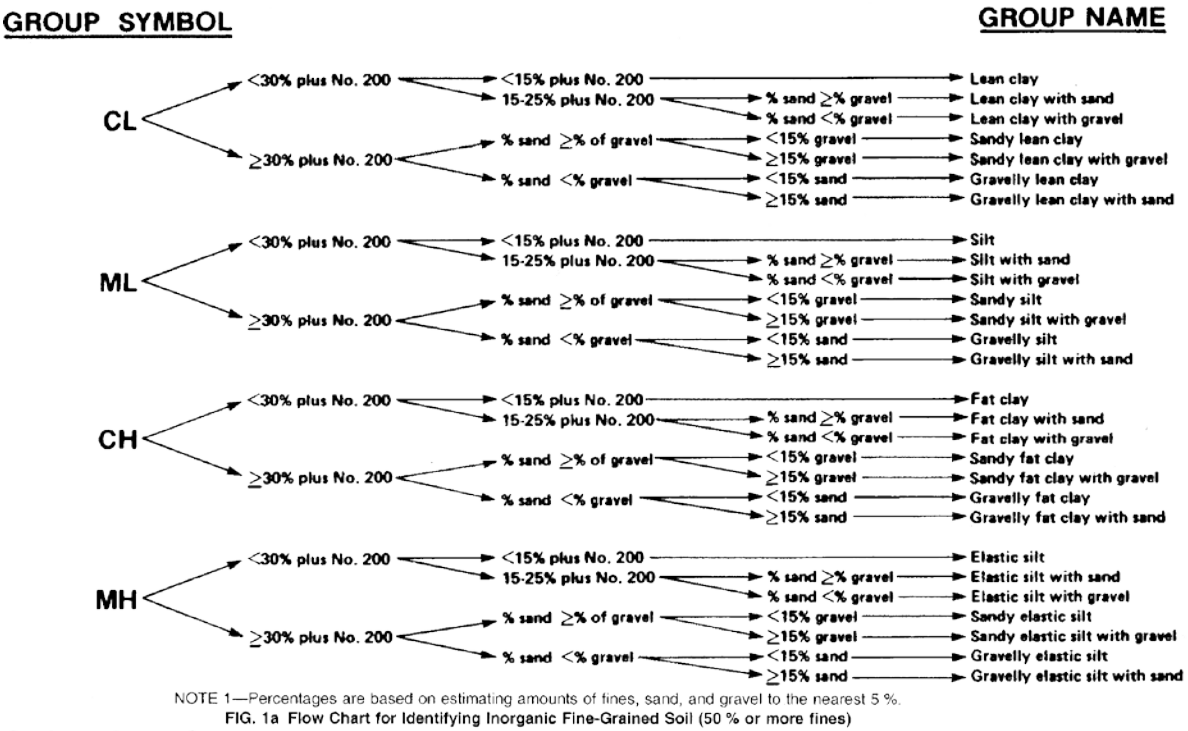
The gradation of coarse-grained soil (more than 50% retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D2488. For a coarse-grained soil, note whether the soil is well-graded or poorly graded. If poorly graded, note whether it is fine-, medium- or coarse-graded. Also record the maximum size and angularity or roundedness of gravel and sand-sized particles. Note that samples from split spoons and small-diameter core tools are not always representative of coarse-grained strata (those with grain sizes of a diameter greater than that of the diameter of the particular coring apparatus used). Be sure to check driller's logs and soil cuttings for boulders, cobbles, gravels, and similar that were encountered during advancement of the boring and note their presence on the Soil Boring Log Datasheet.



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

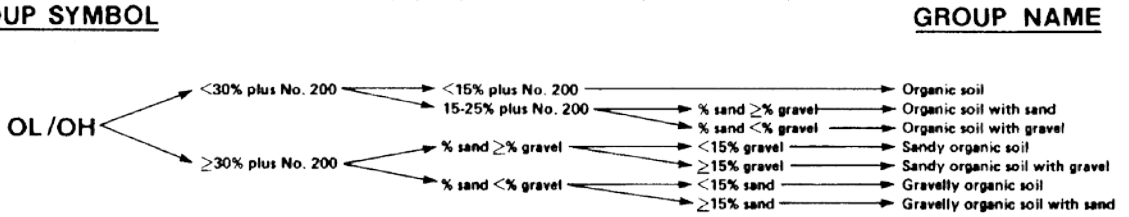
FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

Figure 1: Flow Chart for Identifying Coarse-Grained Soils (less than 50% fines); USCS (ASTM, 2009).



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

Figure 2: Flow Chart for Identifying Inorganic Fine-Grained Soils (50% or more fines); USCS (ASTM, 2009).

For fine-grained soil (50% or more passing the No. 200 sieve), modify the name by the appropriate plasticity/elasticity term, in accordance with ASTM D2488. Take special consideration when dealing with soil samples in which the predominant grain size is fine grained (that is, CLAY or SILT). Because of the fine size of clay and silt, physical properties other than grain size must be used as criteria for identification in the field. The property of plasticity is characteristic of clays and may be determined using a simple field test. If a sample of moist fine-grained soil can be rolled into a long thin thread in the palm of the hand, it contains a significant amount of clay. Silt can seldom be rolled into a thread without severe cracking. If a sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation before rolling. The dilatancy or “shaking test” may be also be used to distinguish between the fractions of clay and silt. To perform this test, mix a small amount of soil with water to a very soft consistency in the palm of the hand. Lightly tap the back of the hand. If the sediment is silty, water rises quickly to the surface of the mixture and gives it a glistening or shiny appearance. Because of the

difficulty in distinguishing between silt and clay, it is not necessary to provide the relative percentage of each. Where helpful, the evaluation of plasticity/elasticity and dilatancy can also be justified in the Comments section of the log by describing the results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength.

For interlayered soils, describe each, starting with the predominant type. Use an introductory name, such as Interlayered Sand and Silt. Also indicate the relative proportion of each soil type and layer thickness.

3.3.2 Group Symbol

The appropriate group symbol from ASTM D2488 (see Figure 3) must be given after each soil name. Place the group symbol in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D2488, dual symbols (for example, GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10% fines. Borderline symbols (for example, GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. Borderline symbols should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

Fill is often encountered when drilling. Fill comprises any materials that people have placed on the naturally occurring ground surface. Fill material can be determined from historical information or from the discovery of human-made materials, such as concrete, brick, glass, plastic, and wood. If the soil being described is determined to be fill material, “fill” should be included in the soil description. If appropriate, provide additional details in the Comments column.

3.3.3 Color

Give the basic color of a soil, such as brown, gray, or red; the color term can be modified, if necessary, by adjectives such as light, dark, or mottled. Especially note staining, iron staining, or mottling. This information might be useful for establishing water table fluctuations or contamination. As an alternative, consider using the Munsell soil color chart designation in addition to the color designation.

3.3.4 Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed in Table 2.

Table 2. Criteria for Describing Moisture Conditions.

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moise	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

3.3.5 Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values from the Standard Penetration Test. (ASTM D1586). If the presence of large gravel or disturbance of the sample makes determining the in situ relative density or consistency difficult, then omit this item from the description and explain it in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values from the Standard Penetration Test. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

Table 3. Relative Density of Coarse-Grained Soil (Developed from Sowers, 1979).

Blows/Ft	Relative Density	Field Test
0-4	Very Loose	Easily penetrated with 12-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with 1/2-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with 1/2-in. steel rod driven with 5-lb. hammer
31-50	Dense	Penetrated a foot with 1/2-in. steel rod driven with 5-lb. hammer
>50	Very Dense	Penetrated only a few inches with 12-in. steel rod driven with 5-lb. hammer

Table 4. Consistency of Fine-Grained Soil (Developed from Sowers, 1979).

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very Soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	<0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very Stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

3.3.6 Soil Structure, Mineralogy, Particle Shape, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, roots, root holes, and wood debris.

Record significant mineralogical information. Describe cementation, abundant mica, or unusual mineralogy, as well as other information, such as organic debris or odor.

Include other descriptors if they are important for the project or for describing the sample. These descriptors include particle size range and percentages, particular angularity, particle shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to hydrochloric acid (HCl), and cementation.

Residual soils have characteristics of both rock and soil and can be difficult to classify. Describe relict rock structure and identify the parent rock, if possible.

3.3.7 Potentially Impacted Subsurface Media

Record observations of any potentially impacted subsurface media in the soil description or as comments. Notable observations of impacted media include staining, sheens, unusual discolorations, unusual crystals, and odors. Make a note about odor and describe the characteristics of the odor (for example, hydrocarbon odor) but do not try to guess what chemical smell is observed. Also describe non-aqueous phase liquids (NAPL) if they are present. Describe *how* they are present, such as sheen, staining along joints or root casts, residual, or free NAPL seeping from the sample. Do not try to guess what fluid is present. Use terms such as phase-separated hydrocarbons if you know a fluid is a fuel, but do not use terms such as diesel, unless you have tested and know that the fluid is diesel. For larger investigation projects, it is advisable to prepare guidelines for describing site contamination in the soil samples.

4.0 Standard Penetration Test Procedures

Standard Penetration Tests (SPT) are conducted to obtain a measure of the resistance of the soil to penetration of the sampler and to recover a disturbed soil sample. They should be conducted in accordance with ASTM D1586, *Penetration Test and Split Barrel Sampling of Soils*. These tests are most commonly performed on geotechnical projects. On environmental projects, a larger split spoon often must be used to collect the amount of soil required for analytical sampling. Recording blow counts can be useful for understanding variations in soil density or consistency on environmental projects, but typically is not done for an SPT. Refer to *SOP* for *Hollow Stem Auger and Direct Push Drilling Methods* for addition details regarding SPT testing during drilling.

4.1 Equipment and Calibration

Before testing is started, inspect equipment for compliance with the requirements of ASTM D1586. The split-barrel sampler outer diameter (O.D.) should measure 2 inches, the inner diameter (I.D.) should measure 1-3/8 inches, and the split tube should be at least 18 inches long. The dimensions should conform to those shown in Figure 1 of ASTM D1586. The minimum size sampler rod allowed is the “A” rod (1-5/8-inch O.D.). A stiffer rod, such as the “N” rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

4.2 Procedures

Ideally, conduct SPTs at every change of stratum, or within a continuous stratum, at intervals not exceeding 5 feet. Before driving the split-barrel sampler, remove loose and foreign material from the bottom of the borehole. It might be helpful to measure the rod stickup to ensure that the sampler is being driven from the bottom of the borehole. Perform the SPT by driving a standard split-barrel sampler 18 inches into undisturbed soil at the bottom of the borehole with a 140-pound guided hammer or ram that falls freely from a height of 30 inches.

Observe the number of blows required to drive the sampler for three 6-inch intervals (for a total of 18 inches) and record that number on the soil boring log. The sum of the number of blows required to drive the sampler for the second and third 6-inch intervals is considered the Standard Penetration Resistance (N) or the *blow count*. If the sampler is driven less than 18 inches, but more than 1 foot, the penetration resistance (N) is the blow count for the last 1 foot of penetration. If less than 1 foot is penetrated, the log must state the number of blows and the fraction of 1 foot penetrated. It is important that the field logger observe the sampler being driven and count the blows for each sample attempt.

4.3 General Considerations

The following steps are recommended to be performed while performing SPT work:

1. The borehole should be cleaned out before every sample attempt. Because a minor amount of caving can be expected, the borehole can be considered adequately clean if no more than 4 inches of loose or foreign material has collected at the bottom. If there is a greater amount of caving, clean the borehole again.

2. The ball check valve in the split-barrel sampler should be cleaned and working properly for each sample. Bent, chipped, or damaged shoes should be replaced. The split-barrel halves should not be warped. In case of zero sample recovery (that is, if the sample is lost during the first attempt), a spring catcher should be used during subsequent attempts to facilitate recovery.

3. During SPT sampling, it is important that all rod connections be tight and that the hammer guide be connected securely to the drill rods. If the hammer guide connection becomes loose, much of the hammer energy can be lost because of deflection of the hammer coupling. The lifting rope should not rub against the mast. Each hammer fall should be 30 inches.

4. During SPT sampling, it is important that the drill rods be positioned at the center of the drill hole to preclude the development of friction between drill rods and the walls of the borehole or casing.

5. If the hammer weight is raised by means of a cathead, generally two wraps on the cathead should be used. The optimal number of wraps varies with the condition of the rope and cathead, and with the weather. Most importantly, the driller should exercise care to prevent friction of the rope on the cathead during the fall of the hammer.

6. Nonstandard procedures or equipment occasionally are used for obtaining samples (for example, 3-inch O.D. split-barrel samplers, or 300-pound hammers). Any nonstandard practice should be described on the boring log form. Also, the blow counts should be clearly marked as not conforming to SPT values.

5.0. Sample Labeling and Packaging

This section addresses only those sample labeling and packaging requirements that apply to *physical* testing of soil samples. For guidance on requirements for samples destined for *chemical* testing.
If the work is being conducted at a site containing hazardous waste (not simply hazardous constituents, but either listed or characteristic hazardous waste) or toxic waste (such as polychlorinated biphenyls), contact the PM, FM, or FTL regarding appropriate sample handling procedures consistent with hazardous or toxic waste management regulations and *the SOP for Sample Handling and Custody*.

The samples recovered from the borehole are an important part of the boring record and must be properly packaged and labeled, if further testing is required. The following description outlines the minimum requirements for packaging and labeling the samples.

1. Place disturbed samples in Ziploc™ bags or jars. If using jars, mark the jar lids and affix labels to the sides of the jars. Labels are usually available from the analytical laboratory. Mark the following information clearly on the bags or jars:

    - Project number

- Boring number
- Sample number
- Sample depth
- Date

Use a permanent marker. If moisture content tests are anticipated, use jars, which should be tightly sealed, then sent to the laboratory. Testing should be initiated as soon as possible (within 1 week). Alternatively store the samples in double-bagged Ziploc™ bags of an appropriate size. Do not expose samples to hot or freezing temperatures which might alter the moisture content of the sample.

2. Label boxes containing the jars, on top and on one end, with the following information:
    - Project name
    - Project number
    - Boring number
    - Sample numbers
    - Sample depths
    - Date
    - Name

    It is helpful to start a new box for each new boring if the boxes are at least half full.

3. Clean Shelby tubes of mud and moisture. When they are dry, use a permanent marker to label them with the following information:
    - An arrow indicating which way is up
    - Project number
    - Boring number
    - Sample number
    - Sample depth
    - Amount of recovery
    - Date

Circumscribe the top and bottom of the sample on the outside of the tube with a marker.

4. Sealing of Shelby tubes is essential if sample testing is not to occur within a few days. In all cases, place lids on the ends and tape them with airtight tape. Be sure to seal the holes in the top of the tube. Pack the open portion of the tube above the sample to prevent shifting of the soil. Dampened newspaper is generally adequate for this purpose, but it should be separated from the soil sample with a wax seal or an inverted cap.

5. Maintain Shelby tubes in upright position at all times. Ship is a manner that will minimize disturbance (vibration) to sample.

6.0 Field Equipment Checklist

The following equipment and supplies are required for soil boring and test pit exploration work:

6.1 Site Setup

- Lath, flagging, orange spray paint, grease pencil, survey stakes
- 100-foot tape measure
- Magnetic compass or Global Positioning System (GPS) receiver

6.2 Logging Equipment

- *SOP for Boring Log Completion, Soil Classification, and Logging*
- Clipboard
- Soil boring Log Datasheet or Test Pit Log Datasheet, on all-weather paper
- Pens/pencils
- Engineer's pocket tape measure with tape lock (with tenths of foot instead of inches)
- Field notebook on all-weather paper
- Squirt bottle with water
- Spatula or large spoon
- Munsell Soil Color chart
- Hand lens

6.3 Sampling and Packaging

- Jars with lids and labels
- Ziploc™ bags
- Shelby tubes and plastic end caps
- Airtight tape (such as electrical)
- Newspaper
- Sealing wax, stove, melting pot, and matches
- Indelible fine felt-tipped markers (such as Sharpie brand)

6.4 Test Equipment

- Pocket penetrometer
- Torvane
- Water Interface Meter

7.0 Records

Fill out Soil Boring Log Datasheets and Test Pit Log Datasheets according to this SOP. The field geologist will check that entries have been appropriately reviewed and that any corrections have been made properly.

To guard against loss of data because of damage or misplacement of datasheets, make regular copies of completed pages and securely retain them in the project-specific files. Upon completion of field activities, save the datasheet to the project folder on the local area network (LAN).

Enter information on soil boring log field forms into a boring log software program such as WinLoG, gINT, or CH Boring Logger. If boring log software is used, do so according to the software instructions.

8.0 References/ Methods

American Society for Testing and Materials (ASTM). June 15, 2009. *Standard Practice for Description of Soils (Visual-Manual Procedure)*. ASTM Standard D2488 Rev A, ASTM International, West Conshohocken, PA.

American Society for Testing and Materials (ASTM). 2008a. *Standard Method for Thin- Walled Tube Sampling of Soils*. ASTM Standard D1587, ASTM International, West Conshohocken, PA. October 1.

American Society for Testing and Materials (ASTM). 2008b. *Standard Method for Penetration Test and Split-Barrel Sampling of Soils*. ASTM Standard D1586 Rev A, ASTM International, West Conshohocken, PA. October 1.

American Society for Testing and Materials (ASTM). May 1, 2006. *Standard Test Method for Classification of Soils for Engineering Purposes*. ASTM Standard D2487, ASTM International, West Conshohocken, PA.

American Society of Civil Engineers. 1976. Subsurface Investigation for Design and Construction of Foundations of Buildings. *American Society of Civil Engineers Manual on Engineering Practice*, No. 56, 53 pp.

Bell, F.G. 1981. *Engineering Properties of Soils and Rocks*. London: Butterworth Publishers, Inc.

Burmister, D.M. 1949. Principles and Techniques of Soil Identification. *Proceedings of the Highway Research Board*, pp. 402-433.

Matula, M. 1981. Rock and Soil Description and Classification for Engineering Geological Mapping. Report by the IAEG Commission on Engineering Geological Mapping. *Bulletin of the International Association of Engineering Geology*, No. 24, pp. 235-274.

ASTM G187-18: Standard Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method.

ASTM D4972-18/ASTM G51-18: Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing.

ASTM C1580: Standard Test Method for Water-Soluble Sulfate in Soil.

AASHTO T 291: Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil.

ASTM D4427-18: Standard Classification of Peat Samples by Laboratory Testing.

ASTM D854-14: Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer.

ASTM D4318-17e1: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

ASTM D2974-14: Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.

ASTM D2216: Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

ASTM D1140-17: Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing.

ASTM D6913/D6913M-17: Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.

ASTM D7928-17: Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis.

ASTM D8037/D8037M-16: Standard Practice for Direct Push Hydraulic Logging for Profiling Variations of Permeability in Soils.

ASTM D5084: Standard Triaxial Permeability (Hydraulic Conductivity) / Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

ASTM D2434-68(2006): Standard Test Method for Permeability of Granular Soils (Constant Head) (WITHDRAWN STANDARD 2015).

ASTM D2435/D2435M-11: Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading.

ASTM D4546-14e1: Standard Test Methods for One-Dimensional Swell or Collapse of Soils.

ASTM D4829-11: Standard Test Method for Expansion Index of Soils.

ASTM D3080/D3080M-11: Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.

ASTM D2166/D2166M-16: Standard Test Method for Unconfined Compressive Strength of Cohesive Soil.

ASTM D2850-15: Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils.

ASTM 4767-11: Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils.

ASTM D448-01(2013) - Standard Guide for Sampling Groundwater Monitoring Wells.

ASTM D6089-15: Standard Guide for Documenting a Groundwater Sampling Event.

ASTM D6771 – 18: Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations.

9.0 Definitions

Angularity: pertaining to the sharpness of edges and corners of individual grains. A grain is angular if most of the edges or corners are sharp and rounded if most are smooth.

Cohesiveness: measure of the strength, when air-dried, of an unconfined soil or sediment, or a measure of the cohesion of a soil or sediment when submerged.

Lamination: the state of being laminated, specifically the thinnest recognizable layer in a sediment differing from other layers in color, composition, or particle size.

Lithologic: pertaining to the physical characteristics of a rock or sediment.

Plasticity: measure of the tendency of a soil or sediment to be deformed without rupturing.

Relative Density: the ratio of (1) the difference between the void ratio of a cohesionless soil in the loosest state and any given void ratio, to (2) the difference between the void ratios in the loosest and in the densest states.

Sample ID: the unique identifier that IEC assigns to a specific environmental sample.

LOCID: the unique identifier that IEC assigns to a specific sampling location.

Sorting: a measure of the uniformity of particle size(s) in a particular soil or sediment.

Texture: the general appearance or character of rock or sediment, including the geometric aspects of, and mutual relations among, its component particles, for example, the size, shape, and arrangement of the constituents of sediment.

10.0 Attachments

Attachment 1: *Soil Boring Log Datasheets*

Attachment 2: *Soil Characterization Field Reference Materials*

Client:		Boring No.:	
		Sheet 3 of	
Site Location:		Date:	
Drilling Co:		*FORMAT FOR CHARACTERIZATION*	
Method:		**Ex.1:** brown, loose F SILTY-SAND, with some C Gravel	
Personnel:		**Ex.2:** grey & brown mottled soft CLAY and brown F SAND, with trace organics	
Total Depth:	Depth to Water:		

depth (feet)	PID (ppm)	Blow Counts	Sample ID	Depth (From-To)	Moisture Content	Recovery	Soil Classification	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

TRACE = 1 - 10% LITTLE = 11 - 20% SOME = 21 - 35% AND = 36 - 50 %

GEOTECHNICAL DESIGN MANUAL

CHAPTER 5

SOIL AND ROCK CLASSIFICATION AND LOGGING

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CHAPTER 5
Soil and Rock Classification and Logging

5.1 OVERVIEW

The detailed description and classification of soil and rock are an essential part of the geologic interpretation process and the geotechnical information developed to support design and construction. The description and classification of soil and rock includes consideration of the physical characteristics and engineering properties of the material. The soil and rock descriptions that are contained on the field logs should be based on factual information. Interpretive information may be included on the field logs if a description is provided on the reason for the interpretive information. This chapter provides standards for describing and logging soil and rock.

The NYSDOT Soil Classification System is outlined in the Geotechnical Engineering Bureau's *An Engineering Description of Soils Visual-Manual Procedure* (GTP-2). This manual presents a procedure for describing soil samples obtained for foundation engineering and earthwork purposes by the New York State Department of Transportation. The procedure involves visually and manually examining soil samples with respect to texture, plasticity and color. The classification method establishes a "word picture" on the moisture and relative percentages of types of soil particles which can be entered onto official documents such as a subsurface exploration log or other appropriate data sheet.

Another classification system, the Unified Soil Classification System (USCS) as outlined in ASTM 2487 – "*Standard Practices for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*", provides a conventional system for classifying soils which is a precise classification system based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index. As an option, ASTM 2488 – "*Standard Practices for Description and Identification of Soils (Visual – Manual Procedure)*" identifies a procedure for the description of soils for engineering purposes. This practice describes a procedure for identifying soils based on visual examination and manual tests.

The NYSDOT Rock Classification System is outlined in the Geotechnical Engineering Bureau's *Rock Core Evaluation Manual* (GEM-23). It presents a procedure for describing rock core samples obtained for the New York State Department of Transportation by State work forces, and/or private drilling companies, for foundation, rockslope, and other engineering purposes. The evaluation is intended to provide a comprehensive word description of the core samples to those involved in the planning, design, construction, and maintenance processes.

There are numerous other rock classification systems, but none of these is universally used. This chapter provides a composite of those classification systems that incorporates the significant descriptive terminology relevant to geotechnical design and construction.

An important facet of soil and rock classification is the determination of what constitutes *"rock"*, as opposed to extremely weathered, partially cemented, or altered material that approaches soil in its character and engineering characteristics. Extremely soft or decomposed rock that is friable (easily crumbled), and can be reduced to gravel size or smaller by normal hand pressure, should be classified as a soil.

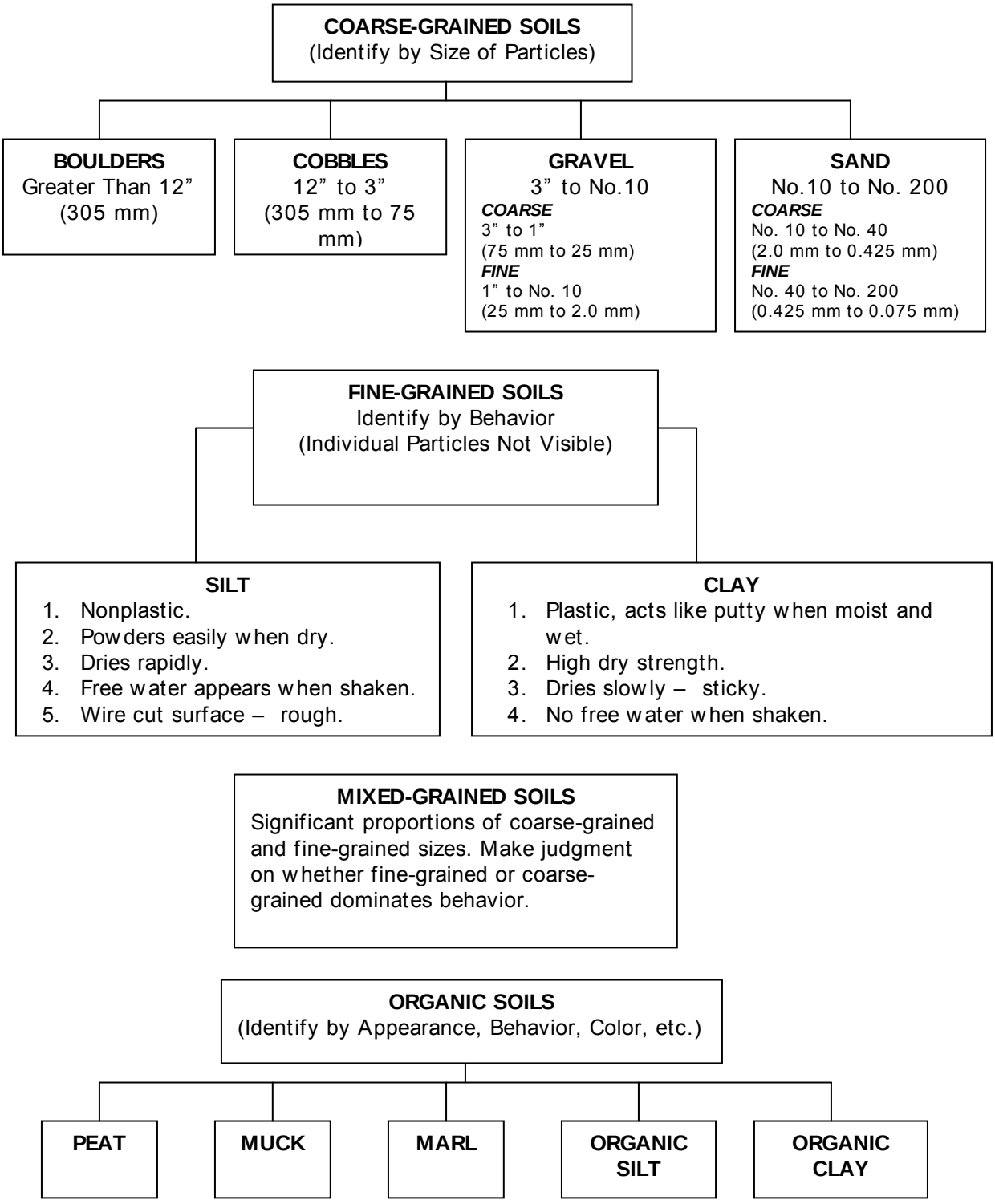

Figure 5-1 NYSDOT Identification Procedure Chart

5.2 SOIL CLASSIFICATION

Soils are divided into four broad categories. These soil categories are coarse-grained soils, fine-grained inorganic soils, organic soils, and peat. The first step in identifying soil is to register the soil into one of the four broad categories. The definitions for these broad categories are as follows:

- Coarse-Grained Soils: Soils that contain 50 % or less of soil particles passing a 0.0030 in. (0.075 mm) opening.
- Fine-Grained Inorganic Soils: Soils that contain more than 50 % of soil particles passing a 0.0030 in. (0.075 mm) opening.
- Fine-Grained Organic Soils: Soils that contain enough organic particles to influence the soil properties.
- Peat: Soils that are composed primarily of vegetative tissue in various stages of decomposition that have a fibrous to amorphous texture, usually dark brown to black, and an organic odor are designated as a highly organic soil called peat. Once a soil has been identified as a peat (group symbol PT), the soil should not be subjected to any further identification procedures.

5.2.1 Brief Definition of Terms

The Geotechnical Engineering Bureau's *An Engineering Description of Soils Visual-Manual Procedure* (GTP-2) presents a brief glossary of terms in GTP-2, Part 2. Definition of Terms.

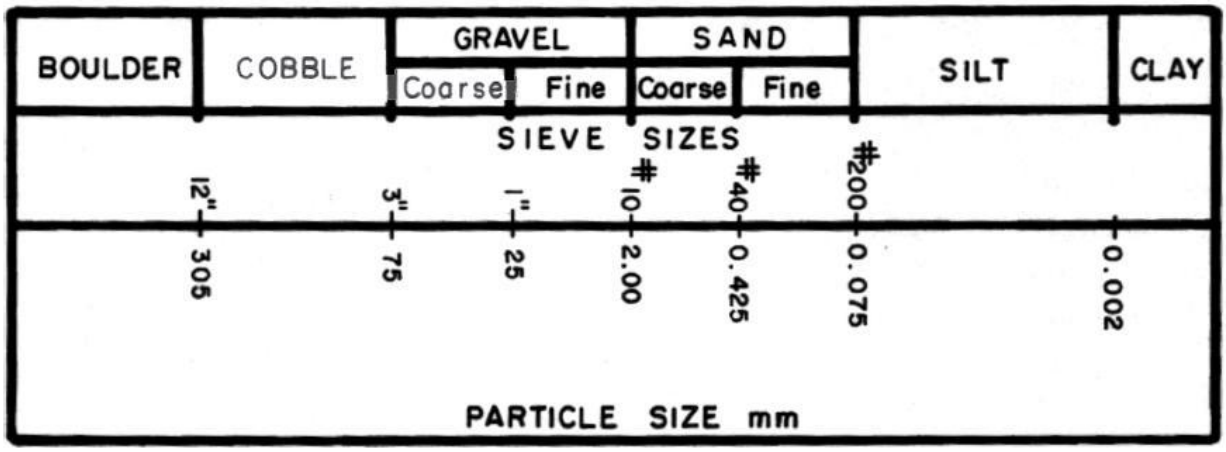

Figure 5-2 Particle Size

5.2.2 Coarse-Grained Soils

Coarse-grained soils consist predominately of cobbles, gravel or sand size particles and are non-plastic. Density of coarse-grained soils in the natural state is often based on the soil sampler blows per foot of penetration. The following general guide may be used for field description by Drillers and Inspectors:

Density	No. of Blows per foot with Automatic Hammer (SPT)[1]
Very Loose	0 – 4
Loose	5 – 10
Medium Compact	11 – 24
Compact	25 – 50
Very Compact	Over 50

[1] Standard Penetration Test – 30 in. drop of 140 lb. hammer, 2 in. OD sampler

Table 5-1 Density of Coarse-Grained Soil Based on Sampler Blows

5.2.3 Fine-Grained Inorganic Soils

Table 5-2 applies to fine-grained plastic soils consisting predominately of silt and clay particles. For non-plastic silt, use adjectives and blows in coarse-grained Table 5-1.

There is an approximate relationship between consistency of plastic fine-grained soil and blows on the sampler as indicated below. Also, the consistency can be estimated for a relatively undisturbed sample by molding in hand as indicated below. If hand rating shows greater consistency, use this rating on log.

Consistency	No. of Blows per foot with Automatic Hammer (SPT)[1]	Field Test on Relatively Undisturbed Samples	Approximate Shear Strength psf
Very Soft	0 – 1	When squeezed in fist will ooze between fingers.	0 to 250
Soft	2 – 4	Easily molded in fingers.	250 to 500
Firm	5 – 8	Can by molded by strong pressure with fingers.	500 to 1000
Stiff	9 – 15	Readily indented with thumb – difficult to mold in fingers.	1000 to 2000
Hard	Over 15	Difficult to indent with thumb nail.	2000 and greater

[1] Standard Penetration Test – 30 in. drop of 140 lb. hammer, 2 in. OD sampler

Table 5-2 Consistency of Fine-Grained Soil Based on Sampler Blows

The field list identified in Table 5-3 may be used to distinguish between the structural characteristics of a silt or clay soil.

Characteristic	Silt	Clay
Plasticity in the moist state	Blocks of soil cannot be reshaped without crumbling.	Blocks of soil are sticky and can be reshaped without crumbling.
Cohesiveness in dry state	Will crumble with moderate hand pressure and slake readily under water.	Crumbles with great difficulty and slakes slowly in water.
Visual inspection and feel	Coarse silt grains can be seen. Silt feels gritty when rubbed between fingers. Wire cut of soil leaves feathered surface.	Clay grains cannot be observed by visual inspection. Soil feels smooth and greasy when rubbed between fingers. Wire cut of soil leaves smooth, shiny surface.
Settlement in water	Will settle out of suspension within 10 hrs.	Will stay in suspension in water for several days.
Movement of water in the voids	When moist silt is shaken in the palm of the hand, a watery sheen will appear on the surface of the soil. When shaking is stopped, the watery sheen will gradually disappear.	When moist clay is shaken in the palm of the hand, a watery sheen will not appear on the surface.

Table 5-3 Field Identification of Fine-Grained Soils

5.2.4 Organic Fine-Grained Soils

If the soil contains enough organic particles to influence the soil properties or performance, it should be identified as an organic fine-grained soil.

- Organic clay and organic silt have microscopic-size organic material dispersed throughout their matrices. This soil may contain shells and/or fibers and has a weak structure, which exhibits little resistance to kneading.
- Marl is a white or gray calcium carbonate paste. It may contain granular spheres, shells, organic material or inorganic soils and reacts with weak hydrochloric acid.
- Muck is a black or dark brown finely divided organic material mixed with various proportions of sand, silt, and clay. It may contain minor amounts of fibrous material such as roots, leaves, and sedges.

5.2.5 Highly Organic Soils

Highly organic soils which have characteristics that are undesirable for construction materials and foundations are individually classified. No laboratory criteria are established for these soils, as they generally can be readily identified in the field by their distinctive color, odor (i.e. decaying vegetation), spongy feel, and, frequently, fibrous textures. Particles of leaves, grass, branches, or other fibrous vegetable matter are common components of these soils.

- Peat is comprised of black or dark brown plant remains. The visible plant remains range from coarse fibers to finely divided organic material.

5.2.6 Particle Shape

The field description of angularity of the coarse-sized particles of a soil (gravel, cobbles and sand) are provided in Table 5-4.

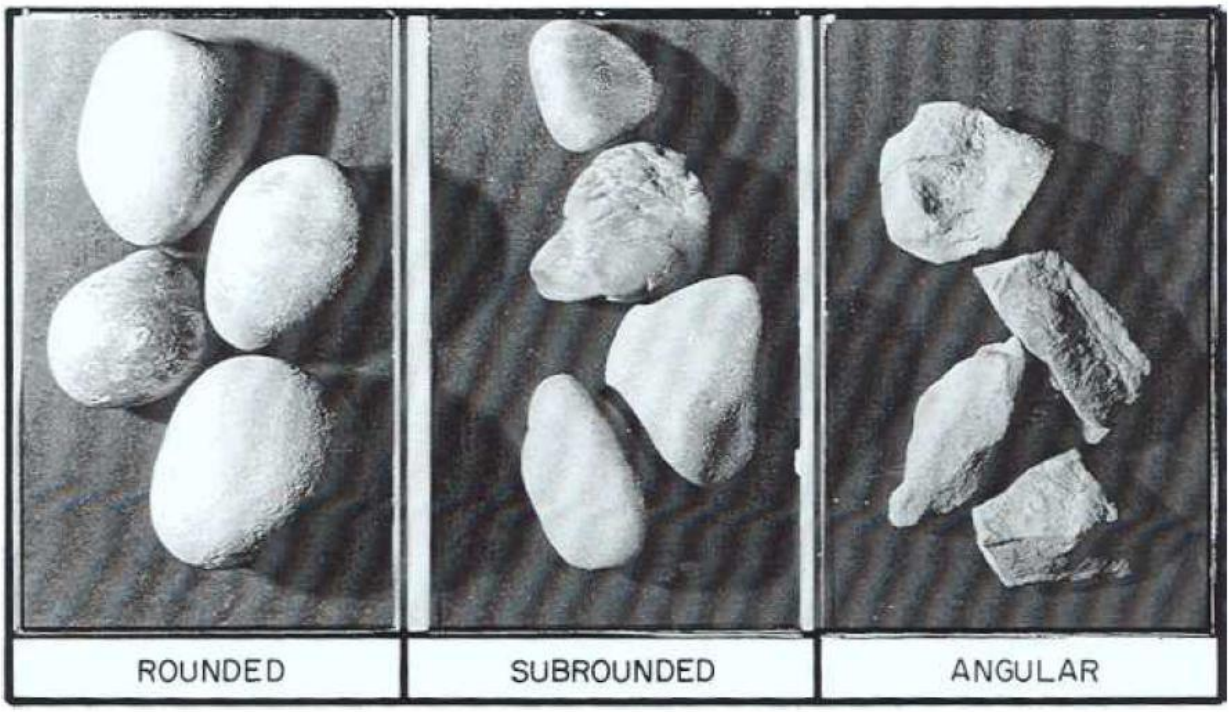

Figure 5-3 Particle Shape

Description	Criteria
Angular	Coarse-grained particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Coarse-grained particles are similar to angular description but have rounded edges.
Subrounded	Coarse-grained particles have nearly plane sides but have well rounded corners and edges.
Rounded	Coarse-grained particles have smoothly curved sides and no edges.

Table 5-4 Particle Shape Description

5.2.7 Color

Soil color is not in itself a specific engineering property, but may be an indicator of other significant geologic processes that may be occurring within the soil mass. Color may also aid in the subsurface correlation of soil units. Soil color should be determined in the field at their natural moisture content. The predominant color of the soil should be based on the *Munsell Soil Color Charts*.

5.2.8 Moisture

A visual estimation of the relative moisture content of the soil should be made during the field classification. The field moisture content of the soil is based on the criteria outlined in Table 5-5 and should be judged by appearance of the sample before manipulating.

Moisture Description	Criteria
Dry	Absence of moisture; dusty; dry to the touch.
Moist	Damp but no visible water.
Wet	Visible free water.

Table 5-5 Moisture Condition

5.2.9 Plasticity

Plasticity is the propensity of a material to undergo permanent deformation under load or remolding. Significantly plastic soils can be transformed from a solid to a putty-like, and ultimately fluid-like, state by adding water to the matrix of the soil. Increasing the moisture content of a plastic soil reduces the soil's shear resistance to sliding.

A fine-grained sample may be termed Plastic (PL), Low Plastic (LPL), or Non-plastic (NP). The sample must be in a moist or wet condition for the plasticity determination. For dry samples requiring wetting, make a note in the description. Example: "plastic (low or nonplastic) when wet". Plasticity is not required for marl, muck and peat.

5.2.10 Soil Structure

Soils often contain depositional or physical features that are referred to as soil structure. These features are described in Table 5-6. The description of layering for coarse-grained soils must be made from field observations before the sample is removed from the sampler.

Description	Criteria
Fissured	Breaks along existing planes with little resistance to fracturing.
Blocky	Low to moderate cohesive soil that can be broken down into smaller angular clumps.
Varved	Varves form in a variety of marine and lacustrine depositional environments. The classic pattern is a light/dark colored couplet. Light layer usually comprised of coarser silt and fine sand deposited under high energy conditions, while the dark is the fine clay-sized sediment.
Layered	Alternating layers of varying material or color with layers at least ¼ in. thick, note thickness and inclination.
Homogeneous	Same color and appearance throughout.

Table 5-6 Soil Structure

5.2.11 HCL Reaction

Calcium carbonate is a common cementing agent in soils. To test for the presence of this cementing agent, the soil sample may be tested with dilute hydrochloric acid (HCL). The reaction of the soil sample with HCL is reported as outlined in Table 5-7.

HCL Reaction Description	Criteria
No HCL Reaction	No visible reaction.
Weak HCL Reaction	Some reaction with bubbles forming slowly.
Strong HCL Reaction	Violent reaction with bubbles forming immediately.

Table 5-7 Soil Reaction to Hydrochloric Acid

5.2.12 Subsurface Exploration Logging

5.2.12.1 NYSDOT Soil Description

The NYSDOT Soil Classification System is outlined in the Geotechnical Engineering Bureau's *An Engineering Description of Soils Visual-Manual Procedure* (GTP-2). It presents a procedure for describing soil samples obtained for earth and foundation engineering purposes by the New York State Department of Transportation. The procedure involves visually and manually examining soil samples with respect to texture, plasticity and color. A method is presented for preparing a "word picture" of a sample for entering on a subsurface exploration log or other appropriate data sheet. The procedure applies to soil descriptions made in the field or laboratory.

It is the intent of this system to describe only the constituent soil sizes that have a significant influence on the visual appearance and behavior of the soil. This description system is intended to provide the best word description of the sample to those involved in the planning, design, construction, and maintenance processes.

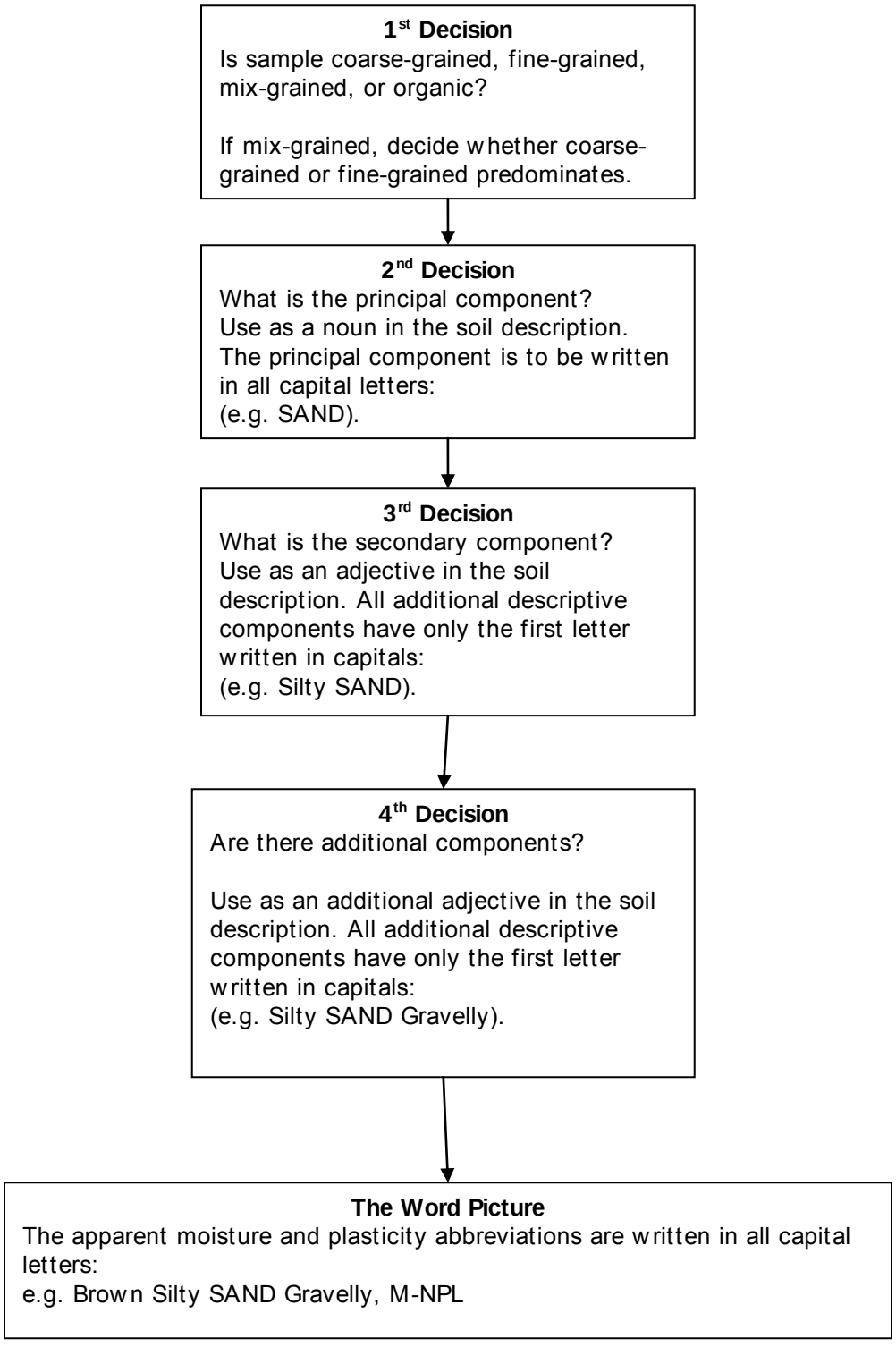

Figure 5-4 NYSDOT Soil Sample Identification Procedure

5.2.12.1.1 Use of NYSDOT Soil Identification System on Subsurface Exploration Log

Field logs, for soil test borings, shall be prepared by the driller at the time of drilling. The field logs shall be reviewed by an experienced geotechnical engineer. In addition, the geotechnical engineer shall also review all samples to confirm the accuracy of the field logs. The Soil Test Boring Logs shall be prepared and forwarded to the geotechnical designer for selection of samples for laboratory testing. Figure 5-5 provides an example of a log used on a NYSDOT project.

SM 282 E 12/02

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING BUREAU
SUBSURFACE EXPLORATION LOG

PSN 10740 BORNUM 542
REGION 8
COUNTY WESTCHESTER
PIN 804094
PROJECT ROUTE 9 RECONSTRUCTION: PEEKSKILL
ACTUAL COORDINATES (N) 272,475.478 (E) 197,817.936 DATUM NAD83
DATE START 25-MAY-2005 DATE FINISH 26-MAY-2005

HOLE DN-W-542
LINE
STA
OFFSET m
SURF. ELEV. 7.74
DEPTH TO WATER SEE NOTE

CASING O. D. 114.30mm I. D. 100.00 mm WT OF HAMMER-CASING kg HAMMER FALL-CASING mm
SAMPLER O. D. 50.80 mm I. D. 35.10 mm WT OF HAMMER-SAMPLER 63.503 kg HAMMER FALL-SAMPLER 762 mm

CASING BLOWS/0.3m	DEPTH m BELOW SURFACE	SAMPLE NO.	BLOWS ON SAMPLER m 0/.15	.15/.3	.3/.45	.45/.6	MOIST. CONT. (%)	DESCRIPTION OF SOIL AND ROCK
	0.0							(0.000m) Drilled 150mm Of Concrete
		J1A	4	4	3	6		(0.152m) Attempted Sample, No Recovery
	1.5	J1	3	5	20	24	19.3%	(1.524m) Brown Silty SAND Gravelly W/ Mica (M-NPL)
	3.0	J2	7	12	32	35	15.8%	(3.048m) Brown Gravelly SAND W/ Mica (M-NPL)
								(3.810m) Drilled Multiple Cobbles From 3.8m To 4.2m
	4.5	R1						(4.572m) Run #1 Drilled from 4.572m To 6.096m ROCK REC. 1473mm 96.7% 18+ pieces NW DOUBLE TUBE, SWIVEL
	6.0							

BOTTOM OF HOLE AT 6.096 m

Notes:
1. *Water level at completion of hole: 3.66m.*
2. *Hole advanced by roller bit ahead of driven casing.*
3. *Automatic hammer used on sampler.*

The subsurface information shown here was obtained for design and estimate purposes. It is made available so that users may have access to the same information available to the State. It is presented in good faith. By the nature of the exploration process, the information represents only a small fraction of the total volume of the material at the site. Interpolation between data samples may not be indicative of the actual material encountered.

CONTRACT _____ CONTRACTOR Aquifer Drilling/Testing

DRILL RIG OPERATOR D. Carter
SOIL & ROCK DESCRIPTION M. Shellhammer
REG GEOTECHNICAL ENGINEER Paul Salchert
DATE APPROVED 24-APR-2006
RESIDENT ENGINEER
STRUCTURE NAME B.I.N.

SHEET 1 OF 1 HOLE DN-W-542

Figure 5-5 NYSDOT Subsurface Exploration Log

5.2.12.2 Unified Soil Classification System (USCS)

Dr. A. Casagrande developed the USCS for the classification of soils used to support Army Air Corps bomber bases. This system incorporates textural (grain-size) characteristics into the engineering classification. The system has 15 different potential soil classifications with each classification having a two-letter designation. The basic letter designations are listed in Table 5-8.

Letter Designation	Meaning	Letter Designation	Meaning
G	Gravel	O	Organic
S	Sand	W	Well-graded
M	Non-plastic or low plasticity fines (Silt)	P	Poorly-graded
C	Plastic fines (Clay)	L	Low liquid limit
Pt	Peat	H	High liquid limit

Table 5-8 USCS Letter Designations

The classification of soil is divided into two general categories, coarse-grained and fine-grained soils. Coarse-grained soils (gravels and sands) have more than 50 percent (by weight) of the material retained on the No. 200 sieve, while fine-grained soils (silts and clays) have more than 50 percent of the material passing the No. 200 sieve. Gravels and sands are typically described in relation to the particle size of the grains (See NYSDOT GDM Section 5.2.2 *Coarse-Grained Soils*). Silts and clays are typically described in relation to plasticity (see NYSDOT GDM Section 5.2.3 *Fine-Grained Inorganic Soils*). Fine-grained soils are defined by the plasticity chart identified in Figure 5-6.

In many soils, two or more soil types are present. When the percentage of the minor soil type is equal to or greater than 30 percent and less than 50 percent of the total sample (by weight), the minor soil type is indicated by adding a “y” to its name; i.e. Sandy SILT, Silty SAND, Silty CLAY, etc.

Figures 5-7, 5-8, 5-9, 5-10, and 5-11 provide the flow charts for the classification of coarse- and fine-grained soils using the USCS.

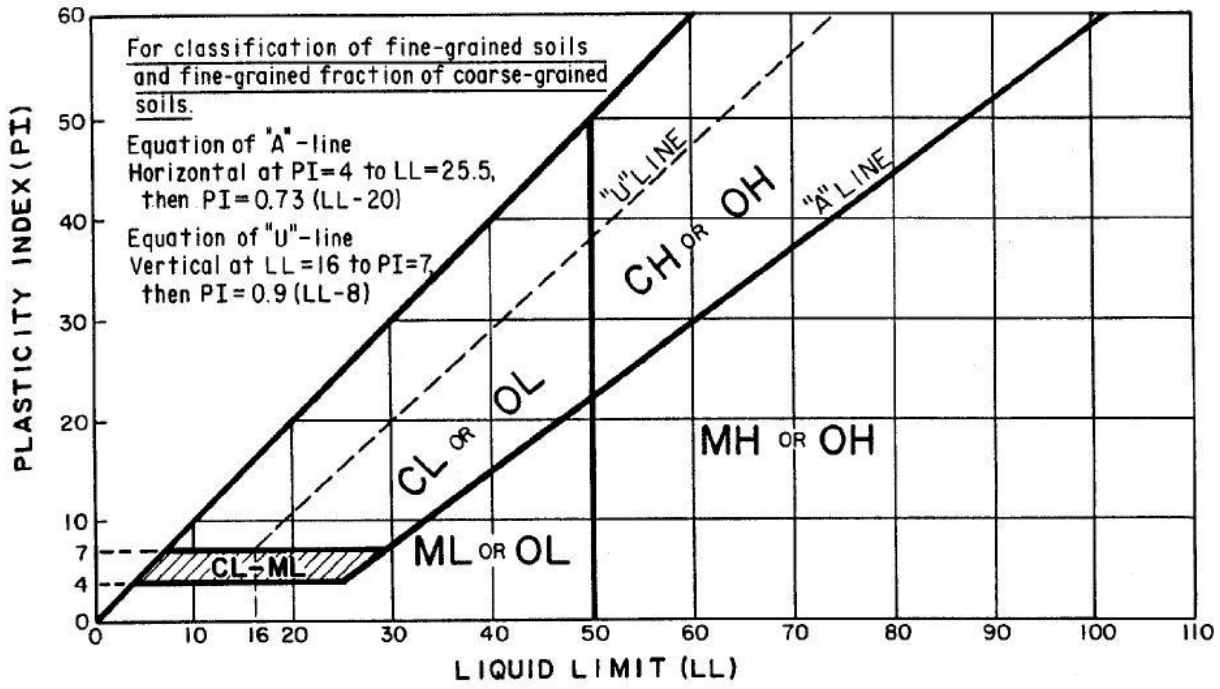

Figure 5-6 Plasticity Chart for Unified Soil Classification System (Mayne, et al. May 2002)

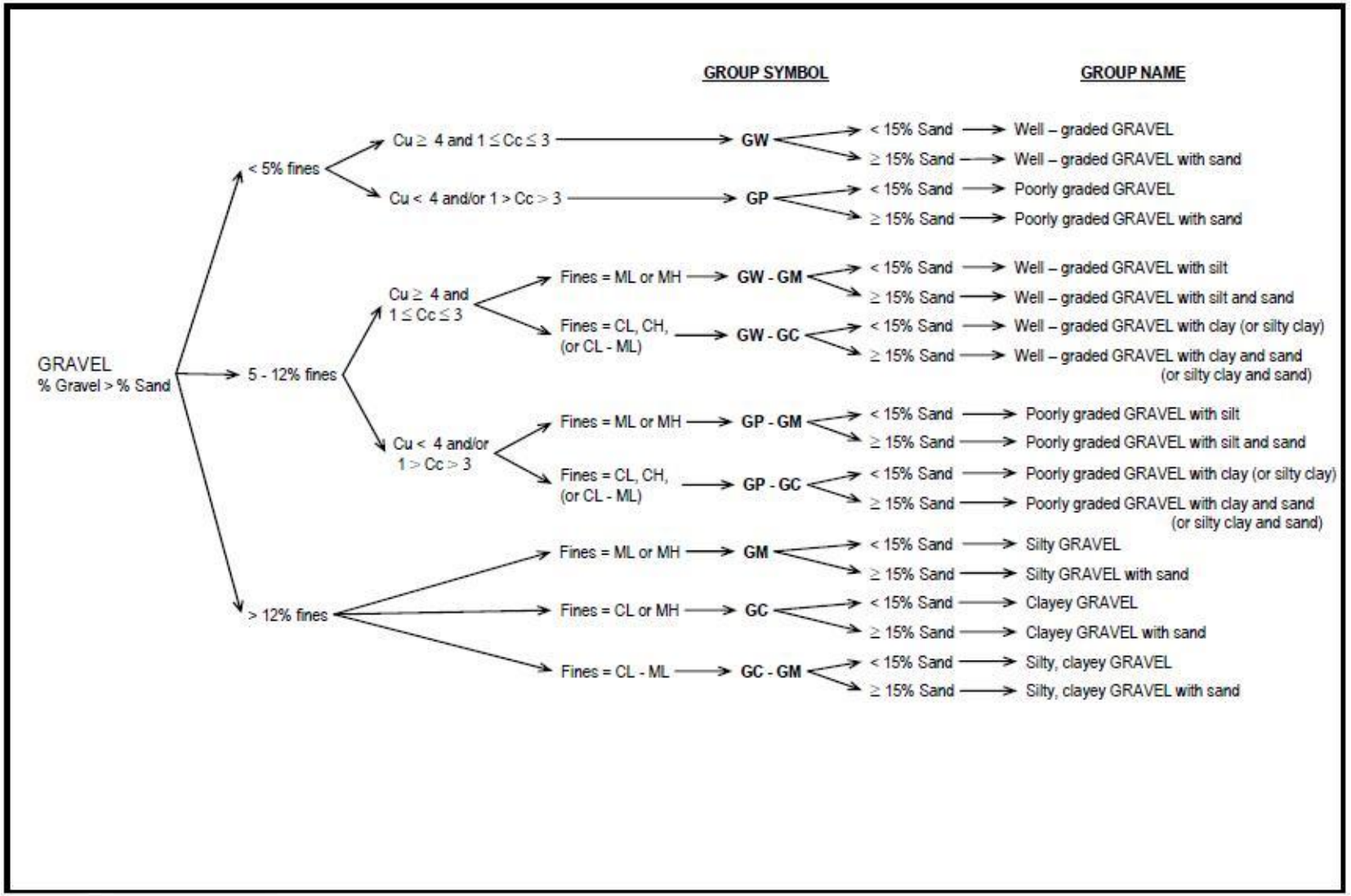

Figure 5-7 USCS Group Symbol and Group Name for Coarse-Grained Soils (Gravel) (Mayne, et al. May 2002)

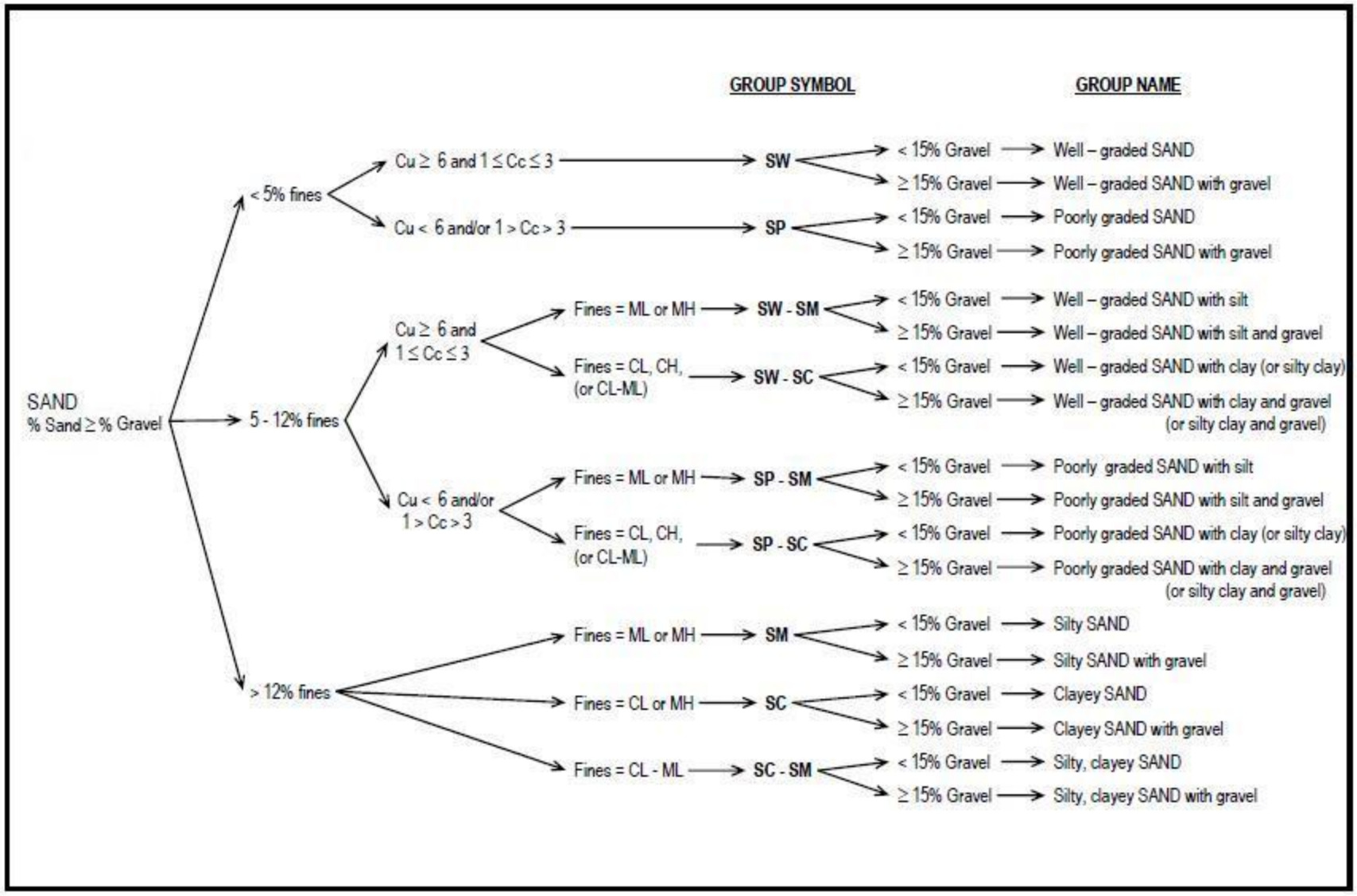

Figure 5-8 USCS Group Symbol and Group Name for Coarse-Grained Soils (Sand) (Mayne, et al. May 2002)

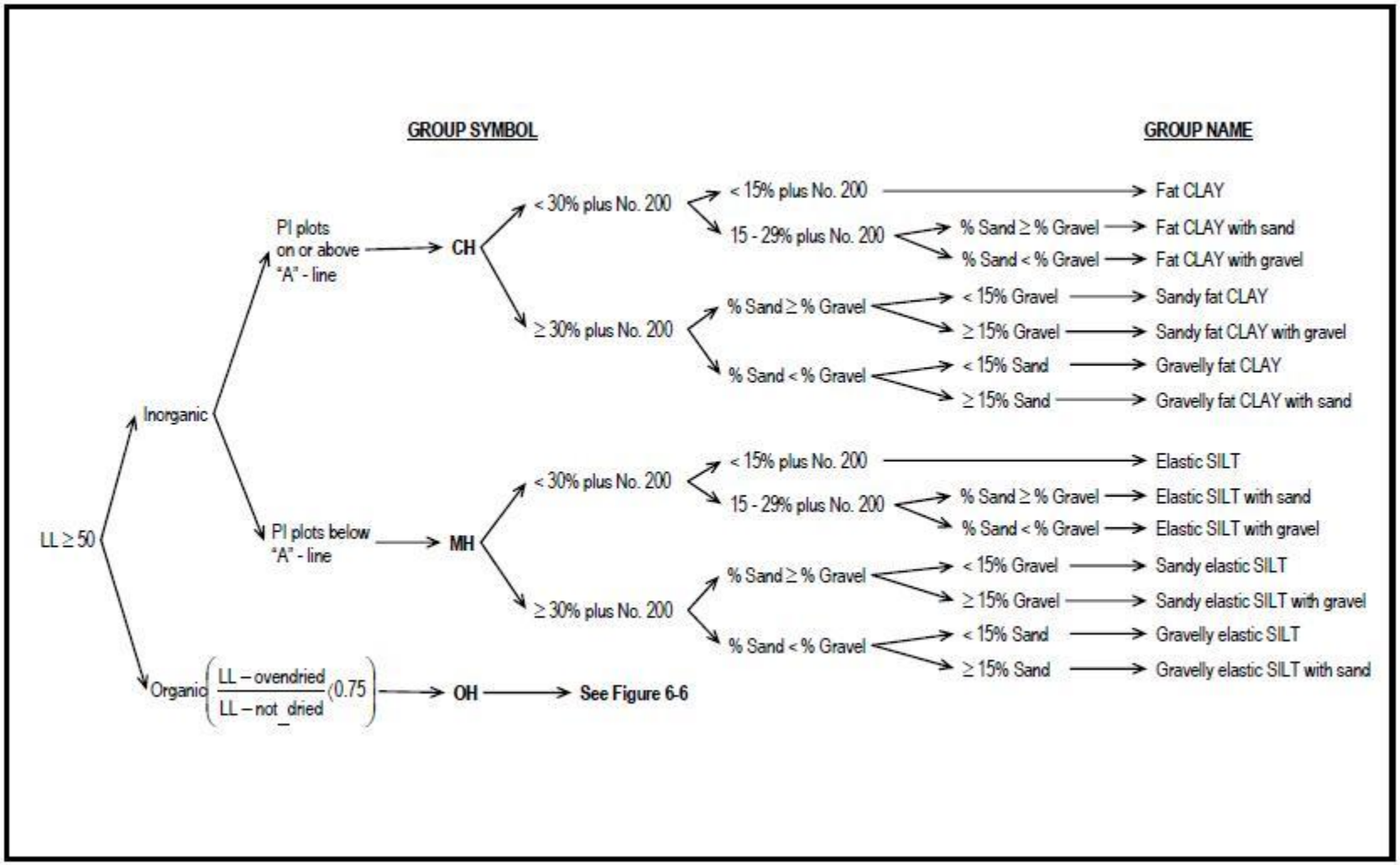

Figure 5-9 USCS Group Symbol and Group Name for Fine-Grained Soils (LL ≥ 50)
(Mayne, et al. May 2002)

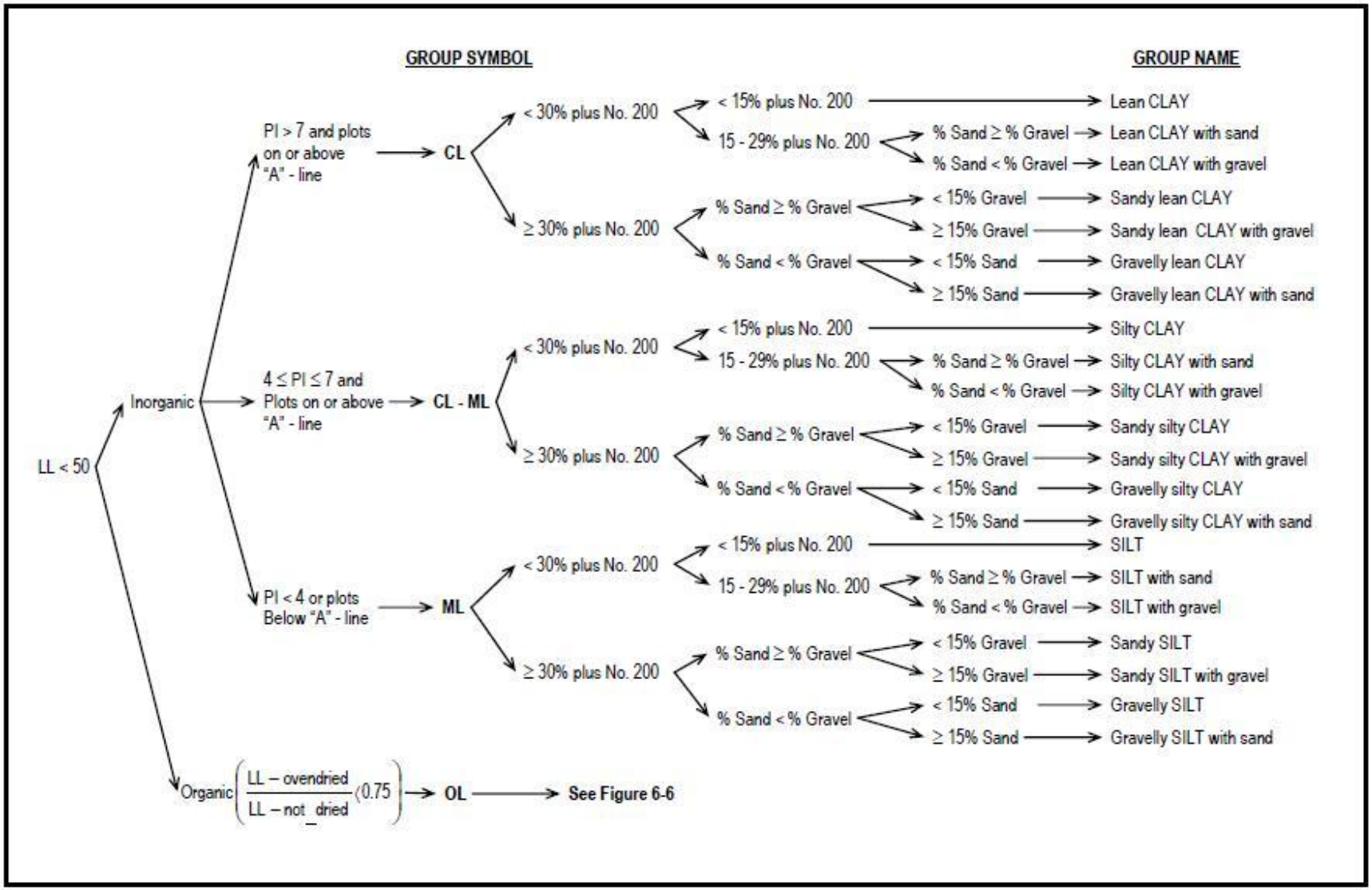

Figure 5-10 USCS Group Symbol and Group Name for Fine-Grained Soils (LL < 50) (Mayne, et al. May 2002)

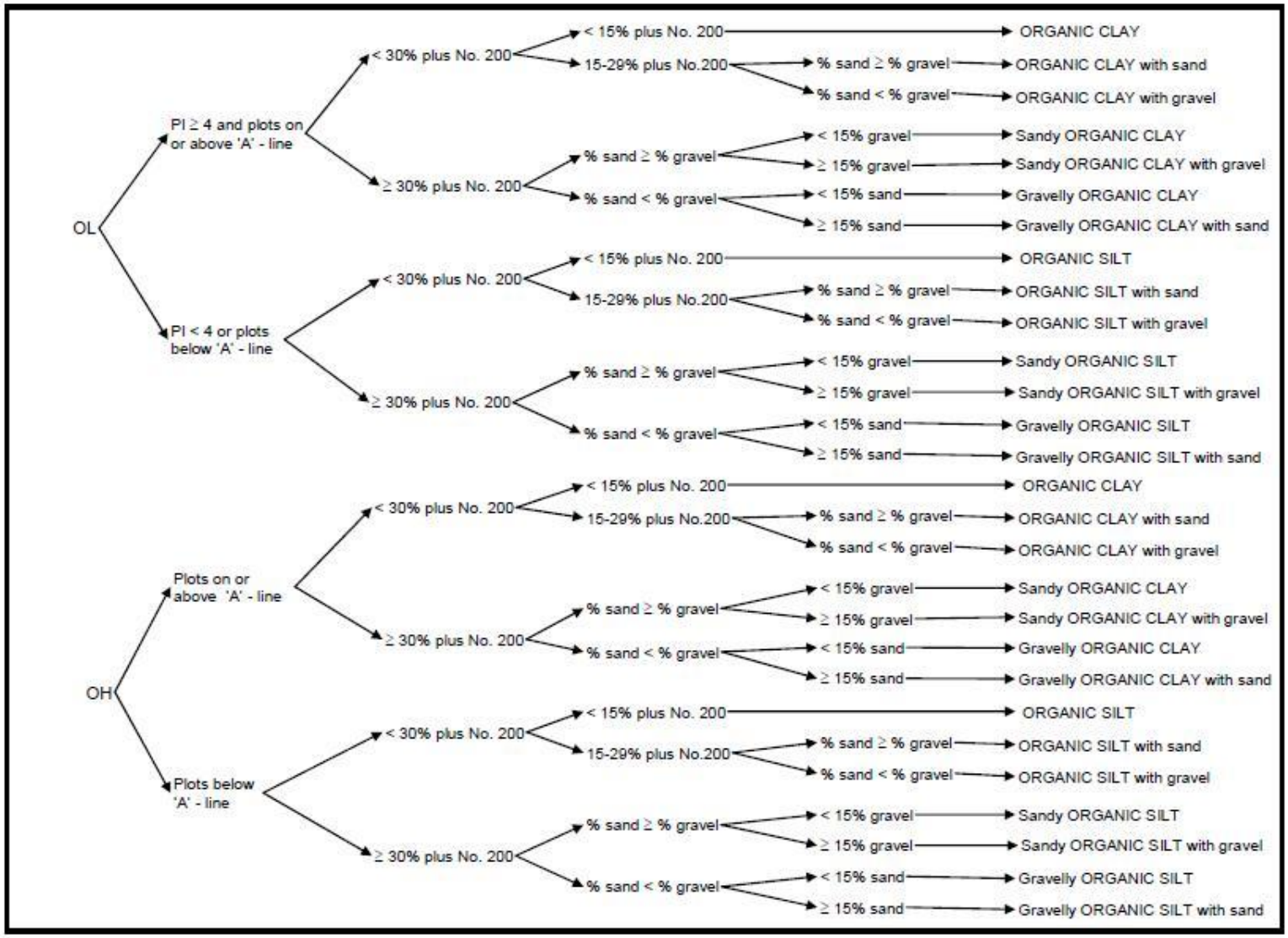

Figure 5-11 USCS Group Symbol and Group Name for Organic Soils (Mayne, et al. May 2002)

5.2.12.3 AASHTO Soil Classification System (AASHTO)

Terzaghi and Hogentogler originally developed this classification system for the U.S. Bureau of Public Roads in the late 1920s. This classification system divides all soils into eight major groups designated A-1 through A-8 (see Figure 5-13). In this classification system, the lower the number the better the soil is for subgrade materials. Coarse-grained soils are defined by groups A-1 through A-3, while groups A-4 through A-7 define the fine-grained soils. Group A-4 and A-5 are predominantly silty soils and group A-6 and A-7 are predominantly clayey soils. Group A-8 refers to peat and muck soils.

Groups A-1 through A-3 have 35 percent or less passing the No. 200 sieve, while groups A-4 through A-7 have more than 35 percent passing the No. 200 sieve. The classification system is presented in Figures 5-12 and 5-13. Table 5-9 indicates the gradation requirements used in the AASHTO classification system.

Soil Component	Grain Size
Gravel	between 3" to No. 10
Sand	between No. 12 to No. 200
Silt and Clay	less than No. 200

Table 5-9 AASHTO Gradation Requirements

For soils in Groups A-2, A-4, A-5, A-6 and A-7 the plasticity of the fines is defined in Table 5-10.

Soil Component	Plasticity Index
Silty	$\leq 10\%$
Clayey	$\geq 11\%$

Table 5-10 AASHTO Plasticity Requirements

To evaluate the quality of a soil as a highway subgrade material, a number called the Group Index (GI) is incorporated with the groups and subgroups of the soil. The GI is written in parenthesis after the group or subgroup designation. The GI is determined by the following equation:

Equation 5-1

$$GI = (F - 35)\{0.2 + (0.005)(LL - 40)\} + 0.01(F - 15)(PI - 10)$$

Where:
F = percent passing No. 200 sieve (in percent)
LL = Liquid Limit
PI = Plasticity Index

Listed below are some rules for determining the GI:

If the equation yields a negative value for the GI, use zero;
Round the GI to the nearest whole number, using proper rules of rounding;
There is no upper limit to the GI;
These groups, A-1-a, A-1-b, A-2-4, A-2-5, A-3, will always have a GI of zero;
The GI for groups A-2-6 and A-2-7 is calculated using the following equation

Equation 5-2

$$GI = 0.01(F - 15)(PI - 10)$$

Figure 5-12 provides the range of liquid limit and plasticity index for group A-2 to A-7 soils.

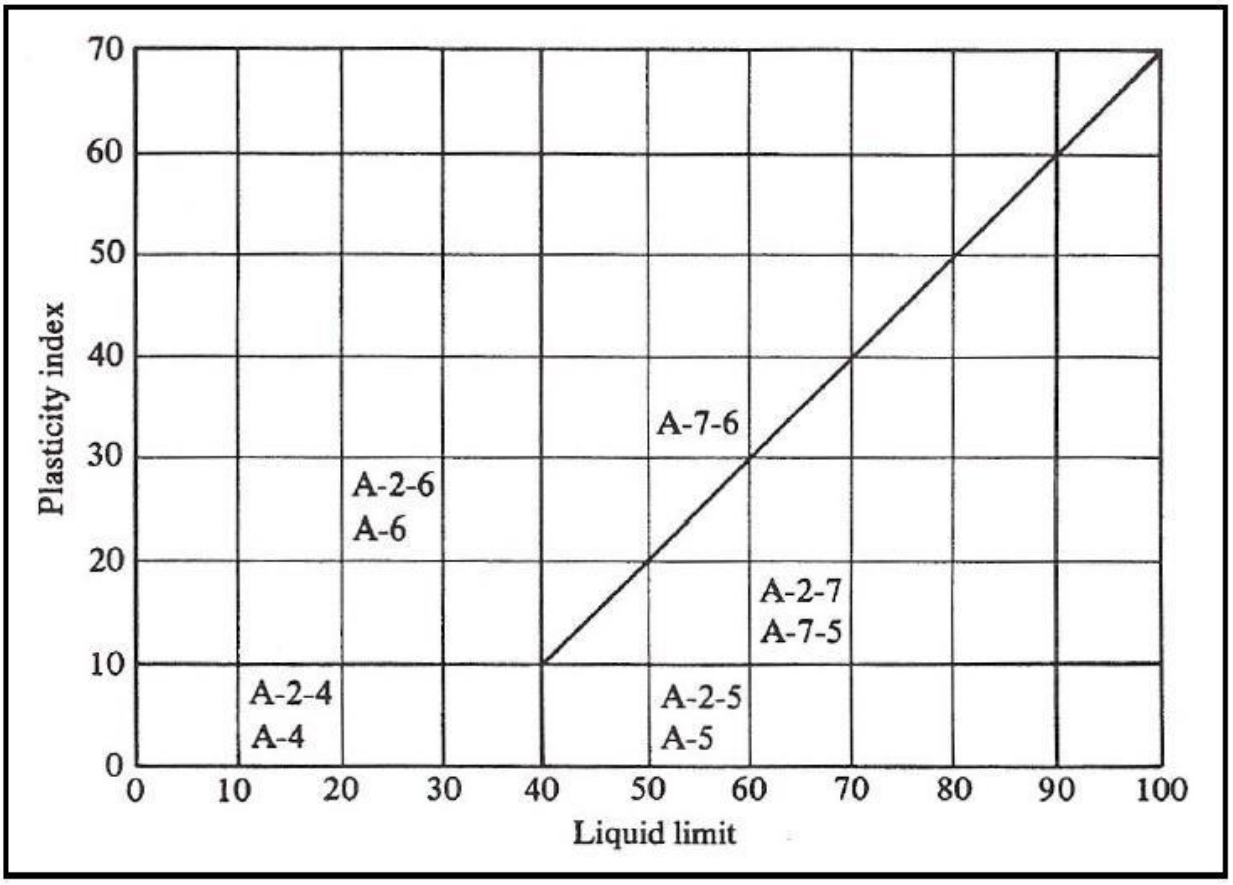

Figure 5-12 AASHTO Range of LL and PI for Soils in Groups A-2 through A-7 (Mayne, et al. May 2002)

GENERAL CLASSIFICATION	GRANULAR MATERIALS (35 percent or less of total sample passing No. 200)							SILT-CLAY MATERIALS (More than 35 percent of total sample passing No. 200)			
GROUP CLASSIFICATION	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5, A-7-6
Sieve analysis, percent passing:											
2 mm (No. 10)	50 max.										
0.425 mm (No. 40)	30 max.	50 max.	51 min.								
0.075 mm (No. 200)	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing 0.425 mm (No. 40)											
Liquid limit				40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.*
Usual significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
Group Index**	0		0	0		4 max.		8 max.	12 max.	16 max.	20 max.

Classification procedure: With required test data available, proceed from left to right on chart; correct group will be found by process of elimination. The first group from left into which the test data will fit is the correct classification.

*Plasticity Index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity Index of A-7-6 subgroup is greater than LL minus 30 (see Fig 4-9).

**See group index formula (Eq. 4-1) Group index should be shown in parentheses after group symbol as: A-2-6(3), A-4(5), A-6(12), A-7-5(17), etc.

Figure 5-13 AASHTO Soil Classification System
(Mayne, et al. May 2002)

5.3 ROCK CLASSIFICATION

Rock classification is based on the character of the intact rock (hand specimens and rock core) in terms of its genetic origin, mineralogical make-up, texture, and degree of chemical alteration and/or physical weathering, and the engineering characteristics (orientation, spacing, etc.) of the bounding discontinuities (bedding, joints, foliation planes, shear zones, faults etc.) within the rock mass.

5.3.1 Rock Type

Geologists divide rocks into three categories based on genetic origin, and then subdivide them into smaller groups on the basis of composition and texture. These categories are *igneous rocks*, *sedimentary rocks*, and *metamorphic rocks*.

5.3.1.1 Igneous Rocks

The Geotechnical Engineering Bureau's *Rock Core Evaluation Manual* (GEM-23) presents a procedure for describing rock core samples for foundation, rockslope, and other engineering purposes. Table 1 of GEM-23 provides rock names, color groups, texture, minerals, and properties of common igneous rocks.

Igneous rocks formed from the solidification of molten material (magma or lava). They can be intrusive (solidifying below the surface from magma) or extrusive (solidifying at the surface from lava). In general, igneous rocks tend to have an interlocking, crystalline texture with little to no appearance of layering, banding, or bedding. Intrusive igneous rocks are generally composed of larger crystals/grains (coarser texture) while extrusive igneous rocks are generally composed of smaller crystals/grains (finer texture).

5.3.1.2 Sedimentary Rocks

Sedimentary rocks (Table 3 of GEM-23) are formed by lithification of accumulated sediments that were transported and deposited by water, wind, ice, biological activity and/or chemical precipitation. Lithification is a complex process whereby freshly deposited loose grains of sediment are converted into rock. Lithification may occur at the time sediment is deposited or later. Cementation is one of the main processes involved, particularly for sandstones and conglomerates. Most sedimentary rocks are composed of the weathering products of pre-existing rocks.

Sedimentary rocks usually, but not always, have a layered appearance due to the presence of bedding planes. The grains of sedimentary rocks can range from sharply angular to well-rounded and from very fine to very coarse. Sedimentary rocks may contain fossils.

Additional characteristics of Sedimentary rocks can be found in GEM-23, Part III, C, 3. Sedimentary Rocks.

5.3.1.3 Metamorphic Rocks

Metamorphic rocks (Table 2 of GEM-23) are Igneous and/or Sedimentary rocks whose textures and /or mineral content have been changed by heat, pressure and/or chemically active solutions (invading gasses and/or liquids). In some instances, metamorphic rocks have been re-metamorphosed into other higher or lower grade metamorphic rocks.

Metamorphic rocks can appear banded or layered due to the alignment of platy, tabular, or elongated mineral grains, or the concentration of different minerals into distinct bands, or the relict structure of the original sedimentary rock.

5.3.2 Rock Properties

5.3.2.1 Rock Color

Rock color is not in itself a specific engineering property, but may be an indicator of the influence of other significant geologic processes that may be occurring in the rock mass (e.g. fracture flow of water, weathering, alteration, etc.). Color may also aid in the subsurface correlation of rock units. The color of the rock is determined by comparing the core pieces with color chips in the Geological Society of America (GSA) *Rock Color Chart*. Rock color should be determined as soon as the core has been recovered from the test hole.

5.3.2.2 Mineralogy

Mineralogy is a description of the major minerals composing the rock. If possible, the size of the individual grains/crystals and the texture of the rock (very fine to very coarse) are noted. General descriptions of mineralogy, grain size, and texture for the various rock types are included in the rock type tables in the Geotechnical Engineering Bureau's *Rock Core Evaluation Manual* (GEM-23).

5.3.2.3 Weathered State of Rock

Weathering is the process of mechanical and/or chemical degradation of the rock mass through exposure to the elements (e.g. rain, wind, ground water, ice, change in temperature etc.). In general, the strength of the rock tends to decrease as the degree of weathering increases. In the earliest stages of weathering only discoloration and slight change in texture occur. As the weathering of the rock advances significant changes occur in the physical properties of the rock mass until, ultimately, the rock is decomposed to soil.

Table 8 of GEM-23 provides weathering categories broken into degrees of weathering with a detailed description of each.

5.3.2.4 Relative Rock Strength and Hardness

Rock strength is controlled by many factors including degree of induration, cementation, crystal bonding, degree of weathering or alteration, etc. Determination of relative rock strength can be estimated by simple field tests, which can be refined, if required, through laboratory testing.

Table 7 of GEM-23 provides a description of rock hardness.

5.3.2.5 Fractures

The spacing, orientation, filling, and degree of healing of the fractures can be important in determining the properties of the rock mass for structure foundation design.

Table 5 of GEM-23 provides fracture density categories with a description for the degree of fracturing, and Table 6 of GEM-23 provides fracture healing categories with a description for the degree of healing.

5.3.2.6 Core Recovery (CR)

Core recovery is defined as the ratio of core recovered to the run length expressed as a percentage. Detailed information on core recovery can be found in GEM-23, Part III, A. Recovery.

5.3.2.7 Rock Quality Designation (RQD)

The Rock Quality Designation (RQD) is a modified measure of recovery, calculated in order to estimate the quality of the intact rock mass. Detailed information on RQD can be found in GEM-23, Part III, B. RQD.

5.3.2.8 Additional Rock Properties

Additional rock properties, such as color, mineralogy, grain size, texture, etc. can be found in the Geotechnical Engineering Bureau's *Rock Core Evaluation Manual* (GEM-23).

5.3.3 Rock Core Logging

5.3.3.1 NYSDOT Rock Core

The Geotechnical Engineering Bureau's *Rock Core Evaluation Manual* (GEM-23) presents a procedure for describing rock core samples for foundation, rockslope, and other engineering purposes. Rock core evaluation data is recorded on a Rock Core Evaluation Sheet (Figure 5-14 and 15), then entered into the Rock Core database.

The Rock Core Log shall be prepared by an Engineering Geologist at the completion of inspection and laboratory testing of the rock core. Figure 5-16 provides an example of a log used on a NYSDOT project.

ROCK CORE EVALUATION SHEET

PSN _____ **Boring ID** _____

PIN _____ Surface Elevation_____

BIN _____ Depth From_____to_____

Project _____ Number of Runs _____

_____ Core Size _____

Date Evaluated _____ Evaluator (s) _____

Top of Rock _____ (Depth) _____ (Elevation)

Top of Sound Rock _____ (Depth) _____ (Elevation)

Comments _____

_____

_____

RUN #1 Run Length _____ Depth Range: From _____ To _____

RQD _____ (as measured) _____ % Photo(s) _____

Rock Type _____

Color _____

Mineralogy, Grain Size, & Texture _____

Bedding _____

Fractures _____

Size Range of Pieces _____

Hardness _____

Weathering _____

Additional Comments _____

_____

_____

Page 1 of *y*

Figure 5-14 NYSDOT Rock Core Evaluation Sheet

ROCK CORE EVALUATION SHEET (CONTINUED)

PSN _____ **PIN** _____ **Boring ID** _____

RUN # _____ Run Length _____ Depth Range: From _____ to_____

RQD _____ (as measured) _____ % Photo(s) _____

Rock Type _____

Color _____

Mineralogy, Grain Size, & Texture _____

Bedding _____

Fractures _____

Size Range of Pieces _____

Hardness _____

Weathering _____

Additional Comments _____

_____

_____

RUN # _____ Run Length _____ Depth Range: From _____ to_____

RQD _____ (as measured) _____ % Photo(s)

_____

Rock Type _____

Color _____

Mineralogy, Grain Size, & Texture _____

Bedding _____

Fractures _____

Size Range of Pieces _____

Hardness _____

Weathering _____

Additional Comments _____

_____

Page *x* of *y*

Figure 5-15 NYSDOT Rock Core Evaluation Sheet (cont.)

PSN 10740 BORNUM 542
REGION 8 COUNTY WESTCHESTER
PIN 804094
PROJECT ROUTE 9 RECONSTRUCTION: PEEKSKILL

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING BUREAU
ROCK CORE EVALUATION LOG

HOLE DN-W-542
Page 1 of 1

SURFACE ELEVATION (m) 7.74
CORE SIZE & BARREL TYPE NW DOUBLE TUBE, SWIVEL
CORE EVALUATED BY Y. F. Nazon

ELEVATION TOP OF ROCK (m) 3.17
ELEVATION TOP OF SOUND ROCK (m) 3.17
EVALUATION DATE 3/28/2006

Comments:

Run#	Depth (m) From	Depth (m) To	Core Recovery (%)	RQD (%)	No. of Pieces	Descriptive Log — ROCK TYPE: Type(s) of rock, color, grain size, texture, mineralogy, bedding, discontinuities, dip and density of discontinuities, size range of pieces, hardness, weathering, additional comments
R-1	4.572	6.096	96.7	82	18+ pieces	Marble: Light & medium gray; Moderately fractured; Fracture angles sub-horizontal & vertical, 60 and 73 deg.; Pieces 3-30.5 cm; Extremely hard. Slightly weathered.

Priscilla Dustin
ENGINEERING GEOLOGY SUPERVISOR

8/14/06
DATE

The subsurface information shown here was obtained for design and estimate purposes. It is made available so that the users may have access to the same information available to the State. It is presented in good faith. By the nature of the exploration process, the information represents only a small fraction of the total volume of the materail at the site. Interpolation between samples may not be indicative of the actual material encountered.

SM122(03/06)

Figure 5-16 NYSDOT Rock Core Log

5.4 BRIEF GLOSSSARY OF GEOLOGIC TERMS

The Geotechnical Engineering Bureau's *Rock Core Evaluation Manual* (GEM-23) presents a procedure for describing rock core samples for foundation, rockslope, and other engineering purposes. A brief glossary of terms can be found in GEM-23, Part II, Brief Glossary of Geologic Terms.

5.5 REFERENCES

ASTM International, American Society for Testing and Materials (ASTM), D2488, S*tandard Practices for Description and Identification of Soils (Visual – Manual Procedure)*, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959

Geotechnical Engineering Bureau, *An Engineering Description of Soils Visual-Manual Procedure*, Geotechnical Test Procedure GTP-2, New York State Department of Transportation, Office of Technical Services, https://www.dot.ny.gov/divisions/engineering/technical-services/technical-services-repository/GTP-2b.pdf

Geotechnical Engineering Bureau, *Rock Core Evaluation Manual*, Geotechnical Engineering Manual GEM-23, New York State Department of Transportation, Office of Technical Services, https://www.dot.ny.gov/divisions/engineering/technical-services/technical-services-repository/GEM-23b.pdf

Mayne, P.W., Christopher, B.R., DeJong, J., *Subsurface Investigations – Geotechnical Site Characterization Reference Manual*, US Department of Transportation, Federal Highway Administration, Publication No. FHWA NHI-01-031, May, 2002: http://isddc.dot.gov/OLPFiles/FHWA/012546.pdf

Munsell Soil Color Charts, 2000, GretagMacbeth, 617 Little Britain Rd., New Windsor, NY 12553.

Rock Color Charts, Geological Society of America, The Rock-Color Chart Committee, Boulder, CO.

Sabatini, P.J., Bachus, R.C., Mayne, P.W., Schneider, J.A., Zettler, T.E., *Evaluation of Soil and Rock Properties*, Geotechnical Engineering Circular No. 5, FHWA-IF-02-034, April 2002.

SOP-19: DISCRETE SURFACE AND SUBSURFACE SOIL SAMPLING

1.0 Purpose

This standard operating procedure (SOP) provides the methodology for collecting discrete surface and subsurface soil samples to characterize the nature of soil contamination, the areal and vertical extent of contaminated soil, and to determine the geotechnical, physical, and chemical properties of the soil.

Selecting the proper methods and tools for surface and subsurface soil sampling is a critical part of field investigations. This SOP describes the methods generally used for surface and subsurface soil sampling, as well as the tools commonly used.

All soil sample collection activities should adhere to the note-taking, decontamination, labeling, packaging, shipping, storage, and chain-of-custody requirements applicable to the soil sampling activities being conducted according to the SOPs discussed in Appendix H, Field Standard Operation Procedures. Refer to technical procedure *SOP for Sample Handling and Custody* for details on sample container labeling, handling, and chain-of- custody requirements.

All personnel who collect or handle the soil samples should wear, at a minimum, disposable nitrile gloves to prevent cross-contamination and provide personal protection. New gloves should be donned for sample collection at each location, or whenever gloves are torn or otherwise compromised. The *Project-Specific Health and Safety Plan* (HASP) provides information on site-specific personal protective equipment (PPE) requirements.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in collecting or otherwise handling surface or subsurface soil samples Site projects and tasks, and was developed per the following United States Environment Protection Agency guidance documents:

This SOP focuses on the most commonly used soil sampling tasks and applications anticipated the Site and should be used in conjunction with other applicable project SOPs in Appendix H, Field Standard Operating Procedures, including the following*:*

- *SOP- Field Documentation*
- *SOP- Organic Vapor Monitoring and Air Monitoring*
- *SOP- Hollow Stem Auger and Direct Push Drilling Methods*
- *SOP- Boring Log Completion, Soil Classification, and Logging*
- *SOP- Equipment Decontamination Procedures*
- *SOP- Sample Handling and Custody*
- *SOP- Field Procedure Change Management*

3.0 Procedures

3.1 General Guidelines

The following procedures should be used to collect soil samples for laboratory analysis:

- Unless otherwise specified, all laboratory soil samples must be discrete samples and may not be composited before analysis.
    - Soil samples must be collected according to the method specifications appropriate for the laboratory parameters to be analyzed.
    - All soil samples must be collected with disposable or clean tools that have been decontaminated as outlined in the *SOP for Equipment Decontamination Procedures*.
    - Disposable nitrile gloves (at a minimum) must be worn and changed between sample collections.
    - Soil samples must be placed in containers quickly and in the order of volatility; for example, volatile organic aromatic samples must be taken first, gasoline range organics next, heavier range organics next, and soil classification samples last.
    - All sample containers must be quickly and adequately sealed, and rims must be cleaned before tightening lids; tape may be used only if known not to affect sample analysis.
    - Samples must immediately be preserved according to the method specifications appropriate for the laboratory parameters to be analyzed. And unless specified otherwise, at a minimum, the samples must be immediately chilled to 4 ±2 degrees Celsius (°C) and this temperature must be maintained through delivery to the laboratory for analysis.
    - Sample holding times must conform to the method specifications of the required analytical methods.
    - Alternative methods to obtain soil samples may be used only if the alternative methods have been approved by the PM and/or FM and documented in the QAPP according to *the SOP for, Field Procedure Change Management* and/or in the *Field Documentation*.
    - Each soil sample fraction collected for analyses other than VOCs will be thoroughly homogenized using a sampling spoon or trowel. The homogenized material will then be divided equally among the appropriate sample containers. The sample containers will then be sealed tightly. Care should be taken to ensure that the sampling tools and containers (such as a spoons and bowls) used for sample collection and homogenization do not interfere with the analytes of interest.
    - Multi-incremental samples (MIS) should be collected by placing equal amounts (or aliquots) of soil collected from multiple locations into a decontaminated, dedicated collection container. The aliquots will then be homogenized using a sample collection tool such as a scoop or spoon. The homogenized material will be divided equally among the appropriate sample containers, and the sample containers will be sealed tightly.

3.2 Sampling Tools and Equipment

Equipment that may be used to facilitate the collection of surface or subsurface soil samples includes, but is not limited to, the following items:

3.2.1 Photoionization devices (PID) or Flame-ionization device (FID)

3.2.2 Stainless-steel trowel, scoop, or spoon

3.2.3 Stainless-steel hand (bucket) auger

3.2.4 Stainless-steel split spoon, split barrel, or continuous sampler

3.2.5 Shovels, pickaxes, pick mattocks, or similar excavating tools

3.2.6 Soil core samplers (En Core® sampler, TerraCore®, or equivalent)

3.2.7 Stainless-steel bowls or pans

3.2.8 Field notebook

3.2.9 *Soil Boring Log Datasheet* or other field datasheet

3.2.10 Waterproof and permanent pens and markers

- Digital camera
- Paper towels
- Aluminum foil
- Decontamination equipment (buckets, brushes, detergent, etc.)
- PPE
- Sample cooler
- Ice or gel-ice
- Sample jars and labels
- Chain-of-custody forms
- Soil classification charts
- Ziploc® (or similar) resealable bags
- Survey stakes or flags
- Hammer

3.3 Decontamination

Before collecting any soil samples, all reusable, non-disposable sampling equipment should be decontaminated. Decontamination supplies must be on hand so that equipment can be decontaminated in the field if sampling equipment is to be reused. Each piece of reusable sampling equipment should be decontaminated between each sample location or interval. Spent decontamination fluids will be managed according to the *SOP for Investigative Derived Waste Management*. Procedures presented in *the SOP for Equipment Decontamination Procedures*, will be followed for decontamination of re-usable field equipment and for personnel decontamination.

Disposable sampling equipment will be used whenever feasible to minimize decontamination and the potential for cross-contamination. All disposable sample equipment will be inspected before use to confirm that it is clean and free of potential contaminant.

3.4 Surface Soil Sampling

Surface soil is defined as soil that extends to 2 feet below ground surface (bgs). However, the depth that is considered surface soil may vary depending on project DQOs and investigation approaches, as defined in *Worksheet 17.*

Surface soil samples can be collected in paved and unpaved areas. In paved locations, surface asphalt or concrete will need to be removed mechanically or by hand, as will any pavement base material located beneath the paving. In unpaved locations, surface vegetation such as a muskeg layer may need to be removed before sampling.

Surface soil samples may be collected as either discrete or MIS samples. Each surface soil sample will be collected using a stainless steel scoop, spoon, or other appropriate tools.

Samples for VOC analysis will be collected directly from the soil column at the specified sampling depth interval bgs if possible (see Section 5.7). For non-VOC samples, the sampler, wearing clean disposable nitrile gloves, will remove materials, including pebbles and roots, from the mixture as the sample is collected. Each non-VOC sample will be collected by thoroughly homogenizing material from the appropriate depth interval bgs (as stated in the site-specific sampling plans in *Worksheet* from the respective sampling location. A clean, decontaminated stainless-steel scoop or spoon will be used to collect the soil sample and fill all laboratory-supplied analytical sample containers.

3.5 Subsurface Soil Sampling

Subsurface soil is defined at as soil that is more than two feet bgs. Before subsurface soil sampling, each sample location should be checked and cleared for buried utilities before intrusive activities begin, according to *the SOP for Utility Clearance for Intrusive Operations*.

3.5.1 Shallow Subsurface Soil Sampling with Hand Tools

Shallow subsurface soil samples will be collected as discrete samples. Shallow subsurface soil samples can be collected by hand using a wide variety of sampling equipment and devices. Common equipment used to collect shallow subsurface soil samples include soil coring devices, various types of hand augers (bucket-type, continuous-flight, and posthole), and other common hand tools such as shovels and pickaxes. Depending on field conditions or sampling objectives, several types of sample collection equipment maybe used to collect soil samples at a single location. Of the equipment listed, only soil coring devices collect an undisturbed soil sample and thus are recommended for sampling of volatile organic (that is, for VOCs, GRO, and/ VPH). Bucket augers and other common hand tools are not recommended when an undisturbed soil sample for volatile organics is desired. Sampling personnel should choose the sampling equipment that is best suited for project requirements and task needs.

Using a decontaminated hand auger (or similar equipment), the soil borehole will be advanced to the depth immediately above the sampling interval, and all cuttings will be removed from the borehole. Before advancing a borehole, remove all unnecessary rocks, twigs, and other non-soil materials from the selected sampling location. Assemble the sampling equipment, if necessary, per the manufactures specifications and place the sampler in position with the bit or cutting shoe touching the ground. Begin turning the auger with a clockwise motion or driving the soil core device with the slide hammer until the desired sampling depth is obtained.

During advancement of the auger or coring device, cuttings from within and around the borehole will be periodically removed and placed next to the borehole. If the sample is to be collected using the same hand auger or soil coring device, the auger bucket or core sampler will be decontaminated (or replaced with a decontaminated bucket or sampler) before collecting the soil sample. The discrete sample will then be collected by advancing the sampling equipment to the appropriate depth interval and retrieving the soil sample. When collecting samples at depths

greater than 12 inches, it is advisable to discard approximately the upper 1 inch of material in the top portion of the auger or sampler because of borehole slough and cave-in. The sample will then be immediately transferred into laboratory-cleaned sample containers using a decontaminated stainless steel spoon or trowel

3.5.2 Deep Subsurface Soil Sampling

Deep subsurface soil samples are typically collected using split-spoon samplers. A split- spoon sampler is a soil coring device that consists of a length of carbon or stainless-steel tubing, split longitudinally and equipped with a sample shoe and a drive head. Split-spoon samplers are used in conjunction with a power auger or drill rig, and are usually either hammered or hydraulically pushed into the interval to be sampled. The interval(s) to be sampled may be either predetermined or determined according to criteria observed during advancement of the drilling equipment as specified in the site-specific sampling plans within the UFP- QAPP. The following procedures focus on sampling soil for chemical analysis, using a split-spoon or DPS continuous tube sampler. Soil samples obtained for physical characterization are typically collected using similar procedures.

Hollow-Stem Auger Drilling

Using hollow-stem auger (HSA) drilling equipment, the soil borehole will be advanced to the depth immediately above the sampling interval as described in *SOP for Hollow Stem Auger and Direct Push Drilling Methods*. During advancement of the auger, cuttings from around the augers will periodically be removed and shoveled into a pile near the borehole or into appropriately labeled drums. A split-spoon sampler then be attached to the end of a series of drive rods and lowered down the center of the hollow auger drill string. The split-spoon sampler will then be advanced ahead of the drill bit in order to collect a relatively undisturbed, representative soil sample. Standard Penetration Test (SPT) blow counts for that sample, as well as the interval from which the sample was obtained, will be recorded in the *Soil Boring Log Datasheet* according to the *SOP for Boring Log Completion, Soil Classification and Logging.* Depending on the size of the split-spoon employed, typically 18 to 24 inches of soil should be recovered in advance of the drill bit. The split-spoon sampler will then be removed from the borehole and opened exposing the soil core for sample collection and examination. Soil samples for laboratory analysis should be collected from the undisturbed, middle portion of the soil core and soil from the very ends of the soil core must be discarded as they often contain disturbed soils. The sample will then be immediately and quickly transferred into clean, laboratory sample containers using a decontaminated stainless steel spoon or scoop as described in previous Section 5.1. The soil core will be examined by the field geologist, screened for VOCs using a PID or FID (see *the SOP for Organic Vapor Monitoring and Air Monitoring*), and logged for lithology (see *the SOP for Boring Log Completion, Soil Classification, and Logging).* Soil cores may also be photographed and recorded per *the SOP for Field Documentation.*

Direct Push System Drilling

Direct push system (DPS) soil samples are typically collected using a continuous tube sampler with polyvinyl chloride (PVC) liners such as Geoprobe's® DT325 Dual Tube Sampling System sampler, using the DPS drilling procedures described in the *SOP for Hollow Stem Auger and Direct Push Drilling Methods*. At the top of each sample interval, the continuous tube sampler will be driven into the substrate to a depth equal to the length of the sampler. After the sampler has been advanced, it is retrieved from the borehole and the PVC liner containing the soil core is placed on a firm, horizontal surface, for opening, inspection, and sampling. The PVC liner for each sample core is then cut open to expose the soil sample core for soil sampling and examination. Samples for laboratory analysis will be immediately transferred into clean laboratory sample containers using a decontaminated stainless-steel spoon or scoop, as described previously in Section 5.1. The soil core will then be examined by the field geologist, screened for VOCs using a PID or FID (see *the SOP for Boring Log Completion, Soil Classification and Logging*). Soil cores may also be photographed and recorded per *the SOP for Field Documentation*. Special attention must be paid to labeling and storage of individual core samples when continuous soil samples are collected from a single boring. In many instances, soil cores can be produced faster than they can be opened, logged, screened and sampled by a technician.

In those instances when a backlog of cores is being generated, care must be made to protect the cores from direct sunlight, excessive ambient temperatures, and rain. These conditions may have an adverse effect on highly sensitive volatile organics within the core or the instruments used for screening. Always keep the cores labeled so that the up/down orientation is not lost. Proceed carefully, but quickly when field screening. If necessary, log soils for lithology information after sample collection.

3.6 Excavation and Stockpile Sampling

Soil sampling of excavations and stockpiles should be conducted using similar techniques as described in Sections 5.4 and 5.5.1.

3.6.1 Excavation Sampling

When collecting soil samples from excavations including test pits, soil samples should generally be collected from freshly uncovered soil. Remove 4 to 6 inches of soil immediately before sample collection. If the excavation has been open for longer than 1 hour, remove at least 12 inches of soil immediately before collection. Do not collect samples from disturbed soil that has fallen into the bottom of the excavation pit. If the depth of the excavation is such that sampling cannot be safely conducted within the excavation, soil samples may be collected directly from the excavator bucket. When collecting soil samples from an excavator bucket, samples should be collected from the center of the bucket and away from the bucket sides. Refer to *Appendix A, Project-specific Health and Safety Plan,* and/or consult the project HSO regarding excavation safety before entering any open excavation.

3.6.2 Stockpile Sampling

Stockpiled soil must be field screened before sample collection. Field screening and analytical soil samples must be collected at least 18 inches beneath the exposed surface of the stockpile, unless additional shallower field screening samples are needed to represent soil contaminant heterogeneity. Contamination can be persistent near the bottom of long-term stockpiles, so it is important that some samples be collected near the base. Soil samples from the surface, within, and near the bottom of a stockpile will be collected using the methods previously discussed in Sections 3.4 and 3.5.1.

3.7 Volatile Organic Soil Sampling

If VOCs are among the analytes to be investigated at a particular site, discrete soil samples will be collected as soon as possible following exposure of the soil core. Special precautions must be taken when collecting samples for VOC analysis, which includes VOCs and/or benzene, toluene, xylenes, and ethylbenzene (BTEX). All soil samples for VOC analysis must be collected in a way that minimizes sample volatilization through excessive atmospheric exposure, mixing, and/or other disturbance. It is recommended that VOC samples be collected using core-type samples such as split-spoons, continuous tube samplers, and soil coring devices that reduce the loss of volatiles during sampling. VOC soil samples analyzed using U.S. Environmental Protection Agency (EPA) Method SW8260B will be collected as follows:

- Collect a minimum of 25 grams of soil (a piece approximately 1 inch in diameter) with minimum disturbance directly into a 4-ounce (oz) or larger jar with a Teflon-lined septum fused to the lid. Interim storage/containers (such as resealable plastic bags) are not allowed.

- Immediately after collection, carefully add 25-milliliters (mL) of methanol until the sample is submerged. This step must be completed within approximately 10 seconds of placing the soil in the sample jar. VOC samples by Method SW8260B will be collected in TerraCore® kits that will include the 4-oz jar preserved with methanol described in this section, and non-methanol preserved containers described in the next section. All containers must be collected at the same time.
- After sealing, gently agitate the sample so that entire sample is submerged.
- Do not place tape, including evidence tape, on the sample container directly.
- Cool and retain samples at 4°C ± 2 degrees Celsius (°C).
- Collect a sample of the same material from the same location in an unpreserved jar for percent moisture determination.
- Collect appropriate field and laboratory quality control samples including field duplicates and matrix spike/matrix spike duplicate (MS/MSD) samples.
- Analytical samples should be collected in the following order:
  - VOCs and BTEX
  - Semi-volatiles organic compounds (SVOCs); including pesticides, herbicides, residual range organics (RRO), and polychlorinated biphenyls (PCBs)
  - Total organic carbon (TOC)
  - Metals
- All VOC samples should be accompanied by an appropriate trip blank from the time of collection until analysis at the project laboratory.

VOC samples analyzed using EPA SW-846 Method 5035A will be collected as follows:

The discrete soil sample must be collected using a 5-gram soil core sampler with a new, dedicated, and disposable sample syringe or tip as described in American Society for Testing and Materials (ASTM) standard D6418-09. These devices are used to collect a specific soil sample mass for volatile organic analysis in a manner that minimizes loss of contaminants because of volatilization or biodegradation. Frequently accepted soil core samplers are listed below and details of these soil core samplers are provided in *Attachment 1: Soil Core Sampler Information.*

  - En Core® sampler
  - TerraCore® sampler
  - EasyDraw Syringe® with PowerStop Handle® sampler
  - Core N' One™ sampler
  - Lock N' Load™ sampler
- Soil samples will be collected from a specified location and soil depth as determined by field screening or as determined in the project-specific field sampling plan (*Worksheet 17* and *Appendix D*). After determining the sample location, the soil core sampler will be plunged into the soil core to collect a sample.

- To collect a sample, have ready a pre-weighed, pre-preserved, and labeled 40 mL volatile organic analysis (VOA) vial containing sodium bisulfate/water preservative. With the syringe or plunger seated in the handle, push the soil core sampler into freshly exposed soil until the sample chamber is filled. Do not pull the syringe or plunger back before use.
- Wipe all soil or debris from the outside of the soil core sampler and remove any excess soil that extends beyond the end of the sampler, so that the soil plug is flush with the end of the sampler. A filled chamber will deliver approximately 5 grams of soil.
- Place the mouth of the soil core sampler into the 40-ml VOA vial containing sodium bisulfate/water preservative and extrude the 5-gram sample into the VOA vial by pushing the syringe or plunger down. These VOC samples will be collected in TerraCore® kits that will include the 4-oz jar preserved with methanol described in the previous section. All containers must be collected at the same time.
- Quickly seal the lid back on the 40-ml VOA vial.
- Take care not to leave any soil grains along the threaded cap area of the VOA vial so that the lid can be screwed on tightly forming a tight seal. Be sure to remove any soil or debris from the top and/or threads of the vial.
- Immediately following collection, samples will be labeled with a unique sample identification, packaged appropriately, and kept at a temperature of approximately 4 degrees Celsius inside a cooler for preservation.
- VOA containers should be padded so that the glass walls of the containers do not come into direct contact with ice or other samples, thereby reducing the risk of cracking the glass containers.
- All volatile organics samples should be accompanied by an appropriate trip blank from the time of collection until analysis at the project laboratory.
- All sample collection details should be noted in the *Field Notebook* and *Soil Boring Log Datasheet*, according to *the SOP or Field Documentation*.

3.8 Quality Assurance/Quality Control Procedures and Samples

Quality Assurance/Quality Control (QA/QC) samples should be collected during soil sampling according to the *Field QC Sample Summary* and *Site-specific Sampling Plans* in *Worksheets 17 and 20* and in *Appendix D*. QA/QC samples should be assigned unique sample identification and handled and submitted to the laboratory the same as field samples.

3.8.1 Equipment Blanks

Equipment blanks should be collected at a frequency specified in *UFP-QAP.* An equipment blank sample is collected in the field by running ASTM Type II Reagent-Grade water (or deionized water with less than 15 microSiemens conductivity) across the surface of re-usable, decontaminated sampling equipment (typically the split-spoon or drive shoe of the DPS continuous tube sampler) and into appropriate sample containers.

3.8.2 Field Duplicate Samples

Field duplicates will be collected at a frequency specified in *Worksheets 17 and 20* and in *Appendix D*. Field duplicate samples will be collected simultaneously or in immediate succession to the normal samples using identical sampling techniques.

4.0 Records

All records should be documented in a bound *Field Notebook* according to *SOP-01, Note Taking and Field Log Books* and/or the *Soil Boring Log Datasheets* provided in *SOP-05, Hollow Stem Auger and Direct Push Drilling Methods*.

5.0 References

American Society for Testing Materials (ASTM). 2009a. *Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds*. ASTM Standard D 4547, ASTM International, West Conshohocken, PA. July 1.

American Society for Testing Materials (ASTM). 2009b. *Standard Practice for Soil Exploration and Sampling by Auger Borings*. ASTM Standard D 1452, ASTM International, West Conshohocken, PA. February 15.

American Society for Testing Materials (ASTM). 2009c. *Standard Practice for Using the Disposable En Core Sampler for Sampling and Storing Soil for Volatile Organic Analysis*. ASTM Standard D 6418, ASTM International, West Conshohocken, PA. June 1.

American Society for Testing Materials (ASTM). 2008a. *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*. ASTM Standard D 1586 Rev A, ASTM International, West Conshohocken, PA. October 1.

American Society for Testing Materials (ASTM). 2008b. *Standard Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities*. ASTM Standard D 6232, ASTM International, West Conshohocken, PA. January 1.

American Society for Testing Materials (ASTM). 2006. *Standard Guide for Soil Sampling from the Vadose Zone*. ASTM Standard D 4700, ASTM International, West Conshohocken, PA. July 15.

En Novative Technologies, Inc. 2010a. *EasyDraw Syringe® & PowerStop Handle® Product Information*. http://www.ennovativetech.com/pages/field-preservation- tools/easydraw-syringer-powerstop-handler-product-information.php. Accessed February 2, 2010.

En Novative Technologies, Inc. 2010b. *Terra Core Soil Sampler Product Information.* http://www.ennovativetech.com/pages/field-preservation-tools/terra-core-soil- sampler-product-information.php. Accessed February 2, 2010.

En Novative Technologies, Inc. 2010c. *The En Core Sampler Product Information.* http://www.ennovativetech.com/pages/the-en-core-sampler.php. Accessed February 2, 2010.

Geotech Environmental Equipment, Inc. 2010. *Soil Sampling Kits and Tools: Core N' One™ Handle and Capsule and Lock N' Load™ Handles and Syringes*. http://www.geotechenv.com/soil_sampling_equip.html. Accessed February 2, 2010.

6.0 Definitions

Discrete soil sample: a discrete aliquot from a distinct sampling interval (of a specific sample size) that is representative of one specific location at a specific point in time.

Surface soil: generally considered to be the top 6 inches of a soil horizon profile (that is, soil from 0 to 6 inches bgs), soil down to depths of 2 feet bgs may be considered surface soil.

For the purposes of this procedure, surface soil represents the soil in the 0- to 6-inch depth interval bgs.

Subsurface soil: the soils, silts, sands, and clays below surface soil.

7.0 Attachments

Attachment 1: *Soil Core Sampler Information*

US EPA ARCHIVE DOCUMENT

Title:	**SOIL SAMPLING**
Category:	ENV 3.13
Revised:	August 1997

STANDARD OPERATING PROCEDURE

SOIL SAMPLING

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368 Pleasant View Drive / Lancaster, New York 14086 / (716) 684-8060

TITLE:	**SOIL SAMPLING**		
CATEGORY:	ENV 3.13		August 1997

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TITLE:	SOIL SAMPLING		
CATEGORY:	ENV 3.13	REVISED:	August 1997

1. Introduction

This document describes the procedures for the collection of representative soil samples. Representative sampling ensures the accurate characterization of site conditions. Analysis of soil samples may determine pollutant concentrations and the accompanying risks to public health, welfare, or the environment.

2. Scope

Included in this discussion are procedures for obtaining representative samples, quality assurance/quality control (QA/QC) measures, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Soil samples may be recovered using a variety of methods and equipment. These are dependent on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type.

Samples of near-surface soils may be easily obtained using a spade, stainless-steel spoon, trowel, or scoop. Sampling at greater depths may be performed using a hand auger; a power auger; or, if a test pit is required, a backhoe.

All sampling devices should be cleaned using pesticide-grade acetone (assuming that acetone is not a target compound) or methanol, then wrapped in clean aluminum foil, and custody sealed for identification. The sampling equipment should remain in this wrapping until it is needed. Each sampler should be used for one sample only. However, dedicated tools may be impractical if there is a large number of soil samples required. In this case, samplers should be cleaned in the field using standard decontamination procedures as outlined in E & E's Standard Operating Procedure (SOP) for Sampling Equipment Decontamination (see ENV 3.15).

4. Sample Preservation, Containers, Handling, and Storage

The chemical preservation of solids is not generally recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time.

Soil samples should be handled according to the procedures outlined in E & E's SOP for Sample Packaging (see ENV 3.16).

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5. Potential Problems

Potential problems with soil sampling include cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection is generally the result of the use of contaminated equipment; the disturbance of the matrix, resulting in compaction of the sample; and inadequate homogenization of the sample where required, resulting in variable, nonrepresentative results. Specific advantages and disadvantages of soil sampling equipment are presented in Table 5-1.

Table 5-1 Soil Sampling Equipment

Equipment	Applicability	Advantages and Disadvantages
Trier	Soft surface soil	Inexpensive; easy to use and decontaminate; difficult to use in stony, dry, or sandy soil.
Scoop, trowel, spoon, or spatula	Soft surface soil	Inexpensive; easy to use and decontaminate; trowels with painted surfaces should be avoided.
Tulip bulb planter	Soft soil, 0 to 6 inches	Easy to use and decontaminate; uniform diameter and sample volume; preserves soil core (suitable for volatile organic analysis (VOA) and undisturbed sample collection); limited depth capability; not useful for hard soils.
Spade or shovel	Medium soil, 0 to 12 inches	Easy to use and decontaminate; inexpensive; can result in sample mixing and loss of volatile organic compounds (VOCs).
Vehimeyer soil outfit	Soil, 0 to 10 feet	Difficult to drive into dense or hard material; can be difficult to pull from ground.
Soil coring device and auger	Soft soil, 0 to 24 inches	Relatively easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); limited depth capability; can be difficult to decontaminate.
Thin-walled tube sampler	Soft soil, 0 to 10 feet	Easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); may be used to help maintain integrity of VOA samples; easy to decontaminate; can be difficult to remove cores from sampler.
Split-spoon sampler	Soil, 0 inches to bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); acetate sleeve may be used to help maintain integrity of VOA samples; useful for hard soils; often used in conjunction with drill rig for obtaining deep cores.

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Table 5-1 Soil Sampling Equipment

Equipment	Applicability	Advantages and Disadvantages
Shelby tube sampler	Soft soil, 0 inches to bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); tube may be used to ship sample to lab undisturbed; may be used in conjunction with drill rig for obtaining deep cores and for permeability testing; not durable in rocky soils.
Laskey sampler	Soil, 0 inches to bedrock	Excellent depth range; preserves soil cores; used in conjunction with drill rig for obtaining deep core; can be difficult to decontaminate.
Bucket auger	Soft soil, 3 inches to 10 feet	Easy to use; good depth range; uniform diameter and sample volume; acetate sleeve may be used to help maintain integrity of VOA samples; may disrupt and mix soil horizons greater than 6 inches in thickness.
Hand-operated power auger	Soil, 6 inches to 15 feet	Good depth range; generally used in conjunction with bucket auger for sample collection; destroys soil core (unsuitable for VOA and undisturbed sample collection); requires two or more equipment operators; can be difficult to decontaminate; requires gasoline-powered engine (potential for cross-contamination).
Continuous-flight auger	Soil, 0 inches to bedrock	Excellent depth range; easy to decontaminate; can be used on all soil samples; results in soil mixing and loss of VOCs.
Dutch auger	Designed specifically for wet, fibrous, or rooted soils (e.g., marshes)	
Eijkelcamp stoney soil auger	Stoney soils and asphalt	
Backhoe	Soil, 0 inches to 10 feet	Good depth range; provides visual indications as to depth of contaminants; allows for recovery of samples at specific depths; can result in loss of VOCs and soil mixing; shoring required at depth.

Note: Samplers may not be suitable for soils with coarse fragments.
Augers are suitable for soils with limited coarse fragments; only the stoney auger will work well in very gravelly soil.

6. Soil Sampling Equipment

Soil Sampling Equipment List

- Stainless-steel spoon
- Trier
- Scoop
- Trowel

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- Spatula
- Stainless-steel tulip bulb planter
- Spade or shovel
- Vehimeyer soil sampler outfit
  - tubes
  - points
  - drive head
  - drop hammer
  - fuller jack and grip
- Soil-coring device
- Thin-walled tube sampler
- Split-spoon sampler
- Shelby tube sampler
- Laskey sampler
- Bucket auger
- Hand-operated power auger
- Continuous-flight auger
- Dutch auger
- Eijkelcamp stoney soil auger
- Backhoe
- Hand auger with replaceable sleeves

Sampling Support Equipment and Documentation List

- Sampling plan
- Sample location map
- Safety equipment, as specified in the Health and Safety Plan
- Decontamination supplies and equipment, as described in the Work Plan
- Compass
- Tape measure
- Survey stakes or flags
- Camera
- Stainless-steel buckets or bowls
- Sample containers, precleaned (e.g., I-Chem)
- Logbook
- Chain-of-custody forms
- Plastic sheet
- Soil gas probes
- Infiltrometer
- Pounding sleeve
- Extension rods
- T-handle

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Labeling, Packaging, and Shipping Supplies

- Coolers
- Labels for sample containers and coolers (e.g., "fragile")
- Ice
- Plastic bags for sample containers and ice
- ESC paint cans and clamps for polychlorinated biphenyl sampling
- Vermiculite
- Duct and strapping tape
- Federal Express airbills and pouches

6.1 Geophysical Equipment

Geophysical techniques can be integrated with field analytical and soil sampling equipment to help define areas of subsurface contamination. For a description of the geophysical techniques and associated applications, refer to E & E's SOP for Surface Geophysical Techniques (see GEO 4.2).

7. Reagents

This procedures does not require the use of reagents except for decontamination of equipment, as required. Refer to E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15) and the Site-Specific Work Plan for proper decontamination procedures and appropriate solvents.

8. Procedures

8.1 Office Preparation

1. The preparation of a Health and Safety Plan is required prior to any sampling. The plan must be approved and signed by the Corporate Health and Safety Officer or his/her designee (i.e., the Regional Safety Coordinator).

2. Prepare a Sampling Plan to meet the data quality objectives of the project in accordance with contract requirements. Review available background information (i.e., topographic maps, soil survey maps, geologic maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling method to be employed, and the type and amounts of equipment and supplies required.

3. Obtain necessary sampling and monitoring equipment (see Section 6), decontaminate or preclean the equipment, and ensure that it is in working order.

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4. Contact the delivery service to confirm the ability to ship all equipment and samples. Determine whether shipping restrictions exist.

5. Prepare schedules and coordinate with staff, clients, and regulatory agencies, if appropriate.

8.2 Field Preparation

1. Identify local suppliers of sampling expendables (e.g., ice and plastic bags) and overnight delivery services (e.g., Federal Express).

2. Decontaminate or preclean all equipment before soil sampling, as described in E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15), or as deemed necessary.

3. A general site survey should be performed prior to site entry in accordance with the Health and Safety Plan, followed by a site safety meeting.

4. Identify and stake all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner or field team prior to soil sampling.

8.3 Representative Sample Collection

The objective of representative sampling is to ensure that a sample or group of samples adequately reflects site conditions.

8.3.1 Sampling Approaches

It is important to select an appropriate sampling approach for accurate characterization of site conditions. Each approach is defined below. Table 8-1 summarizes the following sampling approaches and ranks them from most to least suitable based on the sampling objective.

8.3.1.1 Judgmental Sampling

Judgmental sampling is based on the subjective selection of sampling locations relative to historical site information, on-site investigation (site walk-over), etc. There is no randomization associated with this sampling approach because samples are collected primarily at areas of suspected highest contaminant concentrations. Therefore, any statistical calculations based on the sampling results would be unfairly biased.

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Table 8-1 Representative Sampling Approach Comparison

Sampling Objective	Judgmental	Random	Stratified Random	Systematic Grid	Systematic Random	Search	Transect
Establish Threat	1	4	3	2[a]	3	3	2
Identify Sources	1	4	2	2[a]	3	2	3
Delineate Extent of Contamination	4	3	3	1[b]	1	1	1
Evaluate Treatment and Disposal Options	3	3	1	2	2	4	2
Confirm Cleanup	4	1[c]	3	1[b]	1	1	1[c]

1 Preferred approach.
2 Acceptable approach.
3 Moderately acceptable approach.
4 Least acceptable approach.
a Should be used with field analytical screening.
b Preferred only where known trends are present.
c Allows for statistical support of cleanup verification if sampling over entire site.

8.3.1.2 Random Sampling

Random sampling involves the arbitrary collection of samples within a defined area. Refer to EPA 1984 and EPA 1989 for a random number table and guidelines on selecting sample coordinates. The arbitrary selection of sample locations requires each sample location to be chosen independently so that results in all locations within the area of concern have an equal chance of being selected. To facilitate statistical probabilities of contaminant concentration, the area of concern must be homogeneous with respect to the parameters being monitored. Thus, the higher the degree of heterogeneity, the less the random sampling approach will reflect site conditions (see Figure 8-1).

8.3.1.3 Stratified Random Sampling

Stratified random sampling relies primarily on historical information and prior analytical results to divide the area of concern into smaller sampling areas, or "strata." Strata can be defined by several factors, including sampling depth, contaminant concentration levels, and contaminant source areas. Sampling locations should be selected within a strata using random selection procedures (see Figure 8-2).

8.3.1.4 Systematic Grid Sampling

Systematic grid sampling involves the division of the area of concern into smaller sampling areas using a square or triangular grid. Samples are then collected from the intersections of the grid lines, or "nodes." The origin and direction for placement of the grid should be selected by using an initial random point. The distance between nodes is dependent upon the size of the area of concern and the number of samples to be collected (see Figure 8-3).

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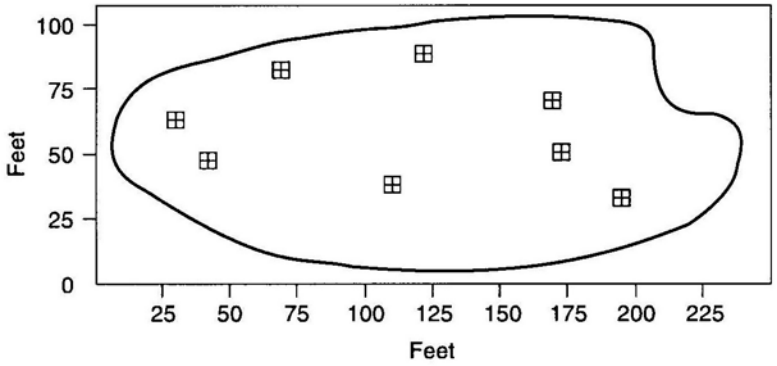


Figure 8-1 Random Sampling**

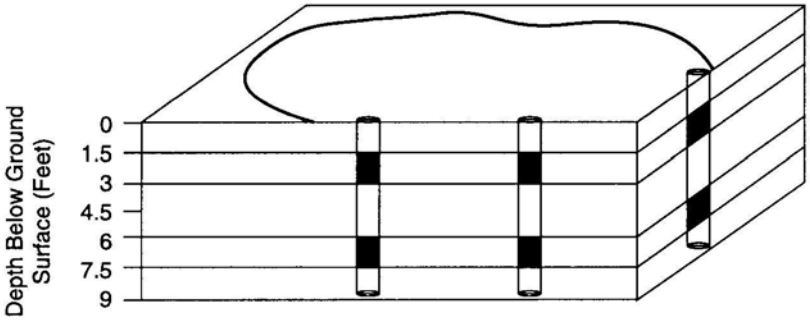


Figure 8-2 Stratified Random Sampling

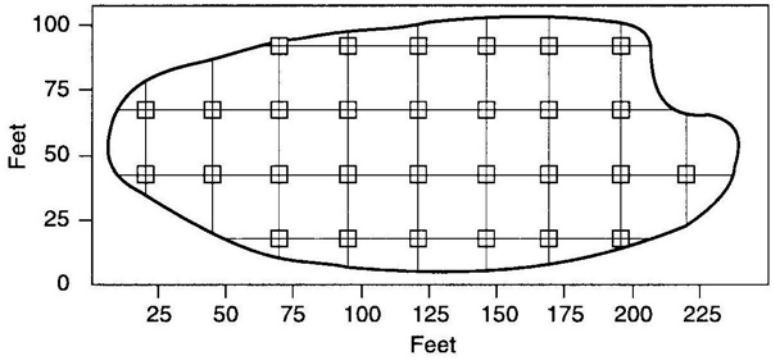
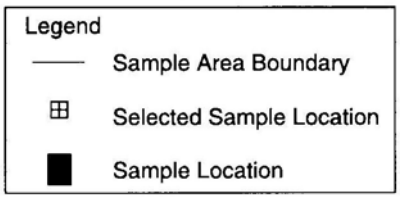


Figure 8-3 Systematic Grid Sampling**

** After EPA, February 1989



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8.3.1.5 Systematic Random Sampling

Systematic random sampling involves dividing the area of concern into smaller sampling areas as described in Section 8.3.1.4. Samples are collected within each grid cell using random selection procedures (see Figure 8-4).

8.3.1.6 Biased-Search Sampling

Search sampling utilizes a systematic grid or systematic random sampling approach to define areas where contaminants exceed cleanup standards (i.e., hot spots). The distance between the grid lines and number of samples to be collected are dependent upon the acceptable level of error (i.e., the chance of missing a hot spot). This sampling approach requires that assumptions be made regarding the size, shape, and depth of hot spots (see Figure 8-5).

8.3.1.7 Transect Sampling

Transect sampling involves establishing one or more transect lines, parallel or nonparallel, across the area of concern. If the lines are parallel, this sampling approach is similar to systematic grid sampling. The advantage of transect sampling over systematic grid sampling is the relative ease of establishing and relocating transect lines as opposed to an entire grid. Samples are collected at regular intervals along the transect line at the surface and/or at a specified depth(s). The distance between the sample locations is determined by the length of the line and the number of samples to be collected (see Figure 8-6).

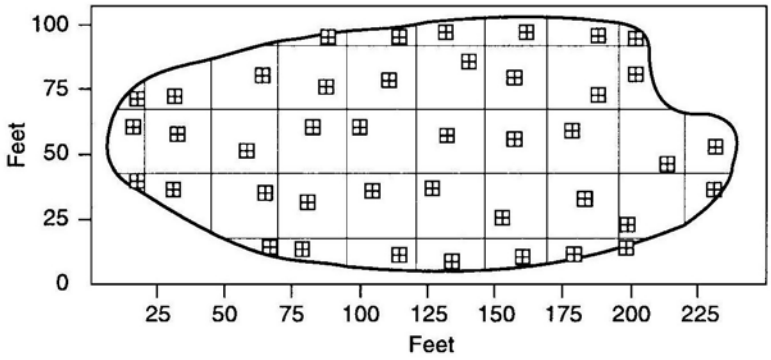

Figure 8-4 Systematic Random Sampling

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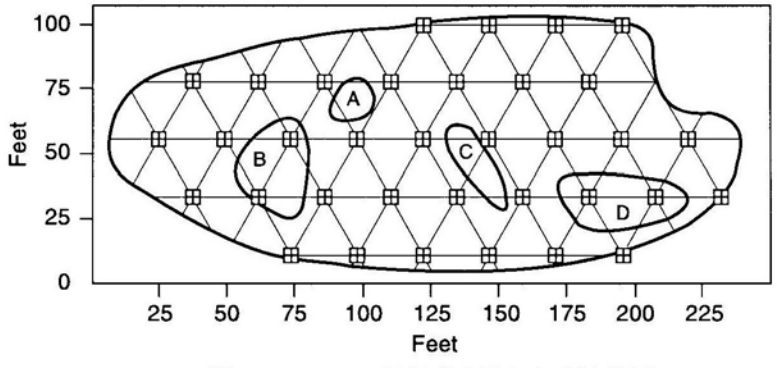

Figure 8-5 Search Sampling

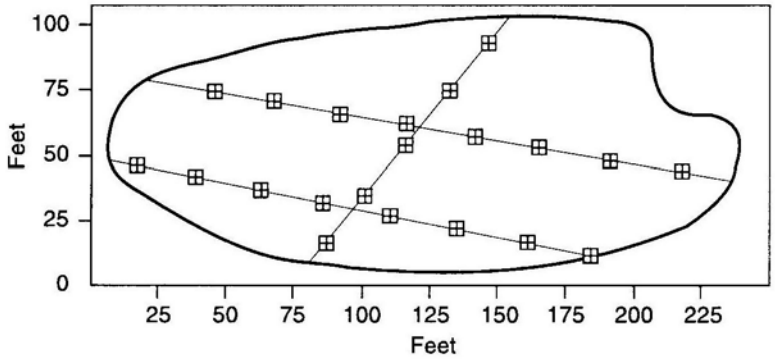

Figure 8-6 Transect Sampling

After EPA, February 1989

Legend
- Sample Area Boundary
- Selected Sample Location
- A — Sample Location

8.3.2 Surface Soil Samples

Collection of samples from near-surface soil can be accomplished with tools such as spades, spoons, shovels, and scoops. The surface material can be removed to the required depth with this equipment; stainless-steel or plastic scoops can then be used to collect the sample.

This method can be used in most soil types, but is limited to sampling near-surface areas. Accurate, representative samples can be collected with this procedure, depending on the care and precision demonstrated by the sampling technician. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required (e.g., for volatile organic analyses [VOAs]). A stainless-steel scoop, lab spoon, or plastic spoon will suf-

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fice in most other applications. Care should be exercised to avoid the use of devices plated with chrome or other materials, as is common with garden implements such as potting trowels.

Soil samples are collected using the following procedure:

1. Carefully remove the top layer of soil to the desired sample depth with a precleaned spade;

2. Using a precleaned, stainless-steel scoop, spoon, trowel, or plastic spoon, remove and discard the thin layer of soil from the area that came into contact with the shovel;

3. Transfer the sample into an appropriate container using a stainless-steel or plastic lab spoon or equivalent. If composite samples are to be collected, place the soil sample in a stainless-steel or plastic bucket and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Place the soil samples into labeled containers. **(Caution: Never composite VOA samples)**;

4. VOA samples should be collected directly from the bottom of the hole before mixing the sample to minimize volatilization of contaminants;

5. Check to ensure that the VOA vial Teflon liner is present in the cap, if required. Fill the VOA vial fully to the top to reduce headspace. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time;

6. Ensure that a sufficient sample size has been collected for the desired analysis, as specified in the Sampling Plan;

7. Decontaminate equipment between samples according to E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15); and

8. Fill in the hole and replace grass turf, if necessary.

QA/QC samples should be collected as specified, according to the Work Plan.

8.3.3 Sampling at Depth with Augers and Thin-Walled Tube Samplers

This system consists of an auger, a series of extensions, a T-handle, and a thin-walled tube. The auger is used to bore a hole to a desired sampling depth and is then withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the soil to the completion depth. The core is then withdrawn and the sample is collected.

Several augers are available, including bucket type, continuous-flight (screw), and post-hole augers. Because they provide a large volume of sample in a short time, bucket types are better for direct sample recovery. When continuous-flight augers are used, the sample can be collected directly off the flights, usually at 5-foot intervals. The continuous-flight augers are sat-

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isfactory for use when a composite of the complete soil column is desired. Posthole augers have limited utility for sample collection because they are designed to cut through fibrous, rooted, swampy soil.

The following procedures will be used for collecting soil samples with the hand auger:

1. Attach the auger bit to a drill rod extension, and attach the T-handle to the drill rod.

2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, and litter). It may be advisable to remove the first 3 to 6 inches of surface soil from an area approximately 6 inches in radius around the drilling location.

3. Begin augering, periodically removing and depositing accumulated soils onto a canvas or plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole and avoids possible contamination of the surrounding area.

4. After reaching the desired depth, slowly and carefully remove the auger from the boring. When sampling directly from the auger, collect the sample after the auger is removed from the boring and proceed to Step 11.

5. A precleaned stainless-steel auger sleeve can also be used to collect a sample. After reaching the desired sampling depth, remove the auger and place the sleeve inside the auger. Collect the sample with the auger. Remove the auger from the boring. The sample will be collected only from the sleeve. The soil from the auger tip should never be used for the sample.

6. Remove the auger tip from the dill rods and replace with a precleaned thin-walled tube sampler. Install the proper cutting tip.

7. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring, because the vibrations may cause the boring walls to collapse.

8. Remove the tube sampler and unscrew the drill rods.

9. Remove the cutting tip and core from the device.

10. Discard the top of the core (approximately 1 inch), because this represents material collected before penetration of the layer in question. Place the remaining core into the sample container.

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11. If required, ensure that a Teflon liner is present in the cap. Secure the cap tightly onto the sample container. Place the sample bottle in a plastic bag and put on ice to keep the sample at 4°Celsius.

12. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

13. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged. Verify that the chain-of-custody form is correctly and completely filled out.

14. Record the time and date of sample collection, as well as a description of the sample, in the field logbook.

15. If another sample is to be collected in the sample hole, but at a greater depth, re-attach the auger bit to the drill and assembly, and follow Steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

16. Abandon the hole according to applicable regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

17. Decontaminate the sampling equipment per E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.3.4 Sampling at Depth with a Trier

1. Insert the trier into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample material. Extraction of samples may require tilting of the containers.

2. Rotate the trier once or twice to cut a core of material.

3. Slowly withdraw the trier, making sure that the slot is facing upward.

4. Transfer the sample into a suitable container with the aid of a spatula and brush.

5. If required, ensure that a Teflon liner is present in the cap. Secure the cap tightly onto the sample container. Samples are handled in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

6. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

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7. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged.

8. Record the time and date of sample collection as well as a description of the sample and any associated air monitoring measurements in the field logbook.

9. Abandon the hole according to applicable regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

10. Decontaminate sampling equipment per E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.3.5 Sampling at Depth with a Split-Spoon (Barrel) Sampler

The procedure for split-spoon sampling describes the extraction of undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be sampled to give a complete soil column, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extraction.

This sampling device may be used to collect information such as soil density. All work should be performed in accordance with American Society for Testing and Materials (ASTM) D 1586-84, *Penetration Test and Split Barrel Sampling of Soils*.

1. Assemble the sampler by aligning both sides of the barrel and then screwing the bit on the bottom and the heavier head piece on top. Install a retaining cap in the head piece if necessary.

2. Place the sampler in a perpendicular position on the sample material.

3. Using a sledge hammer or well ring, if available, drive the tube. Do not drive past the bottom of the head piece because compression of the sample will result.

4. Record the length of the tube used to penetrate the material being sampled and the number of blows required to obtain this depth.

5. Withdraw the split spoon and open by unscrewing the bit and head. If a split sample is desired, a clean stainless-steel knife should be used to divide the tube contents in half, lengthwise. This sampler is available in 2- and 3.5-inch diameters. The required sample volume may dictate the use of the larger barrel. If needed, stainless-steel or Teflon sleeves can be used inside the split-spoon. If sleeves removed from the split-spoon are capped immediately, volatilization of contaminants can be reduced. When split-spoon sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-67 (reapproved in 1974).

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6. Cap the sample container, place in a double plastic bag, and attach the label and custody seal. Record all pertinent data in the field logbook and complete the sample analysis request form and chain-of-custody record before collecting the next sample.

7. If required, preserve or place the sample on ice.

8. Follow proper decontamination procedures and deliver samples to the laboratory for analysis.

8.3.6 Test Pit/Trench Excavation

These relatively large excavations are used to remove sections of soils when detailed examination of soil characteristics (horizontal, structure, color, etc.) is required. It is the least cost-effective sampling method because of the relatively high cost of backhoe operation.

1. Prior to any excavations with a backhoe, it is important to ensure that all sampling locations are clear of utility lines and poles (subsurface as well as above surface).

2. Using the backhoe, a trench is dug to approximately 3 feet in width and approximately 1 foot below the cleared sampling depth. Place removed or excavated soils on canvas or plastic sheets, if necessary. Trenches greater than 4 feet deep must be sloped or protected by a shoring system, as required by Occupational Safety and Health Administration (OSHA) regulations.

3. A shovel is used to remove a 1- to 2-inch layer of soil from the vertical face of the pit where sampling is to be done.

4. Samples are collected using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose soil for sampling. Samples are removed and placed in an appropriate container.

5. If required, ensure that a Teflon liner is present in the cap. Secure the cap tightly onto the sample container. Samples are handled in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

6. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

7. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged.

8. Record the time and date of sample collection as well as a description of the sample and any associated air monitoring measurements in the field logbook.

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9. Abandon the hole according to applicable state regulations. Generally, excavated holes can simply be backfilled with the removed soil material.

10. Decontaminate sampling equipment, including the backhoe bucket, per E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.4 Sample Preparation

In addition to sampling equipment, representative sample collection includes sample quantity, volume, preservation, and holding time (see Table 8-2). *Sample preparation* refers to all aspects of sample handling after collection. How a sample is prepared can affect its representativeness. For example, homogenizing can result in a loss of volatiles and is therefore inappropriate when volatile contaminants are the concern.

8.4.1 Sample Quantity and Volume

The volume and number of samples necessary for site characterization will vary according to the budget, project schedule, and sampling approach.

8.4.2 Sample Preservation and Holding Time

Sample preservation and holding times are as discussed in Section 4.

8.4.3 Removing Extraneous Material

Discard materials in a sample that are not relevant for site or sample characterization (e.g., glass, rocks, and leaves), because their presence may introduce an error in analytical procedures.

8.4.4 Homogenizing Samples

Homogenizing is the mixing of a sample to provide a uniform distribution of the contaminants. Proper homogenization ensures that the containerized samples are representative of the total soil sample collected. All samples to be composited or split should be homogenized after all aliquots have been combined. Do not homogenize samples for volatile compound analysis.

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Table 8-2 Standard Sampling Holding Times, Preservation Methods, and Volume Requirements

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
SW-846								
VOA[e]	14 days from date sampled	14 days from date sampled	15 g	One 40-mL vial; no air space	Two 40-mL vials; no air space	Two 40-mL vials; no air space	Cool to 4°C (ice in cooler)	Add HC1 until pH <2 and cool to 4° (ice in cooler)
Semi-VOA (BNAs)[e]	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
PCBs[d,e]	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	4-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Pesticides/PCBs[d,e]	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Metals[c]	6 months from date sampled	6 months from date sampled	10 g	300 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add HNO_3 until pH <2 and cool to 4°C (ice in cooler)
Cyanide[c]	14 days from date sampled	14 days from date sampled	10 g	100 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add NaOH until pH >12 and cool to 4°C (ice in cooler)
Hexavalent chromium[a]	24 hours from time sampled	24 hours from time sampled	10 g	50 mL	8-oz. glass jar with Teflon-lined cap	125-mL polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Total Organic Carbon (TOC)[a]	NA	28 days from date sampled	5 g	10 mL	8-oz. glass jar with Teflon-lined cap	125-mL polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add H_2SO_4 until pH <2 and cool to 4°C (ice in cooler)
Total Organic Halides (TOX)	NA	7 days from date sampled	100 g	200 mL	8-oz. glass jar with Teflon-lined cap	1-L amber glass bottle	Cool to 4°C (ice in cooler)	Add H_2SO_4 until pH <2 and cool to 4°C (ice in cooler)

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Table 8-2 Standard Sampling Holding Times, Preservation Methods, and Volume Requirements

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
Total Recoverable Petroleum Hydrocarbons[e]	28 days from date sampled	28 days from date sampled	50 g	1 L	8-oz. glass jar with Teflon-lined cap	1-L amber glass bottle	Cool to 4°C (ice in cooler)	Add H_2SO_4 until pH <2 and cool to 4°C (ice in cooler)
EPA-CLP								
VOA[e]	10 days from date received	10 days from date received	15 g	One 40-mL vial; no air space	Two 40-mL vials; no air space	Two 40-mL vials; no air space	Cool to 4°C (ice in cooler)	Add HC1 until pH <2 and cool to 4°C (ice in cooler)
Semi-VOA (BNAs)[e]	10 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
PCBs[d,e]	10 days to extract from date received	5 days to extract from date received	30 g	1 L	4-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Pesticides/PCBs[d,e]	10 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Metals[c]	6 months from date sampled	6 months from date sampled	10 g	300 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add HNO_3 to pH <2 and cool to 4°C (ice in cooler)
Cyanide[c]	12 days from date received	12 days from date received	10 g	100 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add NaOH to pH >12 and cool to 4°C (ice in cooler)
NYSDEC-CLP								
VOA[e]	7 days from date received	10 days from date received	15 g	One 40-mL vial; no air space	Two 40-mL vials; no air space	Two 40-mL vials; no air space	Cool to 4°C (ice in cooler)	Add HC1 until pH <2 and cool to 4°C (ice in cooler)
Semi-VOA (BNAs)[e]	5 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)

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Table 8-2 Standard Sampling Holding Times, Preservation Methods, and Volume Requirements

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
PCBs[d,e]	5 days to extract from date received	5 days to extract from date received	30 g	1 L	4-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Pesticides/PCBs[d,e]	5 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Metals[c]	6 months from date sampled	6 months from date sampled	10 g	300 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add HNO_3 to pH <2 and cool to 4°C (ice in cooler)
Cyanide[c]	12 days from date received	12 days from date received	10 g	100 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add NaOH to pH >12 and cool to 4°C (ice in cooler)
EPA Water and Waste								
Total Dissolved Solids (TDS)	NA	7 days from date sampled	NA	200 mL	NA	1-L polyethylene bottle with polyethylene-lined cap	NA	Cool to 4°C (ice in cooler)

Note: All sample bottles will be prepared in accordance with EPA bottle-washing procedures. These procedures are incorporated in E & E's Laboratory and Field Personnel Chain-of-Custody Documentation and Quality Assurance/Quality Control Procedures Manual, July 1987.

[a] Technical requirements for sample holding times have been established for water matrices only. However, they are also suggested for use as guidelines in evaluating soil data.
[b] Holding time for GC/MS analysis is 7 days if samples are not preserved.
[c] Maximum holding time for mercury is 28 days from time sampled.
[d] If one container has already been collected for PCB analysis, then only one additional container need be collected for extractable organic, BNA, or pesticides/PCB analysis.
[e] Extra containers required for MS/MSD.

Key:

NA = Not applicable.

8.4.5 Compositing Samples

Compositing is the process of physically combining and homogenizing several individual soil aliquots of the same volume or weight. Compositing samples provides an average concentration of contaminants over a certain number of sampling points. Compositing dilutes high-concentration aliquots; therefore, detection limits should be reduced accordingly. If the composite area is heterogeneous in concentration and its composite value is to be compared to a particular action level, then that action level must be divided by the total number of aliquots making up the composite for accurate determination of the detection limit.

8.4.6 Splitting Samples

Splitting samples (after preparation) is performed when multiple portions of the same samples are required to be analyzed separately. Fill the sample containers simultaneously with alternate spoonfuls of the homogenized sample (see Figure 8-7).

8.5 Post-Operations

8.5.1 Field

Decontaminate all equipment according to E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.5.2 Office

Organize field notes into a report format and transfer logging information to appropriate forms.

9. Calculations

There are no specific calculations required for these procedures.

10. Quality Assurance/Quality Control

The objective of QA/QC is to identify and implement methodologies that limit the introduction of error into sampling and analytical procedures.

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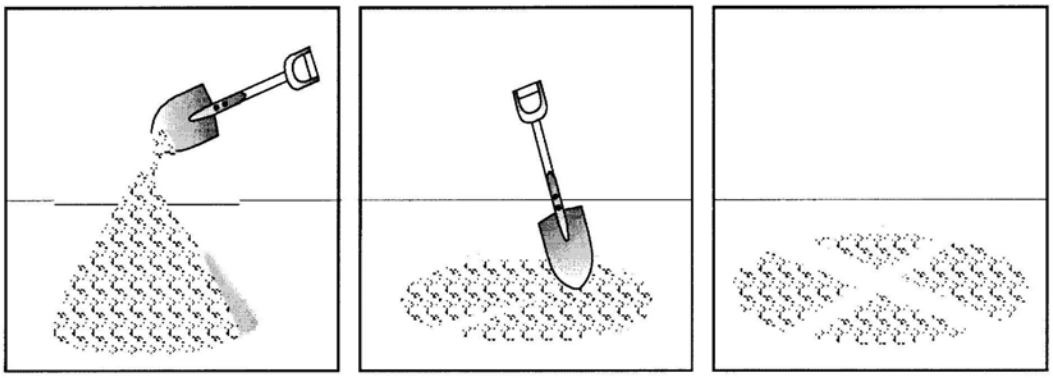

Step 1:

- Cone Sample on hard, clean surface
- Mix by forming new cone

Step 2:

- Quarter after flattening cone

Step 3:

- Divide sample into quarters

Step 4:

- Remix opposite quarters
- Reform cone
- Repeat a minimum of 5 times

After: ASTM Standard C702-87

Figure 8-7 Quartering to Homogenized and Split Samples

10.1 Sampling Documentation

10.1.1 Soil Sample Label

All soil samples shall be documented in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16). The soil sample label is filled out prior to collecting the sample and should contain the following:

1. Site name or identification.
2. Sample location and identifier.
3. Date samples were collected in a day, month, year format (e.g., 03 Jan 88 for January 3, 1988).
4. Time of sample collection, using 24-hour clock in the hours:minutes format.
5. Sample depth interval. Units used for depths should be in feet and tenths of feet.
6. Preservatives used, if any.
7. Analysis required.

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8. Sampling personnel.

9. Comments and other relevant observations (e.g., color, odor, sample technique).

10.1.2 Logbook

A bound field notebook will be maintained by field personnel to record daily activities, including sample collection and tracking information. A separate entry will be made for each sample collected. These entries should include information from the sample label and a complete physical description of the soil sample, including texture, color (including notation of soil mottling), consistency, moisture content, cementation, and structure.

10.1.3 Chain of Custody

Use the chain-of-custody form to document the types and numbers of soil samples collected and logged. Refer to E & E's SOP for Sample Packaging and Shipping (see ENV 3.16) for directions on filling out this form.

10.2 Sampling Design

1. Sampling situations vary widely; thus, no universal sampling procedure can be recommended. However, a Sampling Plan should be implemented before any sampling operation is attempted, with attention paid to contaminant type and potential concentration variations.

2. Any of the sampling methods described here should allow a representative soil sample to be obtained, if the Sampling Plan is properly designed.

3. Consideration must also be given to the collection of a sample representative of all horizons present in the soil. Selection of the proper sampler will facilitate this procedure.

4. A stringent QA Project Plan should be outlined before any sampling operation is attempted. This should include, but not be limited to, properly cleaned samplers and sample containers, appropriate sample collection procedures, chain-of-custody procedures, and QA/QC samples.

11. Data Validation

The data generated will be reviewed according to the QA/QC considerations that are identified in Section 10.

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11.1 Quality Assurance/Quality Control Samples

QA/QC samples are used to identify error due to sampling and/or analytical methodologies and chain-of-custody procedures.

11.1.1 Field Duplicates (Replicates)

Field duplicates are collected from one location and treated as separate samples throughout the sample handling and analytical processes. These samples are used to assess total error for critical samples with contaminant concentrations near the action level.

11.1.2 Collocated Samples

Collocated samples are generally collected 1.5 to 3.0 feet away from selected field samples to determine both local soil and contaminant variations on site. These samples are used to evaluate site variation within the immediate vicinity of sample collection.

11.1.3 Background Samples

Background or "clean" samples are collected from an area upgradient from the contamination area and representative of the typical conditions. These samples provide a standard for comparison of on-site contaminant concentration levels.

11.1.4 Rinsate (Equipment) Blanks

Rinsate blanks are collected by pouring analyte-free water (i.e., laboratory de-ionized water) on decontaminated sampling equipment to test for residual contamination. These samples are used to assess potential cross contamination due to improper decontamination procedures.

11.1.5 Performance Evaluation Samples

Performance evaluation samples are generally prepared by a third party, using a quantity of analyte(s) known to the preparer but unknown to the laboratory. The percentage of analyte(s) identified in the sample is used to evaluate laboratory procedural error.

11.1.6 Matrix Spike/Matrix Spike Duplicates (MS/MSDs)

MS/MSD samples are spiked in the laboratory with a known quantity of analyte(s) to confirm percent recoveries. They are primarily used to check sample matrix interferences.

11.1.7 Field Blanks

Field blanks are prepared in the field with certified clean sand, soil, or water. These samples are used to evaluate contamination error associated with sampling methodology and laboratory procedures.

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11.1.8 Trip Blanks

Trip blanks are prepared prior to going into the field using certified clean sand, soil, or water. These samples are used to assess error associated with sampling methodology and analytical procedures for volatile organics.

12. Health and Safety

12.1 Hazards Associated with On-Site Contaminants

Depending on site-specific contaminants, various protective programs must be implemented prior to soil sampling. The site Health and Safety Plan should be reviewed with specific emphasis placed on a protection program planned for direct-contact tasks. Standard safe operating practices should be followed, including minimization of contact with potential contaminants in both the vapor phase and solid matrix by using both respirators and disposable clothing.

Use appropriate safe work practices for the type of contaminant expected (or determined from previous sampling efforts):

- Particulate or Metals Contaminants
  - Avoid skin contact with, and ingestion of, soils and dusts.
  - Use protective gloves.

- Volatile Organic Contaminants
  - Pre-survey the site with an HNu 101 or OVA 128 prior to collecting soil samples.
  - If monitoring results indicate organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

13. References

ASTM D 1586-67 (reapproved 1974), ASTM Committee on Standards, Philadelphia, PA.

ASTM D 1586-84, Penetration Test and Split Barrel Sampling of Soils.

Barth, D. S. and B. J. Mason, 1984, *Soil Sampling Quality Assurance User's Guide*, EPA-600/4-84-043.

US EPA ARCHIVE DOCUMENT

de Vera, E. R., B. P. Simmons, R. D. Stephen, and D. L. Storm, 1980, *Samplers and Sampling Procedures for Hazardous Waste Streams*, EPA-600/2-80-018.

Ecology and Environment, Inc., 1990, *Standard Operating Procedures*: "Equipment Decontamination," and "Sample Packaging and Shipping."

Mason, B. J., 1983, *Preparation of Soil Sampling Protocol: Technique and Strategies*, EPA-600/4-83-020.

U.S. Environmental Protection Agency (EPA), 1984, *Characterization of Hazardous Waste Sites – A Methods Manual: Volume II, Available Sampling Methods*, (2nd ed.), 1984, EPA-600/4-84-076.

_____, 1991, *Removal Program Representative Sampling Guidance: Volume I – Soil*, (Interim Final), EPA-9360.4-10.

_____, 1984, *Characterization of Hazardous Waste Sites – A Methods Manual: Volume I, Site Investigations*, Section 7: Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, EPA/600/4-84/075.

_____, February 1989, *Methods for Evaluating the Attainment of Cleanup Standards: Volume I, Soils and Solid Media*, EPA/230/02-89/042.

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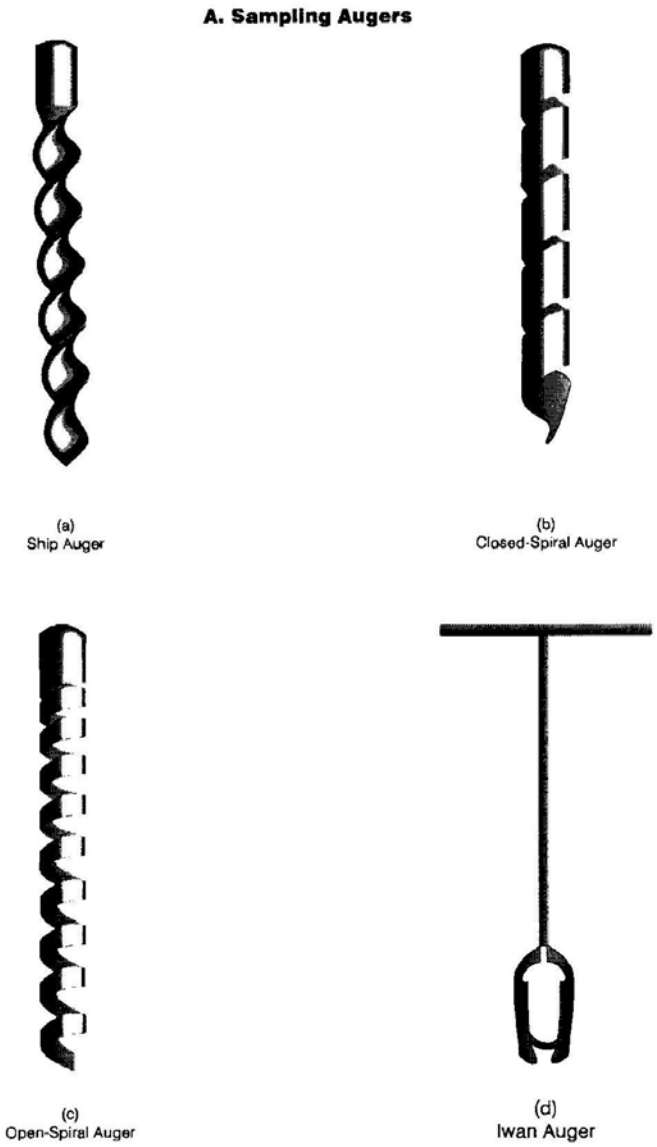
A SAMPLING AUGERS



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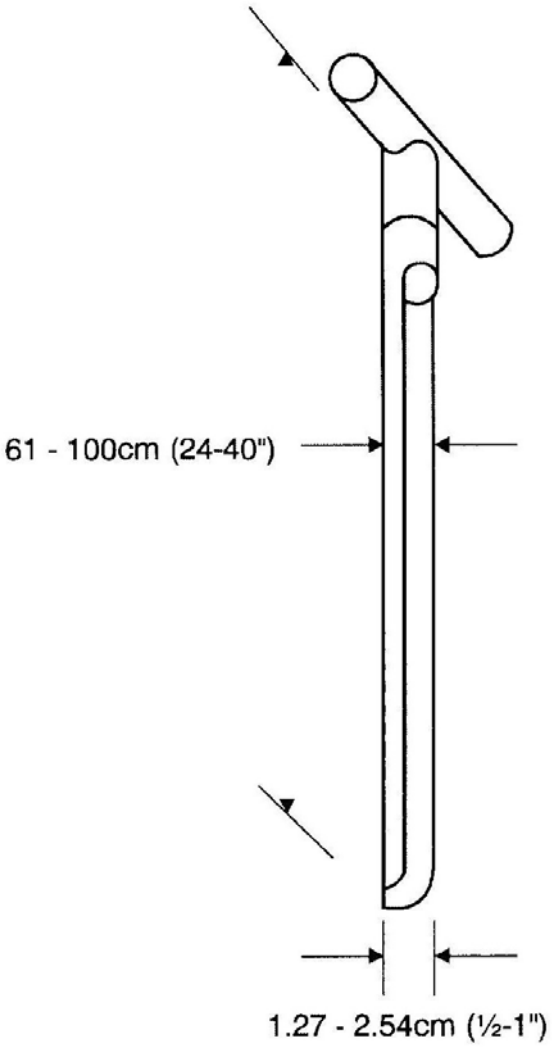
B SAMPLING TRIER



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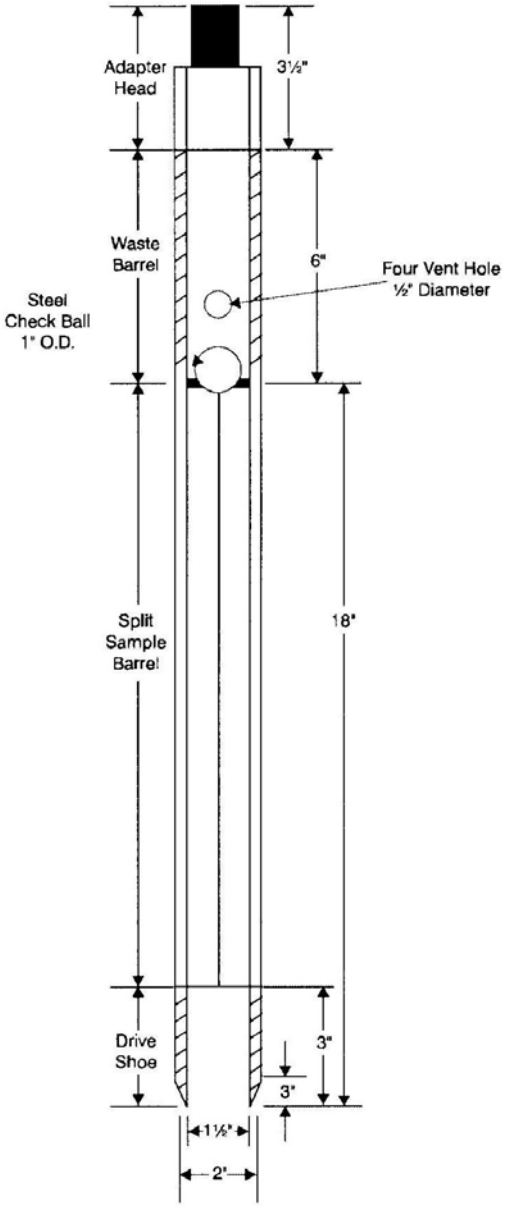
C SPLIT-SPOON SAMPLER



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SOP-20: Pneumatic Slug Test (PST) Procedures/Protocols

1.0 Purpose

The purpose of this standard operating procedure (SOP) is to describe the methodology for conducting pneumatic slug testing (PST) utilizing direct push/percussion (Geoprobe) drilling machinery and appurtenances, in concert with Geoprobe-designed PST equipment, sensors and data recording equipment.

The goal of the PST work is to obtain the field data for determining hydraulic properties of the onsite water table aquifer and/or a specified vertical interval of the aquifer. The resultant data obtained from application of this practice are modeled with appropriate analytical procedures. Field data obtained during this work will be utilized to calculate onsite hydraulic conductivity values at varying depths within the unconfined water table.

Hydraulic conductivity is a measure of a formation's ability to transmit water and is one of the most important hydrogeologic parameters to be determined at a contamination site. Estimates of groundwater flow velocities, well yields, and rates of contaminant migration will be directly proportional to the value of the hydraulic conductivity and associated errors in determining this value.

A slug test involves the abrupt removal, addition, or displacement of a known volume of water and the subsequent monitoring of changes in water level as equilibrium conditions return. The measurements are recorded and analyzed by one or more methods. The rate of water level change is a function of the K of the formation and the geometry of the well or screened interval. By performing a series of slug test at discrete vertical intervals and tests in proximally-spaced temporary wells, important information can be obtained about the vertical and horizontal variations of hydraulic properties for the site. Slug tests provide spatially discrete hydraulic conductivity values; they are relatively quick to perform and involve removal of little or no potentially contaminated water.

A Pneumatic Slug Test system was developed by Geoprobe® Systems to conduct pneumatic slug tests in saturated formations of unconsolidated soils or sediments. The system provides high-quality data for accurate determination of formation hydraulic conductivity (K). The slug test system is self-contained and is easily taken from site to site. In pneumatic slug testing, a temporary well is installed utilizing direct-push/percussion drilling methods and machinery. The temporary well head is sealed, and air pressure is used to displace/lower the water level. As air pressure in the well is increased, the water level falls until the water pressure "up" and the air pressure "down" are equal. Once the water level is stable, a release valve is quickly opened, instantaneously releasing the air pressure. The water level recovers (rising head test) without splashing and the pressure transducer and data logger/computer record the changes in water level and time. The PST system includes a pressure manifold and rod adapters, small diameter high resolution pressure transducer, data logger that adapts to the field technicians portable computer, and a pressure pump for applying air pressure to the top of the casing.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in who are engaged in pneumatic slug testing at the Project Site.

This SOP focuses on the performance of pneumatic slug test applications anticipated at Project SOWand should be used in conjunction with other applicable project SOPs, including the following*:*

- *SOP- Field Documentation*
- *SOP- Hollow Stem Auger and Direct Push Drilling Methods*
- *SOP- Equipment Decontamination Procedures*

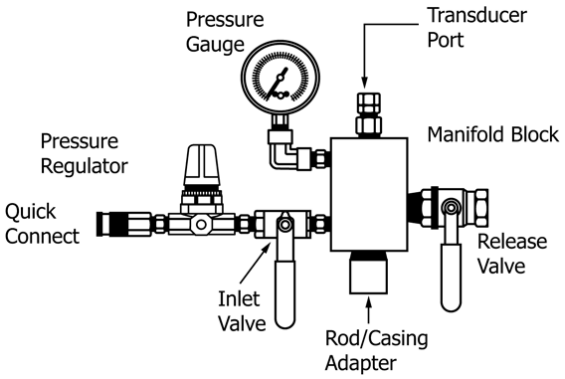
- *SOP- Field Procedure Change Management*

3.0 Protocols and Procedure Description

3.1 Equipment and Materials

The following discussion provides descriptions and details for the Geoprobe® Pneumatic Slug Test Kit in conjunction with direct push (DP) groundwater sampling tools (SP16, SP22, etc.) to perform slug tests at the Site:

- *Pneumatic Manifold:* The pneumatic manifold is an airtight system to allow for control of air pressure inside the wellhead. The primary features of a pneumatic manifold are depicted in the below figure



  - Inlet valve: Connects an air or vacuum source to the assembly
  - Pressure regulator: Modulates the rate of pressurization of the temporary well head
  - Pressure/vacuum gauge: Monitors pressure in the wellhead, graduated in inches of water pressure (Used for leak testing and monitoring the amount of water level change in the wellhead).
  - Transducer Port: Air tight fitting that allows the transducer and cable to move up and down for placement at various depths within the temporary well.
  - Release valve: Ball Valve that may be opened rapidly to allow for quick exchange of air between the wellhead and ambient atmosphere.
  - Note: The release valve opening should be approximately the same diameter or larger than the well casing to be tested. This will provide for unhampered airflow and minimize generation of any noise as the pressure in the wellhead changes rapidly.
  - Casing adapter: Allows the pneumatic manifold to attach to the DP drive rods with an airtight connection. The casing adapter should attach to the well casing or drive rod in such a way as not to reduce the ID below that of the ID of the casing to be tested.

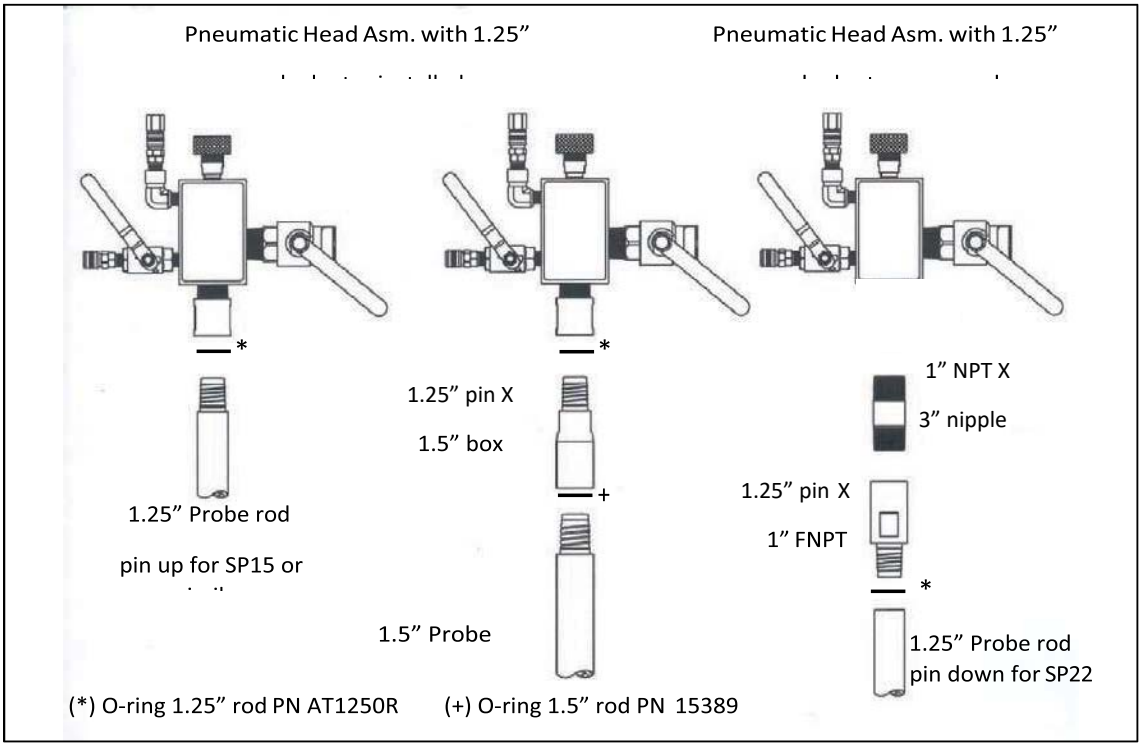
- *Pressure Transducer*: A pressure transducer is a type of submergible measurement device that converts pressure-induced mechanical changes into an electrical signal, which is recorded by an at-grade data logging device. Pressure transducers rated between 5 and 10 psi are generally suitable for this work, because the transducer is placed approximately 3 and 5 feet below the water level for most test conditions. Pressure ratings of 20 psi or higher may be acceptable, but if small head changes are used, resolution of higher pressure transducers may be inadequate. The diameter of the transducer and cable should allow its insertion down hole without interference. Dark cables on pressure transducers are subject to heating when exposed to sunlight. This may cause fluctuations in transducer response and errors in slug test data analysis. Minimize exposure of transducer cables to sunlight. Also allow pressure transducer to equilibrate to ambient water temperature as specified by manufacturer before initiating slug tests.

- *Data Logger/Analog to Digital Inverter*: Portable data loggers utilized to capture the transducer signal and store it for later download to a computer for plotting and analysis. The data logger converts the analog signal from the transducer to digital signal that is received by the computer for live time display and storage in data files. Some systems use an analog to digital inverter to acquire the analog signal from the pressure transducer and convert it to digital format for direct upload to a portable computer. Some data acquisition systems allow the user to observe the slug test response as the test is conducted in the field. Be sure the data acquisition system will provide for sufficient sampling rate to capture fast recovering water levels or oscillatory responses if these conditions are anticipated. Sampling rates of 5 to 10 Hz may be needed when oscillatory responses occur.

  Integral data-power cables will be employed to download data from the data logger to the portable computer. The 12-volt power inverter connection on the cable will provide electrical power required to operate the data logger, pressure transducer and portable computer.

- *Air/Vacuum Supply:* Either a small-scale compressor, hand pump or foot pump may be used to create sufficient pressure inside the temporary well head required to depress the water level a sufficient amount to conduct the slug test(s).

- *Drive Rod Adapters:* Adapters will be used to attach the pneumatic head specifically designed to provide an airtight fitting for the drive rods (see figure below).



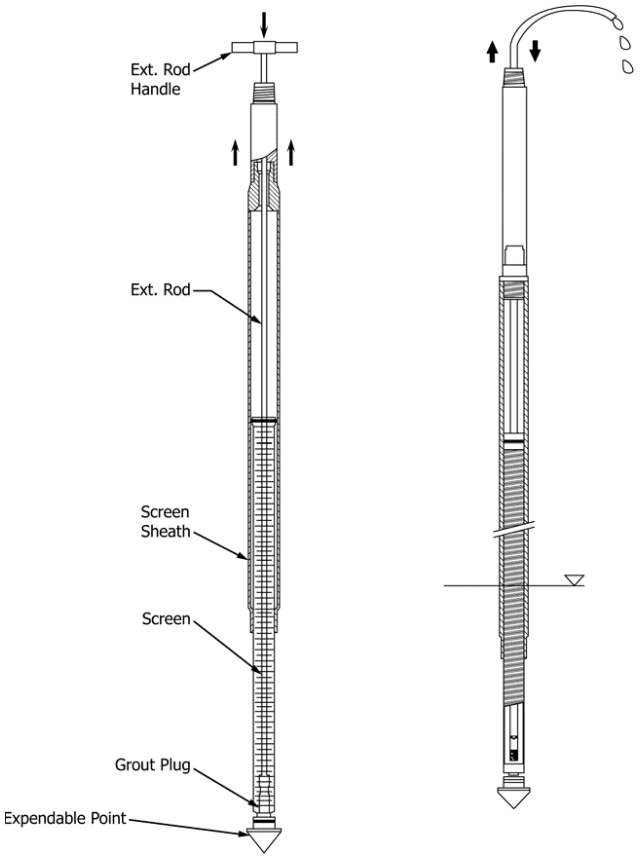
- *Miscellaneous Supplies and Accessories:* O-rings and plumbers tape may be used to ensure airtight manifold fittings. Soapy liquid may be used to conduct leak testing on exposed fittings and connections.

3.2 Temporary Well Point Installation and Test Preparation

3.2.1 Well Installation and Development

Utilizing Geoprobe drilling machinery, a Geoprobe Model Screen Point 16 (SP16) will be driven to the PST depth, utilizing the drilling protocols and procedures cited in the *SOP for Hollow Stem Auger and Direct Push Drilling Methods.* The SP16 is a stainless-steel well screen within a sealed steel sheath. Once the PST desired depth is attained, the well screen is deployed, exposing the screen to the formation and allowing groundwater to enter the temporary well. The SP-16 is designed for use with 1.5-inch probe rod. It is important that connections between the drilling rods and the connection between the SP16 and lead drill rod are tight with correct sized o-rings installed between each piping connection, to ensure an air-tight seal.

Development of the temporary well must be conducted to assure that natural flow of groundwater is established between the formation and sampling device. When installed in sandy formations, such as the Calumet Sand formation located beneath site grade, the temporary well may be adequately developed (see below figure) with a simple check valve attached to LDPE tubing to assure that representative slug tests and hydraulic conductivity (K) values are obtained. Typical purge volumes required for development range between 1 and 5 gallons; said purged groundwater will be containerized and handled in accordance with the protocols and procedures cited in the *SOP-for Investigative/ Remedial Derived Waste Management.*

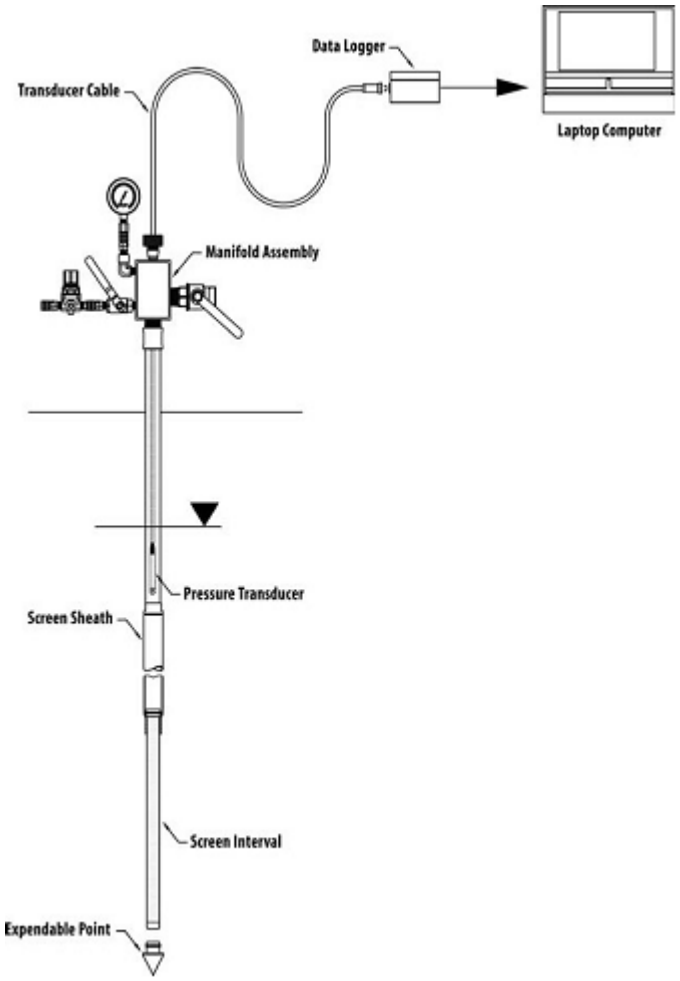


3.2.1 Pneumatic Manifold and Transducer installation

Upon completion of development work, the pneumatic manifold and transducer will be installed using the following procedures:

- Install the pneumatic head on the at grade probe rod using the appropriate adapter.

- Appropriate O-rings, plumbers tape or bushing will be used to obtain an air tight seal between the pneumatic head and probe rod.
- When the pneumatic head is installed unthread the knurled fitting from the transducer port and remove the copper washer and split bushing
- Replace the copper washer and knurled fitting on top of the transducer port.
- Lower the transducer down through the well until it is submerged 3 to 5 feet below the static water level. Allow the transducer to cool to the ambient groundwater temperature (usually 3 to 5 minutes) before slug testing is started.
- Reinstall the split bushing to complete the seal after the transducer is zeroed at atmospheric pressure (see below description).
- Ensure that the transducer cable is out of direct sunlight at grade and that the cable is free from obstructions, which may interfere with transducer venting and render the transducer inoperable. Utilize foam pipe insulation around exposed sections of transducer cable to prevent solar heating and resultant baseline drift.



3.2.2 Transducer Calibration and Data Logging Software Preparation

Baseline transducer calibration and software preparation will be performed prior to initiating the test(s). After the the data power cable is connected the data logger, to the computer and 115VAC power supply, and the transducer is attached to the sensor port on the data logger, the attached power inverter will be plugged into a generator and energized. Generally the transducer is placed at least 3 feet but not more than 6 feet below the static water level. Shallower placement is preferred for oscillatory responses, as deeper placement can result in attenuation of the oscillatory signal.

Once this is performed, the first step is to calibrate the transducer, utilizing the following steps:

- When the software is opened select either English or metric units for display of the data onscreen when prompted.
- Assign the data logger communication port.
- Plug in the USB cable from the data logger into the portable computer
- Select the sampling rate required to obtain sufficient data density for adequate modeling of the slug test recovery curve.
- For slow recovering over damped tests (10 minutes or more to recover) a sampling rate of 1 Hertz (Hz) is usually sufficient.
- For moderately fast over damped tests (e.g. 3 to 10 min.) a sampling rate of 2 Hz is usually sufficient.
- For fast recovering over damped tests and all under damped (oscillatory) responses a sampling rate of 5 Hz or 10 Hz should be selected
- Choose either Monitor and Log to name and save a data file or Monitor Only if you want to only observe the transducer response.
- Note: The monitor only setting is useful for leak testing and initial evaluation of a wells response before saving data.
- After the filename is entered (or monitor only is selected) the transducer zero window opens on the screen. Select the Zero Transducer option.
- A window will open on the computer screen that shows the transducer voltage readout on the screen. At higher frequency sampling rates (e.g. 10 Hz) the voltage readout value will change rapidly in the last 3 decimal places, which is normal. Once the transducer has cooled in the ambient water raise it above the water level and zero it at atmospheric pressure. This will allow the operator to know how deep the transducer is placed below the water level.
- After continuing at zero the monitor screen opens and the transducer signal scrolls horizontally across the screen as the time axis expands with increasing time. Initially the transducer voltage will appear noisy and erratic. This is because the vertical axis auto scales to show a magnified baseline. Once the transducer is submerged below the water the vertical axis (Head in feet) will auto adjust. Baseline noise will usually be greater for higher frequency sampling rates (e.g. 10 Hz) but should be very small compared to the slug test response.
- Once zeroed the transducer is lowered to the desired depth below the water level and the red split bushing is installed around the transducer cable below the copper washer and the blue knurled fitting. The knurled fitting is manually tightened to provide an airtight seal between the bushing and the transducer cable. Lubricate the split bushing with vacuum grease so the bushing slides in the seat and compresses without gaps or voids.

3.2.3 Transducer Calibration and Data Logging Software Preparation

To verify that rod or casing joints and the pneumatic head are air tight a leak test is performed using the following procedural steps:

- Insert the pressure gauge in the upright quick connect and attach the hand pump (or other air pressure source) to the horizontal quick connect.
- If a higher pressure air source is used place the pressure regulator assembly between the source and the

inlet valve to prevent damage to the gauge and jetting air into the formation

- Pressurize the well head to about 20 inches of water pressure. This will result in increased pressure readout on the computer screen that will return to the original baseline pressure. The total combined air pressure and water pressure over the transducer will return to equilibrium.
- If excess air pressure is applied the water level will drop below the transducer and the stabilized pressure observed onscreen will exceed the ambient water pressure observed by the transducer. Reduce excess air pressure so that valuable early time response data is not missed when the test is started.
- Observe the pressure gauge for leak testing. Air pressure observed on the gauge and computer screen will fluctuate up and down as air is pumped into the well head and water flows out of the screen. Once pumping is stopped the air pressure should stabilize and the gauge readout indicates how far (inches) the water level has been lowered in the well.
- Add more air if a larger initial head (Ho) displacement is desired.
- <u>If the air pressure readout on the gauge continues to fall and returns to zero there is a system leak</u>. Tighten any leaky fittings until an air tight system is obtained. Once the system is air tight slug tests may be conducted.

Note: Leaks may occur downhole at probe rod joints or well casing joints. Use a pipe wrench to snug the probe rod tool string and seal joints. If downhole leaks cannot be sealed the pressure regulator and air supply may be used to stabilize slow leaks so that a successful slug test may be obtained. Install the regulator at the inlet valve and use the air supply to provide a steady air flow to offset small air leaks down hole

3.3 Slug Test Performance

Once leak testing is completed, the transducer zeroed and the file has been named slug testing will be initiated. Ensure to click on the SAVE icon on the computer screen so the data is saved to file.

The pressure required to perform a successful slug test is relatively low, not more than 1 to 2 psi maximum. Higher pressures and larger initial head values are not required to obtain a representative slug test as the calculated K value is independent of initial head magnitude For under damped (oscillatory) responses larger H_o values may actually result in attenuation of the test response and an under estimation of K. Usually, H_o values between about 35 to 40 inches of water pressure are used for pneumatic slug tests. For slow recovering over damped responses (over 15 minutes for recovery) it may be useful to allow the test to recover only to about 90% before starting pressurization or evacuation for the next test, note this in the log book (as per *SOP for Field Documentation*). For moderate to fast over damped recoveries and all under damped tests it is best to allow the formation to fully recover between tests. This is necessary so that accurate modeling and calculations can be obtained for these shorter duration tests.

The following slug test procedures will be employed:

- The following Field information and historic geologic information will recorded on a Slug Test form (Attachment A), prior to initiating the test:
    - Le = effective screen length
    - Lw = length of water column
    - Rb = borehole/filter pack radius
    - rt = radius of transducer cable
    - SWL = static water level
    - h = saturated thickness of aquifer
    - Ls = physical screen length
    - Rs = screen radius
    - Rc = casing radius
    - Ts = depth transducer submerged
    - TD = total well depth

- H_o = initial head change for slug test

Note: In wells < 2 inch/50mm diameter the casing radius should be corrected for the diameter of the transducer cable. The corrected radius (Rcc) is calculated as follows: $Rcc = (Rc^2\ rt^2)^{1/2}$.

- To perform rising head tests install the pressure gauge on the pneumatic head and set the valve on the hand pump to pressure. For falling head tests install the vacuum gauge on the pneumatic head and set the valve to vacuum on the hand pump.
- Close the release valve on the pneumatic head and pressurize or evacuate the well head to the desired H_o value.
- Close the inlet valve.
- Allow the pressure to stabilize on the gauge and computer screen.
- Quickly open the release valve to initiate the slug test.
    - The slug test response is observed onscreen in real time. Note the difference in the response of the rising and falling head tests.

Basic field quality control may be performed by conducting repeat tests with the same initial head in the same data file (Figure 15). When this is done the operator can visually compare the peak height, symmetry, and recovery time of the repeat tests. If repeat tests with the same Ho value show noticeable differences in peak height, symmetry or recovery time it is an indication that further development of the well is required.

Additional quality control may be obtained by performing repeat rising or falling head tests with differing H_o values (e.g. 10, 20 and 30 inches of water pressure). Later, these test responses can be normalized and overlaid to verify that the slug test responses were linear over the range of head values used to perform the slug tests. This also provides confidence that the results of the tests conform with the slug test model requirements.

3.4 Slug Test Evaluation

Geoprobe® provides the user friendly Slug Test Analysis software package for modeling and calculation of the formation hydraulic conductivity (K). This package includes the Bouwer and Rice model and the Hvorslev model for calculation of K. The software provides variants of these two basic models for confined or unconfined aquifers, partially or fully penetrating wells, and over or under damped aquifer responses. A correction for oscillatory slug test responses in small diameter wells also is included in the Geoprobe® analysis software. The resultant hydraulic conductivity values will be utilized to create a revise Fate and Transport Model and

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4.0 Investigation-Derived Waste

IDW generated during purging or sampling, store and dispose of according to the Project-specific Waste Management Plan.

5.0 Records

Record details regarding the pumping method, parameter readings, purge volumes, and samples collected in the Field Notebook and on *Attachment 1: Slug Test Field Data Form*.

6.0 References

7.0 Definitions

None.

8.0 Attachments

Attachment 1: *Slug Test Field Data Form*

Geoprobe® Pneumatic Slug Test Kit (GW1600)

Installation and Operation Instructions

Instructional Bulletin No. MK3181

Prepared: January, 2011

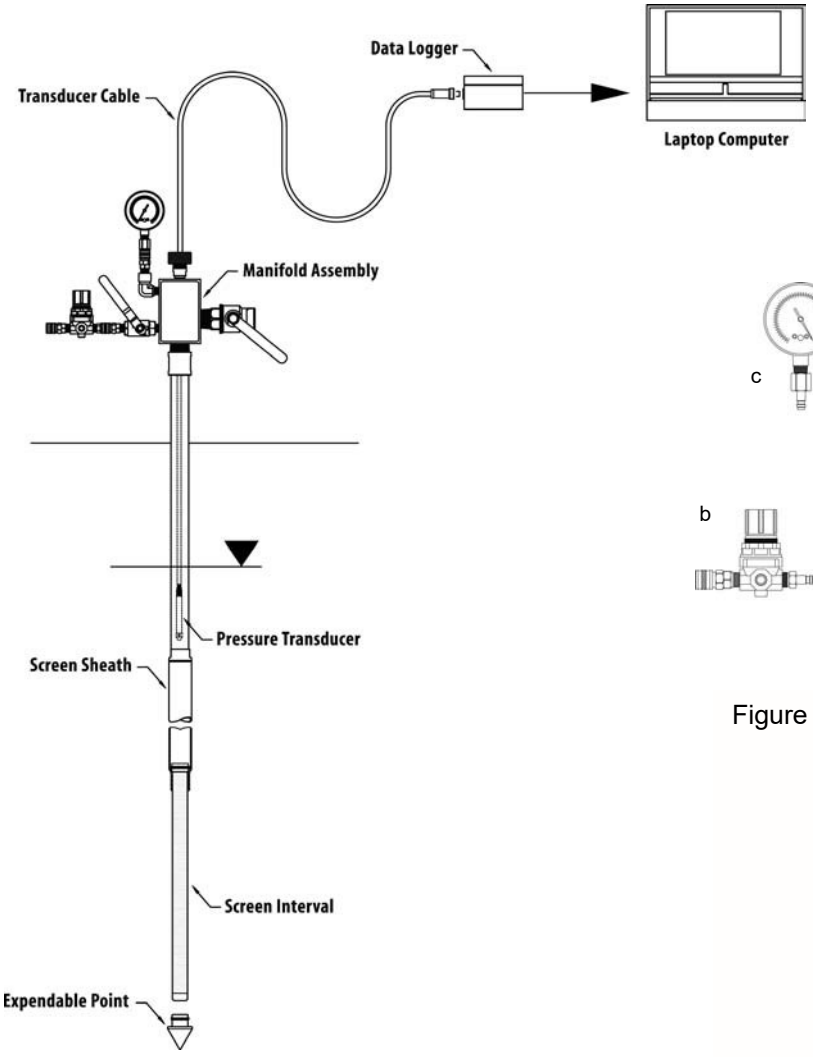

Figure A: Typical field setup with SP15/16 groundwater sampler

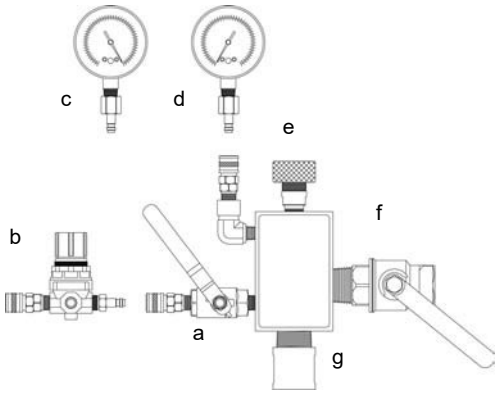

Figure B: Manifold Assembly with:

(a) inlet valve

(b) regulator

(c) vacuum gauge

(d) pressure gauge

(e) transducer port

(f) release valve

(g) 1.25” rod adapter

Operating the Pneumatic Slug Test Kit

1.0 Objective

The Geoprobe® Pneumatic Slug Test Kit is used in conjunction with direct push (DP) groundwater sampling tools (SP16, SP22, etc.) or monitoring wells to perform slug tests. The slug test responses are modeled and used to determine the hydraulic conductivity (K) of the screened aquifer (Butler 1997, Butler and Garnett 2000, Butler et al. 2002, McCall et al. 2002). This bulletin identifies the tools and basic techniques required to successfully operate the Pneumatic Slug Test Kit. The DP groundwater samplers (Geoprobe® 2006a, 2010) may be installed at multiple depths (profiling) and locations across a site to define the spatial variations in K and contaminant distribution. The procedures outlined below conform to the ASTM Standard Practice D 7242 (ASTM 2007a) for performing pneumatic slug tests with DP methods.

2.0 Required Equipment

All the components of the Pneumatic Slug Test kit are provided in a carrying case for ease of transportation. The major components of the kit (Figure 1) include the pneumatic head assembly, pressure transducer, data logger and accessories needed to complete the slug testing process. When slug testing PVC wells additional PVC adapters will be required (PN GW1601K for sch. 40 PVC wells ≤1-inch, PN 35442 for sch. 40, 2-inch PVC wells).

3.0 Preparation Before Slug Testing

The groundwater sampling tools (Figure A, cover; Geoprobe® 2006, 2010, ASTM 2007b) or monitoring wells (Geoprobe® 2006b, 2006c, 2009, ASTM 2007c) must be installed properly before slug testing can be performed. For both wells and DP groundwater samplers O-rings must be used on each casing or rod joint respectively, to provide for an airtight system needed for pneumatic testing. Once installed the groundwater samplers or wells must be adequately developed (ASTM 2007d, Geoprobe® 2002a) to obtain representative slug test results. When installed in sandy formations many groundwater samplers and wells may be adequately developed (Figure 2) with a simple check valve (PN GW4210, GW4230 or GW4230) to assure that representative slug tests and K-values are obtained. Water quality sampling usually requires more stringent methods for well development (Geoprobe® 2002a, ASTM 2007d).

For short screen groundwater samplers and wells purging as little as 1 to 5 gallons (4 to 20 liters) is often sufficient. Be sure to document well construction parameters (screen length, boring diameter, casing radius, etc.) so that K may be correctly calculated. Information about aquifer thickness and whether the aquifer is confined or unconfined will need to be determined to enable correct K calculation.

In order for pneumatic slug tests to be successfully performed the static water level must be above the screened interval of the well, prior to and during the pneumatic slug test. If this is not the case mechanical slug tests may be performed on the well using the transducer, data logger and software included with the kit. A mechanical slug is not included with the GW1600 kit.

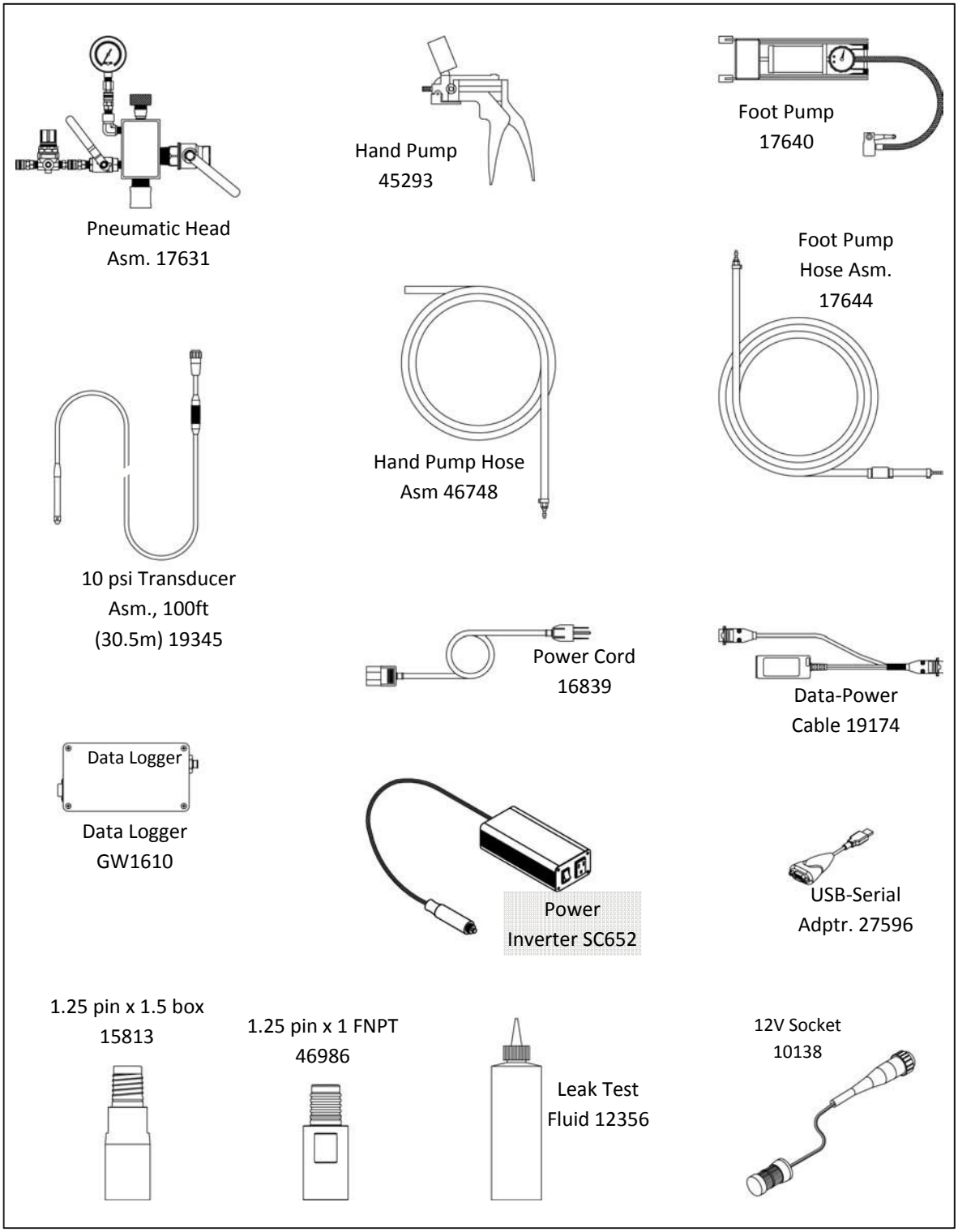

Figure 1: Major Components of the GW1600 Pneumatic Slug Test Kit (not to scale).

4.0 Installation of the Pneumatic Head and Transducer

The pneumatic head is installed on the probe rod using the appropriate adapter (Figure 3). When slug testing PVC wells additional PVC adapters will be required to attach the pneumatic head to the well casing (Geoprobe® 2002b). Use appropriate O-rings, plumbers tape or bushing to obtain an air tight seal between the pneumatic head and probe rod or PVC casing. When the pneumatic head is installed unthread the knurled fitting from the transducer port and remove the copper washer and split bushing (Figure 4). Replace the copper washer and knurled fitting on top of the transducer port. Next lower the transducer down through the well until it is submerged 3 to 5 feet (1 to 1.5m) below the static water level. Allow the transducer to cool to the ambient groundwater temperature (usually 3 to 5 minutes) before slug testing is started. Reinstall the split bushing (Figure 4) to complete the seal after the transducer is zeroed at atmospheric pressure (see below).

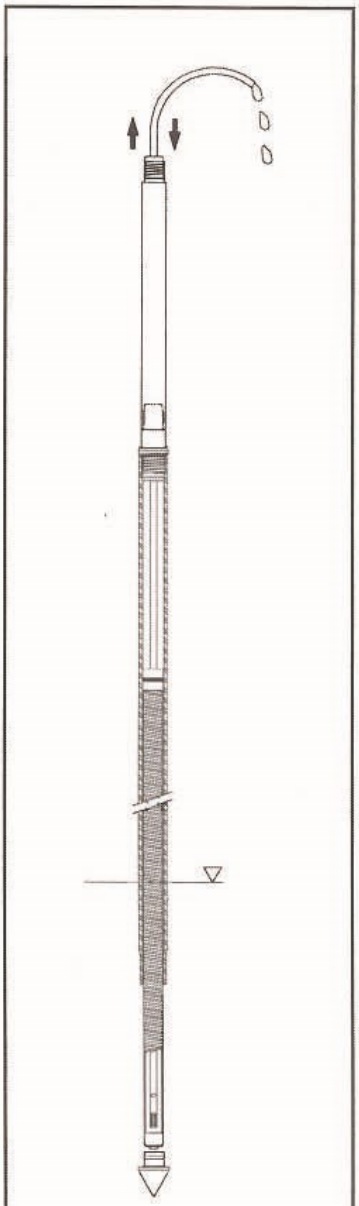

Figure 2: Development with check valve by surging and purging. Mechanical actuator (MB6120) may be used.

Please review the following notes to be sure you obtain valid data and to minimize potential damage to kit components:

NOTE: The inside diameter of the release valve used to initiate the test should be of equal or greater ID than the well casing to assure free flow of air from the well and that no interference or noise occurs to degrade data quality. The release valve on the pneumatic head has an ID of 1.0 inches (25.4 mm). A pneumatic head adapter (PN 35442) is available for 1.5-inch and 2-inch (38 and 50mm) PVC wells.

IMPORTANT: The transducer is delicate. Do not step on or strike the transducer as it may be damaged. Do not submerge the transducer more than 15 ft (4.5 m) below the static water level. Do not place the transducer in water with high concentrations of solvents or where free product is present as it can be damaged.

IMPORTANT: The transducer is vented by a small tube running through the cable. Do not kink the transducer cable as the vent tube may be pinched. This can result in an inoperable transducer.

NOTE: Keep the transducer cable out of direct sunlight before and while tests are being performed. Sunlight will warm the air in the vent tube and may cause noticeable drift of the baseline. This can interfere with modeling of the slug test response and accurate calculation of K. Foam pipe insulation may be placed around exposed sections of transducer cable to prevent solar heating and baseline drift on sunny days.

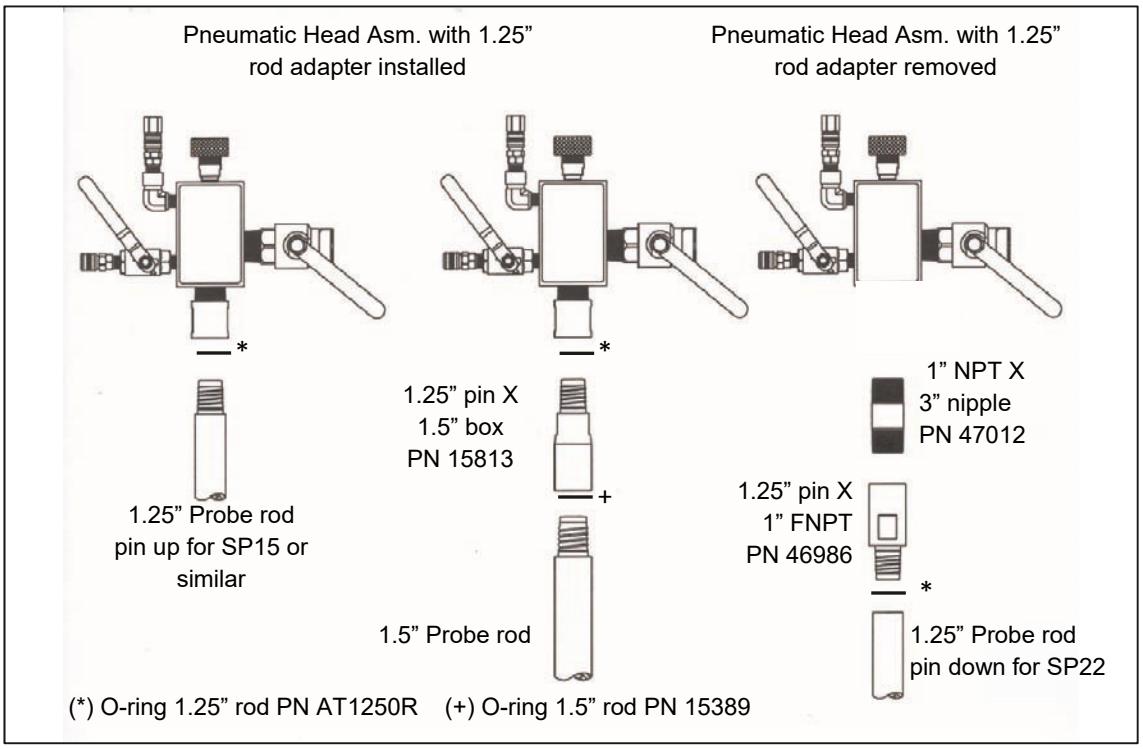

Figure 3: Installation of the pneumatic head on different probe rod/groundwater sampler configurations. When slug testing PVC wells additional PVC adapters will be required to attach the pneumatic head to the well casing (Geoprobe® 2002b).



Figure 4: Transducer seal assembly showing the split bushing on the transducer cable after the transducer is zeroed and lowered to depth.

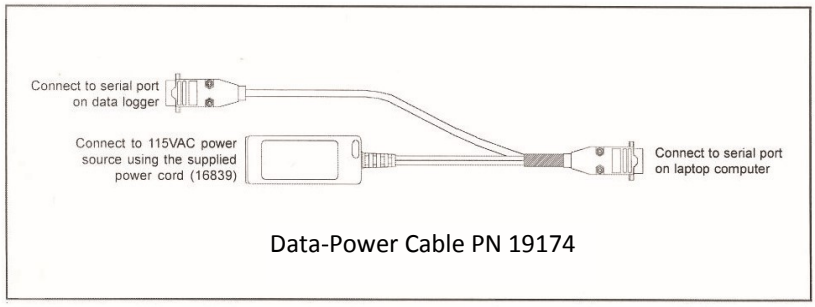

Figure 5: The integral data-power cable is used to attach the data logger to the laptop computer for signal transmission as well as to the external power supply to operate the data logger and transducer. A serial-USB adapter (PN 27596) is included with the kit so the logger can be connected to USB ports. The 12V power inverter (PN SC652) included with the kit may be attached to the Power Point of a Geoprobe® unit or vehicle. This will provide the electrical power required to operate the data logger, transducer and portable computer.

5.0 Acquisition Software and Data Logger

The Slug Test Acquisition software (PN GW1615) is provide on a CD with the kit. Install the CD in the optical drive of the computer and follow the onscreen instructions for installation. This usually requires less than 2 minutes. A folder titled "dirim95" is created on the computer hard drive to store the acquisition software. The data files (*.dat) generated by slug testing are saved in a subfolder titled "logfiles" for later retrieval, viewing and modeling.

The data-power cable (Figure 5, above) is used to connect the data logger (PN GW1610, Figure 1) to the computer and 115VAC power supply. The power inverter (PN SC652) supplied with the kit may be plugged into a vehicle or Geoprobe® unit power point to provide the electrical current required to operate the system. The transducer is attached to the sensor port on the data logger. The data logger converts the analog signal from the transducer to digital signal that is received by the computer for live-time display and storage in data files.

6.0 Initiate Software: Zero Transducer

When the software is opened you are prompted to select either English or metric units (Figure 6) for display of the data onscreen. Next the com port must be assigned for the data logger (Figure 7). Before the data logger is plugged into the USB port on the computer click on the drop down arrow for the com port number and note the previously assigned com ports. Next, plug the USB cable from the data logger (with transducer attached) into an available USB socket. Click the drop down arrow and refresh the com port list to see the newly assigned com port for the data logger. Click on the new com port to assign it to the data logger.

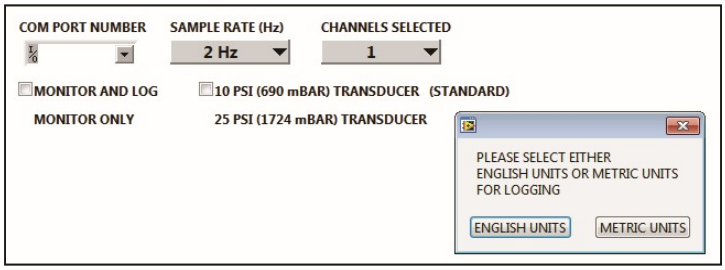

Figure 6: Opening Screen of the acquisition software prompts for units selection.

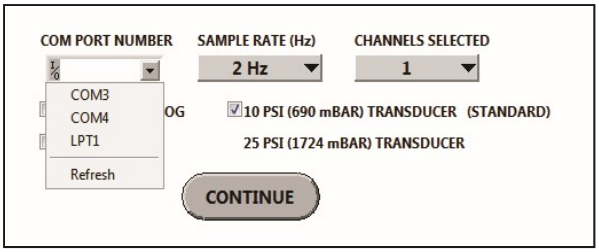

Figure 7: Activate drop down menu to define the com port where the data logger is connected.

Next select the sampling rate (Figure 8) needed to obtain sufficient data density for good modeling of the slug test recovery curve. For slow recovering over damped tests (10 minutes or more to recover) a sampling rate of 1 Hertz (Hz) is usually sufficient. For moderately fast over damped tests (e.g. 3 to 10 min.) a sampling rate of 2 Hz is usually sufficient. For fast recovering over damped tests and all under damped (oscillatory) responses a sampling rate of 5 Hz or 10 Hz should be selected.

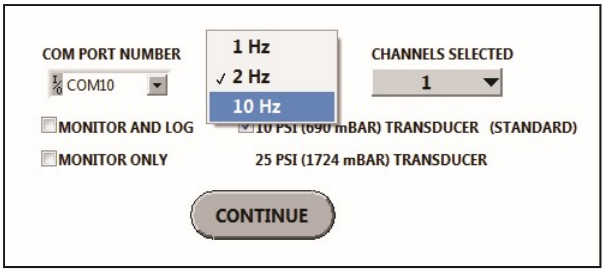

Figure 8: Activate drop down menu to define the sampling rate for the slug test data.

Once the sampling rate is set choose either “Monitor and Log” to name and save a data file (Figure 9) or “Monitor Only” if you want to only observe the transducer response. The monitor only setting is useful for leak testing and initial evaluation of a well’s response before saving data.

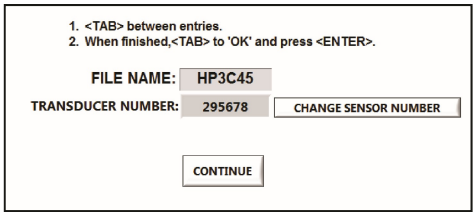

Figure 9: When the monitor and log option is selected this window opens so that a file name can be entered. The transducer serial number can be entered or changed in this window for QC tracking.

After the filename is entered, or monitor only is selected, the transducer zero window opens (Figure 10). The transducer should be zeroed to assure that good data is obtained. After selecting the Zero Transducer option a window will open that shows the transducer voltage readout on the screen. At higher frequency sampling rates (e.g. 10 Hz) the voltage readout value will change rapidly in the last 3 decimal places, this is normal. Once the transducer has cooled in the ambient water raise it above the water level and zero it at atmospheric pressure. This will allow the operator to know how deep the transducer is placed below the water level. Generally the transducer is placed at least 3ft (1 m) but not more than 6ft (2 m) below the static water level. Shallower placement is preferred for oscillatory responses, as deeper placement can result in attenuation of the oscillatory signal.

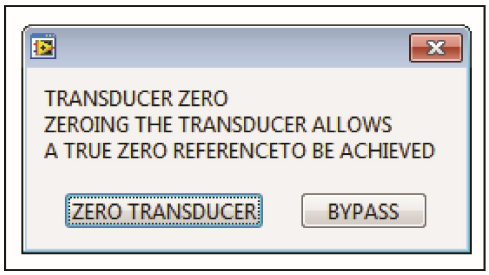

Figure 10: Zero the transducer after it has cooled to ambient groundwater temperature for at least 3 to 5 minutes. After cooling raise the transducer above the water level and click on continue to set the zero voltage.

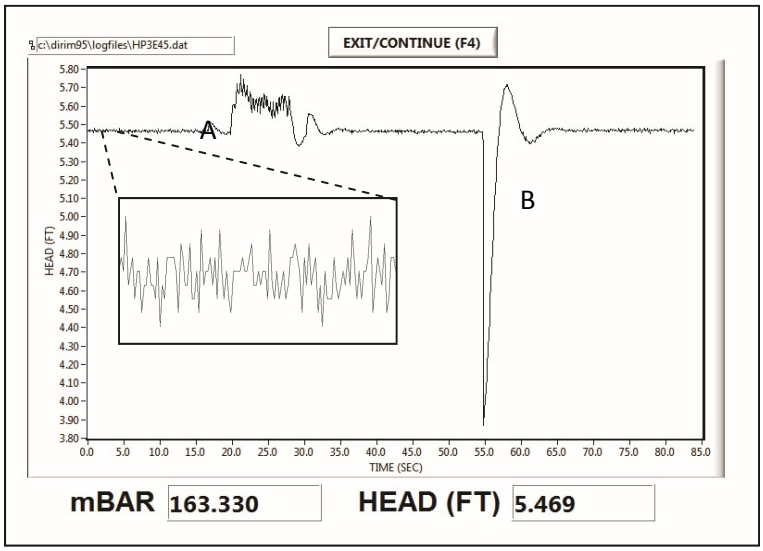

Figure 11: A magnified baseline (inset) initially appears on the screen but once the transducer is set at depth the vertical scale adjusts. Horizontal axis is time and vertical axis is head (ft or mm). A: air pressurization peaks. B: rising head, under damped test response.

After continuing at zero the monitor screen opens (Figure 11) and the transducer signal scrolls horizontally across the screen as the time axis expands with increasing time. Initially the transducer voltage will appear noisy and erratic. This is because the vertical axis auto scales to show a magnified baseline. Once the transducer is submerged below the water the vertical axis (Head in feet or mm) will auto-adjust. Baseline noise will usually be greater for higher frequency sampling rates (e.g. 10 Hz) but should be very small compared to the slug test response.

Once zeroed the transducer is lowered to the desired depth below the water level and the red split bushing is installed around the transducer cable below the copper washer and the blue knurled fitting (Figure 4). The knurled fitting is manually tightened to provide an airtight seal between the bushing and the transducer cable. Lubricate the split bushing with vacuum grease, vaseline or even clean water so the bushing slides in the seat and compresses without gaps or voids.

7.0 Leak Testing

To verify that rod or casing joints and the pneumatic head are air tight a leak test is performed (Figure 12). Insert the pressure gauge in the upright quick connect and attach the hand pump (or other air pressure source) to the horizontal quick connect. If a higher pressure air source is used place the pressure regulator assembly (PN 17633) between the source and the inlet valve to prevent damage to the gauge and jetting air into the formation.



Figure 12: Setup for leak test and rising head tests with the pressure gauge and hand pump. The gauges are graduated in inches and centimeters of water pressure (outer and inner marks respectively).

Pressurize the well head to about 20 inches (50 cm) of water pressure. This will require several pumps on the hand pump and will result in increased pressure readout on the computer screen that will return to the original baseline pressure. The total air pressure + water pressure over the transducer will return to equilibrium with the formation hydrostatic pressure. If excess air pressure is applied the water level will drop below the transducer and the stabilized pressure observed onscreen will exceed the ambient water pressure observed by the transducer. Reduce excess air pressure so that valuable early time response data is not missed when the test is started.

Observe the pressure gauge for leak testing. Air pressure observed on the gauge (and computer screen, Figure 11-A) will bounce up and down as air is pumped into the well head and water flows out of the screen. Once pumping is stopped the air pressure should stabilize and the gauge readout indicates how far (inches/centimeters) the water level has been lowered in the well. Add more air if a larger initial head (H_o) displacement is desired. If the air pressure readout on the gauge continues to fall and returns to zero there is a system leak. Use the leak check fluid (PN 12356) included with the kit and apply it to exposed joints and fittings, watch for small bubbles to appear at leaks. Tighten any leaky fittings until an air tight system is obtained. Once the system is air tight slug tests may be conducted.

Leaks may occur downhole at probe rod joints or well casing joints. Use a pipe wrench to snug the probe rod tool string and seal joints. If downhole leaks cannot be sealed the pressure regulator and air supply may be used to stabilize **slow** leaks so that a successful slug test may be obtained. Install the regulator at the inlet valve and use the air supply to provide a steady air flow to offset small air leaks down hole.

8.0 Performing Slug Tests

Once leak testing is completed, the transducer zeroed and the file has been named (Sections 5, 6 & 7) you are ready to perform slug tests. Be sure to click on the **SAVE** icon so the data is saved to file.

The pressure required to perform a successful slug test is relatively low, not more than 1 to 2 psi (~7 to 14kPa) maximum. Higher pressures and larger initial head values are not required to obtain a representative slug test as the calculated K value is independent of initial head magnitude (Butler 1997). For under damped (oscillatory) responses larger H_o values may actually result in attenuation of the test response and an under-estimation of K. Usually, H_o values between about 5 – 40 inches (~10 – 100 cm) of water pressure are used for pneumatic slug tests. For slow recovering over damped responses (e.g. 15+ minutes) it may be useful to allow the test to recover only to about 90% before starting pressurization or evacuation for the next test, note this in the log book. For moderate to fast over damped recoveries and all under damped tests it is best to allow the formation to fully recover between tests. This is necessary so that accurate modeling and calculations can be obtained for these shorter duration tests.

To perform rising head tests install the pressure gauge on the pneumatic head and set the valve on the hand pump (PN 45293) to pressure. For falling head tests install the vacuum gauge (Figure 13) on the pneumatic head and set the valve to vacuum on the hand pump.

Close the release valve (Figure B, cover) on the pneumatic head and pressurize or evacuate the well head to the desired H_o value. Close the inlet valve (Figure B). Allow the pressure to stabilize on the gauge and computer screen. Then **quickly** open the release valve to initiate the slug test. The slug test response is observed onscreen in real time (Figure 14). Note the difference in the response of the rising and falling head tests.

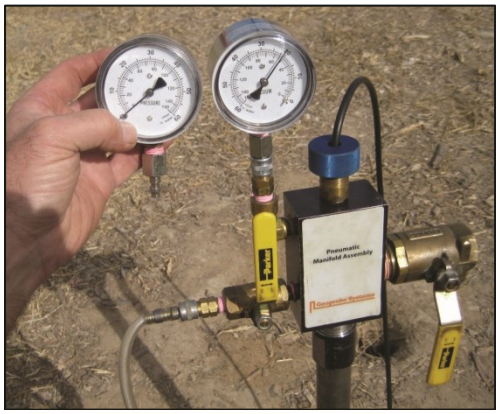

Figure 13: Use the vacuum gauge to perform falling head tests or install the pressure gauge to conduct rising head tests and for leak testing.

Basic field quality control may be performed by conducting repeat tests with the same initial head in the same data file (Figure 15). When this is done the operator can visually compare the peak height, symmetry, and recovery time of the repeat tests. If repeat tests with the same H_o value show noticeable differences in peak height, symmetry or recovery time it is an indication that further development of the well is required.

Additional quality control may be obtained by performing repeat rising or falling head tests with differing H_o values (e.g. 10, 20 and 30 inches of water pressure). Later, these test responses can be normalized and overlaid to verify that the slug test responses were linear over the range of head values used to perform the slug tests. This also provides confidence that the results of the tests conform with the slug test model requirements (Butler 1997). Slug test procedures reviewed in this bulletin meet or exceed ASTM Standard Practice requirements (ASTM 2007a).

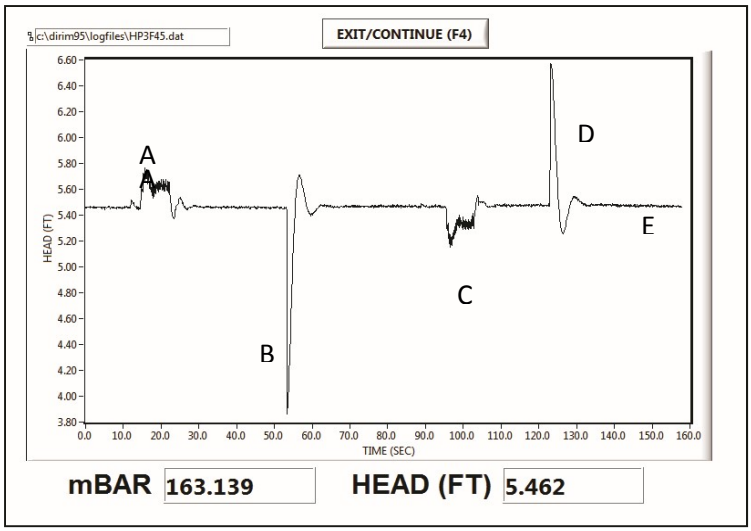

Figure 14: Performing a rising head test and then a falling head test. A: air pressurization peaks. B: rising head test. C: evacuation peaks. D: falling head test. E: stable baseline is about 5.46 ft (163 cm) for these tests, i.e. the static water level is that distance above the transducer sensor. These are examples of underdamped (oscillatory) tests.

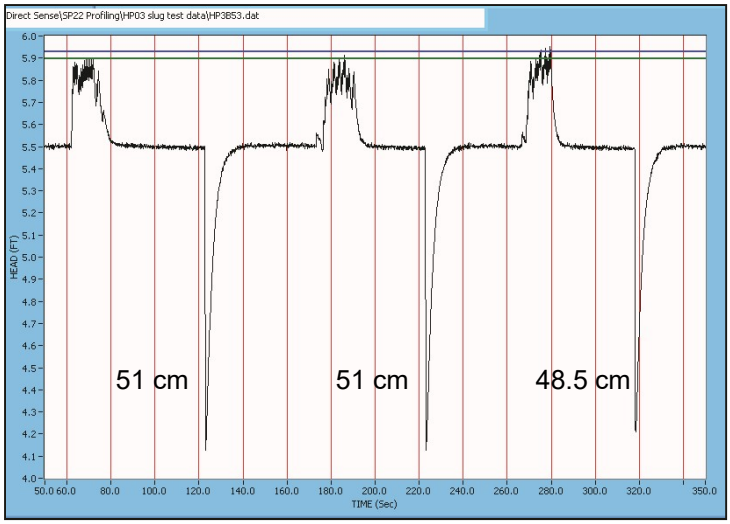

Figure 15: Repeat of over damped slug tests with approximately the same initial head value. These tests can be used for basic field QC. The H_o values were 20, 20 and 19 inches of water respectively. The similarity of peak height, symmetry and recovery time indicates that good quality tests were obtained. If noticeable variations occur between repeat tests further well development may be required.

9.0 Document Test Parameters

The field team should document how the slug tests were performed in the field so that modeling and calculations can be completed correctly once the field work is completed. The slug test field data can be documented in a simple table or form (Figure 16).

Field information about the well construction geometry (Figure 17) and aquifer type (confined/unconfined) also will be required to complete modeling of the slug test data and calculation of the formation K.

Site: ABC Plating Corp
Well No: SP22A-53ft
Operator: Stephanie Jones
Date: Oct. 10, 2010

FileTime (sec)	H_o (in)	**R**ise **F**all	Notes
120	20	R	File = HP3A53
220	20	R	overdamped
320	40	R	Slow leak
450	10	R	No leak
550	20	R	
50	30	F	New File = HP3B53
160	30	F	overdamped
280	10	F	
410	20	F	No leaks

Figure 16: Example table for documentation of slug testing information in the field. See page 14.

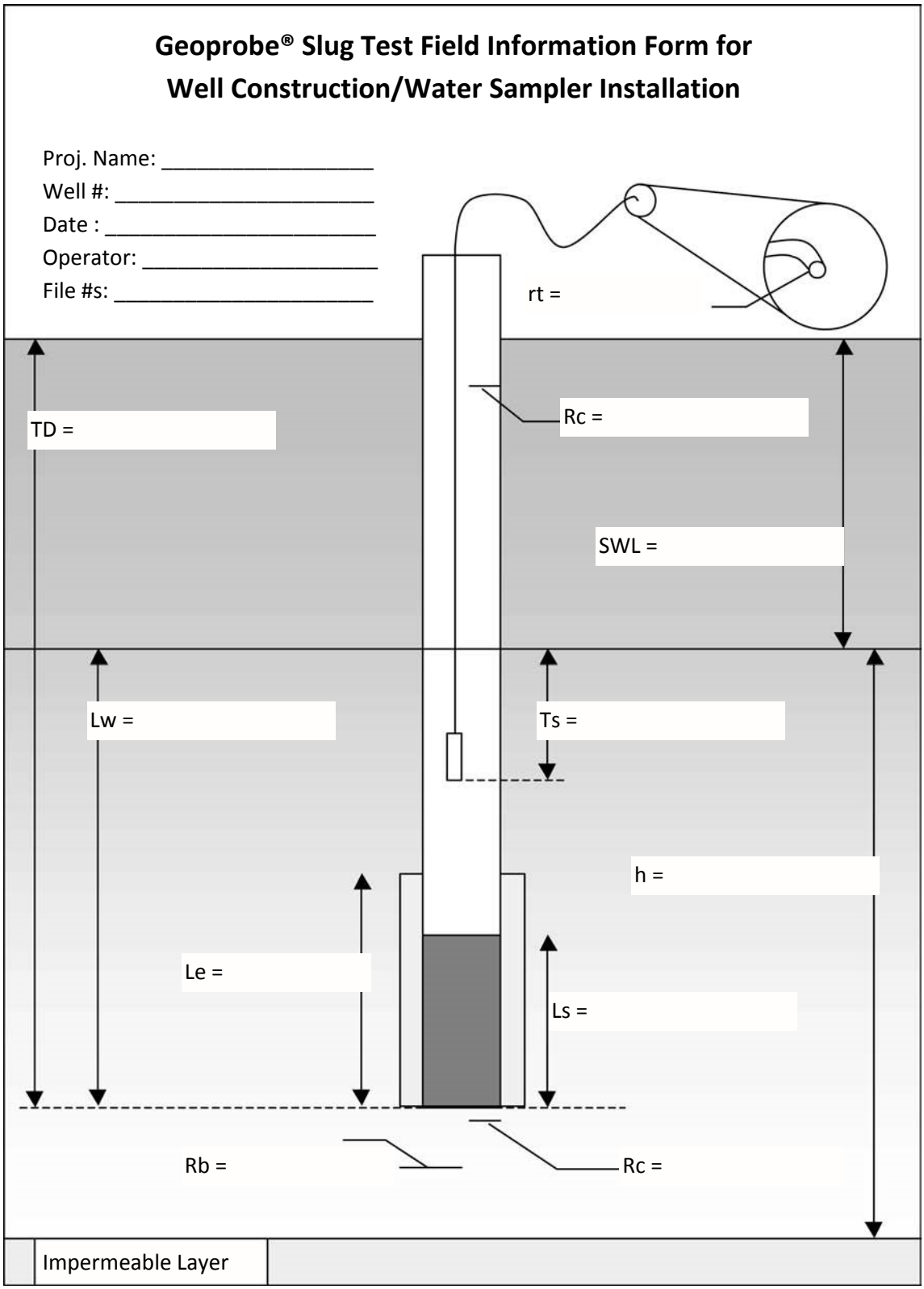

Figure 17: Field form for use in documenting well or groundwater sampler construction that is slug tested. This data required so K value can be calculated. Copy for field use. See below for parameter definitions.

Parameter definitions for Figure 17:

Le = effective screen length
Lw = length of water column
Rb = borehole/filter pack radius
rt = radius of transducer cable
SWL = static water level
h = saturated thickness of aquifer
Ls = physical screen length
Rs = screen radius
Rc = casing radius
Ts = depth transducer submerged
TD = total well depth
H_o = initial head change for slug test

In wells < 2 inch/50mm diameter the casing radius should be corrected for the diameter of the transducer cable. The corrected radius (Rcc) is calculated as follows:

$$Rcc = (Rc^2 - rt^2)^{1/2}$$ **(after Butler et al. 2002)**

10.0 Modeling and Calculation of K

Geoprobe® provides the user friendly Slug Test Analysis software package (PN GW1650) for modeling (Figure 18) and calculation of the formation hydraulic conductivity (K). This package includes the Bouwer and Rice model (Bouwer and Rice, 1976) and the Hvorslev model (Hvorslev, 1951) for calculation of K. The software provides variants of these two basic models for confined or unconfined aquifers, partially or fully penetrating wells, and over or under damped aquifer responses. A correction for oscillatory slug test responses in small-diameter wells (Butler 2002) also is included in the Geoprobe® analysis software.

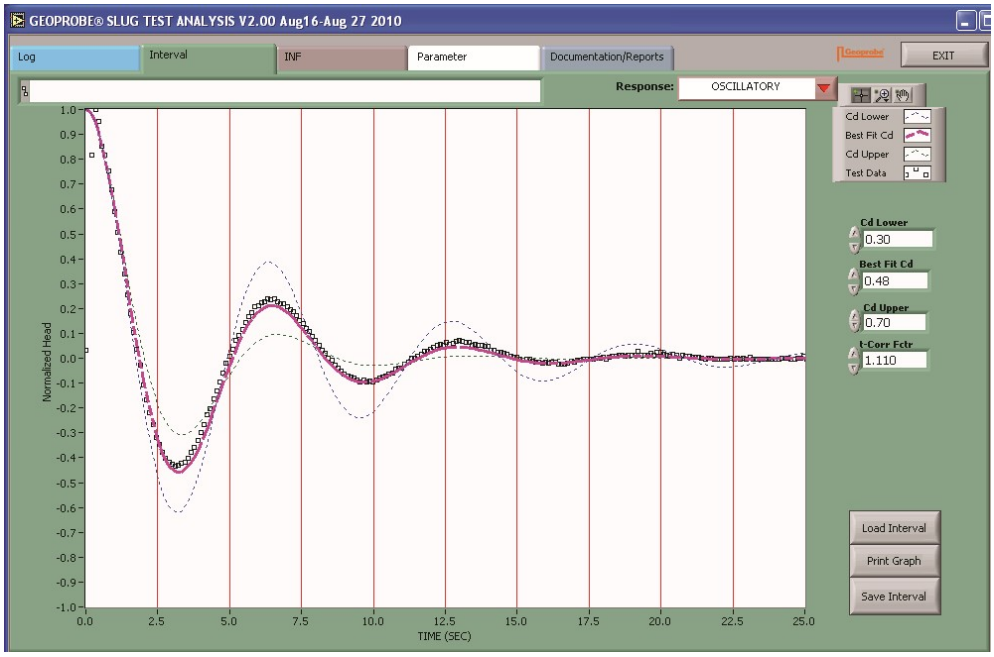

Figure 18: Modeling an underdamped slug test response with the Geoprobe® Slug Test Analysis Software package (GW1650).The software provides for calculation of K and graphical print outs. The analysis software is not included with the kit.

11.0 References

American Society of Standards and Methods (ASTM), 2007a. D 7242 Standard Practice for Field Pneumatic Slug (Instantaneous Change in Head) Tests to Determine Hydraulic Properties of Aquifers with Direct Push Ground Water Samplers. ASTM International, 100 Barr Harbor Dr., PO Box C700, West Conshohocken, PA. www.astm.org

ASTM, 2007b. D 6001 Standard Guide for Direct-Push Ground Water Sampling for Environmental Site Characterization. ASTM International, 100 Barr Harbor Dr., PO Box C700, West Conshohocken, PA. www.astm.org

ASTM, 2007c. D 6725 Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers. ASTM International, 100 Barr Harbor Dr., PO Box C700, West Conshohocken, PA. www.astm.org

ASTM, 2007d. D 5521 Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers. ASTM International, 100 Barr Harbor Dr., PO Box C700, West Conshohocken, PA. www.astm.org

Bouwer, Herman, and R.C. Rice. 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells. Water Resources Res. Vol. 12, pp 423-428.

Butler, James J., Jr. 1997. *The Design, Performance, and Analysis of Slug Tests*. CRC Press, Boca Raton, FL.

Butler, James J., Jr. and Elizabeth J. Garnett, 2000. Simple Procedures for Analysis of Slug Tests in Formations of High Hydraulic Conductivity using Spreadsheet and Scientific Graphics Software. Kansas Geological Survey Open-file Report 2000-40.

Butler, James J., Jr., John M. Healey, G. Wesley McCall, Elizabeth J. Garnett and Steven P. Loheide II, 2002. Hydraulic Tests with Direct Push Equipment. Ground Water, Vol. 40, No.1, pages 25 – 36.

Butler, James J. Jr., 2002. A Simple Correction for Slug Tests in Small-Diameter Wells. Ground Water Vol. 40, No. 3, pages 303-307.

Geoprobe® 2002a. Groundwater Quality and Turbidity vs. Low Flow. Kejr Inc. 1835 Wall St., Salina, KS. www.geoprobe.com

Geoprobe® 2002b. Geoprobe® GW1601K PVC Adapter Kit. Instruction Bulletin No. 21376. September. Kejr Inc. 1835 Wall St., Salina, KS. www.geoprobe.com

Geoprobe® 2006a. Geoprobe® Screen Point 16 Groundwater Sampler, Standard Operating Procedure. Technical Bulletin No. MK3142. Kejr Inc. 1835 Wall St., Salina, KS. www.geoprobe.com

Geoprobe® 2006b. Geoprobe® 0.5-in. x 1.4-in. OD and 0.75-in. x 1.4-in. OD Prepacked Screen Monitoring Wells, Standard Operating Procedure. Technical Bulletin No. 962000. Kejr Inc. 1835 Wall St., Salina, KS. www.geoprobe.com

Geoprobe® 2006c. Geoprobe® 10-in. x 2.5-in. OD and 1.5-in. x 2.5-in. OD Prepacked Screen Monitoring Wells, Standard Operating Procedure. Technical Bulletin No. 992500. Kejr Inc. 1835 Wall St., Salina, KS. www.geoprobe.com

Geoprobe® 2009. Geoprobe® 2.0-in. x 3.4-in. OD Prepacked Screen Monitoring Wells, Standard Operating Procedure. Technical Bulletin No. MK3172. Kejr Inc. 1835 Wall St., Salina, KS. www.geoprobe.com

Geoprobe® 2010. Geoprobe® Screen Point 22 Groundwater Sampler, Standard Operating Procedure. Technical Bulletin No. MK3173. Kejr Inc. 1835 Wall St., Salina, KS. www.geoprobe.com

Hvorslev, M.J., 1951. Time Lag and Soil Permeability in Ground Water Observations. U.S. Army Corps of Engineers Waterway Experiment Station, Bulletin 36.

McCall, Wesley, James J. Butler, John M. Healey, Alyssa A. Lanier, Stephen M. Sellwood and Elizabeth J. Garnett. 2002. A Dual-Tube Direct-Push Method for Vertical Profiling of Hydraulic Conductivity in Unconsolidated Formations. Environ. & Eng. Geoscience, Vol. VIII, No. 2, May. Pages 75-84.

Geoprobe® Slug Test Field Data Form

Site Name: _____
Well No: _____
Screen Interval: _____
Operator: _____
Date: _____
File Name(s): _____

FileTime (sec)	H_o (in/cm)	**R**ise **F**all	Notes

MIP/HPT/EC/CPT log filename: _____

Sample Nos. _____

Aquifer Type: Unconfined Confined Leaky Confined Perched

Screen Penetration: Full Partial Aquifer Thickness_____

Geologic Formation/Soils: _____

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www.geoprobe.com

SOP-21: INVESTIGATIVE/REMEDIAL DERIVED WASTE MANAGEMENT

1.0 Purpose

This standard operating procedure (SOP) provides the methodology, guidelines and procedures for the characterization, handling and disposal of wastes generated during investigative or remedial activities at the Site. The Corrective Measures Implementation Work Plan scope will incorporate various investigative and remedial activities that will likely generative both non-hazardous and potentially hazardous wastes. The planning and execution of such activities are to be in a manner that reduces wastes and consolidates waste streams.

All investigative derived waste (IDW) and remedial derived waste (RDW) will be sorted and stored onsite for characterization prior to disposal with the possible exception to purged groundwater and drill cuttings in some cases.

2.0 Scope

This SOP addresses wastes anticipated below and currently unknown. Source Area Material treatment and disposal is addressed separately from RDW (See SOP for Source Area Material Transport and Disposal). This SOP applies to all IEC personnel and subcontractors engaged in collecting samples or conducting remedial activities at the Former DuPont East Chicago Facility, Indiana (DuPont EC) and was developed per the following United States Environment Protection Agency guidance (USEPA) documents:

This SOP was developed in accordance with the following guidance documents:

- *Guide to Management of Investigation Derived Wastes - Office of Emergency and Remedial Response, Hazardous Site Control Division USEPA April 1992*
- *Operating Procedure – Management of Investigation Derived Waste- USEPA Region 4, July 3, 2014*
- *Title 40 of the Code and Federal Regulations in Part 261-271. USEPA*

This SOP focuses on the most common forms of IDW and RDW anticipated for this Project and should be used in conjunction with other applicable project SOPs including the following*:*

- *SOP-Note Taking and Field Log Books*
- *SOP- Surface and Subsurface Sampling*
- *SOP- Equipment Decontamination Procedures*
- *SOP- Sample Handling and Custody*
- *SOP- Field Procedure Change Management*

3.0 Procedures

3.1 Waste Containment and Storage

Onsite IDW and RDW will be containerized in appropriate containers (55-gal steel drums, Plastic totes etc.) and stored within the designated chemical storage area. Said area will be equipped with spill prevention kits and be situated on non-permeable surfaces. Each container will be labeled with a description of the contents and the accumulation start date. Label information will be completed in permanent marker. Example labels of applicable waste streams are included in Attachment 1. During on site storage, drummed waste must have one label affixed to the top 1/3 of each drum and clearly visible.

When roll-offs utilized, they must comply with DOT rules. Roll-off boxes that contain hazardous waste will require one label per side (four total) before offering the roll-off box for shipment. RCRA non-hazardous wastes need only one label indicating non-hazardous waste for shipment and hazard communication purposes.

Waste containers may be stored within chemical storage areas until characterization is completed or if an intended volume will be accumulated. During storage all waste will be treated as Hazardous pending analysis material and condition be inspected on a weekly basis by the HSO.

The accumulation period for non-hazardous waste should not exceed 365 days from the date of generation. The accumulation period for hazardous waste and waste pending analysis should not exceed 90 days from the date of generation.

3.2 Anticipated IDW and RDW

Based on the scope of work the following anticipated waste streams were identified:

Waste	Anticipated RCRA Classification	Characterization Sampling	Anticipated Onsite Storage Container	Anticipated Disposal
Drill Cuttings	Hazardous / Non-hazardous	TCLP Metals	55-gal Steel Drums	Off-Site – Industrial Waste Landfill (May be consolidated into Source Area Material Treatment/ Disposal)
Decontamination Waste Water	Hazardous / Non-hazardous	Applicable Analytical Suite	55-gal Steel Drums / Plastic Totes	Off-Site Waste Water Disposal Vendor
Excavation Debris	Hazardous / Non-hazardous	None – Triple Rinse until inert	40- yard Roll Off container	Off-Site – Industrial Waste Landfill
PPE and Other Disposables	Non-hazardous	None	55-gal Steel Drums	Off-Site – Industrial Waste Landfill
Chemical Containers	Hazardous / Non-hazardous	None – Triple Rinse until inert	N/A	Recycled

3.3 IDW and RDW Characterization Sampling

Characterization of containerized IDW and RDW are to be sampled in accordance with facility specific acceptance requirements. The following guidelines should be established:

All samples must be collected with disposable or clean tools that have been decontaminated as outlined in *SOP for, Equipment Decontamination Procedures*.

- Disposable nitrile gloves (at a minimum) must be worn and changed between sample collections.
- Soil samples must be placed in containers quickly and in the order of volatility; for example, volatile organic aromatic samples must be taken first, gasoline range organics next, heavier range organics next, and soil classification samples last.
- All sample containers must be quickly and adequately sealed, and rims must be cleaned before tightening lids; tape may be used only if known not to affect sample analysis.
- Sample containers must be labeled and handled as outlined the *SOP for Sample Handling and Custody*.
- Samples must immediately be preserved according to the method specifications appropriate for the laboratory parameters to be analyzed. And unless specified otherwise, at a minimum, the samples must be immediately chilled to 4 ±2 degrees Celsius (°C) and this temperature must be maintained through delivery to the laboratory for analysis.
- Sample holding times must conform to the method specifications of the required analytical methods.
- Alternative methods to obtain samples may be used only if the alternative methods have been approved by the PM and/or FM and documented in the QAPP according to *SOP for Field Procedure Change Management* and/or in the *Field Notebook*.
- Composite samples should be collected by placing equal amounts (or aliquots) of soil collected from multiple locations into a decontaminated, dedicated collection container. The aliquots will then be homogenized using a sample collection tool such as a scoop or spoon. The homogenized material will be divided equally among the appropriate sample containers, and the sample containers will be sealed tightly.

Other sampling considerations should be referenced as per *SOP for Surface and Subsurface Sampling.*

4.0 Records

Weekly inspection sheets, laboratory analytical reports, facility acceptance documentation and transportation manifests will be packaged and issued to the USEPA within monthly progress reports. Furthermore, these documents will be presented in the Corrective Measures Implementation Report (Remedial Completion Report).

5.0 References

Guide to Management of Investigation Derived Wastes - *Office of Emergency and Remedial Response, Hazardous Site Control Division USEPA April 1992*

Operating Procedure – Management of Investigation Derived Waste- *USEPA Region 4, July 3, 2014*

Title 40 of the Code and Federal Regulations Chapter 1 Subchapter 1 Part 261-271*, USEPA*

6.0 Definitions

None

7.0 Attachments

Attachment 1: *Waste Labels*

Attachment 2: Log Sheets/ Daily Inspection Sheets

HAZARDOUS WASTE

FEDERAL LAWS PROHIBIT IMPROPER DISPOSAL

IF FOUND, CONTACT THE NEAREST POLICE OR PUBLIC SAFETY AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERATOR'S INFORMATION

NAME _____

ADDRESS _____ PHONE _____

CITY _____ STATE ____ ZIP _____

EPA ID NO. _____ EPA WASTE NO. _____

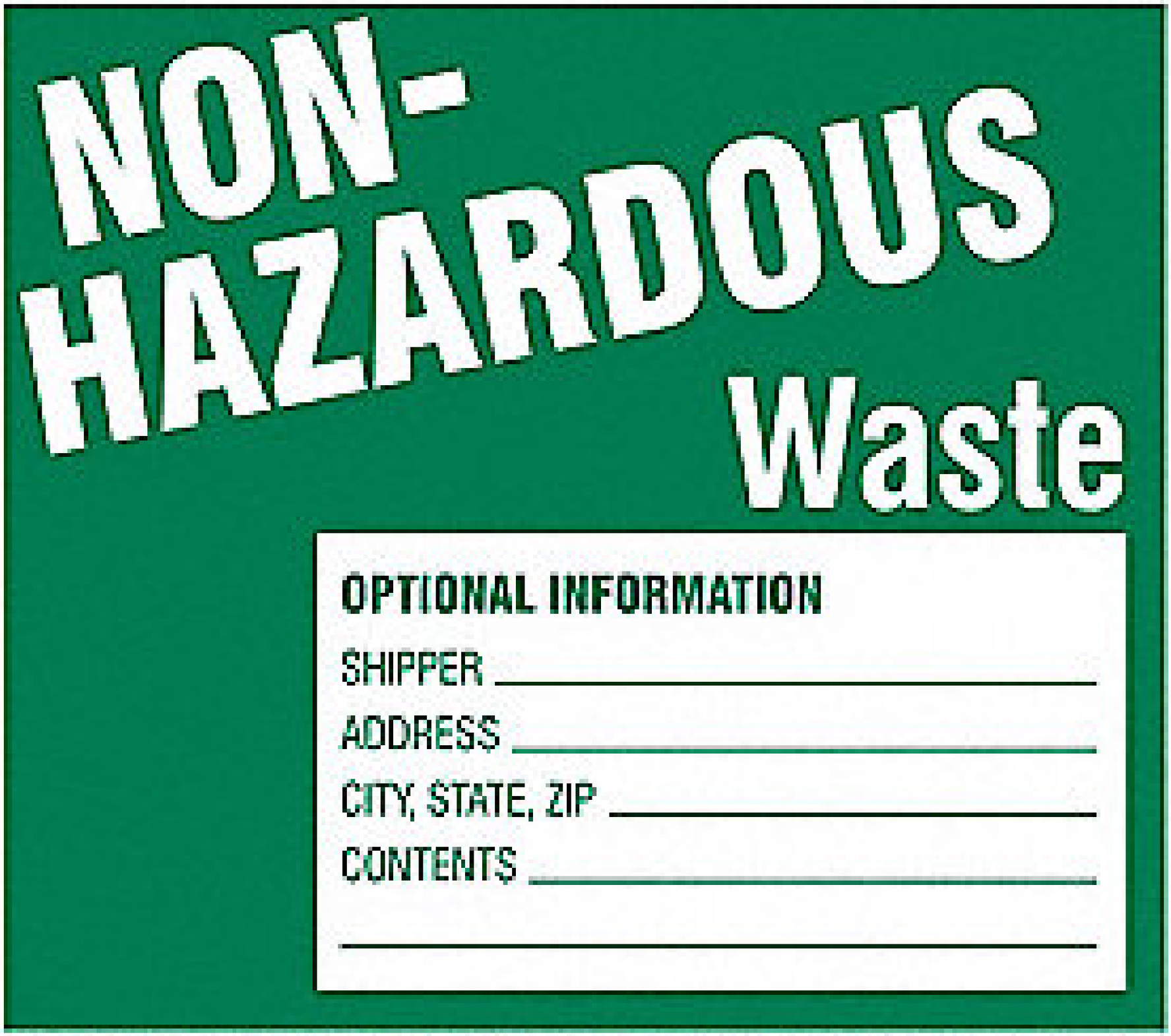
ACCUMULATION START DATE _____ MANIFEST TRACKING NO. _____

[_____ _____ _____]

D.O.T. PROPER SHIPPING NAME AND UN OR NA NO. WITH PREFIX

HANDLE WITH CARE!

BRADY BRADYID.COM



NON-HAZARDOUS WASTE

BRADY. BRADYID.COM

Date

Contractor
(Logging)

DPR
(Review)

Stockpile ID ....

Characterization for Disposal or Off-site Reuse **Yes** **No** ....

Stockpile Sample (SS)

Name and Location of Composite Sample..... ....

Name and Location of Composite Sample..... ....

Name and Location of Composite Sample..... ....

Protocol

• SS Submitted to Laboratory	Yes	No	.....	.....
• Received SS Results from Laboratory	Yes	No	.....	.....
• Submitted SS Results to DPR	Yes	No	.....	.....
• Received Disposal/Reuse Determination from DPR				

Soluble Metals Analytical Results:

Yes No ....

• EPA 6020 with W.E.T.

• TCLP

Disposal or Off-Site Reuse Options

Yes No

Yes No

.....

.....

.....

.....

Off-site Reuse **Yes** **No** ....

Disposal as Non-RCRA Hazardous Waste at a Class I Disposal Facility

Disposal as Non-RCRA Hazardous Waste at a Class II Disposal Facility

Disposal as Non-RCRA Hazardous Waste at a Class III Disposal Facility

Yes **No** ....

Yes **No** ....

Yes **No** ....

State Manifest Document Number …….. .....

Name and ID of designated disposal facility: …… ....

Name and location of reuse facility: …… ....

Date of Loading, Transportation and Disposal/Reuse at designated facility: …….. ....

Notes: 1. Refer to “Sample and Stockpile Description Codes/Sample Number Format” for stockpile nomenclature

SOIL STABILIZATION BATCH TRACKING FORM

Date/

Check Signature

Batch Number ....

Treatment

Date of Treatment ……..

Treated Batch Sample

Name, Date and Location of Composite Soil Sample……

Name, Date and Location of Discrete Sample ……....

Name, Date and Location of Discrete Sample ……....

Laboratory Analytical Results

- Lead TCLP Method SW-846.3-3: <5mg/L
- CAM Metals by EPA 6020: <TC level
- Maximum Unconfined Compressive Strength: <8000 psf
- Maximum Volume Increase: <10%

Treatment Standard Attained Yes No

Re-Treatment

Date of Re-Treatment……..……

Treated Batch Sample

Name, Date and Location of Composite Sample……

Name, Date, and Location of Discrete Sample ……....

Name, Date and Location of Discrete Sample ……....

Laboratory Analytical Results

- Lead TSLP Method SW-846.3-3: <5mg/L
- CAM Metals by EPA 6020: <TC level
- Maximum Unconfined Compressive Strength: <8000 psf
- Maximum Volume Increase: <10%

Treatment Standard Attained Yes No

Date/

Check Signature

Batch Number ....

Disposal

State Manifest Document Number: ……..

Name and ID of designated disposal facility: ……

Date of Loading, Transportation at designated facility: ……..

SOP-22: EQUIPMENT DECONTAMINATION PROCEDURES

1.0 Purpose

The purpose of this standard operating procedure (SOP) is to provide the step-by-step procedures for field decontamination of environmental sampling equipment and personal protective equipment (PPE). Decontamination of equipment and PPE is designed to ensure that sample cross-contamination, human-health exposure, and contamination transport are minimized.

Decontamination consists of physically removing contaminants from the surface of sampling equipment and materials potentially exposed to those contaminants. A decontamination plan should be based on the most conservative, worst-case scenario, using all available information about the work area. The plan can be modified, if justified by supplemental information. Initially, the decontamination plan assumes that all protective clothing and equipment which leave the exclusion zone are contaminated. Based on this assumption, a system is established to wash and rinse all non-disposable equipment and dispose of all disposable equipment.

The type of decontamination procedures and solutions needed at each site should be determined after considering the following site-specific conditions:

- The type of equipment to be decontaminated
- The type of contaminant(s) present
- Extent of contamination
- Potential human and ecological risk scenarios

2.0 Scope

This procedure applies to all IEC personnel and subcontractors engaged in collecting environmental samples or operating in environments in which hazardous or contaminating substances are expected to be present at the Project Site. All decontamination procedures will be conducted per the following guidance documents:

- *American Society for Testing and Materials (ASTM) International. 2008. Standard D5088- 02: Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites.*
- *United States Environmental Protection Agency (EPA). August 1987. A Compendium of Superfund Field Operations Methods. Volumes I and II. EPA/540/P 87/001a & b.*
- Project-specific Health and Safety Plan (HASP)

3.0 Procedure

Decontaminate all non-disposable sampling equipment used at the site both before activities begin and after each sample is collected. Decontaminate all drilling and excavation equipment both before activities begin and between

each investigation location. Take care that materials and solutions used for decontamination procedures are themselves not hazardous or could potentially contaminate samples (that is, are acids and solvents).

3.1 Decontamination Area

Identify a localized decontamination area or drill rigs and other sampling equipment. Select the decontamination area so that decontamination fluids and soil wastes can be managed in a controlled area with minimal risk to the surrounding environment. The decontamination area should be large enough to allow temporary storage of cleaned equipment and materials before use, as well as to stage drums of decontamination investigation-derived waste (IDW). In the case of large decontamination areas (ex. hollow-stem- auger related decontamination, etc.), line each area with a heavy-gauge polyethylene sheeting (4-mil minimum) and include a collection system designed to capture potential decontamination IDW. Decontamination areas will, in all cases, be laid out in such a way as to prevent overspray while performing equipment and personnel decontamination.

Smaller decontamination tasks, such as surface water and sediment equipment decontamination, may take place at the sampling locations. In this case, all required decontamination supplies, and equipment must be mobilized to the site and smaller decontamination areas for personnel and portable equipment will be provided as necessary. These locations will include basins or tubs to capture decontamination IDW, which will be transferred to larger containers as necessary.

3.2 Decontamination Equipment

The following is a list of equipment and materials that may be needed to perform decontamination:

- Concrete or synthetic material-lined decontamination pad
- Plastic sheeting/membrane to serve as secondary containment for liquids
- Brushes and flat-bladed scrapers
- Garden-type water sprayers (without oil-lubricated, moving parts)
- High-pressure washer
- Portable steam cleaner
- Sump or collection system for contaminated liquid
- Wash basins and buckets
- Spray and rinse bottles
- Potable water, deionized water, and laboratory-grade detergent (Liquinox, Alconox, or similar)
- Plastic waste bags
- Leak-tight liquid waste containers (55-gallon drums or similar)
- Bulk solid waste containers (super-sacks, 55-gallon drums, or similar)

3.3 Decontamination Procedures

3.3.1 Personnel and Personal Protective Equipment

Decontamination of personnel and PPE prevents undesired human-health exposure to contaminants via ingestion, absorption, and inhalation. All personnel and PPE will be decontaminated as outlined in the Health and Safety Plan (HASP).

3.3.2 General Sampling Equipment

Conduct consistent decontamination of sampling equipment to ensure the quality of the samples collected. Decontaminate all equipment that comes into contact with potentially contaminated samples. Disposable equipment intended for one-time use that is factory wrapped generally does not need to be decontaminated before use, unless evidence of contamination is present. Disposable equipment, such as disposable bailers, spoons, TerraCore® or Encore® VOC samplers, is preferred over reusable equipment; use wherever appropriate. Decontaminate sampling equipment, including split-barrel samplers, hand- augers, reusable bailers, spoons, trowels, shovels, and pumps used to collect samples for chemical analyses before each use and before sampling at a new sampling location.

Take the following steps to decontaminate non-dedicated sampling equipment:

- Decontamination personnel will wear the appropriate PPE as required by the Health and Safety Plan (HASP).
- The sequence of actual decontamination will be as follows:
    1. Remove as much gross contamination (such as pieces of soil) as possible off equipment at the sampling site.
    2. Wash water-resistant equipment thoroughly and vigorously with potable water containing non-phosphate laboratory-grade detergent such as Liquinox, Alconox, or equivalent, and using a bristle brush or similar utensil to remove any remaining residual contamination.
    3. Rinse equipment thoroughly with potable water (1st rinse).
    4. Rinse equipment thoroughly with distilled or deionized water (2nd rinse).
    5. For sensitive field instruments, rinse equipment with distilled, deionized, or American Society for Testing and Materials (ASTM) reagent grade water (3rd rinse).
    6. Air dry at a location where dust or other fugitive contaminants may not contact the sample equipment. Alternatively, wet equipment maybe dried with a clean, disposable paper towel to assist the drying process. All equipment should be dry before reuse.
- If the equipment is not used soon after decontamination, it should be covered or wrapped in new, oil-free aluminum foil or new, unused plastic bags to protect the decontaminated equipment from fugitive contaminates before reuse.
- Store decontaminated equipment at a secure, unexposed location out of the weather and any potential contaminant exposure.
- Depending on site conditions and the number of samples collected at each location, rinse and detergent water will normally be replaced with new solutions between borings or sample locations.

3.3.3 Groundwater Sampling Equipment

Proper decontamination between wells is essential to avoid introducing contaminants from the sampling equipment. For sampling with decontamination of peristaltic pumps, all that is necessary is to replace the pump head tubing after sampling each well. If sampling with pumps such a submersible, bladder, or similar pump in which mechanisms of the pump come in direct contact with contaminated water, or sampling with a reusable stainless steel bailer, decontaminate the pump or bailer. The following steps will be used for pumps and bailers contaminated with dissolved phase contamination only:

- Wash the exterior of the pump or bailer and any associated cable thoroughly and vigorously with potable water containing non-phosphate laboratory-grade detergent such as Liquinox, Alconox, or equivalent, and using a dedicated wash bristle brush or similar brush.
- Place the pump into a potable water wash basin/reservoir containing non-phosphate laboratory-grade detergent making sure that the pump intake is fully submerged and the pump outlet is allowed to flow directly back into the wash reservoir. Set the pump to a very low flow rate and turn the pump on, allowing the wash water to recirculate through the pump mechanism for a minimum of 5 minutes. Disregard this step for reusable bailers.
- Initially, rinse the pump or bailer by repeating Steps 1 and 2 using potable water, a dedicated rinse bristle brush, and a rinse basin/reservoir containing only potable water (1st rinse).
- Final rinse the pump or bailer by duplicating Step 3 using distilled, deionized, or ASTM reagent grade water (2nd rinse).
- Dry off any excess water with a clean, disposable paper towel and allow to air dry at a location where dust or other fugitive contaminants may not contact the sample pump or bailer.

3.3.4 Measurement Devices and Monitoring Equipment

For water quality instruments, oil-water interface indicators, water level indicators, continuous water level dataloggers, and other field instruments that have the potential to come into contact with site media, at a minimum, wash with dilute laboratory-grade detergent (Liquinox or similar) and double rinse with potable and distilled/deionized water before and after each use using a similar procedure as discussed in Section 3.3.2.

3.3.5 Drilling and Subsurface Soil Sampling Equipment

Drilling equipment and associated materials will be decontaminated by the drilling contractor prior to any drilling operations and between borings. Decontaminate tools used for soil sampling (for example, split spoon samplers) before and between collecting any analytical samples, as outlined in Section 3.3.2. Thoroughly clean external and internal surfaces of drilling equipment (that is, drill bits, auger, drilling stem, and hand tools) before beginning any drilling operations and between borings using the following basic sequence:

- Remove as much gross contamination as possible off equipment at the sampling site.
- Wash equipment thoroughly and vigorously with high-temperature potable water using a high-pressure washer and/or steam cleaner. A bristle brush is also suggested to remove any persistent gross contamination.

- Rinse equipment twice thoroughly with potable water (1st and 2nd rinse).
- Air dry at a location where dust or other fugitive contaminants may not contact the sample equipment. All equipment should be dry before reuse.
- Store decontaminated equipment at a location away from any potential exposure from fugitive contamination.

3.3.6 Decontamination of Earthwork Equipment

Wash earthwork equipment (such as excavators, back-hoes, and trucks) with high-pressure potable water, if possible, before leaving a contaminated area, using similar steps as outlined in Section 3.3.5. Portable steam-cleaners and hand washing with a brush and detergent, followed by a potable water rinse, can also be used. In some instances, tires and tracks of equipment maybe only need to be thoroughly brushed with a dry brush. Take particular care with the components in direct contact with contaminants, such as tires and backhoe buckets. Any part of earthwork equipment that may come in direct contact with analytical samples (that is, sampling from the excavator bucket) must be thoroughly decontaminated before excavation activities and between sample locations.

3.4 Investigation-Derived Wastes

Depending on the contaminant, potentially hazardous IDW (such as wash water or rinsate solutions) will be accumulated in 55-gallon drums and subsequently transported to a waste storage area designated by the client, according to project-specific and installation-wide procedures for management of IDW as described in the Project-specific Waste Management Plan and in accordance with all federal, state, and local waste regulations.

4.0 Records

Sampling personnel will be responsible for documenting decontamination of sampling and drilling equipment. Record documentation in the Field Notebook or on a Field Datasheet as discussed in *SOP for Field Documentation* The information entered in the Field Log Book concerning decontamination should include the following:

- Decontamination personnel
- Decontamination solutions used (such as Alconox or distilled water)
    - Date and time (start and end)
        - Location of decontamination
    - General decontamination methods, tools used, and observations
        - Any deviations from the decontamination methods outlined in this SOP
    - Equipment identification numbers
    - Manufacturer names and lot numbers of decontamination solutions
        - Location and amount of decontamination IDW collected, stored, and/or disposed

- Identification number, date, sampling area, and information of stored decontamination IDW
- Any decontamination IDW spills or releases and associated corrective actions

5.0 References

American Society for Testing and Materials (ASTM) International. 2008. Standard D5088- 02: Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites.

Nielsen, D.M. 1991. *Practical Handbook of Ground-Water Monitoring*. Lewis Publishers. Pages 625-636.

U.S. Environmental Protection Agency (EPA). February 1999. *Procedures to Schedule and Complete Sampling Activities in Cooperation with EPA Region VII Environmental Services Division*.

U.S. Environmental Protection Agency (EPA). Region VII. February 1, 1991. *Environmental Services Division Operations and Quality Assurance Manual.*

U.S. Environmental Protection Agency (EPA). August 1987. *A Compendium of Superfund Field Operations Methods.* Volumes I and II. EPA/540/P 87/001a & b.

6.0 Definitions

Decontamination Area: an area that is not expected to be contaminated and is upwind of suspected contaminants

Decontamination Equipment: any equipment used during the process of decontamination of personnel or sampling equipment.

Drilling and Subsurface Soil Sampling Equipment: any equipment and tools used during the process of drilling or subsurface soil sampling.

Health and Safety Plan: a plan developed to ensure that all hazards associated with a site are evaluated prior to site entry

Measurement/Monitoring Equipment: any equipment used to check or evaluate site conditions

Personal Protective Equipment (PPE): personal health and safety equipment used to protect the individual from contaminant exposure, physical injury, or death.

Potable Water: water acceptable for human consumption and washing

Sampling Equipment: any equipment used during the process of sample collection

Earthwork Equipment: Heavy earthmoving equipment typically used for excavation and test pit investigations.

7.0 Attachments

None

SOP-23: SAMPLE IDENTIFICATION AND NOMENCLATURE

1.0 Purpose

This standard operating procedure (SOP) outlines protocols for sample identification and standardized identification nomenclature. This procedure provides a standard nomenclature convention for environmental sample identification. The use of a standard convention facilitates the progress of field sampling activities, reduces the potential for confusion regarding sample identification, and improves the ease of reviewing laboratory analytical results.

Alternative sample identification conventions other than the below-mentioned identification system may be used, at the request of and/or prior approval of the United States Environmental Protection Agency (USEPA), for the following circumstances:

- When the regulatory program under which the sampling work is being performed requires an alternative sample identification convention.
- At sites where sampling already has been performed and where use of an existing sample identification convention would promote consistency and help avoid potential confusion.
- At sites where unique sampling situations exist

2.0 Scope

This SOP focuses on the most commonly used environmental sample handling and custody tracking tasks and applications anticipated Project Site and should be used in conjunction with other applicable project SOPs, including the following:

- *SOP-Field Documentation*
- *SOP-Hollow Stem Auger and Direct Push Drilling Methods*
- *SOP-Discrete Surface and Subsurface Soil Sampling*
- *SOP-Groundwater Sampling Procedures*
- *SOP-Hazardous Soil Treatment*
- *SOP-Sample Handling and Custody*

3.0 Sample Identification

3.1 Primary Environmental Samples

Verify that all samples are identified with a unique naming convention that identifies the sample area, location type, location number, media matrix, sample depth, and any special designation (for example, matrix spike and matrix spike duplicate samples). Identify samples using the following sample naming convention:

{SITE}VW-X_YZ

where:

{SITE} = Name of the investigation site or area of concern (ECD: East Chicago DuPont)

"V" = Location type:

GP: Direct-Push Soil Boring
HS: Hollow-Stem Auger Soil Boring

HA: Hand Tool Soil Sample/Boring (such as hand auger, shovel, or scoop)
MW: Monitoring Well
WP: Well Point Water Sample
SP: Excavation Stockpile Soil Sample

"W" = Three digit location ID number:

Field duplicate samples should add a "9" as the first digit.

"X" = Matrix type:

GW: Groundwater
SO: Soil

"Y" = Proposed sample depth interval in feet below ground surface with a two-digit numerical format. The actual sample depth intervals should be noted in the field sheets. For groundwater samples from existing monitoring wells, this depth designation will be omitted

"Z" = special designation:

MS: matrix spike
SD: matrix spike duplicates

Soil Sample Example

Soil sample collected at 0 to 2 feet below ground surface (bgs) from direct-push soil borehole number 1 at Site ECD would be identified as follows:
{SITE}VW-XYZ = ECDGP001-SO_00-02

A field duplicate sample collected at the same time would be identified as follows:
ECDGP901-SO_00-02

Matrix spike and matrix spike duplicate samples collected at the same time would be identified as follows:
ECDGP001-SO_00-02MS and ECDGP001-SO_00-02SD

Groundwater Sample Example

A groundwater sample collected at monitoring MW-1 at Site ECD would be identified as follows:
{SITE}VW-XYZ = ECDMW-1-GW

3.2 Field Equipment Blanks and Trip Blanks

Specify field equipment and trip blank samples as follows:

{SITE}-EBY or {SITE}-TBY

where:

{SITE} = Name of the investigation site or area of concern (ECD: East Chicago DuPont)

"Y" = Three digit sample number (such as 001)

As an example, the first field equipment blank collected at Site ECD would be identified as follows:

4.0 Records

Record sample handling and custody information in a Field Notebook and on COCs according to *SOP-XX, Note Taking and Field Log Books*. Complete COC forms, air waybills, and any other shipping documentation according to *SOP-XX* and a copy retained in the project files.

5.0 References

U.S. Environmental Protection Agency (EPA). December 1996. *Sampler's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response. EPA/540/R-96/0.

U.S. Environmental Protection Agency (EPA). February 1994. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response. EPA/540/R- 941/013.

6.0 Definitions

None

7.0 Attachments

None

SOP-24: SAMPLE HANDLING AND CUSTODY

1.0 Purpose

This standard operating procedure (SOP) outlines protocols for sample handling and custody. An example chain-of-custody (COC) form is provided as part of this procedure (see SOP for Attachment 1); other formats with essentially identical information are acceptable.

An essential part of the sampling activities of any environmental project is assuring the integrity of the samples from collection through data reporting. Sample labels and COC forms are used to document identification and handling of samples from the time of collection through the completion of chemical and/or physical analysis. Documentation of the history of a sample should be prepared and maintained to demonstrate that the data are a true representation of the environmental media. In some projects, analytical data may be used in litigation. The COC record is used as evidence in legal proceedings to demonstrate that a sample was not tampered with or altered in any way that may bias the analytical accuracy of the laboratory results. It is extremely important that COC records be complete, accurate, and consistent.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in collecting and handling environmental samples at the Site.

This SOP focuses on the most commonly used environmental sample handling and custody tracking tasks and applications anticipated the Project SIte and should be used in conjunction with other applicable project SOPs, including the following:

- *SOP- Field Documentation*
- *SOP- Hollow Stem Auger and Direct Push Drilling Methods*
- *SOP- Discrete Surface and Subsurface Soil Sampling*
- *SOP- Groundwater Sampling Procedures*
- *SOP- Sample Identification and Nomenclature*

3.0 Procedures

3.1 Sample Custody

A critical aspect of sound sample collection and analysis protocols is the maintenance of strict COC procedures, as described in this technical procedure. COC procedures include tracking and documentation during sample collection, shipment, and laboratory processing.

A sample is considered to be in an individual's custody if any of the following apply:

1. It is in the physical possession of the responsible party.
2. It is in view of the responsible party after being in their possession.
3. It is placed in a designated, secure area that is controlled and restricted by the responsible party.

The following procedures will be followed and adhered to, to preserve and verify the integrity of all samples from the time of collection through analysis:

- Maintain records of the custody of samples, both in the field and in the laboratory.
- Document custody throughout all sampling activities on the COC record for each day of sampling and verify that this record accompanies the samples from the site to the laboratory.
- Transfer sample custody according to Section 3.2.
- Ship samples to subcontractor laboratories via expeditor or courier.
- Place custody seals across the front and back edges of each sample cooler lid to maintain its integrity during shipping until it is opened by the laboratory.

The subcontractor laboratory is responsible for sample custody once samples are received. Custody must be maintained at the laboratory once samples are received until all tests are completed. This will be accomplished using an internal custody system that requires samples to be kept in a secured and restricted area when not in use, and to be checked out and checked back in by the analysts who use them. Internal custody records must be maintained by the laboratory as part of the documentation file for each sample.

3.2 Transfer of Custody and Shipment

All personnel with sample custody are required to sign, date, and record the time on the COC form when receiving and relinquishing samples from their immediate custody. Any discrepancies should be noted at this time. If the samples are required to be shipped, the laboratory project manager or coordinator will be notified by the Field Manager of when and how the samples were shipped. Notification will include the following information:

- Date of shipment
- Number of coolers
- Point of Contact name, phone number, and facsimile number
- Estimated date of shipment arrival
- Sample Matrix

Upon receipt of each sample cooler and after verification of the COC records, the laboratory will provide a cooler receipt form documenting any discrepancies such as, but not limited to, the following:

- Inappropriate sample containers or preservation
- Broken sample containers
- Cooler temperature outside 4 degrees Celsius (^{o}C)
- Missing COC form or quality assurance (QA) sample form
- Errors on COC or QA sample form
- Missing custody seals

The laboratory will be required to notify IEC of any such discrepancies within 24 hours of its receipt of the samples.

3.3 Chain of Custody (COC) Record

COC forms document sample collection and shipment to the laboratory. COCs are a legal document that records the transfer and disposition of collected environmental samples. The COC form will identify the contents of each shipment and maintain the custodial integrity of the samples.

Fill out COC forms at each sampling location for each sample/analysis, to maintain a record of sample collection, transfer of samples between personnel, shipment of samples, and receipt of samples at the laboratory. The Field Manager will generate the COC form using the Sample Tracking and Scheduling Program.

Information entered by the Field Manager includes the following:

- Project name and project number
- Name, address, and phone number of the laboratory to receive the samples
- COC control number
- Sample type/sample collection method
- Location ID
- Unique sample ID
- Matrix type
- Analytical methods requested
- Field duplicate, if applicable
- Field quality control (QC) for matrix spike and matrix spike duplicate (MS/MSD) samples, if applicable
- Container type, size and number
- Preservatives used
- Turnaround-time (TAT) for laboratory analysis
- Air waybill number or Bill of Lading number
- Special instruction or comments to laboratory or Field Sampler, if applicable

The Field Sampler will enter the following information using indelible black or blue ink:

- Date of sample collection
- Time of sample collection (in 24-hour military format)
- Depths, if applicable
- Sampler's initials
- Void reason, if applicable
- Special instruction or comments to laboratory or Field Sampler, if applicable

The Field Team Leader and Field Manager should verify that the COC record is complete, accurate in all aspects, and consistent with all other sample documentation (for example, number of samples, sample labels, and field logs). The Field Sampler will sign the "Sampled By" and "Relinquished By" fields on the COC record, marking the date and time custody is transferred to the Field Manager.

The Field Manager will perform the following duties:

- Obtain the signature of the Field Sampler or Field Team Leader to transfer sample custody
- Prepare the samples for shipment from the field to the laboratory
- Record the carrier service and air waybill number on the COC
- Sign and enter the date and time relinquished to the expeditor or air carrier.

The Field Manager will sign the "Received By" box, marking the date and time of receipt of the samples from the Field Team Leader, Field Sampler, or other sample custodian. Every transfer of physical custody should be documented on the COC record.

Any corrections to the COC form entries will be made by a single-line strike mark through the incorrect item, and then entering the correct entry adjacent to the strikeout item according to the *SOP for Field Documentation*. Corrections will be initialed and dated by the person making the change. After the form has been inspected and determined to be satisfactorily complete, the Field Manager will sign, date, and note the time of transferal and will reference a shipper tracking number (such as an air waybill number) on the form.

COC forms should be completed in duplicate for each sampling event, at a minimum. The original, completed COC form will be delivered with the sample shipping cooler, and a field copy (such as a carbon copy or photocopy) will be retained in the field project files.

3.4 Sample Labels

Attach sample labels to all sample containers at the time of sample collection. Generate the label along with the COC form using a Sample Tracking and Scheduling Program, or similar appropriate database method, depending on the sample container. Verify that labels generated by the Sample Tracking and Scheduling Program are preprinted with the following information:

- Project Name and Number
- Unique Sample ID
- Site
- Sample Location
- Matrix
- Container
- Laboratory
- Preservative used
- Number of containers

- Analytical methods requested

Handwrite the same information listed above on labels not preprinted by the Sample Tracking and Scheduling Program, if necessary. When the sample collection is complete, the Field Sampler fills in the following information in indelible, waterproof ink:

- Date and time of sample collection
- Sampler's initials

3.5 Sample Identification

Sample identification and related nomenclature protocols and procedures related to this SOP and sample collection work at DuPont EC in general are specified and described within *SOP for Sample Identification and Nomenclature.*

3.6 Sample Handling and Storage

Take care when handling environmental samples. Handle samples only while wearing new, disposable nitrile gloves, and keep empty sample containers and collected samples clean, dry, and away from potential cross-contaminant sources (such as vehicle exhausts, fuel sources, and contaminated equipment). Transport collected samples separately from other sampling equipment and tools, and store and transfer samples in an upright position and sealed tightly. Handle and preserve all samples according to the preservation and holding times summarized in *the UFP - QAPP*

If samples cannot be immediately transported to the environmental laboratory and must be temporarily stored until arrangements can be made for delivery, place the samples in a secured Dupont EC sample staging area with sufficient refrigeration or ice in order to maintain 4°C storage temperatures (if required for preservation of the samples). Verify that a temperature blank and COC accompanies samples during storage. Samples may be stored in a secure, temperature-controlled refrigerator as long as reliable power is provided to the refrigerator and the refrigerator is designated for environmental samples only. Do not store samples in refrigerators potentially used for food storage. Use storage custody seals to maintain sample security in refrigerated storage.

Samples temporarily stored overnight must be received by the custodian that placed them in storage and may in turn be relinquished to the appropriate laboratory, the FDM, or another sample custodian. Record each transfer of custody on the appropriate COC form(s).

4.0 Records

Record sample handling and custody information in a Field Notebook and on COCs according to the *SOP for Field Documentation*. Complete COC forms, air waybills, and any other shipping documentation according to *SOP for* and a copy retained in the project files.

5.0 References

American Society for Testing and Materials (ASTM). December 10, 1999. Revised 2004.

Standard Guide for Sampling Chain-Of-Custody Procedures. ASTM Standard D4840, ASTM International, West Conshohocken, PA.

U.S. Environmental Protection Agency (EPA). December 1996. *Sampler's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response. EPA/540/R-96/0.

U.S. Environmental Protection Agency (EPA). February 1994. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response. EPA/540/R- 941/013.

6.0 Definitions

Custody: physical possession or control. A sample is under custody if it is in possession or under control so as to prevent tampering or alteration of its characteristics.

Sample Label: a record attached to samples to verify legal documentation of traceability.

Chain-of-Custody (COC) Form: a legal document that records the transfer and disposition of collected environmental samples. *SOP-XX, Attachment 1* provides an example of a COC form.

Sample Tracking and Scheduling Program: a database program that the Field Data Manager uses to record and track field sample collection. The program is also used to generate COC forms before and after sample collection.

Turnaround-time (TAT): the duration for laboratory sample analysis from the time of sample receiving to the time a laboratory data report is produced.

7.0 Attachments

Attachment 1: *Example Chain-of-Custody Form*

Chicago
2417 Bond Street

University Park, IL 60466
phone 708.534.5200 fax 708.534.5363

Chain of Custody Record

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

TestAmerica Laboratories, Inc.

Client Contact	**Project Manager:**	**Site Contact:**	**Date:**	COC No:
Your Company Name here	**Tel/Fax:**	**Lab Contact:**	**Carrier:**	_____ of _____ COCs
Address	**Analysis Turnaround Time**			Job No.
City/State/Zip	Calendar (C) or Work Days (W) _____			
(xxx) xxx-xxxx Phone	TAT if different from Below _____			SDG No.
(xxx) xxx-xxxx FAX	☐ 2 weeks			
Project Name:	☐ 1 week			
Site:	☐ 2 days			
P O #	☐ 1 day			

Sample Identification	**Sample Date**	**Sample Time**	**Sample Type**	**Matrix**	**# of Cont.**	**Filtered Sample**	Sample Specific Notes:

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other _____

Possible Hazard Identification

☐ *Non-Hazard* ☐ *Flammable* ☐ *Skin Irritant* *Poison B* ☐ *Unknown* ☐

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For _____ Months*

Special Instructions/QC Requirements & Comments:

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:

INSTRUCTIONS

1) Choose the correct TestAmerica Facility from the pull down list by clicking on cell A1

2) Fill in the appropriate information for your location and phone number

3) Choose a default TAT or enter a different one if appropriate

4) Please indicate whether the TAT is Working or Calendar Days

5) In the veritical columns enter the Method/Analysis being requested

6) Fill out the Sample Information -- each line represents one sample

7) Sample Date/Time is required on all samples

8) In the "# of Containers" field enter the total number of bottles for each sample

9) Check the "Field Filter" field if the sample was filtered in the field

10) The Sample name should be the one you wish to see in the final report

11) In the cell where the Sample Information intersects the method information please enter the number of containers submitted for the method. Alternatively simply "x" this field

12) In the last row of the eCOC please choose the code for the right preservative used

13) Use the Special Instructions field to add any special instructions to the lab

14) If samples are sent across the country, consider indicating the Time Zone where samples were collected

15) TestAmerica Terms and Conditions apply for the analysis performed on the submitted samples unless otherwise agreed upon between TestAmerica and Company

Where a purchaser (Client) places an order for laboratory, consulting or sampling services from TestAmerica Laboratories, Inc, a Delaware corporation (referred to as "TestAmerica"), TestAmerica shall provide the ordered services pursuant to these Terms and Conditions, and the related Quotation or Price Schedule, or as agreed in a negotiated contract. In the absence of a written agreement to the contrary, the Order constitutes an acceptance by the Client of TestAmerica's offer to do business under these Terms and Conditions, and an agreement to be bound by these Terms and Conditions. No contrary or additional terms and conditions expressed in a Client's document shall be deemed to become a part of the contract created upon acceptance of these Terms and Conditions, unless accepted by TestAmerica in writing.

1. ORDERS AND RECEIPT OF SAMPLES

1.1 The Client may place the Order (i.e., specify a Scope of Work) either by submitting a purchase order to TestAmerica in writing or by telephone subsequently confirmed in writing, or by negotiated contract. Whichever option the Client selects for placing the Order, the Order shall not be valid unless it contains sufficient specification to enable TestAmerica to carry out the Client's requirements. In particular, samples must be accompanied by: a) adequate instruction on type of analysis requested, and b) complete written disclosure of the known or suspected presence of any hazardous substances, as defined by applicable federal or state law. Where any samples which were not accompanied by the required disclosure, cause interruptions in the lab's ability to process work due to contamination of instruments or work areas, the Client will be responsible for the costs of clean up and recovery.

1.2 The Client shall provide one week's advance notice of the sample delivery schedule, or any changes to the schedule, whenever possible. Upon timely delivery of samples, TestAmerica will use its best efforts to meet mutually agreed turnaround times. All turnaround times will be calculated from the point in time when TestAmerica has determined that it can proceed with defined work following receipt, inspection of samples, and resolution of any discrepancies in Chain-of-Custody forms and project guidance regarding work to be done (Sample Delivery Acceptance). In the event of any changes in the sample delivery schedule by the Client, prior to Sample Delivery Acceptance, TestAmerica reserves the right to modify its turnaround time commitment, to change the date upon which TestAmerica will accept samples, or refuse Sample Delivery Acceptance for the affected samples.

1.3 TestAmerica reserves the right, exercisable at any time, to refuse or revoke Sample Delivery Acceptance for any sample which in the sole judgment of TestAmerica: a) is of unsuitable volume; b) may pose a risk or become unsuitable for handling, transport, or processing for any health, safety, environmental or other reason, whether or not due to the presence in the sample of any hazardous substance and whether or not such presence has been disclosed to TestAmerica by the Client; or c) holding times cannot be met, due to passage of more than 48 hours from the time of sampling or 1/2 the holding time for the requested test, whichever is less.

1.4 Prior to Sample Delivery Acceptance, the entire risk of loss or damage to samples remains with the Client, except where TestAmerica provides courier services. In no event will TestAmerica have any responsibility or liability for the action or inaction of any carrier shipping or delivering any sample to or from TestAmerica's premises. Client is responsible to assure that any sample containing any hazardous substance which is to be delivered to TestAmerica's premises will be packaged, labeled, transported and delivered properly and in accordance with applicable laws.

2. PAYMENT TERMS

2.1 Services performed by TestAmerica will be in accordance with prices quoted and later confirmed in writing or as stated in the Price Schedule. Quoted prices do not include sales tax. Applicable sales tax will be added to invoices where required by law. Where requested services on a group of samples received and logged in together at the laboratory total less than $200, there will be a minimum transaction charge of $200 for the sample group, or as shown on any related quote from TestAmerica. An Environmental Management Fee of 5% of the invoice value will also be applied, at TestAmerica's discretion.

2.2 Invoices may be submitted to Client upon completion of any sample delivery group. Billing corrections must be requested within 30 days of invoice date. Payment in advance is required for all Clients except those whose credit has been established with TestAmerica. For Clients with approved credit, payment terms are net 30 days from the date of invoice by TestAmerica. All overdue payments are subject to an additional interest and service charge of one and one half percent (1.5%) (or the maximum rate permissible by law, whichever is lesser) per month or portion thereof from the due date until the date of payment. All fees are charged or billed directly to the Client. The billing of a third party will not be accepted without a statement, signed by the third party, that acknowledges and accepts payment responsibility.

2.3 TestAmerica may suspend work and withhold delivery of data under this order at any time in the event Client fails to make timely payment of its invoices. Client shall be responsible for all costs and expenses of collection including reasonable attorney's fees. TestAmerica reserves the right to refuse to proceed with work at any time based upon an unfavorable Client credit report.

3. CHANGE ORDERS, TERMINATION

3.1 Changes to the Scope of Work, price, or result delivery date may be initiated by TestAmerica after Sample Delivery Acceptance due to any condition which conflicts with analytical, QA or other protocols warranted in these Terms and Conditions. TestAmerica will not proceed with such changes until an agreement with the Client is reached on the amount of any cost, schedule change or technical change to the Scope of Work, and such agreement is documented in writing.

3.2 Changes to the Scope of Work, including but not limited to increasing or decreasing the work, changing test and analysis specification, or acceleration in the performance of the work may be initiated by the Client after sample delivery acceptance. Such a change will be documented in writing and may result in a change in cost and turnaround time commitment. TestAmerica's acceptance of such changes is contingent upon technical feasibility and operational capacity.

3.3 Suspension or termination of all or any part of the work may be initiated by the Client. TestAmerica will be compensated consistent with Section 2 of these Terms and Conditions. TestAmerica will complete all work in progress and be paid in full for all work completed.

4. WARRANTIES AND LIABILITY

4.1 Where applicable, TestAmerica will use analytical methodologies which are in substantial conformity with published test methods. TestAmerica has implemented these methods in its Laboratory Quality Manuals and referenced Standard Operating Procedures and where the nature or composition of the sample requires it, TestAmerica reserves the right to deviate from these methodologies as necessary or appropriate, based on the reasonable judgment of TestAmerica, which deviations, if any, will be made on a basis consistent with recognized standards of the industry and/or TestAmerica's Laboratory Quality Manuals. Client may request that TestAmerica perform according to a mutually agreed Quality Assurance Project Plan (QAPP). In the event that samples arrive prior to agreement on a QAPP, TestAmerica will proceed with analyses under its standard Quality Manuals then in effect, and TestAmerica will not be responsible for any resampling or other charges if work must be repeated to comply with a subsequently finalized QAPP.

4.2 TestAmerica shall start preparation and/or analysis within holding times provided that Sample Delivery Acceptance occurs within 48 hours of sampling or 1/2 of the holding time for the test, whichever is less. Where resolution of inconsistencies leading to Sample Delivery Acceptance does not occur within this period, TestAmerica will use its best efforts to meet holding times and will proceed with the work provided that, in TestAmerica's judgment, the chain-of-custody or definition of the Scope of Work provide sufficient guidance. Reanalysis of samples to comply with TestAmerica's Quality Manuals will be deemed to have met holding times provided the initial analysis was performed within the applicable holding time. Where reanalysis demonstrates that sample matrix interference is the cause of failure to meet any Quality Manual requirements, the warranty will be deemed to have been met.

4.3 TestAmerica warrants that it possesses and maintains all licenses and certifications which are required to perform services under these Terms and Conditions provided that such requirements are specified in writing to TestAmerica prior to Sample Delivery Acceptance. TestAmerica will notify the Client in writing of any decertification or revocation of any license, or notice of either, which affects work in progress.

4.4 The warranty obligations set forth in Sections 4.1, 4.2 and 4.3 are the sole and exclusive warranties given by TestAmerica in connection with any services performed by TestAmerica or any Results generated from such services, and TestAmerica gives and makes NO OTHER REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. No representative of TestAmerica is authorized to give or make any other representation or warranty or modify this warranty in any way.

4.5 Client's sole and exclusive remedy for the breach of warranty in connection with any services performed by TestAmerica, will be limited to repeating any services performed, contingent on the Client's providing, at the request of TestAmerica and at the Client's expense, additional sample(s) if necessary. Any reanalysis requested by the Client generating Results consistent with the original Results will be at the Client's expense. If resampling is necessary, TestAmerica's liability for resampling costs will be limited to actual cost or one hundred and fifty dollars ($150) per sample, whichever is less.

4.6 TestAmerica's liability for any and all causes of action arising hereunder, whether based in contract, tort, warranty, negligence or otherwise, shall be limited to the lesser amount of compensation for the services performed or $100,000. All claims, including those for negligence, shall be deemed waived unless suit thereon is filed within one year after TestAmerica's completion of the services. Under no circumstances, whether arising in contract, tort (including negligence), or otherwise, shall TestAmerica be responsible for loss of use, loss of profits, or for any special, indirect, incidental or consequential damages occasioned by the services performed or by application or use of the reports prepared.

4.7 In no event shall TestAmerica have any responsibility or liability to the Client for any failure or delay in performance by TestAmerica which results, directly or indirectly, in whole or in part, from any cause or circumstance beyond the reasonable control of TestAmerica. Such causes and circumstances

directly or indirectly, in whole or in part, from any cause or circumstance beyond the reasonable control of TestAmerica. Such causes and circumstances shall include, but not be limited to, acts of God, acts of Client, acts or orders of any governmental authority, strikes or other labor disputes, natural disasters, accidents, wars, civil disturbances, equipment breakdown, matrix interference or unknown highly contaminated samples that impact instrument operation, unavailability of supplies from usual suppliers, difficulties or delays in transportation, mail or delivery services, or any other cause beyond TestAmerica's reasonable control.

5. RESULTS, WORK PRODUCT

5.1 Data or information provided to TestAmerica or generated by services performed under this agreement shall only become the property of the Client upon receipt in full by TestAmerica of payment for the whole Order. Ownership of any analytical method, QA/QC protocols, software programs or equipment developed by TestAmerica for performance of work will be retained by TestAmerica, and Client shall not disclose such information to any third party.

5.2 Data and sample materials provided by Client or at Client's request, and the result obtained by TestAmerica shall be held in confidence (unless such information is generally available to the public or is in the public domain or Client has failed to pay TestAmerica for all services rendered or is otherwise in breach of these Terms and Conditions), subject to any disclosure required by law or legal process.

5.3 Should the Results delivered by TestAmerica be used by the Client or Client's client, even though subsequently determined not to meet the warranties described in these Terms and Conditions, then the compensation will be adjusted based upon mutual agreement. In no case shall the Client unreasonably withhold TestAmerica's right to independently defend its data.

5.4 TestAmerica reserves the right to perform the services at any laboratory in the TestAmerica network, unless the Client has specified a particular location for the work. In addition, TestAmerica reserves the right to subcontract services ordered by the Client to another laboratory or laboratories, if, in TestAmerica's sole judgment, it is reasonably necessary, appropriate or advisable to do so. TestAmerica will in no way be liable for any subcontracted services (outside the TestAmerica network) except for work performed at laboratories which have been audited and approved by TestAmerica.

5.5 TestAmerica shall dispose of the Client's samples 30 days after the analytical report is issued, unless instructed to store them for an alternate period of time or to return such samples to the Client, in a manner consistent with U.S. Environmental Protection Agency regulations or other applicable federal, state or local requirements. Any samples for projects that are canceled or not accepted, or for which return was requested, will be returned to the Client at his own expense. TestAmerica reserves the right to return to the Client any sample or unused portion of a sample that is not within TestAmerica's permitted capability or the capabilities of TestAmerica's designated waste disposal vendor(s). ALL DIOXIN, MIXED WASTE, AND RADIOACTIVE SAMPLES WILL BE RETURNED TO THE CLIENT, unless prior arrangements for disposal are made.

5.6 Unless a different time period is agreed to in any order under these Terms and Conditions, TestAmerica agrees to retain all records for five (5) years.

5.7 In the event that TestAmerica is required to respond to legal process related to services for Client, Client agrees to reimburse TestAmerica for hourly charges for personnel involved in the response and attorney fees reasonably incurred in obtaining advice concerning the response, preparation to testify, and appearances related to the legal process, travel and all reasonable expenses associated with the litigation.

6. INSURANCE

6.1 TestAmerica shall maintain in force during the performance of services under these Terms and Conditions, Workers' Compensation and Employer's Liability Insurance in accordance with the laws of the states having jurisdiction over TestAmerica's employees who are engaged in the performance of the work. TestAmerica shall also maintain during such period, Comprehensive General and Contractual Liability (limit of $1,000,000 per occurrence/ $2,000,000 aggregate), Comprehensive Automobile Liability, owned and hired, ($1,000,000 combined single limit), and Professional/Pollution Liability Insurance (limit of $5,000,000 per occurrence/aggregate).

7. AUDIT

7.1 Upon prior notice to TestAmerica, the Client may audit and inspect TestAmerica's records and accounts covering reimbursable costs related to work done for the Client, for a period of two (2) years after completion of the work. The purpose of any such audit shall be only for verification of such costs, and TestAmerica shall not be required to provide access to cost records where prices are expressed as fixed fees or published unit prices.

8. MISCELLANEOUS PROVISIONS

8.1 These Terms and Conditions, together with any additions or revisions which may be agreed to in writing by TestAmerica, embody the whole agreement of the parties and provide the only remedies available. There are no promises, terms, conditions, understandings, obligations or agreements other than those contained herein, and these Terms and Conditions shall supersede all previous communications, representations, or agreements, either verbal or written, between the Client and TestAmerica. These Terms and Conditions, and any transactions or agreements to which they apply, shall be governed both as to interpretation and performance by the laws of the state where TestAmerica's services are performed.

8.2 The invalidity or unenforceability, in whole or in part of any provision, term or condition hereof shall not affect in any way the validity or enforceability of the remainder to these Terms and Conditions, the intent of the parties being that the provisions be severable. The section headings of these Terms and Conditions are intended solely for convenient reference and shall not define, limit or affect in any way these Terms and Conditions or their interpretations. No waiver by either party of any provision, term or condition hereof or of any obligation of the other party hereunder shall constitute a waiver of any subsequent breach or other obligation.

8.3 The obligations, liabilities, and remedies of the parties, as provided herein, are exclusive and in lieu of any others available at law or in equity. Indemnifications, releases from liability and limitations of liability shall apply, notwithstanding the fault, negligence or strict liability of the party to be indemnified, released, or whose liability is limited, except to the extent of sole negligence or willful misconduct.

SOP-25: IN-SITU STABILIZATION PROCEDURES

1.0 Purpose

The purpose of this standard operating procedure (SOP) is to describe the methodology for conducting in-situ soil stabilization remediation treatment of onsite impacted saturated soil.

ISS is a remedial procedure which treated impacted saturated soil by hydraulic mixing and concurrent reagent injection applications. This agency approved remedy will be employed to stabilize speciated and total arsenic in saturated soil using a proprietary binding agent. The goal of the ISS work is stabilized speciated and total arsenic in saturate soil and prevent further dissolution into onsite groundwater.

2.0 Scope

This SOP applies to all IEC personnel and subcontractors engaged in who are engaged in in-situ soil stabilization remedial work at the former DuPont East Chicago facility, Indiana (DuPont EC) site projects and tasks.

This SOP focuses on the performance of pneumatic slug test applications anticipated at DuPont EC and should be used in conjunction with other applicable project SOPs, including the following*:*

- *SOP- Field Documentation*
- *SOP- Hazardous Soil Stabilization and Treatment*
- *SOP- Equipment Decontamination Procedures*
- *SOP- Field Procedure Change Management*

3.0 Protocols and Procedure Description

3.1 Equipment and Materials

The following discussion provides descriptions and details for the machinery, equipment, remedial agent, meters and appurtenances to conduct the ISS remedial work at the Site:

- *ALLU PMX 300 HD Power Mixer: T*he ALLU PMX Power Mixer is an attachment for a conventional excavator and powered by the excavator's hydraulic system. Attaching the PMX converts the excavator to a powerful mixing tool. The mixing drums penetrate and mix a variety of material in place or in-situ. Remedial chemical agents are delivered to the area of the highest mixing shear by an attached 3-inch I.D. pipe, injected via nozzle located between the mixing drums. The ALLU PMX is mounted on an excavator with pin mounts or with a quick hitch adapter plate.

- *Komatsu PC360LC-11 Excavator*: Large-scale earth moving machinery, equipped with a 10-foot arm assembly (with piping) and 21-foot HD boom assembly with piping. Utilized to control and operate the power mixer, inject the remedial agent into source area saturated soil, mix remedial agent in saturated soil, and inject compressed area into the soil to distribute within the treatment cell(s).

- ChemGrout CG-400 Remediator Pump: The ChemGrout CG-400 Remediator is a skid mounted, gas/hydraulic, high pressure, environmental remediation injection system. This unit is designed to inject environmental compounds into contaminated saturate soil. The injection pump is a positive displacement, rotary diaphragm

pump that delivers 15 GPM, 750 PSI. The pump is equipped with a pressure relief valve to control the injection pressure.

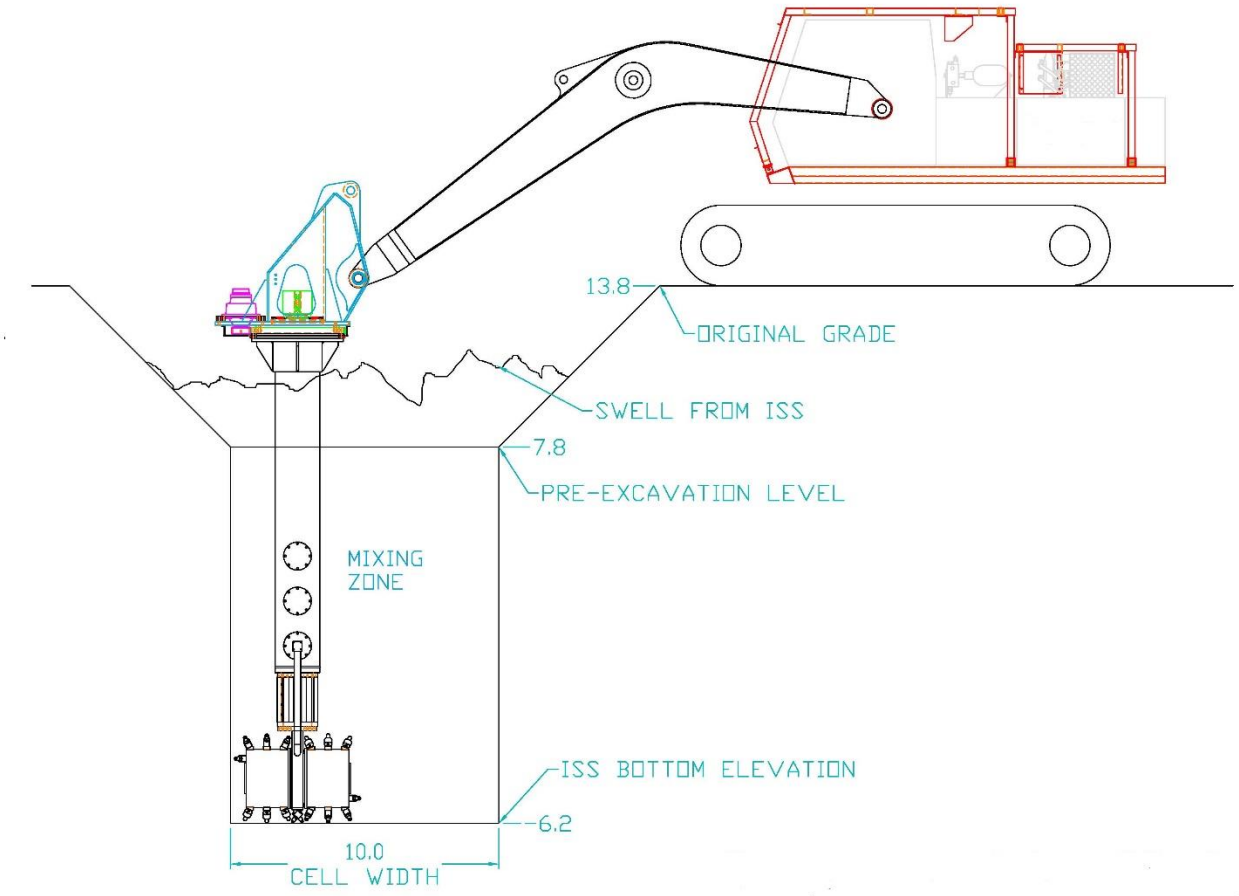
- *FerroBlack-Hybrid ISCR Reagent (ReDox Solutions, LLC., Carmel, IN)*: FerroBlack-Hybrid is a formulated blend amorphous ferrous iron (FeS) liquid suspension amendment, that when mixed and injected within metal-impacted saturated soil, will induce microbial sulfate reduction and concurrently creating biogeochemical conditions that favor the formation of minerals (ex. arsenic/iron-sulfides) that incorporate arsenic during precipitation or create kinetically favorable surfaces upon which dissolved arsenic sequesters to.

- Flow Totalizer: A digital flow totalizer will be utilized to monitor the volume of remedial ISCR reagent introduced to the saturated substratum, concurrent with rotary soil mixing.

- Kaeser M50 185 Compressor: A compressor will be utilized to facilitate distribution of the installed remedial agent within each treatment cell, after the agent dosage installation is completed and concurrent with continued rotary soil mixing within the treatment cell(s).

- *6,000-Gallon Capacity Polyethylene (10 -Degree) Cone Bottom Tank*: Said storage tank will be utilized for onsite storage of the remedial ISCR agent and allow for gravity feed conveyance of the agent to the agent conveyance pump.

Technical specifications, cut sheets, Chemical SDS forms and associative documentation for the abovementioned of the abovementioned machinery, equipment, remedial agent, meters and appurtenances are provided in *Attachment 1 – Equipment/Reagent Specifications*.



4.2 ISS Preparation

4.2.1 Reagent Storage and Transfer

A temporary chemical (remedial agent) storage area will be constructed at the Site, prior to the start of the ISS/remedial soil mixing work. The chemical containment area will be utilized to stage a 6,000-gallon capacity polyethylene liquid reagent tank (with stand) and associated medium-scale reagent transfer pump(s) and hoses prior to use. A pre-existing concrete pad will act as a base for the staging area. The concrete pad will be covered with 4-mil polyethylene sheeting, overlapping a temporary wooden berm surrounding the pad. The reagent storage area will be designed to contain 110% of the total reagent storage volume.

Reagent delivered to the site via tanker truck will transfer the contents to the holding tank. Daily inspections of the containment area for evidence of tank leaks, standing reagent on containment pad and integrity of containment pad will be performed routinely by the FTL and documented.

The ISCR reagent will be conveyed to each of the source areas during the course of the work by the following methods:

- The contents of the tank will be gravity fed to a transfer pump which will transfer the reagent liquid to a medium scale tanker truck. The tanker truck will then transport the liquid reagent proximal to the ISS source area work zone.
- The transported reagent (via manufacturers large scale tanker truck will be directly staged adjacent to the ISS source area work zone; remaining reagent left in the tanker after the end of the work day will be transported to the reagent storage area and transferred to the holding tank.
- Chemical conveyance hoses/piping utilized in the transfer procedure outside the reagent containment area will be required to have polyethylene sheeting installed beneath said hoses/piping, to prevent against accidental discharge(s) to the site.

4.2.2 Source Area and ISS Grid Demarcation

After ex-situ soil excavation is performed within each of the designated ISS source areas, the northing and easting perimeter of each ISS area will be identified via GPS, in concert with further grid delineation (20 foot x 20 foot) within each source area. Each delineation point will be recorded and staked for visual confirmation. The resultant data, concurrent with source area specific dosage calculations, will be populated into a GIS-based ISS grid soil mixing/reagent dosage map, for each source area requiring rotary soil mixing/saturated soil remediation. The protocols and procedures for the GPS demarcation work are presented in the *SOP for GPS*.

4.2.3 Dosage Calculations

The remedial agent dosage calculations will be performed prior to the start of ISS work and concurrent with the Geophysical boring work, as described within the CMI Work Plan. Additional in-house bench-scale testing of saturated Source Area soil and groundwater will be required to refine estimated dosage calculations and confirm the actual ISS agent dosages to be installed in saturated soil within each Source Area.

A total of 4 to 5 pounds of soil will be collected from geophysical boring spoils generated during the geophysical work conducted within each source area, and a total of 2 to 3 gallons of groundwater will be collected from existing wells located within the Source Area via or adjacent monitoring wells. The abovementioned material will be utilized

to conduct ISCR reagent dosage bench scale testing; said tests will be performed in-house by the reagent manufacturer to determine dosage rates within each source area.

4.2.4 ISS/Soil Mixing Personnel

Field personnel overseeing the ISS soil mixing and reagent installation work will have specific tasks and responsibilities to be performed prior to, during and after the work is performed. The following work tasks and responsibilities assigned to key field personnel cited in Section 3.0 and additional personnel directly involved with the work are as follows:

- Field Team Leader: In addition to the responsibilities cited in Section 3.0 the Field Team Leader will direct the excavator operator with the treatment cell identification and soil mixing/reagent application, manage and communicate to all personnel the treatment depth and reagent dosage rates for the treatment cell, implement changes to soil mixing/reagent dosages as specified by the Project Manager and/or Field Manager, and certify/document that the work was completed at each treatment cell as specified in the Work Plan.
- Excavator Operator: The Excavator Operator will be responsible for the operation and maintenance of the excavator, rotary mixing attachment and reagent conveyance hose connections. The Excavator Operator will perform the soil mixing and reagent installation work following the real-time direction of the Field Team Leader.
- Senior Field Technician: The Senior Field Technician will be responsible for the set-up and operation of the reagent conveyance pumps, compressors, flow totalizers and other conveyance appurtenances. The Senior Field Technician will measure and record the actual volume of reagent delivered, directly communicate with the Field Team Leader when the prescribed reagent volume has been achieved and initiate changeover from reagent flow to compressed air flow to the excavator and mixing head.
- Field Technician: The Field Technician will be responsible for the reagent feed to the reagent pump and operation of said pump during the course of the work at each treatment zone.

4.3 ISS Procedures

After ex-situ remedial soil excavation, treatment grid (GPS/Field Stake) is completed at each source area where ISS is to be performed, the ISS reagent system assembly will be constructed, consisting of the following equipment train:

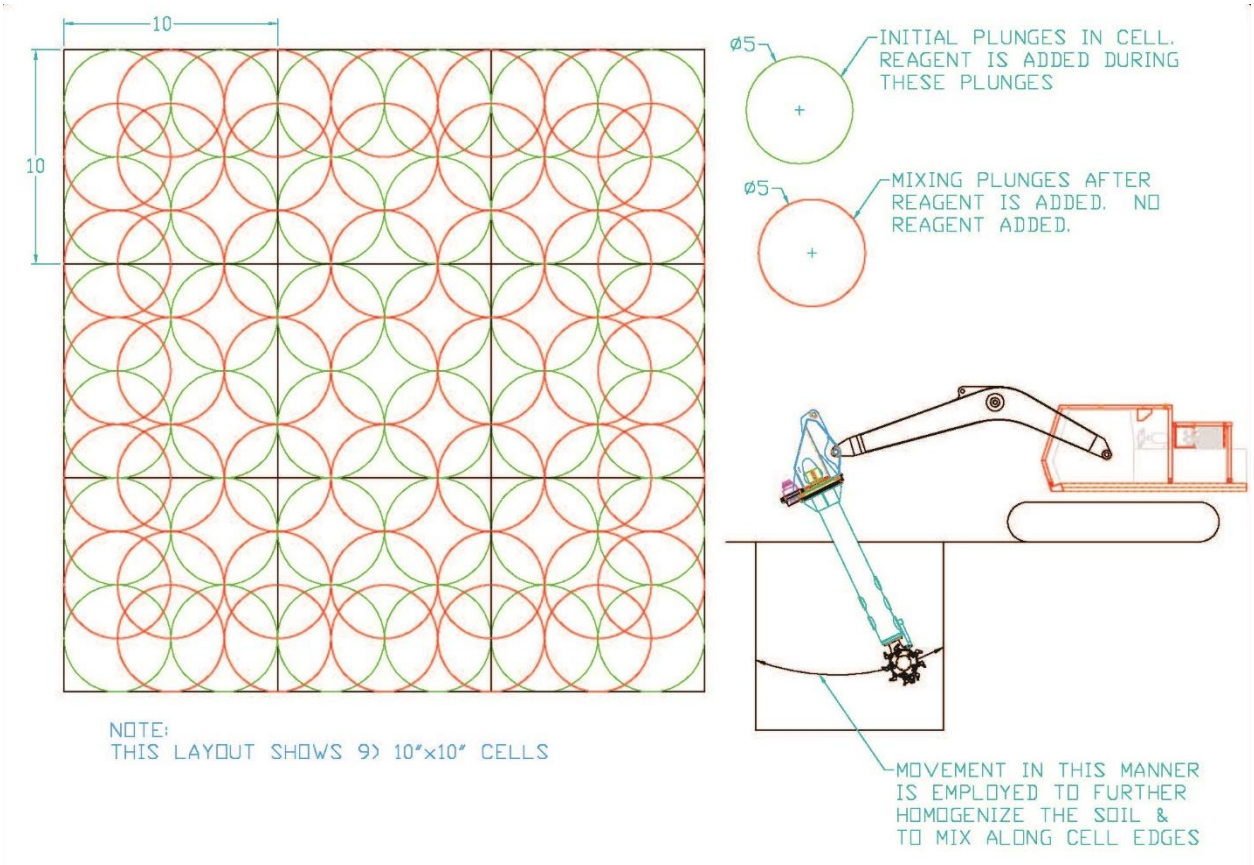
- The reagent pump assembly will be staged on polyethylene sheeting in close proximity to the work zone area. Reagent inflow piping will be installed at the which will convey the reagent material from the tanker truck(s) to the pump inlet.
- Three-inch I.D. chemical conveyance piping will be connected from the pump outlet to a three-way gate valve. A compressed air feed line connection will be made to the gate vale and three-inch I.D. outlet piping connected to the third valve connection.
- An in-line digital flow totalizer will be connected to the outlet piping after the ball valve, prior to the connection to the excavator inlet piping.
- The power mixing head, hydraulic lines and reagent feed lines will be attached to the excavator boom assembly.

After the mixing head is installed to the excavator boom assembly and associative hydraulic/feed lines are connected/inspected, reagent feed, compressor feed and pump feed piping are connected and inspected, flow totalizer is calibrated and reagent pump/compressor inspected, the ISS soil mixing work and reagent delivery work will proceed. The work will proceed starting with the pressurized reagent conveyance to the excavator and the excavator mixing head initially plunged into the saturated soil within each specific source area treatment grid; it is

estimated that each mixing plunge will mix approximately 5 square feet (areal) of saturated soil; approximately 16 (or more) overlapping soil mixing plunges per treatment grid.

After an initial plunge to the terminal treatment depth, pressurized reagent will be delivered at the mixing head at subsequent plunges within the designated treatment grid. Said reagent will be conveyed to the excavator via a large-scale grout mixer; a minimum of 100 psi of pressure will be required for reagent delivery. Adjustments to the reagent delivery pressure will be made at the pump assembly and excavator flow controls to achieve the desired pressure. As specified in Section 4.2.4, the Field Team Leader will directly guide the Excavator Operator with the mixing head positioning and depth within each treatment zone, and the Senior Field Technician will oversee the volume delivered to each treatment grid, within each source area, based on the manufacturers final dosage calculations, and will record the volume in a field log (See SOP for Field Documentation).

After the required dosage volume is installed to the treatment grid cell, the soil mixing will continue, with a minimum of 75 psi of compressed air directed to the mixing head, to disperse the agent throughout the treatment cell. Once the remedial work is completed at the treatment cell, the resultant "swell" soil will be compacted and backfilled, the assembly will be moved to the next treatment cell within the source area gird and the abovementioned procedure repeated.



4.4 Equipment Decontamination

All equipment in contact with the impacted saturated soil will be decontaminated following the protocols and procedures cited within see *SOP for Equipment Decontamination*.

5.0 Remedial-Derived Waste

In the event that remedial-derived wastes are generated during the ISS Remedial soil mixing and reagent installation work will be performed in accordance with the protocols and procedures cited within the SOP for Investigative and Remedial Derived Waste Management.

6.0 Records

Work details observed and recorded during the performance of the ISS work, including measured reagent volumes delivered to the subsurface and changes in the prescribed ISS work, in the Field Notebook and within the work form provided in *the SOP for Field Documentation.*

7.0 References

8.0 Definitions

None.

9.0 Attachments

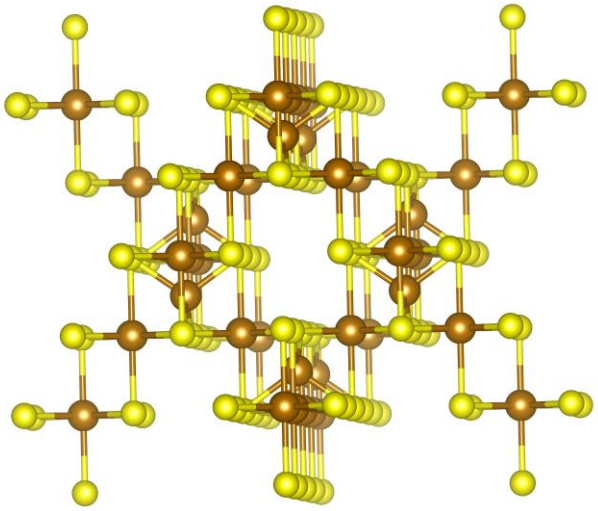
Attachment 1: *Equipment/Reagent Technical Specifications*

Attachment 2: ISS Field Data Form

FerroBlack®

Metals Remediation Technology

Redox Technology Group, LLC (d/b/a Redox Solutions) is an Indiana-based chemical manufacturer specializing in the development and production of reagents marketed under the FerroBlack® trade names. These proprietary compounded reagents are designed for the treatment of **aqueous, gaseous, and solid media** contaminated with heavy metals. FerroBlack® is currently being incorporated into one of the largest reactive barriers in the United States for the treatment of hexavalent chrome (Cr^{+6}) contaminated ground water.



REAGENT DESCRIPTION AND APPLICATION

The building block of our patented FerroBlack® chemistry is a proprietary amorphous iron sulfide (mackinawite) particle with other compounds to create site-specific remediation reagents. This chemistry is minimally soluble which lends itself to cost effective in-situ application of mixed metals contaminated groundwater and soils.

Through a combination of adsorption, chemical reduction, precipitation, and conversion to stable sulfide and iron-sulfide precipitates, FerroBlack® reagents are able to control a wide array of heavy metals.

PROJECT APPLICATIONS

- Chromite ore processing residue (COPR) impacted sites
- Plating facilities
- CCA wood preserving facilities
- Chlor-alkali sites contaminated with Hg
- Chlorinated solvent impacted sites

ADVANTAGES OF FerroBlack® REAGENTS

- Control of wide array of heavy metals including As, Cd, Cr^{+6}, Cu, Hg^{+2}, Hg^{0},Ni, Pb, Sb, and Se^{+4}
- Cost effective for mixed metals remediation
- Minimally soluble with ground water
- In-situ and ex-situ stabilization or treatment of soils
- In-situ treatment of contaminated groundwater
- Compatible with wide variety of traditional application methods
- Use in augmentation of fill materials to create permeable reactive sub-surface barrier to prevent target metals from moving beyond site

PHYSICAL & CHEMICAL PROPERTIES

Physical Form:	Colloidal Suspension
Color:	Black
Odor:	Sulfurous
Specific Gravity:	1.15 – 1.22
Density:	9.6 - 10.2 lb/gal
Solubility in Water:	Minimal
pH:	9.5 – 12.5
ORP:	-700 to -1300 mV

WASTE MATRIX TESTING AND APPLICATION

The specific FerroBlack® formulation delivered to a customer is blended to meet specific reduction goals. This formulation is developed based on the waste matrix to be treated. FerroBlack® is compatible with a variety of application methods including bucket mixing, pug milling, in-situ mixing, and direct injection.

MATERIALS OF CONSTRUCTION

Below are all suitable materials for use with FerroBlack®:

- 304L or 316L stainless steel
- Fiberglass
- Polypropylene
- PVC
- high density polyethylene
- lined carbon steel

PACKAGING OPTIONS

Totes:	300 gallons
Bulk Tanker:	4,250 gallons

ACTIVE CONSTITUENTS

Please consult the SDS or Product Data Sheet (PDS) for further information.

For additional information contact:

Thomas P. McCullough
President/CEO
Redox Solutions
11711 N. College Ave.
Suite 170
Carmel, IN 46032
Corporate Tel: (317) 660-6867
Direct Tel: (317) 660-6869
tpm@redoxsolutions.com
www.redoxsolutions.com

Charles McPheeters
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11711 N. College Ave.
Suite 170
Carmel, IN 46032
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cmcpheeters@redoxsolutions.com
www.redoxsolutions.com

FerroBlack®-H

Safety Data Sheet

according to Federal Register / Vol. 77, No. 58 / Monday, March 26, 2012 / Rules and Regulations

Date of issue: 06/14/2016 Revision date: 06/14/2016 Supersedes: 06/25/2015

SECTION 1: Identification

1.1. Identification

Product form : Mixture

Trade name : FerroBlack®-H

CAS No : 1317-37-9

Formula : FeS

Synonyms : Ferrous sulfide / Iron sulfide / Iron sulphide / Iron(II) sulfide / Ferrous sulfide / Iron sulfide / Iron sulphide / Iron(II) sulfide

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/mixture : Chemical used for the remediation of heavy metal(s) for liquid and solid wastes.

1.3. Details of the supplier of the safety data sheet

Redox Technology Group, LLC
d/b/a Redox Solutions
1580 Research Way
Indianapolis, IN 46231

Company Contact: Jim Kissel
Telephone Number: (317) 660-6867 or (317) 412-3267

1.4. Emergency telephone number

CHEMTREC: (800) 424-9300

SECTION 2: Hazard(s) identification

2.1. Classification of the substance or mixture

GHS-US classification

Skin corrosion/irritation Category 2 H315
Serious eye damage/eye irritation Category 2A H319

Full text of H statements : see section 16

2.2. Label elements

GHS-US labeling

Hazard pictograms (GHS-US) :



GHS07

Signal word (GHS-US) : Warning

Hazard statements (GHS-US) : H315 - Causes skin irritation
H319 - Causes serious eye irritation

Precautionary statements (GHS-US) : P264 - Wash hands thoroughly after handling
P280 - Wear eye protection, protective clothing, protective gloves
P302+P352 - If on skin: Wash with plenty of water
P305+P351+P338 - If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P321 - Specific treatment (see Consult a doctor/medical service if you feel unwell on this label)
P332+P313 - If skin irritation occurs: Get medical advice/attention
P337+P313 - If eye irritation persists: Get medical advice/attention
P362+P364 - Take off contaminated clothing and wash it before reuse

2.3. Other hazards

HMIS Classification:
Health hazard: 0
Flammability: 0
Physical hazards: 0

NFPA Rating:
Health hazard: 1
Fire: 0
Reactivity Hazard: 0

Inhalation May be harmful if inhaled. May cause respiratory tract irritation.
Skin May be harmful if absorbed through skin. May cause skin irritation.
Eyes May cause eye irritation.
Ingestion May be harmful if swallowed.
Other Hazards not contributing to the classification: Generates toxic gas in contact with acid.

2.4. Unknown acute toxicity (GHS US)

Not applicable

SECTION 3: Composition/Information on ingredients

3.1. Substance

Not applicable

3.2. Mixture

Name	Product Identifier	%	GHS-US classification
Iron sulfide (FeS)	(CAS No) 1317-37-9	7 - 11	Not classified
Sodium Sulfide	(CAS No) 1313-82-2	0.1 - 1	Acute Tox. 3 (Oral), H301

Full text of hazard classes and H-statements : see section 16

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures general : Never give anything by mouth to an unconscious person. If you feel unwell, seek medical advice (show the label where possible).

First-aid measures after inhalation : Remove person to fresh air and keep comfortable for breathing. Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a poison center or doctor/physician.

First-aid measures after skin contact : Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower. If skin irritation occurs: Get medical advice/attention.

First-aid measures after eye contact : Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a doctor/physician. If eye irritation persists: Get medical advice/attention.

First-aid measures after ingestion : Rinse mouth. Do NOT induce vomiting. Immediately call a poison center or doctor/physician. Call a poison center/doctor/physician if you feel unwell.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms/injuries : Causes skin and eye irritation.

Symptoms/injuries after skin contact : Irritation.

Symptoms/injuries after eye contact : Causes serious eye damage. Eye irritation.

4.3. Indication of any immediate medical attention and special treatment needed

Treat symptomatically.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Foam. Dry powder. Carbon dioxide. Water spray. Sand.

Unsuitable extinguishing media : Do not use a heavy water stream.

5.2. Special hazards arising from the substance or mixture

Reactivity : Corrosive vapors.

5.3. Advice for firefighters

Firefighting instructions : Use water spray or fog for cooling exposed containers. Exercise caution when fighting any chemical fire. Prevent fire-fighting water from entering environment.

Protection during firefighting : Do not enter fire area without proper protective equipment, including respiratory protection. Do not attempt to take action without suitable protective equipment. Self-contained breathing apparatus. Complete protective clothing.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

6.1.1. For non-emergency personnel

Emergency procedures : Ventilate spillage area. Evacuate unnecessary personnel. Avoid contact with skin and eyes.

6.1.2. For emergency responders

Protective equipment : Do not attempt to take action without suitable protective equipment. Equip cleanup crew with proper protection. For further information refer to section 8: "Exposure controls/personal protection".

Emergency procedures : Ventilate area.

6.2. Environmental precautions

Avoid release to the environment. Prevent entry to sewers and public waters. Notify authorities if liquid enters sewers or public waters.

6.3. Methods and material for containment and cleaning up

Methods for cleaning up : Take up liquid spill into absorbent material. Soak up spills with inert solids, such as clay or diatomaceous earth as soon as possible. Collect spillage. Store away from other materials.

Other information : Dispose of materials or solid residues at an authorized site.

6.4. Reference to other sections

See Heading 8. Exposure controls and personal protection. For further information refer to section 13.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling : Ensure good ventilation of the work station. Wash hands and other exposed areas with mild soap and water before eating, drinking or smoking and when leaving work. Provide good ventilation in process area to prevent formation of vapor. Do not breathe dust, fume, gas, mist, spray, vapors. Avoid contact during pregnancy/while nursing. Avoid contact with skin and eyes. Wear personal protective equipment.

Hygiene measures : Wash hands thoroughly after handling. Wash contaminated clothing before reuse. Do not eat, drink or smoke when using this product. Always wash hands after handling the product.

7.2. Conditions for safe storage, including any incompatibilities

Technical measures : Comply with applicable regulations.

Storage conditions : Keep only in the original container in a cool, well ventilated place away from : Ignition sources, Incompatible materials. Keep container closed when not in use. Store in a well-ventilated place. Keep cool.

Incompatible products : Strong bases. Strong acids.

Incompatible materials : Sources of ignition. Direct sunlight.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Iron sulfide (FeS) (1317-37-9)

Not applicable

Sodium sulfide (1313-82-2)

Not applicable

8.2. Exposure controls

Appropriate engineering controls : Ensure good ventilation of the work station.

Personal protective equipment : Avoid all unnecessary exposure.

Hand protection	:	Wear protective gloves.
Eye protection	:	Chemical goggles or face shield. Safety glasses.
Skin and body protection	:	Wear suitable protective clothing.
Respiratory protection	:	Wear appropriate mask.
Environmental exposure controls	:	Avoid release to the environment.
Other information	:	Do not eat, drink or smoke during use.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	:	Liquid
Appearance	:	Black liquid with visible suspended solids.
Color	:	Black
Odor	:	Mild
Odor threshold	:	No data available
pH	:	11.0 - 12.5
Melting point	:	Not applicable
Freezing point	:	No data available
Boiling point	:	No data available
Flash point	:	No data available
Relative evaporation rate (butyl acetate=1)	:	No data available
Flammability (solid, gas)	:	Non flammable.
Vapor pressure	:	No data available
Relative vapor density at 20 °C	:	No data available
Relative density	:	1.15 - 1.22
Solubility	:	Mininally soluble in water.
Log Pow	:	No data available
Auto-ignition temperature	:	No data available
Decomposition temperature	:	No data available
Viscosity, kinematic	:	No data available
Viscosity, dynamic	:	No data available
Explosion limits	:	No data available
Explosive properties	:	No data available
Oxidizing properties	:	No data available

9.2. Other information

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

Acidic vapors.

10.2. Chemical stability

Not established.

10.3. Possibility of hazardous reactions

Contact with acids liberates toxic gas.

10.4. Conditions to avoid

Direct sunlight. Extremely high or low temperatures.

10.5. Incompatible materials

Acids will cause the release of highly toxic Hydrogen Sulfide. Reacts violently with diazonium salts. Ferrous sulfide(s) solution is not compatible with copper, zinc, aluminum or their **alloys** (i.e. bronze, brass, galvanized metals, etc.). Corrosive to steel above 150º F (65.5º C). These materials of construction should not be used in handling systems or storage containers for this product.

10.6. Hazardous decomposition products

Hazardous decomposition products formed under fire may include sulfur oxides, iron oxides.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute toxicity : Not classified

Sodium Sulfide (113-82-2)	
LD50 oral rat	208 mg/kg
ATE US (oral)	208.000 mg/kg body weight
LD50 dermal rabbit	< 340 mg/kg
ATE US (dermal)	300.000 mg/kg body weight

Skin corrosion/irritation : Causes skin irritation.
pH: 11.0 - 12.5

Serious eye damage/irritation : Causes eye irritation.
pH: 11.0 - 12.5

Respiratory or skin sensitization : Not classified

Germ cell mutagenicity : Not classified

Carcinogenicity : Not classified

Reproductive toxicity : Not classified

Specific target organ toxicity (single exposure) : Not classified

Specific target organ toxicity (repeated exposure) : Not classified

Aspiration hazard : Not classified

Potential Adverse human health effects and symptoms : Based on available data, the classification criteria are not met.

Symptoms/injuries after skin contact : Irritation.

Symptoms/injuries after eye contact : Causes eye irritation.

SECTION 12: Ecological information

12.1. Toxicity

Ecology - general : The product is not considered harmful to aquatic organisms or to cause long-term adverse effects in the environment.

FeS (1317-37-9)	
LC50 fish 1	> 10000 mg/l Mosquito fish

Sodium Sulfide (1313-82-2)	
LC50 fish 1	7.7 - 29.1 mg/l (Exposure time: 96 h - Species: Poecilia reticulata)
EC50 Daphnia 1	2.1 mg/l (Exposure time: 48 h - Species: Daphnia magna)

12.2. Persistence and degradability

Redox-Hg (1317-37-9)	
Persistence and degradability	Not established.

12.3. Bioaccumulative potential

FeS (1317-37-9)	
Bioaccumulative potential	Not established.

Sodium Sulfide (16721-80-5)	
Log Pow	-3.5 (at 25 °C)

12.4. Mobility in soil

No additional information available

12.5. Other adverse effects

Effect on the global warming : No known effects from this product.
GWPmix comment : No known effects from this product.

Other information : Avoid release to the environment.

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Waste treatment methods : Dispose of contents/container in accordance with licensed collector's sorting instructions.
Waste disposal recommendations : Dispose of contents/container to hazardous or special waste collection point, in accordance with local, regional, national and/or international regulation.
Ecology - waste materials : Avoid release to the environment.

SECTION 14: Transport information

Department of Transportation (DOT)

In accordance with DOT

Not Regulated

Transport by sea

Not Regulated

Air transport

Not Regulated

SECTION 15: Regulatory information

15.1. US Federal regulations

Iron sulfide (FeS) (1317-37-9)
Listed on the United States TSCA (Toxic Substances Control Act) inventory

Sodium Sulfide (1313-82-2)
Listed on the United States TSCA (Toxic Substances Control Act) inventory

15.2. International regulations

CANADA

Iron sulfide (FeS) (1317-37-9)	
Listed on the Canadian DSL (Domestic Substances List)	
WHMIS Classification	Uncontrolled product according to WHMIS classification criteria

Sodium Sulfide (1313-82-2)
Listed on the Canadian DSL (Domestic Substances List)

EU-Regulations

Iron sulfide (FeS) (1317-37-9)
Listed on the EEC inventory EINECS (European Inventory of Existing Commercial Chemical Substances)

Sodium Sulfide (1313-82-2)
Listed on the EEC inventory EINECS (European Inventory of Existing Commercial Chemical Substances)

National regulations

Iron sulfide (FeS) (1317-37-9)
Listed on the AICS (Australian Inventory of Chemical Substances) Listed on IECSC (Inventory of Existing Chemical Substances Produced or Imported in China) Listed on the Japanese ENCS (Existing & New Chemical Substances) inventory Listed on the Korean ECL (Existing Chemicals List) Listed on NZIoC (New Zealand Inventory of Chemicals) Listed on PICCS (Philippines Inventory of Chemicals and Chemical Substances)

Sodium Sulfide (1313-82-2)
Listed on the AICS (Australian Inventory of Chemical Substances) Listed on IECSC (Inventory of Existing Chemical Substances Produced or Imported in China) Listed on the Japanese ENCS (Existing & New Chemical Substances) inventory Listed on the Korean ECL (Existing Chemicals List) Listed on NZIoC (New Zealand Inventory of Chemicals) Listed on PICCS (Philippines Inventory of Chemicals and Chemical Substances) Listed on INSQ (Mexican National Inventory of Chemical Substances) Listed on CICR (Turkish Inventory and Control of Chemicals)

15.3. US State regulations

Sodium Sulfide (1313-82-2)
U.S. - Massachusetts - Right To Know List U.S. - New Jersey - Right to Know Hazardous Substance List

SECTION 16: Other information

Revision date : 06/14/2016

Other information : None.

Full text of H-phrases:

H301	Toxic if swallowed
H315	Causes skin irritation
H319	Causes serious eye irritation
H400	Very toxic to aquatic life

SDS US (GHS HazCom 2012)

This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product

FerroBlack®-H

Safety Data Sheet

according to Federal Register / Vol. 77, No. 58 / Monday, March 26, 2012 / Rules and Regulations

Date of issue: 06/14/2016 Revision date: 06/14/2016 Supersedes: 06/25/2015

SECTION 1: Identification

1.1. Identification

Product form : Mixture

Trade name : FerroBlack®-H

CAS No : 1317-37-9

Formula : FeS

Synonyms : Ferrous sulfide / Iron sulfide / Iron sulphide / Iron(II) sulfide / Ferrous sulfide / Iron sulfide / Iron sulphide / Iron(II) sulfide

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/mixture : Chemical used for the remediation of heavy metal(s) for liquid and solid wastes.

1.3. Details of the supplier of the safety data sheet

Redox Technology Group, LLC
d/b/a Redox Solutions
1580 Research Way
Indianapolis, IN 46231

Company Contact: Jim Kissel
Telephone Number: (317) 660-6867 or (317) 412-3267

1.4. Emergency telephone number

CHEMTREC: (800) 424-9300

SECTION 2: Hazard(s) identification

2.1. Classification of the substance or mixture

GHS-US classification

Skin corrosion/irritation Category 2 H315
Serious eye damage/eye irritation Category 2A H319

Full text of H statements : see section 16

2.2. Label elements

GHS-US labeling

Hazard pictograms (GHS-US) :



GHS07

Signal word (GHS-US) : Warning

Hazard statements (GHS-US) : H315 - Causes skin irritation
H319 - Causes serious eye irritation

Precautionary statements (GHS-US) : P264 - Wash hands thoroughly after handling
P280 - Wear eye protection, protective clothing, protective gloves
P302+P352 - If on skin: Wash with plenty of water
P305+P351+P338 - If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P321 - Specific treatment (see Consult a doctor/medical service if you feel unwell on this label)
P332+P313 - If skin irritation occurs: Get medical advice/attention
P337+P313 - If eye irritation persists: Get medical advice/attention
P362+P364 - Take off contaminated clothing and wash it before reuse

2.3. Other hazards

HMIS Classification:
Health hazard: 0
Flammability: 0
Physical hazards: 0

NFPA Rating:
Health hazard: 1
Fire: 0
Reactivity Hazard: 0

Inhalation May be harmful if inhaled. May cause respiratory tract irritation.
Skin May be harmful if absorbed through skin. May cause skin irritation.
Eyes May cause eye irritation.
Ingestion May be harmful if swallowed.
Other Hazards not contributing to the classification: Generates toxic gas in contact with acid.

2.4. Unknown acute toxicity (GHS US)

Not applicable

SECTION 3: Composition/Information on ingredients

3.1. Substance

Not applicable

3.2. Mixture

Name	Product Identifier	%	GHS-US classification
Iron sulfide (FeS)	(CAS No) 1317-37-9	7 - 11	Not classified
Sodium Sulfide	(CAS No) 1313-82-2	0.1 - 1	Acute Tox. 3 (Oral), H301

Full text of hazard classes and H-statements : see section 16

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures general : Never give anything by mouth to an unconscious person. If you feel unwell, seek medical advice (show the label where possible).

First-aid measures after inhalation : Remove person to fresh air and keep comfortable for breathing. Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a poison center or doctor/physician.

First-aid measures after skin contact : Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower. If skin irritation occurs: Get medical advice/attention.

First-aid measures after eye contact : Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a doctor/physician. If eye irritation persists: Get medical advice/attention.

First-aid measures after ingestion : Rinse mouth. Do NOT induce vomiting. Immediately call a poison center or doctor/physician. Call a poison center/doctor/physician if you feel unwell.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms/injuries : Causes skin and eye irritation.

Symptoms/injuries after skin contact : Irritation.

Symptoms/injuries after eye contact : Causes serious eye damage. Eye irritation.

4.3. Indication of any immediate medical attention and special treatment needed

Treat symptomatically.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Foam. Dry powder. Carbon dioxide. Water spray. Sand.

Unsuitable extinguishing media : Do not use a heavy water stream.

5.2. Special hazards arising from the substance or mixture

Reactivity : Corrosive vapors.

5.3. Advice for firefighters

Firefighting instructions : Use water spray or fog for cooling exposed containers. Exercise caution when fighting any chemical fire. Prevent fire-fighting water from entering environment.

Protection during firefighting : Do not enter fire area without proper protective equipment, including respiratory protection. Do not attempt to take action without suitable protective equipment. Self-contained breathing apparatus. Complete protective clothing.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

6.1.1. For non-emergency personnel

Emergency procedures : Ventilate spillage area. Evacuate unnecessary personnel. Avoid contact with skin and eyes.

6.1.2. For emergency responders

Protective equipment : Do not attempt to take action without suitable protective equipment. Equip cleanup crew with proper protection. For further information refer to section 8: "Exposure controls/personal protection".

Emergency procedures : Ventilate area.

6.2. Environmental precautions

Avoid release to the environment. Prevent entry to sewers and public waters. Notify authorities if liquid enters sewers or public waters.

6.3. Methods and material for containment and cleaning up

Methods for cleaning up : Take up liquid spill into absorbent material. Soak up spills with inert solids, such as clay or diatomaceous earth as soon as possible. Collect spillage. Store away from other materials.

Other information : Dispose of materials or solid residues at an authorized site.

6.4. Reference to other sections

See Heading 8. Exposure controls and personal protection. For further information refer to section 13.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling : Ensure good ventilation of the work station. Wash hands and other exposed areas with mild soap and water before eating, drinking or smoking and when leaving work. Provide good ventilation in process area to prevent formation of vapor. Do not breathe dust, fume, gas, mist, spray, vapors. Avoid contact during pregnancy/while nursing. Avoid contact with skin and eyes. Wear personal protective equipment.

Hygiene measures : Wash hands thoroughly after handling. Wash contaminated clothing before reuse. Do not eat, drink or smoke when using this product. Always wash hands after handling the product.

7.2. Conditions for safe storage, including any incompatibilities

Technical measures : Comply with applicable regulations.

Storage conditions : Keep only in the original container in a cool, well ventilated place away from : Ignition sources, Incompatible materials. Keep container closed when not in use. Store in a well-ventilated place. Keep cool.

Incompatible products : Strong bases. Strong acids.

Incompatible materials : Sources of ignition. Direct sunlight.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Iron sulfide (FeS) (1317-37-9)

Not applicable

Sodium sulfide (1313-82-2)

Not applicable

8.2. Exposure controls

Appropriate engineering controls : Ensure good ventilation of the work station.

Personal protective equipment : Avoid all unnecessary exposure.

Hand protection	:	Wear protective gloves.
Eye protection	:	Chemical goggles or face shield. Safety glasses.
Skin and body protection	:	Wear suitable protective clothing.
Respiratory protection	:	Wear appropriate mask.
Environmental exposure controls	:	Avoid release to the environment.
Other information	:	Do not eat, drink or smoke during use.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	:	Liquid
Appearance	:	Black liquid with visible suspended solids.
Color	:	Black
Odor	:	Mild
Odor threshold	:	No data available
pH	:	11.0 - 12.5
Melting point	:	Not applicable
Freezing point	:	No data available
Boiling point	:	No data available
Flash point	:	No data available
Relative evaporation rate (butyl acetate=1)	:	No data available
Flammability (solid, gas)	:	Non flammable.
Vapor pressure	:	No data available
Relative vapor density at 20 °C	:	No data available
Relative density	:	1.15 - 1.22
Solubility	:	Mininally soluble in water.
Log Pow	:	No data available
Auto-ignition temperature	:	No data available
Decomposition temperature	:	No data available
Viscosity, kinematic	:	No data available
Viscosity, dynamic	:	No data available
Explosion limits	:	No data available
Explosive properties	:	No data available
Oxidizing properties	:	No data available

9.2. Other information

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

Acidic vapors.

10.2. Chemical stability

Not established.

10.3. Possibility of hazardous reactions

Contact with acids liberates toxic gas.

10.4. Conditions to avoid

Direct sunlight. Extremely high or low temperatures.

10.5. Incompatible materials

Acids will cause the release of highly toxic Hydrogen Sulfide. Reacts violently with diazonium salts. Ferrous sulfide(s) solution is not compatible with copper, zinc, aluminum or their **alloys** (i.e. bronze, brass, galvanized metals, etc.). Corrosive to steel above 150º F (65.5º C). These materials of construction should not be used in handling systems or storage containers for this product.

10.6. Hazardous decomposition products

Hazardous decomposition products formed under fire may include sulfur oxides, iron oxides.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute toxicity : Not classified

Sodium Sulfide (113-82-2)	
LD50 oral rat	208 mg/kg
ATE US (oral)	208.000 mg/kg body weight
LD50 dermal rabbit	< 340 mg/kg
ATE US (dermal)	300.000 mg/kg body weight

Skin corrosion/irritation : Causes skin irritation.
pH: 11.0 - 12.5

Serious eye damage/irritation : Causes eye irritation.
pH: 11.0 - 12.5

Respiratory or skin sensitization : Not classified

Germ cell mutagenicity : Not classified

Carcinogenicity : Not classified

Reproductive toxicity : Not classified

Specific target organ toxicity (single exposure) : Not classified

Specific target organ toxicity (repeated exposure) : Not classified

Aspiration hazard : Not classified

Potential Adverse human health effects and symptoms : Based on available data, the classification criteria are not met.

Symptoms/injuries after skin contact : Irritation.

Symptoms/injuries after eye contact : Causes eye irritation.

SECTION 12: Ecological information

12.1. Toxicity

Ecology - general : The product is not considered harmful to aquatic organisms or to cause long-term adverse effects in the environment.

FeS (1317-37-9)	
LC50 fish 1	> 10000 mg/l Mosquito fish

Sodium Sulfide (1313-82-2)	
LC50 fish 1	7.7 - 29.1 mg/l (Exposure time: 96 h - Species: Poecilia reticulata)
EC50 Daphnia 1	2.1 mg/l (Exposure time: 48 h - Species: Daphnia magna)

12.2. Persistence and degradability

Redox-Hg (1317-37-9)	
Persistence and degradability	Not established.

12.3. Bioaccumulative potential

FeS (1317-37-9)	
Bioaccumulative potential	Not established.

Sodium Sulfide (16721-80-5)	
Log Pow	-3.5 (at 25 °C)

12.4. Mobility in soil

No additional information available

12.5. Other adverse effects

Effect on the global warming : No known effects from this product.
GWPmix comment : No known effects from this product.

Other information : Avoid release to the environment.

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Waste treatment methods : Dispose of contents/container in accordance with licensed collector's sorting instructions.
Waste disposal recommendations : Dispose of contents/container to hazardous or special waste collection point, in accordance with local, regional, national and/or international regulation.
Ecology - waste materials : Avoid release to the environment.

SECTION 14: Transport information

Department of Transportation (DOT)

In accordance with DOT

Not Regulated

Transport by sea

Not Regulated

Air transport

Not Regulated

SECTION 15: Regulatory information

15.1. US Federal regulations

Iron sulfide (FeS) (1317-37-9)
Listed on the United States TSCA (Toxic Substances Control Act) inventory

Sodium Sulfide (1313-82-2)
Listed on the United States TSCA (Toxic Substances Control Act) inventory

15.2. International regulations

CANADA

Iron sulfide (FeS) (1317-37-9)	
Listed on the Canadian DSL (Domestic Substances List)	
WHMIS Classification	Uncontrolled product according to WHMIS classification criteria

Sodium Sulfide (1313-82-2)
Listed on the Canadian DSL (Domestic Substances List)

EU-Regulations

Iron sulfide (FeS) (1317-37-9)
Listed on the EEC inventory EINECS (European Inventory of Existing Commercial Chemical Substances)

Sodium Sulfide (1313-82-2)
Listed on the EEC inventory EINECS (European Inventory of Existing Commercial Chemical Substances)

National regulations

Iron sulfide (FeS) (1317-37-9)
Listed on the AICS (Australian Inventory of Chemical Substances) Listed on IECSC (Inventory of Existing Chemical Substances Produced or Imported in China) Listed on the Japanese ENCS (Existing & New Chemical Substances) inventory Listed on the Korean ECL (Existing Chemicals List) Listed on NZIoC (New Zealand Inventory of Chemicals) Listed on PICCS (Philippines Inventory of Chemicals and Chemical Substances)

Sodium Sulfide (1313-82-2)
Listed on the AICS (Australian Inventory of Chemical Substances) Listed on IECSC (Inventory of Existing Chemical Substances Produced or Imported in China) Listed on the Japanese ENCS (Existing & New Chemical Substances) inventory Listed on the Korean ECL (Existing Chemicals List) Listed on NZIoC (New Zealand Inventory of Chemicals) Listed on PICCS (Philippines Inventory of Chemicals and Chemical Substances) Listed on INSQ (Mexican National Inventory of Chemical Substances) Listed on CICR (Turkish Inventory and Control of Chemicals)

15.3. US State regulations

Sodium Sulfide (1313-82-2)
U.S. - Massachusetts - Right To Know List U.S. - New Jersey - Right to Know Hazardous Substance List

SECTION 16: Other information

Revision date : 06/14/2016

Other information : None.

Full text of H-phrases:

H301	Toxic if swallowed
H315	Causes skin irritation
H319	Causes serious eye irritation
H400	Very toxic to aquatic life

SDS US (GHS HazCom 2012)

This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product

KOMATSU®

PC360LC-11

Tier 4 Final Engine

PC360LC

HYDRAULIC EXCAVATOR



Photos may include optional equipment.

NET HORSEPOWER
257 HP @ 1950 rpm
192 kW @ 1950 rpm

OPERATING WEIGHT
78,645–80,547 lb
35,627–36,535 kg

BUCKET CAPACITY
0.89–2.56 yd^3
0.68–1.96 m^3

WALK-AROUND

PC360LC-11



Photos may include optional equipment.

NET HORSEPOWER
257 HP @ 1950 rpm
192 kW @ 1950 rpm

OPERATING WEIGHT
78,645–80,547 lb
35,627–36,535 kg

BUCKET CAPACITY
0.89–2.56 yd³
0.68–1.96 m³

KOMATSU CARE®

GREATER PERFORMANCE & FASTER CYCLE TIMES

Komatsu's Closed-center Load Sensing System (CLSS) provides quick response and smooth operation to maximize productivity.

Power Mode with enhanced engine and hydraulic pump control logic provides greater hydraulic power and speed for faster cycle times, improved multifunction performance and up to 12% greater productivity than the previous model.



A powerful Komatsu SAA6D114E-6 engine provides a net output of 192 kW **257 HP**. This engine is EPA Tier 4 Final emissions certified.

Variable Geometry Turbocharger (VGT) uses a hydraulic actuator to provide optimum air flow under all speed and load conditions.

Komatsu Diesel Particulate Filter (KDPF) and Selective Catalytic Reduction (SCR) system reduce particulate matter and NOx while providing automatic regeneration that does not interfere with daily operation.

Large displacement high efficiency pumps provide high flow output at lower engine speed, improving efficiency.

6 Working modes are designed to match engine speed, pump delivery and system pressure to the application.

Power Mode
provides improved power and hydraulic flow for faster cycle times and multifunction operation.

Two boom mode settings provide power mode for maximum digging force or smooth mode for fine grading operations.

Komatsu's Closed-center Load Sensing System (CLSS)
provides quick response and smooth operation to maximize productivity.

Rearview monitoring system (standard) with integrated camera display in the default monitor screen.

KOMTRAX® equipped machines can send location, SMR and operation maps to a secure website or smart phone utilizing wireless technology. Machines also relay error codes, cautions, maintenance items, fuel & Diesel Exhaust Fluid (DEF) levels, and much more.

Large LCD color monitor:

- 7" high resolution display
- Enhanced hydraulic attachment control with one way/two way flow and programmable work tool names and settings
- Rear view camera display integrated into the default monitor screen
- Key machine settings and controls easily accessible through the monitor

Enhanced working environment

- High back, heated air suspension seat with adjustable arm rests
- Integrated ROPS cab design
- Cab meets ISO Level 1 Operator Protective Guard (OPG) top guard
- Standard pattern change valve to switch between ISO and BH control pattern
- Auxiliary jack and (2) 12V power outlets
- Auto climate control

Komatsu designed and manufactured components

Handrails (standard) located on the machine upper structure provide a convenient work area in front of the engine.

Battery disconnect switch allows a technician to disconnect the power supply before servicing the machine.

Heavy duty boom design with large one piece castings provide increased strength and durability.

Komatsu Auto Idle Shutdown helps reduce nonproductive engine idle time and reduces operating costs.

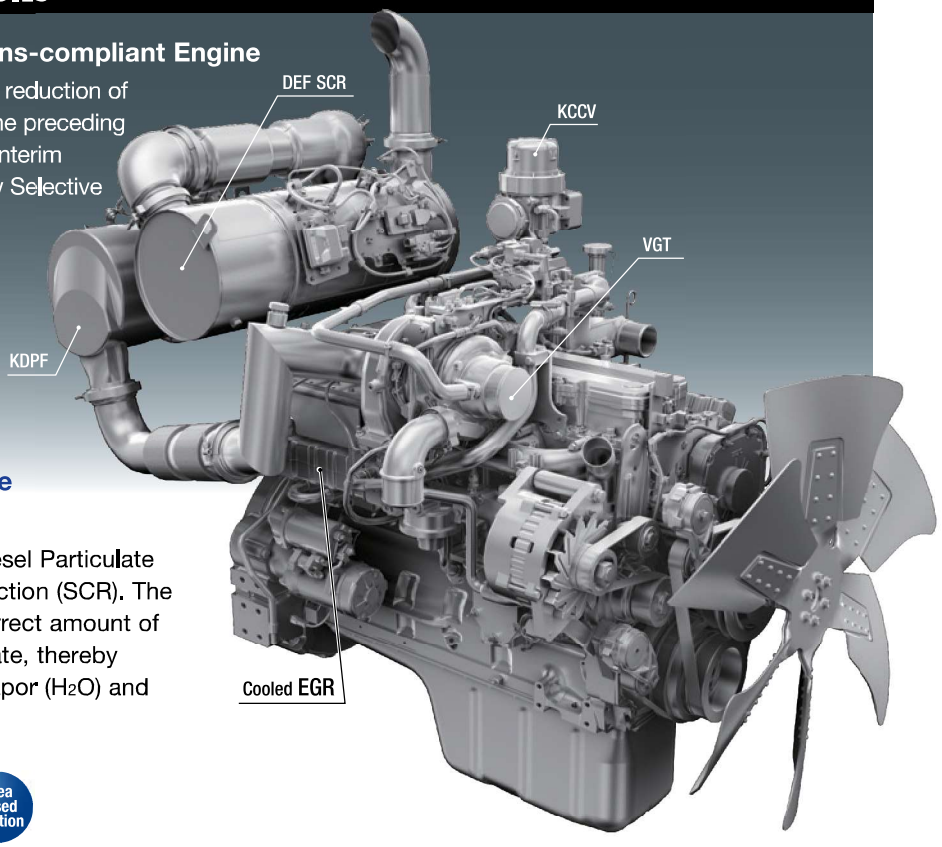
Operator Identification System records KOMTRAX® machine operation and application data for up to 100 individual ID codes.

PERFORMANCE FEATURES

KOMATSU NEW ENGINE TECHNOLOGIES

Komatsu's New Emission Regulations-compliant Engine

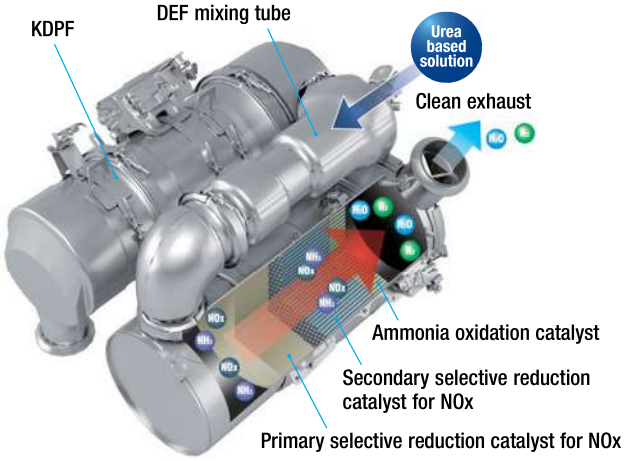
New regulations effective in 2014 require the reduction of NOx emissions to one tenth or below from the preceding regulations. In addition to refining the Tier 4 Interim technologies, Komatsu has developed a new Selective Catalytic Reduction (SCR) device in-house.



Technologies Applied to New Engine

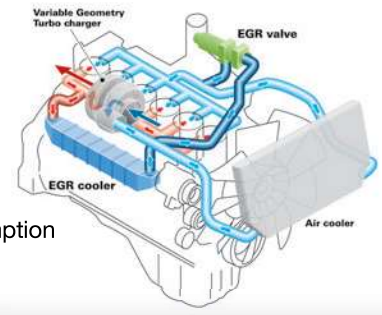
Heavy-duty aftertreatment system

This new system combines a Komatsu Diesel Particulate Filter (KDPF) and Selective Catalytic Reduction (SCR). The SCR NOx reduction system injects the correct amount of Diesel Exhaust Fluid (DEF) at the proper rate, thereby decomposing NOx into non-toxic water vapor (H_2O) and nitrogen gas (N_2).



Heavy-duty cooled Exhaust Gas Recirculation (EGR) system

The system recirculates a portion of exhaust gas into the air intake and lowers combustion temperatures, thereby reducing NOx emissions. EGR gas flow has been decreased for Tier 4 Final with the addition of SCR technology. The system achieves a dynamic reduction of NOx, while helping reduce fuel consumption below Tier 4 Interim levels.

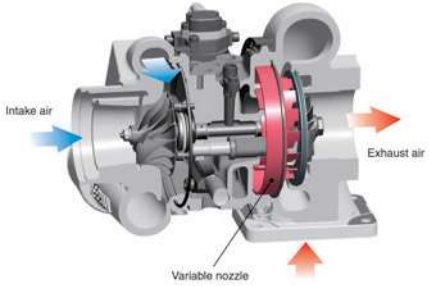


Advanced Electronic Control System

The electronic control system performs high-speed processing of all signals from sensors installed in the vehicle providing total control of equipment in all conditions of use. Engine condition information is displayed via an on-board network to the monitor inside the cab, providing necessary information to the operator. Additionally, managing the information via KOMTRAX helps customers keep up with required maintenance.

Variable Geometry Turbocharger (VGT) system

The VGT system features proven Komatsu design hydraulic technology for variable control of air-flow and supplies optimal air according to load conditions. The upgraded version provides better exhaust temperature management.



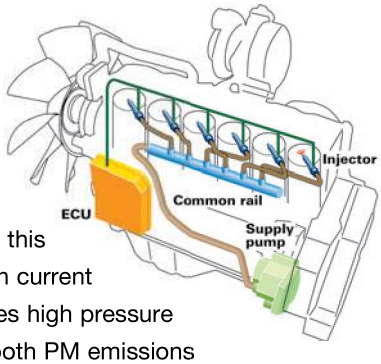
Komatsu Auto Idle Shutdown

Komatsu auto idle shutdown automatically shuts the engine down after idling for a set period of time to reduce unnecessary fuel consumption and exhaust emissions. The amount of time before the engine is shutdown can be easily programmed from 5 to 60 minutes.



Heavy-Duty High-Pressure Common Rail (HPCR) Fuel Injection System

The system is designed to achieve an optimal injection of high-pressure fuel by means of computerized control, providing close to complete combustion to reduce PM emissions. While this technology is already used in current engines, the new system uses high pressure injection, thereby reducing both PM emissions and fuel consumption over the entire range of engine operating conditions. The Tier 4 Final engine has advanced fuel injection timing for reduced fuel consumption and lower soot levels.



Enhanced Productivity

The PC360LC-11's P Mode provides improved performance in demanding applications.

Productivity

Up to 12% increase
(compared to the PC360LC-10 in P Mode)

P mode (90° swing truck loading)

Increased Work Efficiency

Large digging force

With the one-touch Power Max. function, digging force is increased for 8.5 seconds of operation.

Maximum arm crowd force (ISO)

160 kN(16.3t) ➡ 171 kN(17.4t) 7% UP
(With Power Max.)

Maximum bucket digging force (ISO)

213 kN(21.7t) ➡ 228 kN(23.2t) 7% UP
(With Power Max.)

Measured with Power Max. function, 3185 mm arm and ISO rating

Faster arm cycle speeds

Two return hoses improve arm cylinder hydraulic flow for faster arm out performance.

Two-mode settings for boom

- Smooth boom mode reduces boom down force for working on hard surfaces or for hydraulic hammer operation.
- Power boom mode maximizes digging force for more effective excavating

Lifting mode

When the Lifting mode is selected, lifting capacity is increased 7% by raising hydraulic pressure.



WORKING ENVIRONMENT





Comfortable Working Space

Wide spacious cab

Wide spacious cab includes seat with reclining backrest. The seat height and longitudinal inclination are easily adjusted using a pull-up lever. You can set the appropriate operational posture of armrest together with the console. Reclining the seat further enables you to place it into the fully flat state with the headrest attached.

Arm rest with simple height adjustment function

The addition of a knob and a plunger to the armrest permits the height of the armrest to be easily adjusted without the use of tools.



Low vibration with cab damper mounting

Automatic climate control

Pressurized cab

Auxiliary input jack

Connecting a regular audio device to the auxiliary jack allows the operator to hear the sound from the speakers installed in the cab.



Standard Equipment

Sliding window glass (left side)



AM/FM stereo radio & ashtray



Remote intermittent wiper with windshield washer



Cigarette lighter



Opening & closing skylight



Magazine box & cup holder



Defroster
(conforms to the ISO standard)



One-touch storable front window lower glass



WORKING ENVIRONMENT

LARGE HIGH RESOLUTION LCD MONITOR



New Monitor Panel Interface Design

An updated large high resolution LCD color monitor enables accurate and smooth work. The interface has been redesigned to display key machine information in a new user friendly interface. A rear view camera and a DEF level gauge display have been added to the default main screen. The interface has a function that enables the main screen mode to be switched, thus enabling the optimum screen information for the particular work situation to be displayed.

Indicators

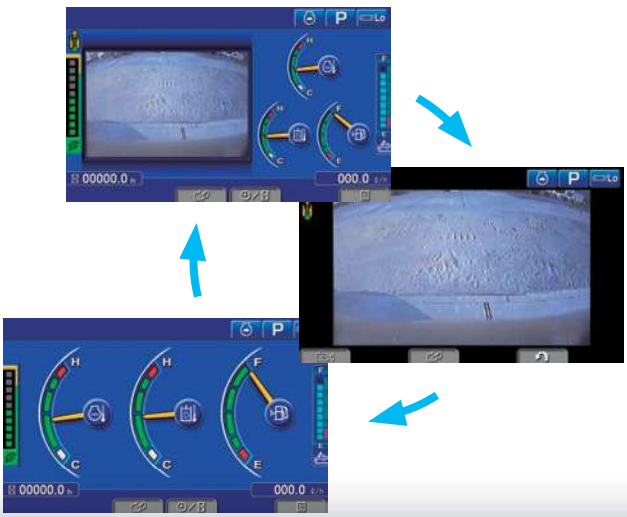
1. Auto-decelerator
2. Working mode
3. Travel speed
4. Ecology gauge
5. Camera display
6. Engine coolant temperature gauge
7. Hydraulic oil temperature gauge
8. Fuel gauge
9. DEF level gauge
10. Service meter, clock
11. Fuel consumption gauge
12. Guidance icon
13. Function switches
14. Camera direction display
15. DEF level caution lamp

Basic operation switches

1. Auto-decelerator
2. Working mode selector
3. Travel speed selector
4. Buzzer cancel
5. Wiper
6. Window washer
7. Auto climate controls

Switchable Display Modes

The main screen display mode can be changed by pressing the pressing the F3 key.



Visual user menu

Pressing the F6 key on the main screen displays the user menu screen. The menus are grouped for each function, and use easy-to-understand icons which enable the machine to be operated easily.



1 Energy saving guidance 2 Machine settings
3 Aftertreatment devices regeneration 4 SCR information
5 Maintenance 6 Monitor setting 7 Message check

Support Efficiency Improvement

Ecology guidance

While the machine is operating, ecology guidance pops up on the monitor screen to notify the operator of the status of the machine in real time.

Ecology gauge & fuel consumption gauge

The monitor screen is provided with an ecology gauge and also a fuel consumption gauge which is displayed continuously. In addition, the operator can set any desired target value of fuel consumption (within the range of the green display), enabling the machine to be operated with better fuel economy.

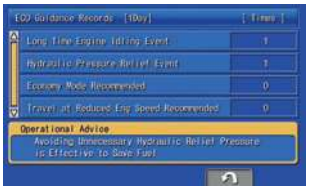


Operation record, fuel consumption history, and ecology guidance record

The ecology guidance menu enables the operator to check the operation record, fuel consumption history and ecology guidance record from the ecology guidance menu, using a single touch, thus enabling the total fuel consumption to be reduced.


Operation record


Fuel consumption history


Ecology guidance record

Operator Identification Function

An identification ID can be set up for individual operator, application or jobs, and used to manage operation information of individual machines using KOMTRAX data. Data sent from KOMTRAX can be used to analyze operation status by operator as well as by machine.



MAINTENANCE FEATURES



Large capacity air cleaner

The larger air cleaner can extend air cleaner life during long-term operation and helps prevent early clogging, and resulting power loss. A radial seal design is used for reliability.



Engine Access

Large rear opening hood provides excellent maintenance and service access to key engine components.



Fuel Filters

Large high-efficiency fuel filter and pre-filter with water separator removes contaminants from fuel for improved fuel injection system life. Built-in priming pump simplifies maintenance.



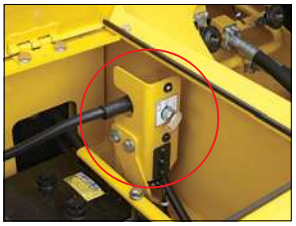
Easy access to engine oil filter and fuel drain valve

Engine oil filter and fuel drain valve are remote mounted to improve accessibility.



Battery disconnect switch

A standard battery disconnect switch allows a technician to disconnect the power supply and lock out before servicing the machine.



Air conditioner filter

The air conditioner filter can be removed and installed without the use of tools for easy filter maintenance.



Washable cab floormat

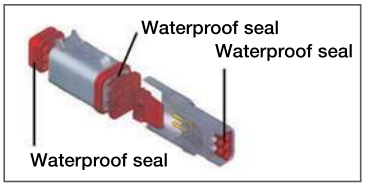
Sloping track frame

Long-life oils, filters

Engine oil & engine oil filter	every 500 hours
Hydraulic oil	every 5000 hours
Hydraulic oil filter	every 1000 hours

DT-type connectors

Sealed DT-type electrical connectors provide high reliability, water and dust resistance.



Diesel Exhaust Fluid (DEF) tank

A large tank volume extends operating time before refilling and is installed on the right front platform for easy access. DEF tank and pump are separated for improved service access.



Maintenance Information

"Maintenance time caution lamp" display

When the remaining time to maintenance becomes less than 30 hours*, a maintenance time monitor appears. Pressing the F6 key switches the monitor to the maintenance screen.

* : The setting can be changed within the range between 10 and 200 hours.



Maintenance screen

Manual Stational Regeneration

Under most conditions, active regeneration will occur automatically with no effect on machine operation. In case the operator needs to disable active regeneration or initiate a manual stationary regeneration, this can be easily accomplished through the monitor panel. A soot level indicator is displayed to show how much soot is trapped in the KDPF.

Soot level indicator



Aftertreatment device regeneration screen

Supports the DEF level and refill timing

The DEF level gauge is displayed continuously on the right side of the monitor screen. In addition, when DEF level is low, DEF low level guidance messages appear in pop up displays to inform the operator in real time.



DEF level gauge

DEF low level guidance

MAINTENANCE FEATURES

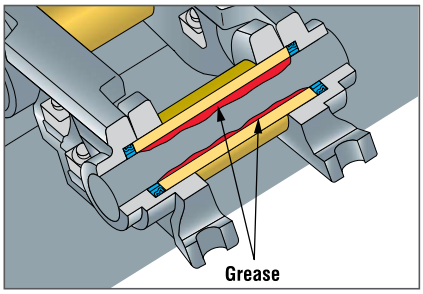
Drawbar Pull

The Komatsu designed final drives and undercarriage provide high drawbar pull for good maneuverability and performance when working on adverse grades or soft ground.



Grease Sealed Track

The PC360LC-11 uses grease sealed tracks for extended undercarriage life.



Large Displacement High Efficiency Pump

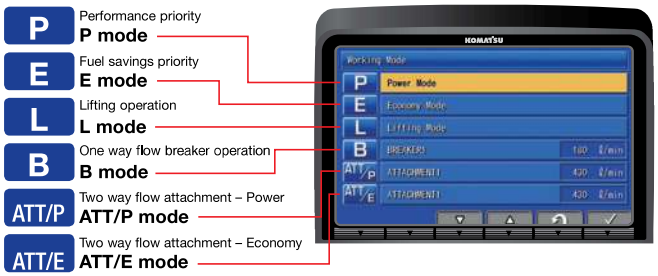
Large displacement hydraulic implement pumps provide high flow output at lower engine RPM as well as operation at the most efficient engine speed.



Working Mode Selection

The PC360LC-11 excavator is equipped with six working modes (P, E, L, B, ATT/P and ATT/E). Power Mode provides improved hydraulic power and faster cycle times for improved performance in demanding applications. Each mode is designed to match engine speed, pump flow, and system pressure to the application. The PC360LC-11 features an attachment mode (ATT/E) that allows operators to run attachments while in Economy mode.

Working Mode	Application	Advantage
P	Power Mode	•Maximum production, power & multifunction
E	Economy Mode	•Good cycle times with reduced fuel consumption
L	Lifting Mode/ Fine Control	•Increased lifting power & fine control
B	Breaker Mode	•One way flow for hydraulic breaker operation
ATT/P	Attachment Power Mode	•Two way flow with maximum power
ATT/E	Attachment Economy Mode	•Two way flow with most efficient fuel economy



High Rigidity Work Equipment

Booms and arms are constructed with thick plates of high tensile strength steel. In addition, these structures are designed with large cross sectional areas and large one piece castings in the boom foot, the boom tip, and the arm tip. The result is work equipment that exhibits long term durability and high resistance to bending and torsional stress. A standard HD boom design provides increased strength and reliability.



GENERAL FEATURES

ROPS CAB STRUCTURE

ROPS Cab (ISO 12117-2)

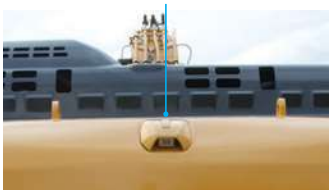
The machine is equipped with a ROPS cab that conforms to ISO 12117-2 for excavators as standard equipment. It also satisfies the requirements for Level 1 Operator Protective Guard (OPG) and top guard (ISO 10262).



Rear View Monitoring System

A new rear view monitoring system display has a rear view camera image that is continuously displayed together with the gauges and important vehicle information. This enables the operator to carry out work while easily checking the surrounding area.

Rear view camera

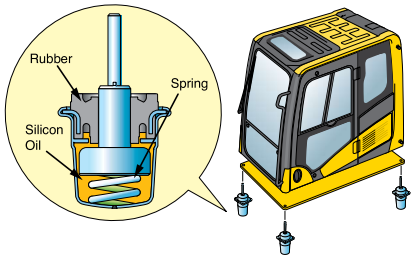


Rear view image on monitor



Low Vibration with Viscous Cab Mounts

The PC360LC-11 uses viscous mounts for the cab that incorporate a longer stroke and the addition of a spring. The cab damper mounting combined with a high rigidity deck reduces vibration at the operator's seat.



General Features

Secondary engine shut down switch at base of seat to shutdown the engine.



Lock lever

Retractable seat belt

Tempered & tinted glass

Large cab entrance step

Left and right side hand rails

Seat belt caution indicator



Large mirrors

Slip-resistant plates

Thermal and fan guards

Pump/engine compartment partition

Travel alarm



KOMATSU PARTS & SERVICE SUPPORT

Every new Komatsu Tier 4 Final construction machine is covered.

The Komatsu CARE program covers all new Komatsu Tier 4 Final construction equipment, whether rented, leased or purchased. For the first 3 years or 2,000 hours, whichever occurs first, you'll receive:

- Regular service at 500, 1,000, 1,500 and 2,000-hr. intervals
- DEF tank breather element replacement at 1,000 hours
- DEF and CCV filters replacement at 2,000 hours
- 50-point inspection by factory-trained technician at each scheduled interval
- Technician labor
- Fluids, oils, coolant, filters, SCR screen, tank breather and parts
- Technician travel to and from your equipment location

Plus two complimentary KDPF exchanges and SCR system service for 5 years-no hours limits. *

Service will be performed by a Komatsu Distributor and only Komatsu genuine fluids and filters will be used.

Komatsu CARE® services are available from every Komatsu Distributor in the U.S. and Canada.



Komatsu CARE® – Extended Coverage

- Extended Coverage can provide peace of mind by protecting customers from unplanned expenses that effect cash flow
- Purchasing extended coverage locks-in the cost of covered parts and labor for the coverage period and helps turn these into fixed costs



* Some exclusions apply. Please contact your Komatsu distributor for specific program details.



Komatsu Parts Support

- 24/7/365 to fulfill your parts needs
- 9 parts Distribution Centers strategically located across the U.S. and Canada
- Distributor network of more than 300 locations across U.S. and Canada to serve you
- Online part ordering through Komatsu eParts
- Remanufactured components with same-as-new warranties at a significant cost reduction



Komatsu Oil and Wear Analysis (KOWA)

- KOWA detects fuel dilution, coolant leaks, and measures wear metals
- Proactively maintain your equipment
- Maximize availability and performance
- Can identify potential problems before they lead to major repairs
- Reduce life cycle cost by extending component life

KOMTRAX EQUIPMENT MONITORING

GET THE WHOLE STORY WITH KOMTRAX®

WHAT

- KOMTRAX is Komatsu's remote equipment monitoring and management system
- KOMTRAX **continuously monitors and records** machine health and operational data
- Information such as fuel consumption, utilization, and a detailed history **lowering owning and operating cost**

WHO

- KOMTRAX is **standard** equipment on all Komatsu construction products

WHEN

- Know when your machines are **running or idling** and make decisions that will improve your fleet utilization
- Detailed movement records ensure you know when and where your equipment is moved
- Up to date records allow you to **know when maintenance is due** and help you plan for future maintenance needs

WHERE

- KOMTRAX data **can be accessed virtually anywhere** through your computer, the web or your smart phone
- Automatic alerts keep fleet managers up to date on the latest machine notifications

WHY

- Knowledge is power - **make informed decisions** to manage your fleet better
- Knowing your idle time and fuel consumption will help maximize your machine efficiency
- **Take control of your equipment** - any time, anywhere





KOMTRAX®

For construction and compact equipment.

KOMTRAX Plus®

For production and mining class machines.

SPECIFICATIONS

PC360LC-11

ENGINE

Model.....Komatsu SAA6D114E-6*
Type.....Water-cooled, 4-cycle, direct injection
Aspiration.....Komatsu Variable Geometry Turbocharger with air-to-air aftercooler and EGR
Number of cylinders..... 6
Bore..... 114 mm **4.49"**
Stroke.....144.5 mm **5.69"**
Piston displacement..... 8.85 ltr **540 in³**
Horsepower:
SAE J1995.....Gross 202 kW **271 HP**
ISO 9249 / SAE J1349..... Net 192 kW **257 HP**
Rated rpm..... 1950
Governor..... All-speed control, electronic
Fan drive method for radiator cooling ..... Mechanical

*EPA Tier 4 Final emissions certified

HYDRAULICS

Type ... HydrauMind (Hydraulic Mechanical Intelligence) system, closed-center system with load sensing valve and pressure compensated valves, 6 selectable working modes
Main pump:
Pumps for.....Boom, arm, bucket, swing, and travel circuits
Type.....Variable displacement axial piston type
Maximum flow ..... 535 ltr/min **141.3 gal/min**
Supply for control circuit..... Self reducing valve
Hydraulic motors:
Travel ..... 2 x axial piston motors with parking brake
Swing ..... 1 x axial piston motor with swing holding brake
Relief valve setting:
Implement circuits ..... 37.3 MPa 380 kgf/cm² **5,400 psi**
Travel circuit..... 37.3 MPa 380 kgf/cm² **5,400 psi**
Swing circuit..... 27.9 MPa 285 kgf/cm² **4,050 psi**
Pilot circuit..... 3.2 MPa 33 kgf/cm² **470 psi**
Hydraulic cylinders:
(Number of cylinders – bore x stroke x rod diameter)
Boom .... 2–140 mm x 1480 mm x 100 mm **5.5" x 58.3" x 3.9"**
Arm ..... 1–160 mm x 1825 mm x 110 mm **6.3" x 71.9" x 4.3"**
Bucket..... for 3.2 m **10'5"** and 4.0 m **13'2"** Arms
1–140 mm x 1285 mm x 100 mm **5.5" x 50.6" x 3.9"**
.....for 2.54 m **8'4"** Arm
1–150 mm x 1285 mm x 110 mm **5.9" x 50.6" x 4.3"**

DRIVES AND BRAKES

Steering control.....Two lever with pedals
Drive method ..... Hydrostatic
Maximum drawbar pull ..... 290 kN 29570 kgf **65,191 lbf**
Gradeability..... 70%, 35°
Maximum travel speed (auto shift):
High..... 5.5 km/h **3.4 mph**
Mid..... 4.2 km/h **2.8 mph**
Low..... 3.2 km/h **2.0 mph**
Service brake.....Hydraulic lock
Parking brake.....Mechanical disc brake

SWING SYSTEM

Driven by..... Hydraulic motor
Swing reduction..... Planetary gear
Swing circle lubrication ..... Grease-bathed
Service brake..... Hydraulic lock
Holding brake/Swing lock.....Mechanical disc brake
Swing speed..... 9.5 rpm
Swing torque.....11386 kg•m **82,313 ft lbs**

UNDERCARRIAGE

Center frame.....X-frame
Track frame.....Box-section
Track type ..... Sealed
Track adjuster .....Hydraulic
Number of shoes (each side) 48
Number of carrier rollers (each side) 2
Number of track rollers (each side) 8

COOLANT & LUBRICANT CAPACITY (REFILLING)

Fuel tank ..... 605 ltr **159.8 U.S. gal**
Radiator ..... 37 ltr **9.7 U.S. gal**
Engine..... 35 ltr **9.2 U.S. gal**
Final drive, each side.....9.0 ltr **2.4 U.S. gal**
Swing drive ..... 13.7 ltr **3.6 U.S. gal**
Hydraulic tank..... 188 ltr **49.7 U.S. gal**
Diesel Exhaust Fluid (DEF) tank ..... 39 ltr **10.3 U.S. gal**

OPERATING WEIGHT (APPROXIMATE)

Operating weight includes 6500 mm **21'3"** one-piece HD boom, 3185 mm **10'5"** arm, SAE heaped 1.96 m³ **2.56 yd³** bucket, rated capacity of lubricants, coolant, full fuel tank, operator, and standard equipment.

Triple-Grouser Shoes	Operating Weight	Ground Pressure
700 mm **28"**	35748 kg **78,645 lb**	0.59 kg/cm² **8.35 psi**
800 mm **31.5"**	36129 kg **79,483 lb**	0.52 kg/cm² **7.44 psi**
850 mm **33.5"**	36509 kg **80,320 lb**	0.50 kg/cm² **7.03 psi**

WORKING FORCES

	Arm Length	2540 mm 8'4"	3185 mm 10'5"	4020 mm 13'2"
ISO rating	Bucket digging force	229 kN 23300 kgf / **51,370 lb**	200 kN 20400 kgf / **44,970 lb**	200 kN 20400 kgf / **44,970 lb**
	Arm crowd force	193 kN 19700 kgf / **43,430 lb**	165 kN 16800 kgf / **37,040 lb**	139 kN 14200 kgf / **31,310 lb**
SAE rating	Bucket digging force	259 kN 26400 kgf / **58,200 lb**	228 kN 23200 kgf / **51,150 lb**	227 kN 23100 kgf / **50,930 lb**
	Arm crowd force	201 kN 20500 kgf / **45,190 lb**	171 kN 17400 kgf / **38,360 lb**	144 kN 14700 kgf / **32,410 lb**

Component Weights

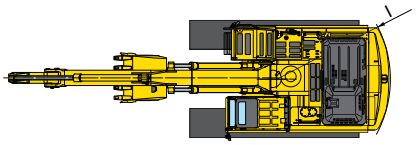
Arm including bucket cylinder and linkage
3185 mm **10'5"** arm assembly ..... 1761 kg **3,882 lb**
4020 mm **13'2"** arm assembly ..... 1988 kg **4,383 lb**
One piece HD boom including arm cylinder
6500 mm **21'3"** boom assembly ..... 3135 kg **6,912 lb**
Boom cylinders x 2 ..... 259 kg **571 lb**
Counterweight ..... 6920 kg **15,255 lb**

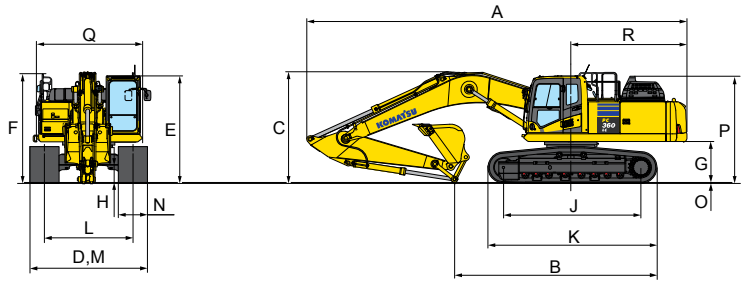
DIMENSIONS

	Arm Length	3185 mm	10'5"	4020 mm	13'2"
A	Overall length	11145 mm	36'7"	11170 mm	36'8"
B	Length on ground (transport)	5935 mm	19'6"	5475 mm	18'0"
C	Overall height (to top of boom)*	3285 mm	10'9"	3760 mm	12'4"
D	Overall width	3440 mm	11'3"		
E	Overall height (to top of cab)*	3160 mm	10'4"		
F	Overall height (to top of handrail)*	3255 mm	10'8"		
G	Ground clearance, counterweight	1185 mm	3'11"		
H	Ground clearance, minimum	498 mm	1'8"		
I	Tail swing radius	3445 mm	11'4"		
J	Track length on ground	4030 mm	13'3"		
K	Track length	4955 mm	16'3"		
L	Track gauge	2590 mm	8'6"		
M	Width of crawler	3440 mm	11'3"		
N	Shoe width	850 mm	33.5"		
O	Grouser height	36 mm	1.4"		
P	Machine height to top of engine cover	3135 mm	10'3"		
Q	Machine upper width **	3145 mm	10'4"		
R	Distance, swing center to rear end	3405 mm	11'2"		

* : Including grouser height

** : Including handrail





BACKHOE BUCKET, ARM AND BOOM COMBINATION

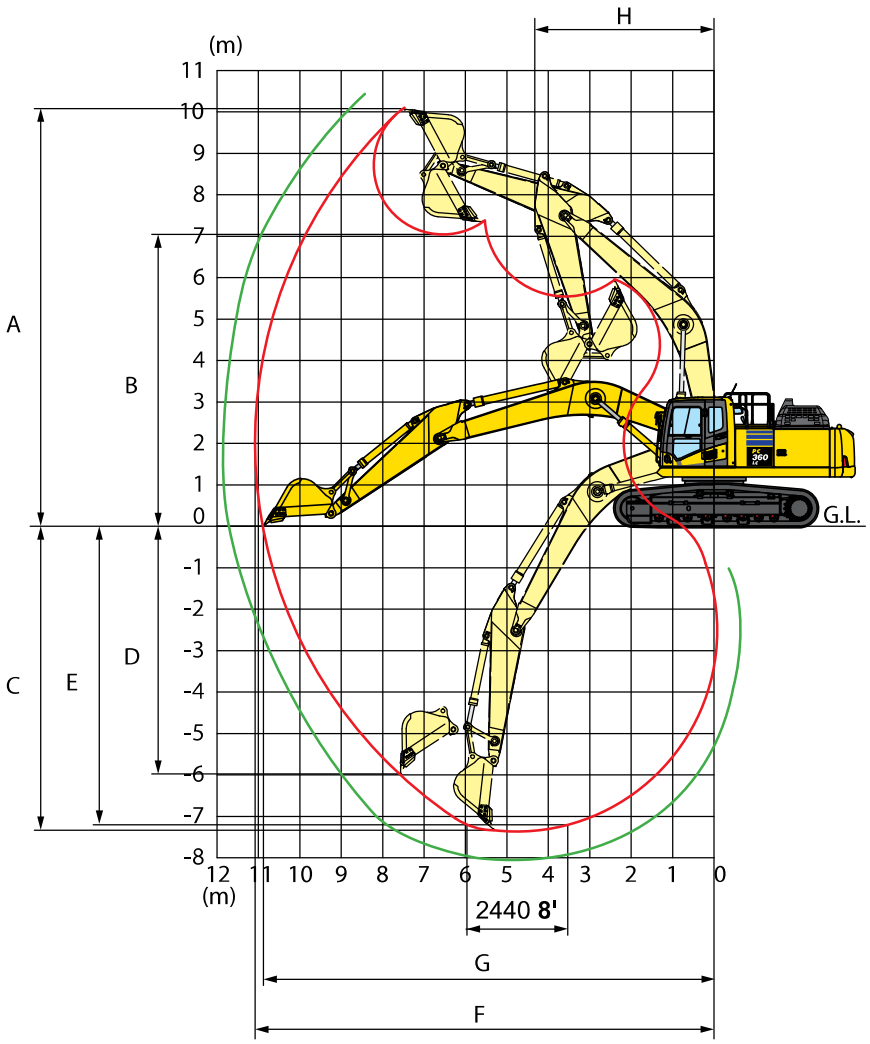
Bucket Type	Bucket Capacity		Teeth	Width		Weight		Tip Radius		6.5 m (21'3") Boom 3.2 m (10'5")	6.5 m (21'3") Boom 4.0 m (13'2")
Komatsu TL	0.93 m³	1.21 yd³	4	762 mm	30"	1097 kg	2418 lb	1674 mm	65.9"	●	●
	1.18 m³	1.54 yd³	4	914 mm	36"	1198 kg	2641 lb	1674 mm	65.9"	●	●
	1.44 m³	1.88 yd³	5	1067 mm	42"	1325 kg	2921 lb	1674 mm	65.9"	●	●
	1.70 m³	2.22 yd³	5	1219 mm	48"	1426 kg	3144 lb	1674 mm	65.9"	●	○
	1.96 m³	2.56 yd³	6	1372 mm	54"	1554 kg	3425 lb	1674 mm	65.9"	○	□
Komatsu HP	0.68 m³	0.89 yd³	3	610 mm	24"	1022 kg	2254 lb	1674 mm	65.9"	●	●
	0.93 m³	1.21 yd³	4	762 mm	30"	1178 kg	2598 lb	1674 mm	65.9"	●	●
	1.18 m³	1.54 yd³	4	914 mm	36"	1358 kg	2993 lb	1674 mm	65.9"	●	●
	1.44 m³	1.88 yd³	5	1067 mm	42"	1439 kg	3173 lb	1674 mm	65.9"	●	●
	1.70 m³	2.22 yd³	5	1219 mm	48"	1555 kg	3429 lb	1674 mm	65.9"	●	□
	1.96 m³	2.56 yd³	6	1372 mm	54"	1701 kg	3750 lb	1674 mm	65.9"	□	⊙
Komatsu HPS	0.68 m³	0.89 yd³	3	610 mm	24"	1112 kg	2451 lb	1674 mm	65.9"	●	●
	0.93 m³	1.21 yd³	4	762 mm	30"	1294 kg	2853 lb	1674 mm	65.9"	●	●
	1.18 m³	1.54 yd³	4	914 mm	36"	1437 kg	3167 lb	1674 mm	65.9"	●	●
	1.44 m³	1.88 yd³	5	1067 mm	42"	1607 kg	3543 lb	1674 mm	65.9"	●	○
	1.70 m³	2.22 yd³	5	1219 mm	48"	1750 kg	3857 lb	1674 mm	65.9"	○	□
	1.96 m³	2.56 yd³	6	1372 mm	54"	1921 kg	4236 lb	1674 mm	65.9"	□	⊙
Komatsu HPX	0.68 m³	0.89 yd³	3	610 mm	24"	1239 kg	2731 lb	1674 mm	65.9"	●	●
	0.93 m³	1.21 yd³	4	762 mm	30"	1421 kg	3133 lb	1674 mm	65.9"	●	●
	1.18 m³	1.54 yd³	4	914 mm	36"	1564 kg	3447 lb	1674 mm	65.9"	●	●
	1.44 m³	1.88 yd³	5	1067 mm	42"	1734 kg	3823 lb	1674 mm	65.9"	●	○
	1.70 m³	2.22 yd³	5	1219 mm	48"	1877 kg	4137 lb	1674 mm	65.9"	○	□
	1.96 m³	2.56 yd³	6	1372 mm	54"	2048 kg	4516 lb	1674 mm	65.9"	□	⊙

● - Used with material weights up to 3,500 lb/yd³ - Quarry/rock/high abrasion applications
□ - Used with material weights up to 2,500 lb/yd³ – General construction
○ - Used with material weights up to 3,000 lb/yd³ – Tough digging applications
⊙ - Used with material weights up to 2,000 lb/yd³ – Light materials applications
X - Not useable

Komatsu recommends the use of buckets sized to machine capacity. Buckets listed in the table above are sized appropriate to the specified material densities. Buckets exceeding recommended sizes may result in reduced performance

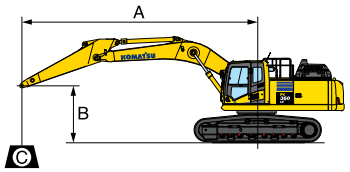
SPECIFICATIONS

WORKING RANGE



	Arm Length	3185 mm	10'5"	4020 mm	13'2"
A	Max. digging height	10210 mm	**33'6"**	10550 mm	**34'7"**
B	Max. dumping height	7110 mm	**23'4"**	7490 mm	**24'7"**
C	Max. digging depth	7380 mm	**24'3"**	8180 mm	**26'10"**
D	Max. vertical wall digging depth	6480 mm	**21'3"**	7280 mm	**23'11"**
E	Max. digging depth for 8' level bottom	7180 mm	**23'7"**	8045 mm	**26'5"**
F	Max. digging reach	11100 mm	**36'5"**	11900 mm	**39'1"**
G	Max. digging reach at ground level	10920 mm	**35'10"**	11730 mm	**38'6"**
H	Min. swing radius	4310 mm	**14'2"**	4320 mm	**14'2"**
SAE rating	Bucket digging force at power max.	200 kN 20400 kg / **44,970 lb**		200 kN 20400 kg / **44,970 lb**	
SAE rating	Arm crowd force at power max.	165 kN 16800 kg / **37,040 lb**		139 kN 14200 kg / **31,310 lb**	
ISO rating	Bucket digging force at power max.	228 kN 23200 kg / **51,150 lb**		227 kN 23100 kg / **50,930 lb**	
ISO rating	Arm crowd force at power max.	171 kN 17400 kg / **38,360 lb**		144 kN 14700 kg / **32,410 lb**	

LIFTING CAPACITY WITH LIFTING MODE



A: Reach from swing center
B: Bucket hook height
C: Lifting capacity
Cf: Rating over front
Cs: Rating over side
⊗ : Rating at maximum reach

Conditions :
- 6500 mm **21' 3"** one-piece boom
- Bucket: None
- Lifting mode: On

Arm: 3185 mm **10'5"** **Shoes:** 800 mm **31.5"** **Unit:** kg lb

A / B	3.0 m 10' Cf	3.0 m 10' Cs	4.6 m 15' Cf	4.6 m 15' Cs	6.1 m 20' Cf	6.1 m 20' Cs	7.6 m 25' Cf	7.6 m 25' Cs	9.1 m 30' Cf	9.1 m 30' Cs	⊗ MAX Cf	⊗ MAX Cs
7.6 m											* 7250	* 7250
25'											* **15900**	* **15900**
6.1 m							* 8890	7600			* 7050	6440
20 '							* **19600**	**16700**			* **15500**	**14200**
4.6 m					* 10740	10260	* 9370	7430			* 7100	5750
15'					* **23600**	**22600**	* **20600**	**16300**			* **15600**	**12600**
3.0 m			* 16210	14630	* 12090	9790	* 10030	7200	8240	5570	* 7380	5390
10'			* **35700**	**32200**	* **26600**	**21500**	* **22100**	**15800**	**18100**	**12200**	* **16200**	**11800**
1.5 m			* 18180	13820	* 13220	9370	10510	6980	8120	5460	7820	5260
5'			* **40000**	**30400**	* **29100**	**20600**	**23100**	**15300**	**17900**	**12000**	**17200**	**11600**
0 m			* 18550	13460	* 13740	9100	10330	6810	8040	5390	7990	5360
0'			* **40900**	**29600**	* **30200**	**20000**	**22700**	**15000**	**17700**	**11800**	**17600**	**11800**
-1.5 m	* 13710	* 13710	* 17720	13380	* 13480	8980	10240	6730			8570	5710
-5'	* **30200**	* **30200**	* **39000**	**29500**	* **29700**	**19800**	**22500**	**14800**			**18800**	**12600**
-3.0 m	* 20540	* 20540	* 15850	13490	* 12300	9010	* 9440	6780			* 8870	6490
-10'	* **45200**	* **45200**	* **34900**	**29700**	* **27100**	**19800**	* **20800**	**14900**			* **19500**	**14300**
-4.6 m	* 15670	* 15670	* 12560	* 12560	* 9590	9210					* 8350	8250
-15'	* **34500**	* **34500**	* **27600**	* **27600**	* **21100**	**20300**					* **18400**	**18100**

Arm: 3185 mm **10'5"** **Shoes:** 850 mm **33.5"** **Unit:** kg lb

A / B	3.0 m 10' Cf	3.0 m 10' Cs	4.6 m 15' Cf	4.6 m 15' Cs	6.1 m 20' Cf	6.1 m 20' Cs	7.6 m 25' Cf	7.6 m 25' Cs	9.1 m 30' Cf	9.1 m 30' Cs	⊗ MAX Cf	⊗ MAX Cs
7.6 m											* 7250	* 7250
25'											* **15900**	* **15900**
6.1 m							* 8890	7630			* 7050	6470
20 '							* **19600**	**16800**			* **15500**	**14200**
4.6 m					* 10740	10300	* 9370	7460			* 7100	5770
15'					* **23600**	**22700**	* **20600**	**16400**			* **15600**	**12700**
3.0 m			* 16210	14690	* 12090	9830	* 10030	7230	8280	5590	* 7380	5410
10'			* **35700**	**32300**	* **26600**	**21600**	* **22100**	**15900**	**18200**	**12300**	* **16200**	**11900**
1.5 m			* 18180	13880	* 13220	9410	10560	7010	8160	5490	7850	5290
5'			* **40000**	**30600**	* **29100**	**20700**	**23200**	**15400**	**18000**	**12100**	**17300**	**11600**
0 m			* 18550	13520	* 13740	9140	10380	6840	8080	5410	8030	5380
0'			* **40900**	**29800**	* **30200**	**20100**	**22800**	**15000**	**17800**	**11900**	**17700**	**11800**
-1.5 m	* 13710	* 13710	* 17720	13450	* 13480	9020	10290	6770			8610	5740
-5'	* **30200**	* **30200**	* **39000**	**29600**	* **29700**	**19900**	**22700**	**14900**			**18900**	**12600**
-3.0 m	* 20540	* 20540	* 15850	13550	* 12300	9050	* 9440	6810			* 8870	6520
-10'	* **45200**	* **45200**	* **34900**	**29800**	* **27100**	**19900**	* **20800**	**15000**			* **19500**	**14300**
-4.6 m	* 15670	* 15670	* 12560	* 12560	* 9590	9260					* 8350	8290
-15'	* **34500**	* **34500**	* **27600**	* **27600**	* **21100**	**20400**					* **18400**	**18200**

Arm: 4020 mm **13'2"** **Shoes:** 800 mm **31.5"** **Unit:** kg lb

A / B	3.0 m 10' Cf	3.0 m 10' Cs	4.6 m 15' Cf	4.6 m 15' Cs	6.1 m 20' Cf	6.1 m 20' Cs	7.6 m 25' Cf	7.6 m 25' Cs	9.1 m 30' Cf	9.1 m 30' Cs	⊗ MAX Cf	⊗ MAX Cs
7.6 m							* 7750	* 7750			* 5610	* 5610
25'							* **17000**	* **17000**			* **12300**	* **12300**
6.1 m							* 7950	7680	* 6550	5740	* 5460	* 5460
20 '							* **17500**	**16900**	* **14400**	**12600**	* **12000**	* **12000**
4.6 m							* 8520	7470	* 7870	5660	* 5470	4980
15'							* **18700**	**16400**	* **17300**	**12400**	* **12000**	**10900**
3.0 m			* 14340	* 14340	* 11020	9870	* 9280	7190	8210	5520	* 5640	4700
10'			* **31600**	* **31600**	* **24300**	**21700**	* **20400**	**15800**	**18100**	**12100**	* **12400**	**10300**
1.5 m			* 16890	13900	* 12370	9350	* 10010	6900	8040	5370	* 5950	4590
5'			* **37200**	**30600**	* **27200**	**20600**	* **22000**	**15200**	**17700**	**11800**	* **13100**	**10100**
0 m	* 8320	* 8320	* 18090	13270	* 13230	8960	10200	6670	7910	5240	* 6480	4640
0'	* **18300**	* **18300**	* **39800**	**29200**	* **29100**	**19700**	**22500**	**14700**	**17400**	**11500**	* **14200**	**10200**
-1.5 m	* 12420	12420	* 17980	13030	* 13400	8740	10050	6530	7840	5180	* 7330	4890
-5'	* **27300**	**27300**	* **39600**	**28700**	* **29500**	**19200**	**22100**	**14400**	**17200**	**11400**	* **16100**	**10700**
-3.0 m	* 17840	* 17840	* 16780	13030	* 12760	8700	* 10020	6510			* 8040	5410
-10'	* **39300**	* **39300**	* **37000**	**28700**	* **28100**	**19100**	* **22000**	**14300**			* **17700**	**11900**
-4.6 m	* 19190	* 19190	* 14360	13230	* 11040	8810	* 8190	6640			* 7850	6480
-15'	* **42300**	* **42300**	* **31600**	**29100**	* **24300**	**19400**	* **18000**	**14600**			* **17300**	**14300**

Arm: 4020 mm **13'2"** **Shoes:** 850 mm **33.5"** **Unit:** kg lb

A / B	3.0 m 10' Cf	3.0 m 10' Cs	4.6 m 15' Cf	4.6 m 15' Cs	6.1 m 20' Cf	6.1 m 20' Cs	7.6 m 25' Cf	7.6 m 25' Cs	9.1 m 30' Cf	9.1 m 30' Cs	⊗ MAX Cf	⊗ MAX Cs
7.6 m							* 7750	* 7750			* 5610	* 5610
25'							* **17000**	* **17000**			* **12300**	* **12300**
6.1 m							* 7950	7720	* 6550	5770	* 5460	* 5460
20 '							* **17500**	**17000**	* **14400**	**12700**	* **12000**	* **12000**
4.6 m							* 8520	7500	* 7870	5690	* 5470	5010
15'							* **18700**	**16500**	* **17300**	**12500**	* **12000**	**11000**
3.0 m			* 14340	* 14340	* 11020	9910	* 9280	7220	* 8220	5550	* 5640	4720
10'			* **31600**	* **31600**	* **24300**	**21800**	* **20400**	**15900**	* **18100**	**12200**	* **12400**	**10400**
1.5 m			* 16890	13960	* 12370	9390	* 10010	6940	8080	5400	* 5950	4610
5'			* **37200**	**30700**	* **27200**	**20700**	* **22000**	**15300**	**17800**	**11900**	* **13100**	**10100**
0 m	* 8320	* 8320	* 18090	13330	* 13230	9000	10250	6710	7950	5270	* 6480	4660
0'	* **18300**	* **18300**	* **39800**	**29400**	* **29100**	**19800**	**22600**	**14700**	**17500**	**11600**	* **14200**	**10200**
-1.5 m	* 12420	* 12420	* 17980	13090	* 13400	8790	10100	6570	7880	5200	* 7330	4910
-5'	* **27300**	* **27300**	* **39600**	**28800**	* **29500**	**19300**	**22200**	**14400**	**17300**	**11400**	* **16100**	**10800**
-3.0 m	* 17840	* 17840	* 16780	13090	* 12760	8740	10020	6540			* 8040	5440
-10'	* **39300**	* **39300**	* **37000**	**28800**	* **28100**	**19200**	**22000**	**14400**			* **17700**	**11900**
-4.6 m	* 19190	* 19190	* 14360	13290	* 11040	8860	8190	6670			* 7850	6520
-15'	* **42300**	* **42300**	* **31600**	**29300**	* **24300**	**19500**	**18000**	**14700**			* **17300**	**14300**

*Load is limited by hydraulic capacity rather than tipping. Ratings are based on ISO standard No. 10567. Rated loads do not exceed 87% of hydraulic lift capacity or 75% of tipping load.

STANDARD EQUIPMENT

- 3 speed travel with auto shift
- Alternator, 90 Ampere, 24V
- AM/FM radio
- Arm holding valve
- Automatic engine warm-up system
- Automatic climate control/air conditioner/heater/defroster
- Auto idle
- Auto idle shut down, programmable
- Auxiliary input (3.5mm jack)
- Batteries, large capacity (2 x 12V)
- Battery master disconnect switch
- Boom holding valves
- Carrier rollers, (2 each side)
- Converter, (2) x 12V
- Counterweight, 6920 kg **15,255 lb**
- Dry type air cleaner, double element
- Electric horn
- Engine, Komatsu SAA6D114E-6
- Engine coolant to -25°C **-13°F**
- EMMS monitoring system
- Engine overheat prevention system
- Extended work equipment grease interval
- Fan guard structure
- Fuel priming pump
- Fuel system pre-filter 10 micron
- Grease sealed track chain
- High back air suspension seat, with heat
- Hydraulic cooling fan (reversible)
- Hydraulic track adjusters
- KOMTRAX® Level 5.0
- Large LCD color monitor, high resolution
- Lock lever
- Mirrors, (LH and RH)
- Operator Protective Top Guard (OPG), Level 1
- Operator identification system
- Pattern change valve (ISO to BH control)
- Power maximizing system
- PPC hydraulic control system
- Pump/engine room partition cover
- Radiator and oil cooler dustproof net
- Rear reflectors
- Rearview monitoring system (1 camera)
- Revolving frame deck guard
- Revolving frame undercovers
- ROPS cab (ISO12117-2)
- Seat belt indicator
- Seat belt, retractable, 76mm **3"**
- Secondary engine shutoff switch
- Service valve
- Skylight
- Slip resistant foot plates
- Starter motor, 11.0kW/24V x 1
- Suction fan
- Thermal and fan guards
- Track frame swivel guard
- Track roller guards, center section
- Track rollers, 8 (each side)
- Track shoes, triple grouser, 800mm **31.5"**
- Travel alarm
- Two boom mode settings
- Working lights, 2 (boom and RH front)
- Working mode selection system

OPTIONAL EQUIPMENT

- Arms
  - 3185 mm **10'5"** arm assembly
  - 3185 mm **10'5"** arm assembly with piping
  - 4020 mm **13'2"** arm assembly
  - 4020 mm **13'2"** arm assembly
- Booms
  - 6500 mm **21'3"** HD boom assembly
  - 6500 mm **21'3"** HD boom assembly with piping
- Cab guards
  - Lower front window guard
  - Full front guard, OPG Level 1
  - Full front guard, OPG Level 2
  - Bolt-on top guard, OPG Level 2
- Counterweight, 7400 kg **16,315 lb** with revolving frame reinforcement for use with super long fronts only
- High pressure in-line hydraulic filters
- Hydraulic control unit, 1 actuator
- Proportional control handles
- Rain visor
- Revolving frame undercovers, heavy duty
- Revolving frame undercovers, severe duty
- Sun visor
- Straight travel pedal
- Track roller guards, full length
- Track shoes, triple grouser, 700 mm **28"**
- Track shoes, triple grouser, 850 mm **33.5"**
- Track shoes, single grouser, 800 mm **31.5"**
- Working lights, front, two additional cab mounted

ATTACHMENT OPTIONS

- Grade control systems
- Hydraulic couplers
- Hydraulic kits, field installed
- Load hold, anti-burst valves
- Material handler front
- Super long fronts
- PSM thumbs
- Rockland thumbs
- Vandalism protection guards with storage box

For a complete list of available attachments, please contact your local Komatsu distributor.

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KOMATSU®

Note: All comparisons and claims of improved performance made herein are made with respect to the prior Komatsu model unless otherwise specifically stated.

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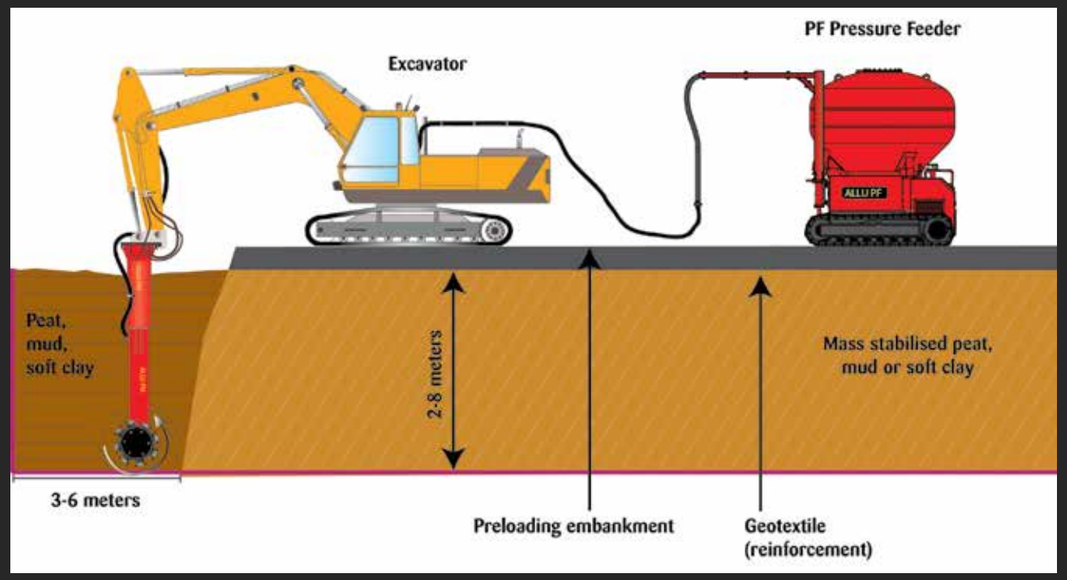
ALLU
One Step Ahead

ALLU STABILISATION SYSTEM

SOIL STABILISATION METHOD



Mass stabilisation is a ground improvement method for soft soil layers. Stabilisation is done by mixing an appropriate amount of binder throughout the volume of the treated soil layer. The binder can consist of a single substance or be a mixture of various substances like cement, lime, fly ash or furnace slag.

Mass stabilisation method was developed in Finland in the early 1990´s and in the development work the experiences from column stabilisation were utilized. The machinery designed and dedicated only for mass stabilisation was developed by ALLU in the early 2000´s.

Mass Stabilisation is a versatile technology for civil engineering and environmental applications for:

- in-situ improving of soft soils
- remediation of contaminated soils
- improving and utilizing clean and contaminated soft sediments

Stabilisation is a geotechnical method to improve the bearing capacity and stability of ground. This is done by mixing binders into the subject soil. A similar technique is used in contaminated site remediation.

Stabilisation Method

Stabilisation is a geotechnical method to improve the bearing capacity and stability of marginal ground. Clay, peat, silt, sediment, sludge, or dredged material can be transformed into solid ground. The method relies on thoroughly mixing binders into subject material while the material remains in-place or insitu.

Stabilisation is quick and cost effective compared to other traditional methods such as: excavation of incompetent soil and replacement, or compaction by surcharge. The ALLU Stabilisation system allows you to treat and quickly access low bearing capacity ground for infrastructure development. The stabilisation method can also be used to remediate contaminated property. The technology immobilizes or destroys hazardous constituents to permit reuse or redevelopment of the property.

Benefits of stabilisation with ALLU equipment

- Fast ground improvement, stabilised ground can support advancing equipment and structures often within a day.
- Sustainability-Stabilisation facilitates reuse of existing on-site material
- No need to use off-site material as replacement fill, avoids excavation and transportation costs
- Conserves landfill space, unsuitable soil is treated, not disposed
- Lower carbon footprint than excavation, transportation and replacement
- Cost-effective use of binders, accurate binder dosing and thorough mixing
- Industrial by-products such as fly ash and slag may be used as binders



APPLICATIONS



Applications for Soil Stabilisation

Civil Engineering

- Stiffening of pavement subgrades
- Stabilisation of embankments
- Protection of adjacent structures from transmitted vibration
- Improvement of clay, silt, or peat soils
- Improve bearing capacity of soil for building foundations
- Modification of very soft soils for tunnel boring
- Cable/pipe channel construction sites
- Support of noise attenuation barriers
- Low permeability ground water protection layers
- Reduction of soil hydraulic conductivity
- Erosion control
- Protection layers for permafrost and frost

Processing or Mixing of different materials

- Recycling of the industrial by-products

Stabilisation of dredged sludge

- Reuse of dregded material management areas for infrastructure development
- Treatment of dredge within barges producing engineered fill

Treatment of waste or contaminated material

- Solidify free-liquids
- Increase compressive strength
- Insitu solidification/stabilisation (ISS)
- Immobolize hazardous constituents
- Insitu chemical oxidation or reduction (ISCO or ISCR)
- Reduction of hydraulic conductivity





ALLU STABILISATION PRODUCTS



ALLU PMX Power Mixer

The ALLU PMX Power Mixer is an attachment for a conventional excavator. The ALLU PMX is powered by the excavator's hydraulic system. Attaching the PMX converts the excavator to a powerful and versatile mixing tool. The mixing drums penetrate and mix a variety of material in place or insitu. Materials can be mixed anywhere the excavator can go, capitalizing on the excavator's mobility and articulation to reach difficult or soft areas. Binders or chemical agents are delivered to the area of the highest mixing shear by an attached 80-mm (3-inch) dia. pipe, injected via nozzle located between the mixing drums. The ALLU PMX is easily mounted on an excavator with pin mounts or with a quick hitch adapter plate.

Intelligent construction

The ALLU Power Mixer is able to effectively mix a variety of difficult materials including, clay, silt, peat, sludge, sediment, dredged material, and contaminated soil. The ALLU PMX penetrates through hard crust layers and mixes the soils effectively. Penetration and mixing effectiveness is enhanced by angled position of the drums that minimizes the "dead" area at the bottom frame.

Material processing to a depth up to 7 meters (23 feet)

ALLU Power Mixer can process materials to a depth of up to 7 meters (23 feet) depending on the PMX model extension, and the nature of the material.

Designed for durability

Made from wear-resistant steel, the ALLU PMX's stem is engineered to be strong, streamlined, and lightweight. This design lowers penetration resistance by the material subject to treatment and prevents any stress concentration within the stem. Hydraulic hoses are routed within the stem for protection. There are no service hatches at the lower part of the PMX and mixing drum seals are engineered for long life.

Individual hydraulic motors within each mixing drum are powered by the excavator hydraulic system. The final drives rotate the mixing drums directly through planetary gears. ALLU PMX is equipped with automatic torque adjustment valves between the two hydraulic motors. The excavator operator controls the rotational direction and rpm of the drums to adjust for the most effective mixing of the material encountered. Cabin-mounted display indicates mixing drum rpm, temperatures, and internal hydraulic leak detection.



ALLU PMX 300 HD		ALLU PMX 500 HD	
Working depth:	3 meters (10 feet)	Working depth:	5 meters (16 feet)
Hydraulics: (required)	23-35 MPa (3,300 - 5,100 psi), 200 - 300 l/min (50 - 80 gpm) 160 kW (215 hp) max power	Hydraulics: (required)	23-35 MPa (3,300 - 5,100 psi), 200 - 300 l/min (50 - 80 gpm) 160 kW (215 hp) max power
Weight:	2,095 kg (4,620 lb) + fabricated mount plate 400 kg (900 lb)	Weight:	2,445 kg (5,390 lb) + fabricated mountplate 400 kg (900 lb)
Base machine:	25-40 metric ton (55,000 - 88,000 lb)	Base machine:	25-40 metric ton (55,000 - 88,000 lb)
Option:	2 m (7 ft) extension tube 770 kg (1,700 lb)	Option:	2 m (7 ft) extension tube 770 kg (1,700 lb)

ALLU STABILISATION PRODUCTS



ALLU PF 7 & PF 7+7 Pressure Feeders

The ALLU PF Pressure Feeders are self-contained pneumatic-based binder delivery systems. The ALLU PF's use an on-board air compressor to pressurize a tank of binder and deliver the binder in dry form to the operational mixing depths of the ALLU PMX or other mixing equipment. Delivering and mixing binder in dry form conserves the "drying" capacity of a binder. Dry mixing is a more cost-effective use of binders when wet soil or sediment is to be stabilized. The ALLU PFs are on a tracked chassis and are remotely controlled from within an excavator cabin allowing the operator to adjust for site and material conditions.

Engine:	74.5 kW (99 hp) diesel
Compressor:	
Working pressure	max 800 kPa (120 psi)
Output	6.5 m³ (230 ft³) / min
Tank:	
Maximum working pressure	800 kPa (120 psi)
Gross Volume	approx 7 m³ (250 ft³)/tank
Approx. weight of binder charge (based on portland cement)	7 metric ton (8 ton)/tank
Feeder:	
Feeding capacity, adjustable	up to 5 kg (11 lb) / sec
Feeding Distance	up to 75 m (250 ft) at 5 kg/sec
Weight (empty):	
PF 7	7,900 kg (17,500 lb)
PF 7+7	13,500 kg (29,800 lb)



Option:
Bag filter for use while filling tank(s).

ALLU DAC. (Data Acquisition Control) system measures, controls and reports the feeding operation of the ALLU PFs. The ALLU DAC. enables user friendly control of the dry powder feeding system. Data is recorded and can be transferred onto other computers. Feeding operation is properly documented for quality control purposes.



ALLU PF 7



ALLU PF 7+7



ALLU STABILISATION PRODUCTS



3D Positioning System

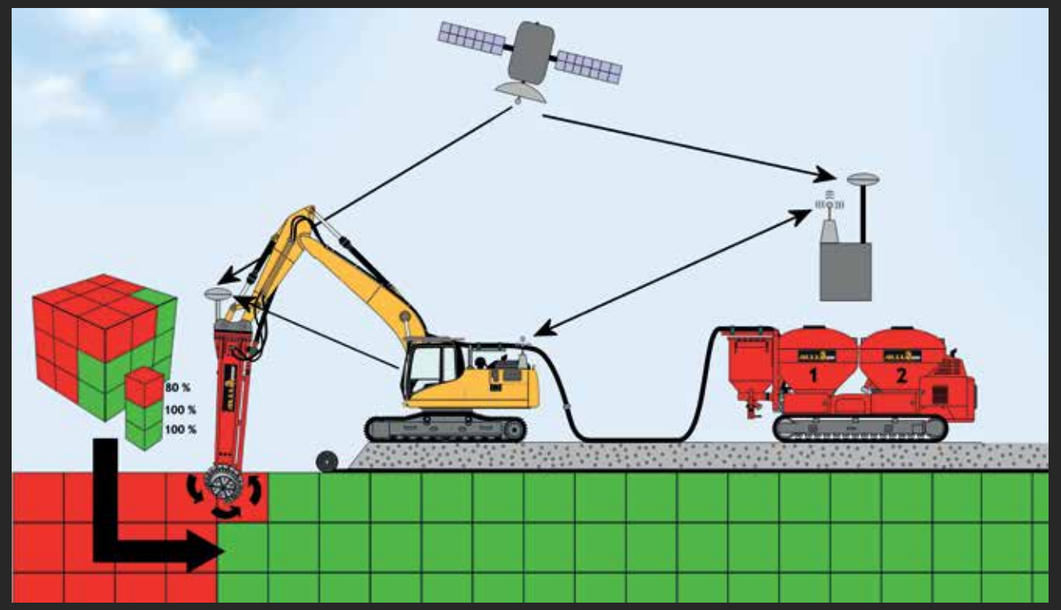
3D Positioning System is a GPS-based insitu mixing guidance and recording system.

- An option used with PMX power mixer and PF pressure feeders to guide excavator operator on mixing location, depth and binder dosing
- Generates reports on mixing location, depth, mixing time and binder addition rate for construction quality control and quality assurance (QC/QA)

The 3D positioning system informs the excavator driver the position of the mixing head at the accuracy of +/- 2 cm. The system consists of four modules: computer unit with ALLU software, touch screen, base station sending correction signal and GPS sensors.

The system guides the driver to feed right amount of binder and to mix adequately each cell of the block. It eases the mixing, ensures homogenous mixing results and accurate binder feeding for the entire block. The system has advanced data logging and reporting system.

The ALLU 3D Positioning System can be mounted on every ALLU Stabilisation System, new or old.



APPLICATIONS





Coastal Facility Examples

Expansion of ports and other industrial facilities near coastal areas often involve building new infrastructure onto former dredge material management areas or other areas of poor bearing capacity ground.

ALLU's soil stabilisation technology has been successfully used in Europe and North America to improve marginal coastal land. Increased production of natural gas in the U.S. has led to construction of new expansion of existing, liquefied natural gas (LNG) facilities around the Gulf of Mexico. In 2015, an LNG facility construction project in Lousiana began using ALLU Power Mixers and Pressure Feeder to improve the bearing capacity of clay/silt soil areas.

The treated areas quickly provide support for additional construction activities to build new tanks, roads, pipe racks, and liquefaction equipment.

Reuse of dredged material from harbours is often complication not just by the low-bearing capacity of the material but also environmental contaminants within the material. This was the problem faced during the construction of the new Vuosaari Harbor Center near Helsinki, Finland. ALLU's equipment was used to create a 10-hectare (25-acre) container storage area by treating and reusing tributyltin (TBT)-impacted dredged material.





Rail and Transportation Examples

Soil stabilisation technology is often the answer for improvements to rail right-of-way. Heavier, more frequent freight trains, or high speed passenger service demand stiffer, higher bearing-capacity railroad subgrade.

ALLU's soil stabilisation technology has been used in new rail construction and to improve/repair existing rail. Soil stabilisation was used during construction of a new high-speed passenger service corridor in southern Finland. An area of unsuitable soft peaty soil was treated, creating a stiff competent subgrade that now supports smooth, precise rail alignment.

Soft areas in existing right-of-way can limit freight train weight and/or speeds. A 2014 project in Ontario demonstrated the use of ALLU soil stabilisation equipment to address areas of mud pumping between ties. Stabilisation was used to "spot treat" problem areas. The mobility of the excavator-mounted ALLU Power Mixer and self-contained Pressure Feeder facilitates use in remote areas.





Contaminated Site Remediation Examples

ALLU soil stabilisation equipment has been used for remediation of contaminated sites. Remediation technologies including Insitu Solidification/Stabilisation (ISS), Insitu Chemical Oxidation (ISCO) and Insitu Chemical Reduction (ISCR) involve mixing binder/reagents into contaminated media such as oil, sediment, or sludge.

ALLU Power Mixer's injection tube and nozzle deliver grouted or dry binders/reagents to the area of high mixing shear between the mixing drum. High mixing shear thoroughly mixes additives into contaminated media.

ALLU's Pressure Feeder can deliver dry binder/reagent conserving drying capacity or reactivity. ALLU soil stabilisation equipment has been used for decades in ISS projects treating contaminated soil, dredged material and sediment. In 2015, an ALLU Power Mixer was utilized at an ISCO project in Kenova, WV. The ALLU equipment mixed sodium persulfate and activator into petroleum-impacted soil.

ALLU - AT YOUR SERVICE!







Project planning

Our goal is to provide our customers comprehensive service. During almost twenty years in mass stabilisation business, we have built a strong relationship in the field with various operators.

In addition to the machinery, we offer our help and knowledge for carrying out “the whole package” including project and site planning.







Training and start-up/comissioning

Training and commissioning is part of our service package to our customers.

We tailor the training according to customer’s unique needs. The focus in the training is on practical matters. After approximately one week training, one can operate ALLU Stabilisation System independently.







Spare parts and accesories

ALLU After Sales Team is committed to serve our clients fast and efficiently.

We provide a wide range of spare parts and wear parts straight out of the factory stock. Our aim is to minimize the downtime for our clients. By using original factory provided spare parts you ensure the effective operation of your ALLU machinery.







Product support

The support of ALLU Team doesn’t end after delivery of the machinery and commissioning.

ALLU specialists are ready to help you with all questions and information you might need during your stabilisation projects and with service work concerning ALLU equipment.

ALLU, 30 years of experience at your service!

The ALLU attachments are designed to perform cost-effectively on demanding job sites and materials so you can work faster and improve profitability. The ALLU attachments are known for their reliability and superior quality for already 30 years.

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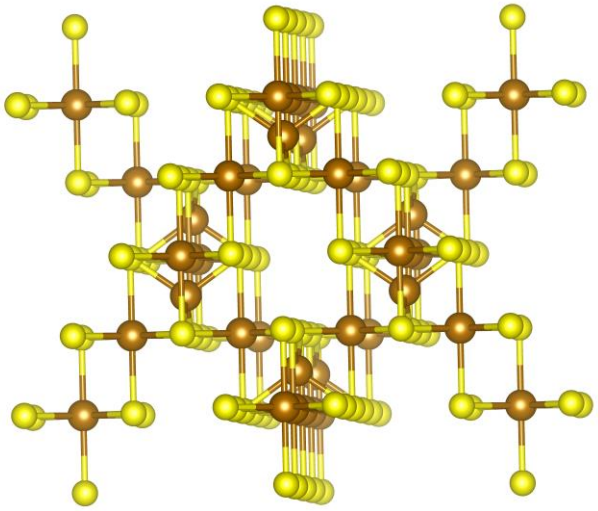
www.stamix.net

FerroBlack®

Metals Remediation Technology

Redox Technology Group, LLC (d/b/a Redox Solutions) is an Indiana-based chemical manufacturer specializing in the development and production of reagents marketed under the FerroBlack® trade names. These proprietary compounded reagents are designed for the treatment of **aqueous, gaseous, and solid media** contaminated with heavy metals. FerroBlack® is currently being incorporated into one of the largest reactive barriers in the United States for the treatment of hexavalent chrome (Cr^{+6}) contaminated ground water.



REAGENT DESCRIPTION AND APPLICATION

The building block of our patented FerroBlack® chemistry is a proprietary amorphous iron sulfide (mackinawite) particle with other compounds to create site-specific remediation reagents. This chemistry is minimally soluble which lends itself to cost effective in-situ application of mixed metals contaminated groundwater and soils.

Through a combination of adsorption, chemical reduction, precipitation, and conversion to stable sulfide and iron-sulfide precipitates, FerroBlack® reagents are able to control a wide array of heavy metals.

PROJECT APPLICATIONS

- Chromite ore processing residue (COPR) impacted sites
- Plating facilities
- CCA wood preserving facilities
- Chlor-alkali sites contaminated with Hg
- Chlorinated solvent impacted sites

ADVANTAGES OF FerroBlack® REAGENTS

- Control of wide array of heavy metals including As, Cd, Cr^{+6}, Cu, Hg^{+2}, Hg^{0},Ni, Pb, Sb, and Se^{+4}
- Cost effective for mixed metals remediation
- Minimally soluble with ground water
- In-situ and ex-situ stabilization or treatment of soils
- In-situ treatment of contaminated groundwater
- Compatible with wide variety of traditional application methods
- Use in augmentation of fill materials to create permeable reactive sub-surface barrier to prevent target metals from moving beyond site

PHYSICAL & CHEMICAL PROPERTIES

Physical Form:	Colloidal Suspension
Color:	Black
Odor:	Sulfurous
Specific Gravity:	1.15 – 1.22
Density:	9.6 - 10.2 lb/gal
Solubility in Water:	Minimal
pH:	9.5 – 12.5
ORP:	-700 to -1300 mV

WASTE MATRIX TESTING AND APPLICATION

The specific FerroBlack® formulation delivered to a customer is blended to meet specific reduction goals. This formulation is developed based on the waste matrix to be treated. FerroBlack® is compatible with a variety of application methods including bucket mixing, pug milling, in-situ mixing, and direct injection.

MATERIALS OF CONSTRUCTION

Below are all suitable materials for use with FerroBlack®:

- 304L or 316L stainless steel
- Fiberglass
- Polypropylene
- PVC
- high density polyethylene
- lined carbon steel

PACKAGING OPTIONS

Totes:	300 gallons
Bulk Tanker:	4,250 gallons

ACTIVE CONSTITUENTS

Please consult the SDS or Product Data Sheet (PDS) for further information.

For additional information contact:

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President/CEO
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FerroBlack®-H

Safety Data Sheet

according to Federal Register / Vol. 77, No. 58 / Monday, March 26, 2012 / Rules and Regulations

Date of issue: 06/14/2016 Revision date: 06/14/2016 Supersedes: 06/25/2015

SECTION 1: Identification

1.1. Identification

Product form : Mixture

Trade name : FerroBlack®-H

CAS No : 1317-37-9

Formula : FeS

Synonyms : Ferrous sulfide / Iron sulfide / Iron sulphide / Iron(II) sulfide / Ferrous sulfide / Iron sulfide / Iron sulphide / Iron(II) sulfide

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/mixture : Chemical used for the remediation of heavy metal(s) for liquid and solid wastes.

1.3. Details of the supplier of the safety data sheet

Redox Technology Group, LLC
d/b/a Redox Solutions
1580 Research Way
Indianapolis, IN 46231

Company Contact: Jim Kissel
Telephone Number: (317) 660-6867 or (317) 412-3267

1.4. Emergency telephone number

CHEMTREC: (800) 424-9300

SECTION 2: Hazard(s) identification

2.1. Classification of the substance or mixture

GHS-US classification

Skin corrosion/irritation Category 2 H315
Serious eye damage/eye irritation Category 2A H319

Full text of H statements : see section 16

2.2. Label elements

GHS-US labeling

Hazard pictograms (GHS-US) :



GHS07

Signal word (GHS-US) : Warning

Hazard statements (GHS-US) : H315 - Causes skin irritation
H319 - Causes serious eye irritation

Precautionary statements (GHS-US) : P264 - Wash hands thoroughly after handling
P280 - Wear eye protection, protective clothing, protective gloves
P302+P352 - If on skin: Wash with plenty of water
P305+P351+P338 - If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P321 - Specific treatment (see Consult a doctor/medical service if you feel unwell on this label)
P332+P313 - If skin irritation occurs: Get medical advice/attention
P337+P313 - If eye irritation persists: Get medical advice/attention
P362+P364 - Take off contaminated clothing and wash it before reuse

2.3. Other hazards

HMIS Classification:
Health hazard: 0
Flammability: 0
Physical hazards: 0

NFPA Rating:
Health hazard: 1
Fire: 0
Reactivity Hazard: 0

Inhalation May be harmful if inhaled. May cause respiratory tract irritation.
Skin May be harmful if absorbed through skin. May cause skin irritation.
Eyes May cause eye irritation.
Ingestion May be harmful if swallowed.
Other Hazards not contributing to the classification: Generates toxic gas in contact with acid.

2.4. Unknown acute toxicity (GHS US)

Not applicable

SECTION 3: Composition/Information on ingredients

3.1. Substance

Not applicable

3.2. Mixture

Name	Product Identifier	%	GHS-US classification
Iron sulfide (FeS)	(CAS No) 1317-37-9	7 - 11	Not classified
Sodium Sulfide	(CAS No) 1313-82-2	0.1 - 1	Acute Tox. 3 (Oral), H301

Full text of hazard classes and H-statements : see section 16

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures general : Never give anything by mouth to an unconscious person. If you feel unwell, seek medical advice (show the label where possible).

First-aid measures after inhalation : Remove person to fresh air and keep comfortable for breathing. Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a poison center or doctor/physician.

First-aid measures after skin contact : Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower. If skin irritation occurs: Get medical advice/attention.

First-aid measures after eye contact : Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a doctor/physician. If eye irritation persists: Get medical advice/attention.

First-aid measures after ingestion : Rinse mouth. Do NOT induce vomiting. Immediately call a poison center or doctor/physician. Call a poison center/doctor/physician if you feel unwell.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms/injuries : Causes skin and eye irritation.

Symptoms/injuries after skin contact : Irritation.

Symptoms/injuries after eye contact : Causes serious eye damage. Eye irritation.

4.3. Indication of any immediate medical attention and special treatment needed

Treat symptomatically.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Foam. Dry powder. Carbon dioxide. Water spray. Sand.

Unsuitable extinguishing media : Do not use a heavy water stream.

5.2. Special hazards arising from the substance or mixture

Reactivity : Corrosive vapors.

5.3. Advice for firefighters

Firefighting instructions : Use water spray or fog for cooling exposed containers. Exercise caution when fighting any chemical fire. Prevent fire-fighting water from entering environment.

Protection during firefighting : Do not enter fire area without proper protective equipment, including respiratory protection. Do not attempt to take action without suitable protective equipment. Self-contained breathing apparatus. Complete protective clothing.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

6.1.1. For non-emergency personnel

Emergency procedures : Ventilate spillage area. Evacuate unnecessary personnel. Avoid contact with skin and eyes.

6.1.2. For emergency responders

Protective equipment : Do not attempt to take action without suitable protective equipment. Equip cleanup crew with proper protection. For further information refer to section 8: "Exposure controls/personal protection".

Emergency procedures : Ventilate area.

6.2. Environmental precautions

Avoid release to the environment. Prevent entry to sewers and public waters. Notify authorities if liquid enters sewers or public waters.

6.3. Methods and material for containment and cleaning up

Methods for cleaning up : Take up liquid spill into absorbent material. Soak up spills with inert solids, such as clay or diatomaceous earth as soon as possible. Collect spillage. Store away from other materials.

Other information : Dispose of materials or solid residues at an authorized site.

6.4. Reference to other sections

See Heading 8. Exposure controls and personal protection. For further information refer to section 13.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling : Ensure good ventilation of the work station. Wash hands and other exposed areas with mild soap and water before eating, drinking or smoking and when leaving work. Provide good ventilation in process area to prevent formation of vapor. Do not breathe dust, fume, gas, mist, spray, vapors. Avoid contact during pregnancy/while nursing. Avoid contact with skin and eyes. Wear personal protective equipment.

Hygiene measures : Wash hands thoroughly after handling. Wash contaminated clothing before reuse. Do not eat, drink or smoke when using this product. Always wash hands after handling the product.

7.2. Conditions for safe storage, including any incompatibilities

Technical measures : Comply with applicable regulations.

Storage conditions : Keep only in the original container in a cool, well ventilated place away from : Ignition sources, Incompatible materials. Keep container closed when not in use. Store in a well-ventilated place. Keep cool.

Incompatible products : Strong bases. Strong acids.

Incompatible materials : Sources of ignition. Direct sunlight.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Iron sulfide (FeS) (1317-37-9)

Not applicable

Sodium sulfide (1313-82-2)

Not applicable

8.2. Exposure controls

Appropriate engineering controls : Ensure good ventilation of the work station.

Personal protective equipment : Avoid all unnecessary exposure.

Hand protection	:	Wear protective gloves.
Eye protection	:	Chemical goggles or face shield. Safety glasses.
Skin and body protection	:	Wear suitable protective clothing.
Respiratory protection	:	Wear appropriate mask.
Environmental exposure controls	:	Avoid release to the environment.
Other information	:	Do not eat, drink or smoke during use.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	:	Liquid
Appearance	:	Black liquid with visible suspended solids.
Color	:	Black
Odor	:	Mild
Odor threshold	:	No data available
pH	:	11.0 - 12.5
Melting point	:	Not applicable
Freezing point	:	No data available
Boiling point	:	No data available
Flash point	:	No data available
Relative evaporation rate (butyl acetate=1)	:	No data available
Flammability (solid, gas)	:	Non flammable.
Vapor pressure	:	No data available
Relative vapor density at 20 °C	:	No data available
Relative density	:	1.15 - 1.22
Solubility	:	Mininally soluble in water.
Log Pow	:	No data available
Auto-ignition temperature	:	No data available
Decomposition temperature	:	No data available
Viscosity, kinematic	:	No data available
Viscosity, dynamic	:	No data available
Explosion limits	:	No data available
Explosive properties	:	No data available
Oxidizing properties	:	No data available

9.2. Other information

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

Acidic vapors.

10.2. Chemical stability

Not established.

10.3. Possibility of hazardous reactions

Contact with acids liberates toxic gas.

10.4. Conditions to avoid

Direct sunlight. Extremely high or low temperatures.

10.5. Incompatible materials

Acids will cause the release of highly toxic Hydrogen Sulfide. Reacts violently with diazonium salts. Ferrous sulfide(s) solution is not compatible with copper, zinc, aluminum or their **alloys** (i.e. bronze, brass, galvanized metals, etc.). Corrosive to steel above 150º F (65.5º C). These materials of construction should not be used in handling systems or storage containers for this product.

10.6. Hazardous decomposition products

Hazardous decomposition products formed under fire may include sulfur oxides, iron oxides.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute toxicity : Not classified

Sodium Sulfide (113-82-2)	
LD50 oral rat	208 mg/kg
ATE US (oral)	208.000 mg/kg body weight
LD50 dermal rabbit	< 340 mg/kg
ATE US (dermal)	300.000 mg/kg body weight

Skin corrosion/irritation : Causes skin irritation.
pH: 11.0 - 12.5

Serious eye damage/irritation : Causes eye irritation.
pH: 11.0 - 12.5

Respiratory or skin sensitization : Not classified

Germ cell mutagenicity : Not classified

Carcinogenicity : Not classified

Reproductive toxicity : Not classified

Specific target organ toxicity (single exposure) : Not classified

Specific target organ toxicity (repeated exposure) : Not classified

Aspiration hazard : Not classified

Potential Adverse human health effects and symptoms : Based on available data, the classification criteria are not met.

Symptoms/injuries after skin contact : Irritation.

Symptoms/injuries after eye contact : Causes eye irritation.

SECTION 12: Ecological information

12.1. Toxicity

Ecology - general : The product is not considered harmful to aquatic organisms or to cause long-term adverse effects in the environment.

FeS (1317-37-9)	
LC50 fish 1	> 10000 mg/l Mosquito fish

Sodium Sulfide (1313-82-2)	
LC50 fish 1	7.7 - 29.1 mg/l (Exposure time: 96 h - Species: Poecilia reticulata)
EC50 Daphnia 1	2.1 mg/l (Exposure time: 48 h - Species: Daphnia magna)

12.2. Persistence and degradability

Redox-Hg (1317-37-9)	
Persistence and degradability	Not established.

12.3. Bioaccumulative potential

FeS (1317-37-9)	
Bioaccumulative potential	Not established.

Sodium Sulfide (16721-80-5)	
Log Pow	-3.5 (at 25 °C)

12.4. Mobility in soil

No additional information available

12.5. Other adverse effects

Effect on the global warming : No known effects from this product.
GWPmix comment : No known effects from this product.

Other information : Avoid release to the environment.

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Waste treatment methods : Dispose of contents/container in accordance with licensed collector's sorting instructions.
Waste disposal recommendations : Dispose of contents/container to hazardous or special waste collection point, in accordance with local, regional, national and/or international regulation.
Ecology - waste materials : Avoid release to the environment.

SECTION 14: Transport information

Department of Transportation (DOT)

In accordance with DOT

Not Regulated

Transport by sea

Not Regulated

Air transport

Not Regulated

SECTION 15: Regulatory information

15.1. US Federal regulations

Iron sulfide (FeS) (1317-37-9)
Listed on the United States TSCA (Toxic Substances Control Act) inventory

Sodium Sulfide (1313-82-2)
Listed on the United States TSCA (Toxic Substances Control Act) inventory

15.2. International regulations

CANADA

Iron sulfide (FeS) (1317-37-9)	
Listed on the Canadian DSL (Domestic Substances List)	
WHMIS Classification	Uncontrolled product according to WHMIS classification criteria

Sodium Sulfide (1313-82-2)
Listed on the Canadian DSL (Domestic Substances List)

EU-Regulations

Iron sulfide (FeS) (1317-37-9)
Listed on the EEC inventory EINECS (European Inventory of Existing Commercial Chemical Substances)

Sodium Sulfide (1313-82-2)
Listed on the EEC inventory EINECS (European Inventory of Existing Commercial Chemical Substances)

National regulations

Iron sulfide (FeS) (1317-37-9)
Listed on the AICS (Australian Inventory of Chemical Substances) Listed on IECSC (Inventory of Existing Chemical Substances Produced or Imported in China) Listed on the Japanese ENCS (Existing & New Chemical Substances) inventory Listed on the Korean ECL (Existing Chemicals List) Listed on NZIoC (New Zealand Inventory of Chemicals) Listed on PICCS (Philippines Inventory of Chemicals and Chemical Substances)

Sodium Sulfide (1313-82-2)
Listed on the AICS (Australian Inventory of Chemical Substances) Listed on IECSC (Inventory of Existing Chemical Substances Produced or Imported in China) Listed on the Japanese ENCS (Existing & New Chemical Substances) inventory Listed on the Korean ECL (Existing Chemicals List) Listed on NZIoC (New Zealand Inventory of Chemicals) Listed on PICCS (Philippines Inventory of Chemicals and Chemical Substances) Listed on INSQ (Mexican National Inventory of Chemical Substances) Listed on CICR (Turkish Inventory and Control of Chemicals)

15.3. US State regulations

Sodium Sulfide (1313-82-2)
U.S. - Massachusetts - Right To Know List U.S. - New Jersey - Right to Know Hazardous Substance List

SECTION 16: Other information

Revision date : 06/14/2016

Other information : None.

Full text of H-phrases:

H301	Toxic if swallowed
H315	Causes skin irritation
H319	Causes serious eye irritation
H400	Very toxic to aquatic life

SDS US (GHS HazCom 2012)

This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product

CG-400 "Environmental" Series



Product Page:
https://www.chemgrout.com/products/specialty-equipment/cg-400-environmental-series/

Product Summary

Product Description

The ChemGrout CG-400 Remediator is a skid mounted, gas/hydraulic, high pressure, environmental remediation injection system. This unit is designed to inject environmental compounds into contaminated ground conditions. Materials include ORC, HRC, Potassium Permanganates and other low viscosity remediation compounds. This unit features a 34-gallon (128 liters) high shear mixing tank, the powerful HC25 injection pump all powered by a Honda gas engine. The mixing tank is equipped with baffles and a variable speed high-shear propeller that provides rapid mixing action. The tank outlet is a large 2" ball valve. The injection pump is a positive displacement, rotary diaphragm pump that delivers 15 GPM, 750 PSI. (57 LPM, 50 Bar) The pump is equipped with a pressure relief valve to control the injection pressure. This unit is powered by an electric start 13 HP Honda gasoline engine that drives the hydraulic motors for the mixer and pump. The rugged steel frame stands up to the toughest conditions on the job site. Operator controls are centrally located for efficient production.

Applications

Geotechnical - environmental remediation, monitor wells, in situ injection, direct push injection

Specifications

Model	Pump	Mixing Tank	Max. Output	Max. Pressure
CG400	HC 25	34 gallon	15 GPM	750 PSI

Requirements, Weights, and Dimensions

Model Number	Description	Dimensions	Weight
CG400/HC25/GHES	Skid Mounted Hydraulic Grout Plant 13 HP Honda Gas Engine with Electric Start	37" L X 37" W X 46" H	680 lbs

Product Gallery





Product added date: 2015-10-27 19:30:29
Product modified date: 2016-03-01 07:47:10

Export date: Thu Apr 4 14:00:42 2019 / +0000 GMT
Product data have been exported from Chemgrout [https://www.chemgrout.com]

Product Print by WooCommerce PDF & Print plugin.

KAESER COMPRESSORS

Built for a lifetime.™

Portable Compressors

Mobilair™ M50

185 cfm @ 100 psig

NEW!



Tough, Dependable, and Quiet

The Mobilair™ M50 is a versatile portable screw compressor that offers heavy-duty performance in a light weight package. It is well suited for many applications including sand-blasting, pavement breaking, and general air tool use. These units are built to meet the demands of rental houses, repair trucks, and railroad applications.

Both the double-walled, rotomolded polyethylene canopy and the solid steel flooring protect the motor, airend, and critical components from dirt, water, and other contaminants. Rugged construction combined with extensive engineering allow the M50 to retain it's value year after year. The canopy is also designed to provide extremely low noise levels. Maximum sound level measured at 23 ft. is 76 db(A).

The M50 also features Kaeser's patent-pending anti-frost control feature. This thermostatically controlled valve automatically controls the compressed air temperature in relation to the current ambient temperature, which protects construction tools from freezing up, increases tool life, and extends compressor fluid life.

Standard Features:

- Direct drive rotary screw airend: Sigma profile produces more air with less fuel consumption
- Rotomolded polymer canopy is scratch and dent resistant
- 1 micron, 2-stage compressor inlet filter with maintenance indicator
- 10 micron engine air filter with maintenance indicator
- Exclusive anti-frost valve maintains optimum operating temperature and prevents tool freeze up
- Heavy duty, 4-cylinder Kubota diesel engine complies with Tier 4 emissions standards
- Tool box for convenient storage
- Highly efficient cooling system
- Modulation control
- Lighting package

Optional Features:

- Five year airend warranty
- Skid mount

Outstanding Advantages

- Contemporary, compact design
- Light weight, easily maneuverable
- One piece rotomolded canopy
- Easily accessible control panel
- Reflector and lighting package
- Torsion bar suspension
- Direct drive Sigma rotary screw airend
- Transparent fuel tank
- Thermstatically controlled combination valve
- Heavy duty inlet filter



Specifications

Compressor		Diesel Engine		Package		Dimensions (in.)	
Free air delivery	185 cfm	**Make**	Kubota V1505-T IDI	**Fuel tank capacity**	21 gal.	**Length***	136½
Working Pressure	100 psig	**Power at full load**	41 hp	**Weight, dry**	1470 lb.	**Width**	56¾
		Full load speed	3000 rpm	**Outlets**	2 x 3/4"; 1 x 1	**Height**	55¾
		Off load running speed	2200 rpm	**Sound level max**	76 db(A) at 23 ft.	*includes tow bar	

Specifications are subject to change without notice.

KAESER COMPRESSORS

Built for a lifetime.™

www.kaeser.com

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Toll free: (800) 477-1416
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Kaeser Compresores de México S de RL de CV
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sales.mexico@kaeser.com

Kaeser Compresores de Guatemala y Cia. Ltda.
Calz. Atanasio Tzul 21-00, zona 12
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Telephone: +502 2412-6000
info.guatemala@kaeser.com

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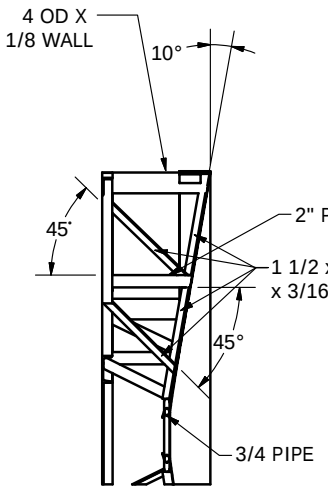
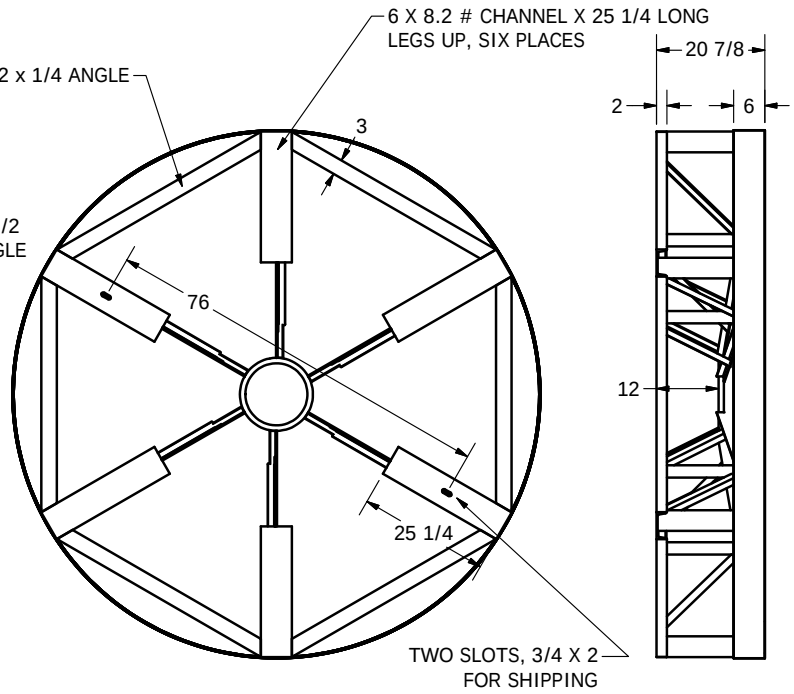
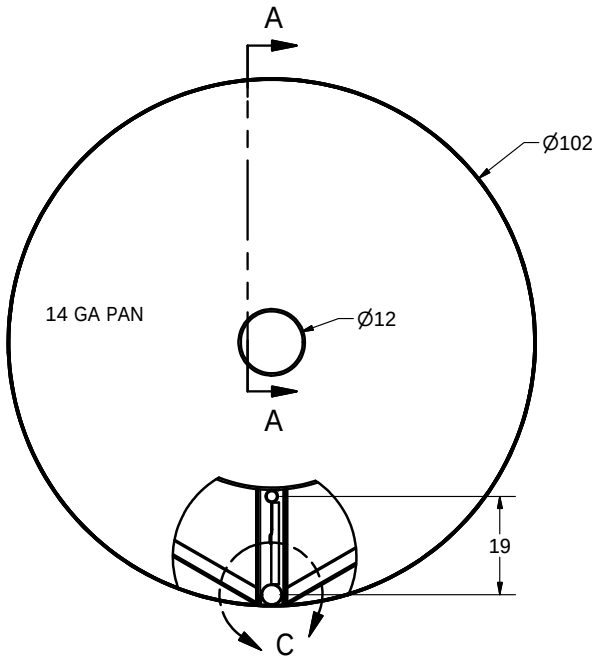
USM50

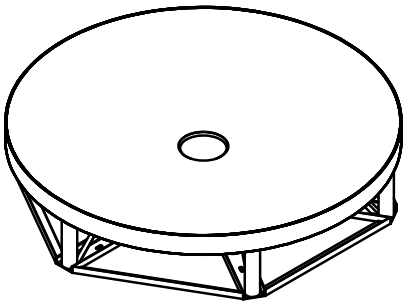
REV	DESCRIPTION	DATE	AUTHOR
A	WAS 4500/6000 X 102	2/3/2015	Jerry Paulson

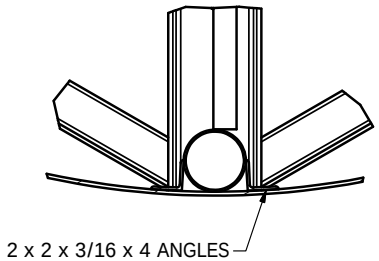


SECTION A-A
SCALE 1 /24









DETAIL C
SCALE 1 / 8

FOB HANFORD, CA

DRAWN	Jerry Paulson	7/22/2009
CHECKED		
QA		
MFG		
APPROVED		

NORWESCO, INC., ST. BONIFACIUS, MN

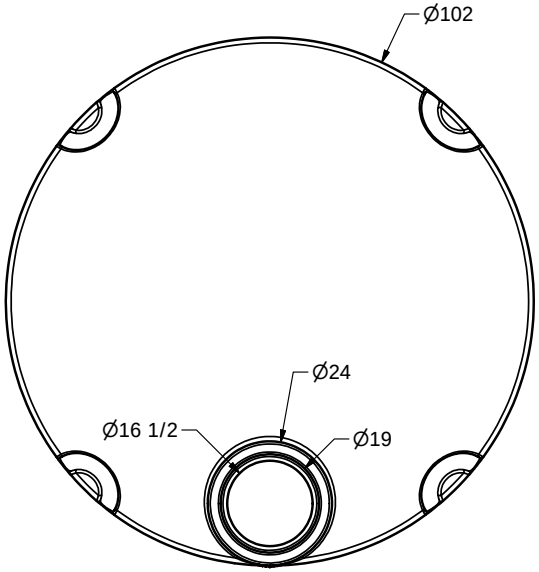
TITLE

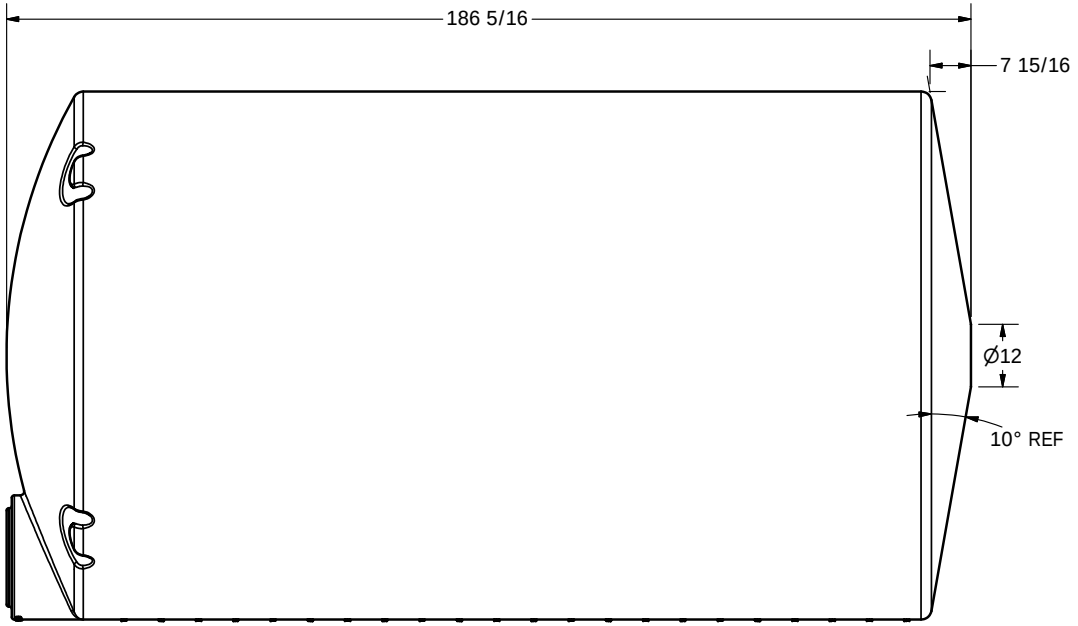
BASE WELDMENT FOR 6000 X 102 X 10 DEG CONE BOTTOM TANK

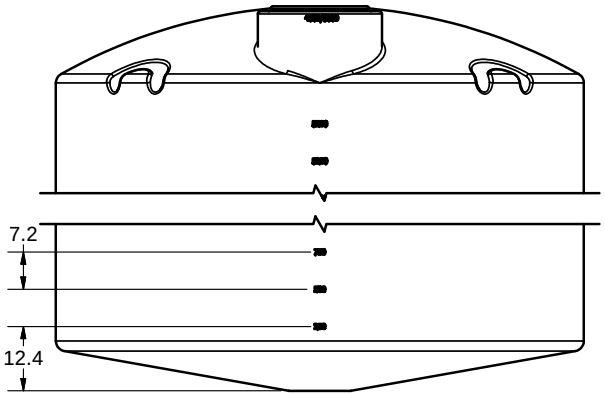
(A)

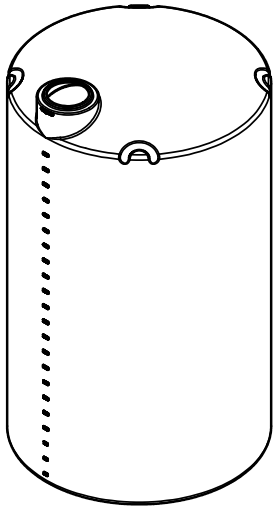
SIZE	DWG NO	REV
B	63675	A

SCALE: 1/24 SHEET 1 OF 1









FOB HANFORD, CA

DRAWN Jerry Paulson	7/1/2008	NORWESCO, INC., ST. BONIFACIUS, MN
CHECKED		TITLE: 6000 GALLON CONE BOTTOM TANK X 102 DIA WITH 10 DEGREE CONE
QA		
MFG		
APPROVED		

SIZE		DWG NO	REV
B			

SCALE: 1/24 SHEET 1 OF 1

SOP-26: HAZARDOUS SOIL STABILIZATION AND TREATMENT

1.0 Purpose

This standard operating procedure (SOP) outlines proticols for the application and treatment of hazardous soil/fill excavated from site source areas.

This hazardous fill/soils will be stabilized onsite to reduce leachability of Lead, Arsenic and Cadmium into the environment and treated to meet non-hazardous requirements for toxicity prior to transport for disposal. The TerraBond® reagent manufactured by Terra Materials has been selected as the hazardous waste stabilization product.

2.0 Scope

This SOP applies to all Impact personnel and/or subcontractors engaged in hazardous soil/fill treatment of source area material at the Former DuPont East Chicago Facility, Indiana (DuPont EC), and was developed according to the following documents:

- ***Stabilization and Solidification of Contaminated Soil and Wastes: A Manual of Practice***
  Edward Bates & Colin Hills et al 2015. Cincinnati, Ohio/ University of Greenwich, UK

- ***Handbook for Stabilization/Solidification of Hazardous Wastes***
  U.S. Environmental Protection Agency. 1986. Hazardous Waste Engineering Research Laboratory. Office of Research and Development. Cincinnati, OH.

This SOP focuses on site-specific tasks and procedures associated with the stabilization (treatment) soil/fill material mentioned above and should be used in conjunction with other applicable project SOPs, including the following:

- *SOP-Note Taking and Field Log Books*
- *SOP-Clearing and Grubbing Activities*
- *SOP-Discrete Surface and Subsurface Soil Sampling*
- *SOP-Packing and Shipping of Environmental Samples*

3.0 Procedures

3.1 Source Area Soil/Fill Pile Formation

Source Area material has been pre-characterized as hazardous or non-hazardous for TCLP Arsenic, Lead and Cadmium in a previous investigation and will segregated as per this characteristic. A critical aspect of source area material treatment is stockpile management and configuration. After excavation of source area material. Buckets of material are to be carried 10 feet from the outer excavation boundary and staged in a designated location upon a wood-chip bed.

A Source Area Pile will be configured to the following specifications:

- Laydown will be 10 feet from the furthest excavation boundary
- Laydown will be a top at least 6 inches of wooded chips or mulch
- Piles will be configured longitudinally perpendicular to the edge of the excavation boundary
- Approximately 80 feet in length
- Approximately 40 feet in width

- Approximately 8.5 feet in height
- At each longitudinal end will have a “C”- shaped depression on opposite facing sides
- Contain 1,000 Cubic Yards
- Must not contain debris, or other material that would impede mixing
- A 1-foot low void aggregate (LVA) product berm must surround the pile

Signage must be observable from each facing side of the pile and contain the following information:

- Pile ID
- Hazardous material, Non-hazardous material
- Pre-characterized origin grid
- Date of last characterization sampling
- Stage designation – Non-treated, Treated awaiting non-hazardous confirmation, Must be Re-treated, Ready for disposal

Hazardous Piles must be tarped by end of work day to reduce dust emissions and stormwater runoff risks.

3.2 Off-loading of Stabilization Product

Transportation of the stabilization product, Terrabond will be delivered via end-dump tractor trailers from point of manufacturing directly to point of application. Prior to trailer delivery, onsite access routes must be established and fortified to support truck passage over undeveloped and possible forested portions of the Site. Onsite access roads and stockpile areas should already have been cleared and grubbed however further maintence may be needed on an ongoing basis. Gravel and/or wood chips may be applied and compacted to create access roads for truck and equipment passage to Source Areas.

Upon tractor trailer entry the following protocols are to be conducted:

- Inspect condition of truck (note any damage to wheel base, tires or cover)
- Scale payload (to verify tonnage of product delivery for proper application)
- Inform the driver of Application Point location and onsite access route
- Exchange scale ticket and delivery paperwork

After entry protocols are completed, field team personnel will accompany the tractor trailer to the designated Application Point refer to the *SOP for Sample Identification and Nomenclature* for Source Area Pile and Application Point nomenclature. Once the trailer has arrived at Application Point driver will complete the following:

- Confirm there is ample space to maneuver and free of overhead lines
- Have wetting or misting equipment ready
- Confirm with the field team leader approval to dump product
- Maneuver truck and back into designated Application Point
- Uncover load
- Lift bed and dump stabilization product into Application Point
- Lower truck bed and pull forward

Once trailer is steady and completely free of stabilization product within the bed. The driver will confirm with the field team leader application is completed and exit the Site.

3.3 Source Area Pile Preparation and Mixing

Source Area Piles designated "Ready for Mixing" means the stabilization product has been properly applied to the pile (two 23-ton truck dumps per 1,000 CY Source Area Piles). Prior to mixing the following should be verified:

- Dust suppression BMPs are in place and/or readily available
- Confirm the Source Area Pile is free of debris (drum carcasses, wood posts, etc.) that would impede mixing
- Confirm with Field Team Leader pile is ready for mixing
- Inspect mixing equipment (mixing bucket, excavator) for wear and tear or damage

Once the above has been completed mixing can begin. The operator will use the slotted mixing bucket to manually mix the stabilization product into the pile from each longitudinal end to the center of the pile. Mixing should be conducted in a repetitive folding motion of the bucket. The pile must be mixed to uniformity. This can be assumed by the following:

- Homogenous in color (stabilization product is grey/white - the pile as a whole should be the same in color)
- Wood chips from below the pile are mixed into the upper portions of the pile

The Field Team Leader will inspect the pile for uniformity and guide the operator to further mix or designate the pile as treated. Pile signage must be updated immediately after treatment.

Once treatment of the pile is complete it must be covered with plastic to reduce dust emissions and stormwater runoff.

4.0 Records

Record all Source Area Pile treatment activities according to *SOP for Note Taking and Field Log Books*. This includes but is not limited to the following per each pile:

- The date pile is formed and constructed
- The date of stabilization product is delivered
- Truck ID, tonnage, per Application Point (ex. ID82387, 22.87 tons, Pile ID)

5.0 References

Stabilization and Solidification of Contaminated Soil and Wastes: A Manual of Practice *Edward Bates & Colin Hills et al 2015. Cincinnati, Ohio/ University of Greenwich, UK*

Handbook for Stabilization/Solidification of Hazardous Wastes *U.S. Environmental Protection Agency. 1986. Hazardous Waste Engineering Research Laboratory. Office of Research and Development. Cincinnati, OH.*

U.S. Environmental Protection Agency (EPA). February 1994. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response. EPA/540/R- 941/013.

6.0 Definitions

Best Management Practices (BMPs): a record attached to samples to verify legal documentation of traceability.

Characterization Sampling: Sampling of all treated piles will be used to verify achievement of treatment objectives and for material acceptance into a disposal facility.

Source Areas: Soil/ fill designated above 1,000 mg/kg for Arsenic as specified in the Corrective Measures Study prepared in 2014 by Parsons.

Application Point: This is a designated "C"-shaped pocket or depression on the longitudinal face of the stockpile for the deposit of stabilization product prior to mixing uniformly with the Source Area material.

7.0 Attachments

Attachment 1: *Source Area Pile Construction Diagram and Detail*

TerraBond®

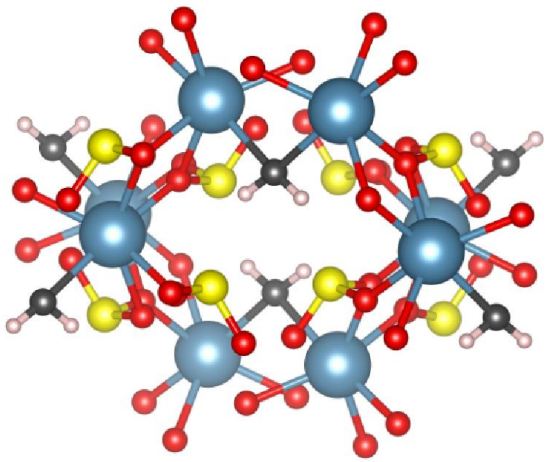
Heavy Metal Control Technology

REMEDIUM
Services Group, LLC

Remedium Services Group, LLC (d/b/a Terra Materials) is an environmental management company that specializes in the development and production of reagents marketed under the TerraBond® trade names. These reagents, manufactured at our plants located throughout the United States, provide our customers a reliable and cost-effective treatment reagent for the management of RCRA and non-RCRA leachable heavy metal impacted waste.

PRODUCT DESCRIPTION

Our products are buffered sulfur-based compounds that have proven to be effective in treating a wide range of heavy metal impacted waste streams. Some traditional treatment reagents merely "adjust" the pH to a range where certain metals are insoluble. If however the pH readjusts overtime, the metals may become mobile again. Though cognizant of the pH sensitivity of metals, our products permanently treat the heavy metals by creating an insoluble metal sulfur complex. Simply, the targeted metals are surrounded and bound by the active ingredients in our products to mineralize the metal ions and reduce their mobility to below the regulatory limits set forth by the United States Environmental Protection Agency (USEPA).



TerraBond® has proven to be effective in treating a wide range of metals including:

- Lead
- Cadmium
- Arsenic
- Barium
- Zinc
- Copper
- Radium

ADVANTAGES OF TerraBond®

- Not pH dependent.
- De-characterize RCRA metals onsite.
- Cost-effective alternative to competing stabilization chemistry.

PHYSICAL & CHEMICAL PROPERTIES

Physical Form:	Powder
Color:	Off White
Odor:	None
Density:	35-45 lbs. / Cubic Foot
Solubility in Water:	Slightly
pH:	10.5 – 12.5

PACKAGING OPTIONS

Supersacks:	2,000-2,200 lbs. / sack
Pneumatic Tanks:	22-24 tons / load
End-dump Trailer	22-24 ton / load

For additional information contact:

Charles McPheeters
Remedium Services Group, LLC
d/b/a Terra Materials
11711 N. College Ave., Suite 170
Carmel, IN 46032
Corporate Tel: (317) 660-6865
Direct Tel: (812) 869-1575
cmcpheeters@terraindy.com
www.terramaterials.com

SAFETY DATA SHEET

TerraBond®

1. Product And Company Identification

Remedium Services Group, LLC
d/b/a Terra Materials
11711 N. College Avenue, Suite 170
Carmel, IN 46032

Company Contact: Tom McCullough
Telephone Number: (317) 660-6868
Web Site: www.terramaterials.com

Supplier Emergency Contacts & Phone Number
Terra Materials: (317) 660-6868

Issue Date: 06/01/16

Product Name: TerraBond®
Chemical Formula: Proprietary Formulation

2. Hazard(s) Identification

Pictograms:



Signal Word: Warning

Hazard Statements:
H315 May cause skin irritation
H319 May cause eye irritation
H335 May cause respiratory irritation

Precautionary Statements:
P280 Wear Protective gloves and eye protection
P305 & P351 If in eye rinse cautiously with water for several minutes.
P337 & P313 If eye irritation persists, get medical advice/attention.
P302 & P352 If on skin wash with plenty of soap and water.
P261 Avoid breathing dust

SAFETY DATA SHEET

TerraBond®

3. Composition/Information On Ingredients

Ingredient Name	CAS Number		Percent of Total Weight
Proprietary Formulation	N/A		60-80
Calcium Hydroxide	1305-62-0		0-15
Calcium Carbonate	471-34-1		0-15

4. First Aid Measures

Eye

Contact with eyes may cause irritation, redness, pain and tearing. Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician

Skin

Contact with skin may cause irritation

Ingestion

Ingestion of this product may cause irritation of the mucus membranes of the mouth, throat, esophagus and stomach. Drink plenty of water. **Do not induce vomiting unless directed by a physician**

Inhalation

May cause respiratory irritation. Get medical attention if experiencing cough, irritation or difficulty breathing.

5. Fire Fighting Measures

Fire and Explosion Hazards

Material is not considered to be combustible.

Extinguishing Media

Any means suitable for extinguishing surrounding fire.

6. Accidental Release Measure

Keep spills out of sewers and bodies of water. Contain the spill and transfer material to a container for disposal or recovery.

7. Handling And Storage

Handling And Storage Precautions

Handle in accordance with good industrial hygiene and safety practice. Avoid contact with skin and eyes. Store in a dry place.

8. Exposure Controls/Personal Protection

Eye/Face Protection
Safety glasses or safety goggles.

Skin Protection
Chemical resistant gloves.

Respiratory Protection
None required under normal conditions. If dust is generated from release wear OSHA approved dust mask.

9. Physical And Chemical Properties

Appearance	Cream powder
Odor	Odorless
Density:	35 to 45 lbs/ft^3
Vapor Density:	Not applicable
Solubility:	Partially soluble
pH	10.50 – 12.50

10. Stability and Reactivity

Chemical Stability
Stable under normal temperature and pressures.

Hazardous Polymerization
Has not been reported

Conditions To Avoid (Stability)
None known

Incompatible Materials
Not compatible with acids. May generate $S0_2$ gas when in contact with acids.

SAFETY DATA SHEET

TerraBond®

11. Toxicological Information

Component Information:

Component	LD50 Oral	LD50 Dermal	LC50 Inhalation
Calcium Carbonate ($CaCO_3$)	No Information Available	No Information Available	No Information Available

Chronic Toxicity:

No Information Available

12. Ecological Information

Ecotoxicity:

Not considered detrimental to water or soil. Avoid release into environment. Follow government regulations.

13. Disposal Considerations

Dispose of in accordance with local, state and federal regulations.

14. Transport Information

Proper Shipping Name:

Non-Hazardous, Non-Regulated Solid

15. Regulatory Information

CERCLA

Not applicable- contains no hazardous substances at or above de minimis concentrations.

SARA TITLE III:

Section 302 Extremely Hazardous Substances: None at or above de minimis concentrations.
Section 311/312 Health and Physical Hazards: Delayed (chronic) health hazard from long-term inhalation of dust.
Section 313 Toxic Chemicals: None at or above de minimis concentrations.

16. NFPA

Health – 1 **Flammability – 0** **Reactivity – 0** **Special Hazard=None**

17. Disclaimer

Terra Materials provides the information contained herein in good faith but makes no representation as to its

comprehensiveness or accuracy. The information is based upon our current knowledge and experience of our product and is not exhaustive. It applies to the product as defined by the specifications. In case of combinations or mixtures with other chemicals, one must confirm that no new hazards are likely to exist. In any case, the user is not exempt from observing all legal, administrative, and regulatory procedures relating to the product, personal hygiene, and integrity of the work environment.

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KOMATSU®

PC360LC-11

Tier 4 Final Engine

PC360LC

HYDRAULIC EXCAVATOR



Photos may include optional equipment.

NET HORSEPOWER
257 HP @ 1950 rpm
192 kW @ 1950 rpm

OPERATING WEIGHT
78,645–80,547 lb
35,627–36,535 kg

BUCKET CAPACITY
0.89–2.56 yd^3
0.68–1.96 m^3

WALK-AROUND

PC360LC-11



Photos may include optional equipment.

NET HORSEPOWER
257 HP @ 1950 rpm
192 kW @ 1950 rpm

OPERATING WEIGHT
78,645–80,547 lb
35,627–36,535 kg

BUCKET CAPACITY
0.89–2.56 yd³
0.68–1.96 m³

KOMATSU CARE®

GREATER PERFORMANCE & FASTER CYCLE TIMES

Komatsu's Closed-center Load Sensing System (CLSS) provides quick response and smooth operation to maximize productivity.

Power Mode with enhanced engine and hydraulic pump control logic provides greater hydraulic power and speed for faster cycle times, improved multifunction performance and up to 12% greater productivity than the previous model.



A powerful Komatsu SAA6D114E-6 engine provides a net output of 192 kW **257 HP**. This engine is EPA Tier 4 Final emissions certified.

Variable Geometry Turbocharger (VGT) uses a hydraulic actuator to provide optimum air flow under all speed and load conditions.

Komatsu Diesel Particulate Filter (KDPF) and Selective Catalytic Reduction (SCR) system reduce particulate matter and NOx while providing automatic regeneration that does not interfere with daily operation.

Large displacement high efficiency pumps provide high flow output at lower engine speed, improving efficiency.

6 Working modes are designed to match engine speed, pump delivery and system pressure to the application.

Power Mode
provides improved power and hydraulic flow for faster cycle times and multifunction operation.

Two boom mode settings provide power mode for maximum digging force or smooth mode for fine grading operations.

Komatsu's Closed-center Load Sensing System (CLSS)
provides quick response and smooth operation to maximize productivity.

Rearview monitoring system (standard) with integrated camera display in the default monitor screen.

KOMTRAX® equipped machines can send location, SMR and operation maps to a secure website or smart phone utilizing wireless technology. Machines also relay error codes, cautions, maintenance items, fuel & Diesel Exhaust Fluid (DEF) levels, and much more.

Large LCD color monitor:

- 7" high resolution display
- Enhanced hydraulic attachment control with one way/two way flow and programmable work tool names and settings
- Rear view camera display integrated into the default monitor screen
- Key machine settings and controls easily accessible through the monitor

Enhanced working environment

- High back, heated air suspension seat with adjustable arm rests
- Integrated ROPS cab design
- Cab meets ISO Level 1 Operator Protective Guard (OPG) top guard
- Standard pattern change valve to switch between ISO and BH control pattern
- Auxiliary jack and (2) 12V power outlets
- Auto climate control

Komatsu designed and manufactured components

Handrails (standard) located on the machine upper structure provide a convenient work area in front of the engine.

Battery disconnect switch allows a technician to disconnect the power supply before servicing the machine.

Heavy duty boom design with large one piece castings provide increased strength and durability.

Komatsu Auto Idle Shutdown helps reduce nonproductive engine idle time and reduces operating costs.

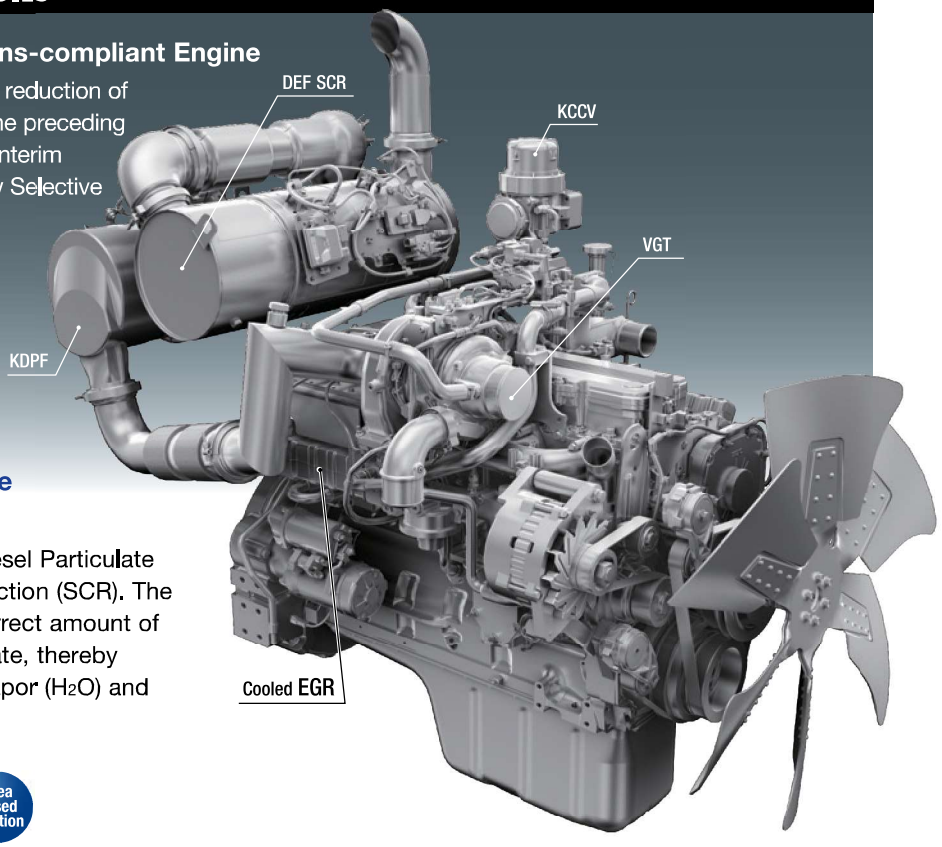
Operator Identification System records KOMTRAX® machine operation and application data for up to 100 individual ID codes.

PERFORMANCE FEATURES

KOMATSU NEW ENGINE TECHNOLOGIES

Komatsu's New Emission Regulations-compliant Engine

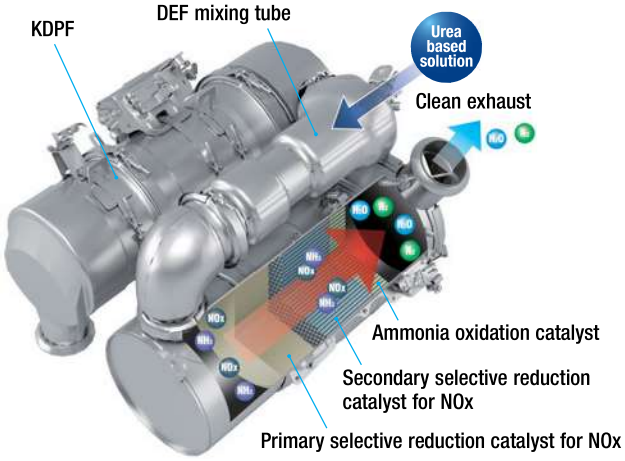
New regulations effective in 2014 require the reduction of NOx emissions to one tenth or below from the preceding regulations. In addition to refining the Tier 4 Interim technologies, Komatsu has developed a new Selective Catalytic Reduction (SCR) device in-house.



Technologies Applied to New Engine

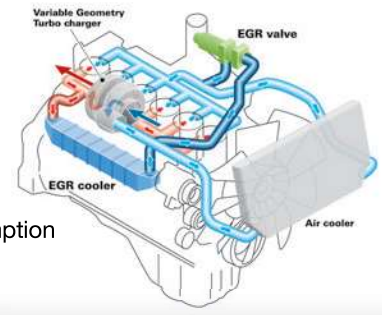
Heavy-duty aftertreatment system

This new system combines a Komatsu Diesel Particulate Filter (KDPF) and Selective Catalytic Reduction (SCR). The SCR NOx reduction system injects the correct amount of Diesel Exhaust Fluid (DEF) at the proper rate, thereby decomposing NOx into non-toxic water vapor (H_2O) and nitrogen gas (N_2).



Heavy-duty cooled Exhaust Gas Recirculation (EGR) system

The system recirculates a portion of exhaust gas into the air intake and lowers combustion temperatures, thereby reducing NOx emissions. EGR gas flow has been decreased for Tier 4 Final with the addition of SCR technology. The system achieves a dynamic reduction of NOx, while helping reduce fuel consumption below Tier 4 Interim levels.

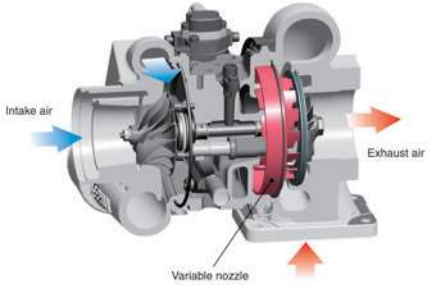


Advanced Electronic Control System

The electronic control system performs high-speed processing of all signals from sensors installed in the vehicle providing total control of equipment in all conditions of use. Engine condition information is displayed via an on-board network to the monitor inside the cab, providing necessary information to the operator. Additionally, managing the information via KOMTRAX helps customers keep up with required maintenance.

Variable Geometry Turbocharger (VGT) system

The VGT system features proven Komatsu design hydraulic technology for variable control of air-flow and supplies optimal air according to load conditions. The upgraded version provides better exhaust temperature management.



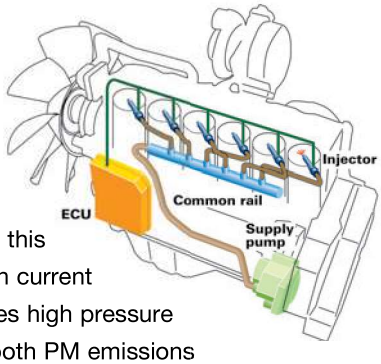
Komatsu Auto Idle Shutdown

Komatsu auto idle shutdown automatically shuts the engine down after idling for a set period of time to reduce unnecessary fuel consumption and exhaust emissions. The amount of time before the engine is shutdown can be easily programmed from 5 to 60 minutes.



Heavy-Duty High-Pressure Common Rail (HPCR) Fuel Injection System

The system is designed to achieve an optimal injection of high-pressure fuel by means of computerized control, providing close to complete combustion to reduce PM emissions. While this technology is already used in current engines, the new system uses high pressure injection, thereby reducing both PM emissions and fuel consumption over the entire range of engine operating conditions. The Tier 4 Final engine has advanced fuel injection timing for reduced fuel consumption and lower soot levels.



Enhanced Productivity

The PC360LC-11's P Mode provides improved performance in demanding applications.

Productivity

Up to 12% increase
(compared to the PC360LC-10 in P Mode)

P mode (90° swing truck loading)

Increased Work Efficiency

Large digging force

With the one-touch Power Max. function, digging force is increased for 8.5 seconds of operation.

Maximum arm crowd force (ISO)

160 kN(16.3t) ➡ 171 kN(17.4t) 7% UP
(With Power Max.)

Maximum bucket digging force (ISO)

213 kN(21.7t) ➡ 228 kN(23.2t) 7% UP
(With Power Max.)

Measured with Power Max. function, 3185 mm arm and ISO rating

Faster arm cycle speeds

Two return hoses improve arm cylinder hydraulic flow for faster arm out performance.

Two-mode settings for boom

- Smooth boom mode reduces boom down force for working on hard surfaces or for hydraulic hammer operation.
- Power boom mode maximizes digging force for more effective excavating

Lifting mode

When the Lifting mode is selected, lifting capacity is increased 7% by raising hydraulic pressure.



WORKING ENVIRONMENT





Comfortable Working Space

Wide spacious cab

Wide spacious cab includes seat with reclining backrest. The seat height and longitudinal inclination are easily adjusted using a pull-up lever. You can set the appropriate operational posture of armrest together with the console. Reclining the seat further enables you to place it into the fully flat state with the headrest attached.

Arm rest with simple height adjustment function

The addition of a knob and a plunger to the armrest permits the height of the armrest to be easily adjusted without the use of tools.



Low vibration with cab damper mounting

Automatic climate control

Pressurized cab

Auxiliary input jack

Connecting a regular audio device to the auxiliary jack allows the operator to hear the sound from the speakers installed in the cab.



Standard Equipment

Sliding window glass (left side)



AM/FM stereo radio & ashtray



Remote intermittent wiper with windshield washer



Cigarette lighter



Opening & closing skylight



Magazine box & cup holder



Defroster
(conforms to the ISO standard)



One-touch storable front window lower glass



WORKING ENVIRONMENT

LARGE HIGH RESOLUTION LCD MONITOR



New Monitor Panel Interface Design

An updated large high resolution LCD color monitor enables accurate and smooth work. The interface has been redesigned to display key machine information in a new user friendly interface. A rear view camera and a DEF level gauge display have been added to the default main screen. The interface has a function that enables the main screen mode to be switched, thus enabling the optimum screen information for the particular work situation to be displayed.

Indicators

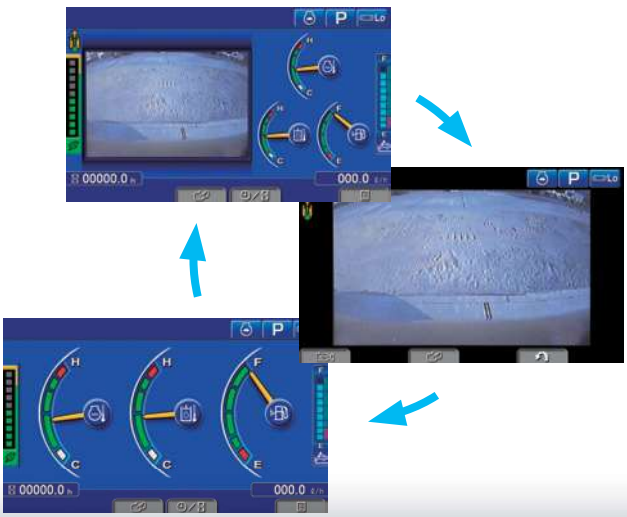
1. Auto-decelerator
2. Working mode
3. Travel speed
4. Ecology gauge
5. Camera display
6. Engine coolant temperature gauge
7. Hydraulic oil temperature gauge
8. Fuel gauge
9. DEF level gauge
10. Service meter, clock
11. Fuel consumption gauge
12. Guidance icon
13. Function switches
14. Camera direction display
15. DEF level caution lamp

Basic operation switches

1. Auto-decelerator
2. Working mode selector
3. Travel speed selector
4. Buzzer cancel
5. Wiper
6. Window washer
7. Auto climate controls

Switchable Display Modes

The main screen display mode can be changed by pressing the pressing the F3 key.



Visual user menu

Pressing the F6 key on the main screen displays the user menu screen. The menus are grouped for each function, and use easy-to-understand icons which enable the machine to be operated easily.



1 Energy saving guidance 2 Machine settings
3 Aftertreatment devices regeneration 4 SCR information
5 Maintenance 6 Monitor setting 7 Message check

Support Efficiency Improvement

Ecology guidance

While the machine is operating, ecology guidance pops up on the monitor screen to notify the operator of the status of the machine in real time.

Ecology gauge & fuel consumption gauge

The monitor screen is provided with an ecology gauge and also a fuel consumption gauge which is displayed continuously. In addition, the operator can set any desired target value of fuel consumption (within the range of the green display), enabling the machine to be operated with better fuel economy.

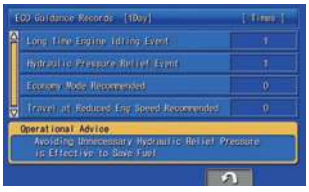


Operation record, fuel consumption history, and ecology guidance record

The ecology guidance menu enables the operator to check the operation record, fuel consumption history and ecology guidance record from the ecology guidance menu, using a single touch, thus enabling the total fuel consumption to be reduced.


Operation record


Fuel consumption history


Ecology guidance record

Operator Identification Function

An identification ID can be set up for individual operator, application or jobs, and used to manage operation information of individual machines using KOMTRAX data. Data sent from KOMTRAX can be used to analyze operation status by operator as well as by machine.



MAINTENANCE FEATURES



Large capacity air cleaner

The larger air cleaner can extend air cleaner life during long-term operation and helps prevent early clogging, and resulting power loss. A radial seal design is used for reliability.



Engine Access

Large rear opening hood provides excellent maintenance and service access to key engine components.



Fuel Filters

Large high-efficiency fuel filter and pre-filter with water separator removes contaminants from fuel for improved fuel injection system life. Built-in priming pump simplifies maintenance.



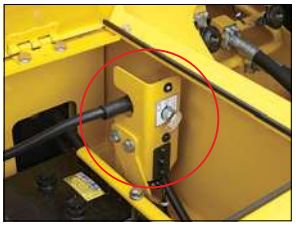
Easy access to engine oil filter and fuel drain valve

Engine oil filter and fuel drain valve are remote mounted to improve accessibility.



Battery disconnect switch

A standard battery disconnect switch allows a technician to disconnect the power supply and lock out before servicing the machine.



Air conditioner filter

The air conditioner filter can be removed and installed without the use of tools for easy filter maintenance.



Washable cab floormat

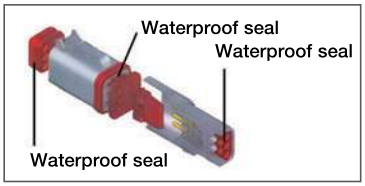
Sloping track frame

Long-life oils, filters

Engine oil & engine oil filter	every 500 hours
Hydraulic oil	every 5000 hours
Hydraulic oil filter	every 1000 hours

DT-type connectors

Sealed DT-type electrical connectors provide high reliability, water and dust resistance.



Diesel Exhaust Fluid (DEF) tank

A large tank volume extends operating time before refilling and is installed on the right front platform for easy access. DEF tank and pump are separated for improved service access.



Maintenance Information

"Maintenance time caution lamp" display

When the remaining time to maintenance becomes less than 30 hours*, a maintenance time monitor appears. Pressing the F6 key switches the monitor to the maintenance screen.

* : The setting can be changed within the range between 10 and 200 hours.



Maintenance screen

Manual Stational Regeneration

Under most conditions, active regeneration will occur automatically with no effect on machine operation. In case the operator needs to disable active regeneration or initiate a manual stationary regeneration, this can be easily accomplished through the monitor panel. A soot level indicator is displayed to show how much soot is trapped in the KDPF.

Soot level indicator



Aftertreatment device regeneration screen

Supports the DEF level and refill timing

The DEF level gauge is displayed continuously on the right side of the monitor screen. In addition, when DEF level is low, DEF low level guidance messages appear in pop up displays to inform the operator in real time.



DEF level gauge

DEF low level guidance

MAINTENANCE FEATURES

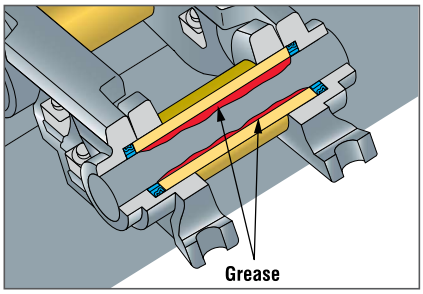
Drawbar Pull

The Komatsu designed final drives and undercarriage provide high drawbar pull for good maneuverability and performance when working on adverse grades or soft ground.



Grease Sealed Track

The PC360LC-11 uses grease sealed tracks for extended undercarriage life.



Large Displacement High Efficiency Pump

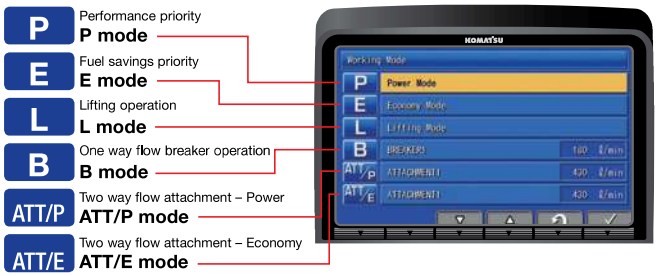
Large displacement hydraulic implement pumps provide high flow output at lower engine RPM as well as operation at the most efficient engine speed.



Working Mode Selection

The PC360LC-11 excavator is equipped with six working modes (P, E, L, B, ATT/P and ATT/E). Power Mode provides improved hydraulic power and faster cycle times for improved performance in demanding applications. Each mode is designed to match engine speed, pump flow, and system pressure to the application. The PC360LC-11 features an attachment mode (ATT/E) that allows operators to run attachments while in Economy mode.

Working Mode	Application	Advantage
P	Power Mode	•Maximum production, power & multifunction
E	Economy Mode	•Good cycle times with reduced fuel consumption
L	Lifting Mode/ Fine Control	•Increased lifting power & fine control
B	Breaker Mode	•One way flow for hydraulic breaker operation
ATT/P	Attachment Power Mode	•Two way flow with maximum power
ATT/E	Attachment Economy Mode	•Two way flow with most efficient fuel economy



High Rigidity Work Equipment

Booms and arms are constructed with thick plates of high tensile strength steel. In addition, these structures are designed with large cross sectional areas and large one piece castings in the boom foot, the boom tip, and the arm tip. The result is work equipment that exhibits long term durability and high resistance to bending and torsional stress. A standard HD boom design provides increased strength and reliability.



GENERAL FEATURES

ROPS CAB STRUCTURE

ROPS Cab (ISO 12117-2)

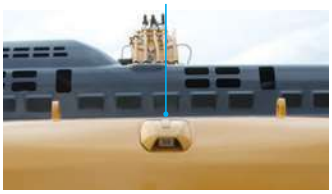
The machine is equipped with a ROPS cab that conforms to ISO 12117-2 for excavators as standard equipment. It also satisfies the requirements for Level 1 Operator Protective Guard (OPG) and top guard (ISO 10262).



Rear View Monitoring System

A new rear view monitoring system display has a rear view camera image that is continuously displayed together with the gauges and important vehicle information. This enables the operator to carry out work while easily checking the surrounding area.

Rear view camera

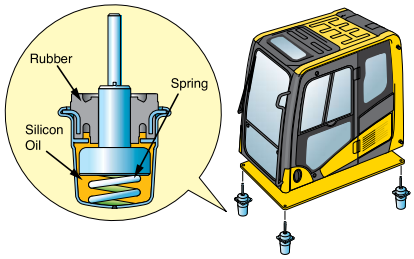


Rear view image on monitor



Low Vibration with Viscous Cab Mounts

The PC360LC-11 uses viscous mounts for the cab that incorporate a longer stroke and the addition of a spring. The cab damper mounting combined with a high rigidity deck reduces vibration at the operator's seat.



General Features

Secondary engine shut down switch at base of seat to shutdown the engine.



Lock lever

Retractable seat belt

Tempered & tinted glass

Large cab entrance step

Left and right side hand rails

Seat belt caution indicator



Large mirrors

Slip-resistant plates

Thermal and fan guards

Pump/engine compartment partition

Travel alarm



KOMATSU PARTS & SERVICE SUPPORT

Every new Komatsu Tier 4 Final construction machine is covered.

The Komatsu CARE program covers all new Komatsu Tier 4 Final construction equipment, whether rented, leased or purchased. For the first 3 years or 2,000 hours, whichever occurs first, you'll receive:

- Regular service at 500, 1,000, 1,500 and 2,000-hr. intervals
- DEF tank breather element replacement at 1,000 hours
- DEF and CCV filters replacement at 2,000 hours
- 50-point inspection by factory-trained technician at each scheduled interval
- Technician labor
- Fluids, oils, coolant, filters, SCR screen, tank breather and parts
- Technician travel to and from your equipment location

Plus two complimentary KDPF exchanges and SCR system service for 5 years-no hours limits. *

Service will be performed by a Komatsu Distributor and only Komatsu genuine fluids and filters will be used.

Komatsu CARE® services are available from every Komatsu Distributor in the U.S. and Canada.



Komatsu CARE® – Extended Coverage

- Extended Coverage can provide peace of mind by protecting customers from unplanned expenses that effect cash flow
- Purchasing extended coverage locks-in the cost of covered parts and labor for the coverage period and helps turn these into fixed costs



* Some exclusions apply. Please contact your Komatsu distributor for specific program details.



Komatsu Parts Support

- 24/7/365 to fulfill your parts needs
- 9 parts Distribution Centers strategically located across the U.S. and Canada
- Distributor network of more than 300 locations across U.S. and Canada to serve you
- Online part ordering through Komatsu eParts
- Remanufactured components with same-as-new warranties at a significant cost reduction



Komatsu Oil and Wear Analysis (KOWA)

- KOWA detects fuel dilution, coolant leaks, and measures wear metals
- Proactively maintain your equipment
- Maximize availability and performance
- Can identify potential problems before they lead to major repairs
- Reduce life cycle cost by extending component life

KOMTRAX EQUIPMENT MONITORING

GET THE WHOLE STORY WITH KOMTRAX®

WHAT

- KOMTRAX is Komatsu's remote equipment monitoring and management system
- KOMTRAX **continuously monitors and records** machine health and operational data
- Information such as fuel consumption, utilization, and a detailed history **lowering owning and operating cost**

WHO

- KOMTRAX is **standard** equipment on all Komatsu construction products

WHEN

- Know when your machines are **running or idling** and make decisions that will improve your fleet utilization
- Detailed movement records ensure you know when and where your equipment is moved
- Up to date records allow you to **know when maintenance is due** and help you plan for future maintenance needs

WHERE

- KOMTRAX data **can be accessed virtually anywhere** through your computer, the web or your smart phone
- Automatic alerts keep fleet managers up to date on the latest machine notifications

WHY

- Knowledge is power - **make informed decisions** to manage your fleet better
- Knowing your idle time and fuel consumption will help maximize your machine efficiency
- **Take control of your equipment** - any time, anywhere





KOMTRAX®

For construction and compact equipment.

KOMTRAX Plus®

For production and mining class machines.

SPECIFICATIONS

PC360LC-11

ENGINE

Model.....Komatsu SAA6D114E-6*
Type.....Water-cooled, 4-cycle, direct injection
Aspiration.....Komatsu Variable Geometry Turbocharger with air-to-air aftercooler and EGR
Number of cylinders..... 6
Bore..... 114 mm **4.49"**
Stroke.....144.5 mm **5.69"**
Piston displacement..... 8.85 ltr **540 in³**
Horsepower:
SAE J1995.....Gross 202 kW **271 HP**
ISO 9249 / SAE J1349..... Net 192 kW **257 HP**
Rated rpm..... 1950
Governor..... All-speed control, electronic
Fan drive method for radiator cooling ..... Mechanical

*EPA Tier 4 Final emissions certified

HYDRAULICS

Type ... HydrauMind (Hydraulic Mechanical Intelligence) system, closed-center system with load sensing valve and pressure compensated valves, 6 selectable working modes
Main pump:
Pumps for.....Boom, arm, bucket, swing, and travel circuits
Type.....Variable displacement axial piston type
Maximum flow ..... 535 ltr/min **141.3 gal/min**
Supply for control circuit..... Self reducing valve
Hydraulic motors:
Travel ..... 2 x axial piston motors with parking brake
Swing ..... 1 x axial piston motor with swing holding brake
Relief valve setting:
Implement circuits ..... 37.3 MPa 380 kgf/cm² **5,400 psi**
Travel circuit..... 37.3 MPa 380 kgf/cm² **5,400 psi**
Swing circuit..... 27.9 MPa 285 kgf/cm² **4,050 psi**
Pilot circuit..... 3.2 MPa 33 kgf/cm² **470 psi**
Hydraulic cylinders:
(Number of cylinders – bore x stroke x rod diameter)
Boom .... 2–140 mm x 1480 mm x 100 mm **5.5" x 58.3" x 3.9"**
Arm ..... 1–160 mm x 1825 mm x 110 mm **6.3" x 71.9" x 4.3"**
Bucket..... for 3.2 m **10'5"** and 4.0 m **13'2"** Arms
1–140 mm x 1285 mm x 100 mm **5.5" x 50.6" x 3.9"**
.....for 2.54 m **8'4"** Arm
1–150 mm x 1285 mm x 110 mm **5.9" x 50.6" x 4.3"**

DRIVES AND BRAKES

Steering control.....Two lever with pedals
Drive method ..... Hydrostatic
Maximum drawbar pull ..... 290 kN 29570 kgf **65,191 lbf**
Gradeability..... 70%, 35°
Maximum travel speed (auto shift):
High..... 5.5 km/h **3.4 mph**
Mid..... 4.2 km/h **2.8 mph**
Low..... 3.2 km/h **2.0 mph**
Service brake.....Hydraulic lock
Parking brake.....Mechanical disc brake

SWING SYSTEM

Driven by..... Hydraulic motor
Swing reduction..... Planetary gear
Swing circle lubrication ..... Grease-bathed
Service brake..... Hydraulic lock
Holding brake/Swing lock.....Mechanical disc brake
Swing speed..... 9.5 rpm
Swing torque.....11386 kg•m **82,313 ft lbs**

UNDERCARRIAGE

Center frame.....X-frame
Track frame.....Box-section
Track type ..... Sealed
Track adjuster .....Hydraulic
Number of shoes (each side) 48
Number of carrier rollers (each side) 2
Number of track rollers (each side) 8

COOLANT & LUBRICANT CAPACITY (REFILLING)

Fuel tank ..... 605 ltr **159.8 U.S. gal**
Radiator ..... 37 ltr **9.7 U.S. gal**
Engine..... 35 ltr **9.2 U.S. gal**
Final drive, each side.....9.0 ltr **2.4 U.S. gal**
Swing drive ..... 13.7 ltr **3.6 U.S. gal**
Hydraulic tank..... 188 ltr **49.7 U.S. gal**
Diesel Exhaust Fluid (DEF) tank ..... 39 ltr **10.3 U.S. gal**

OPERATING WEIGHT (APPROXIMATE)

Operating weight includes 6500 mm **21'3"** one-piece HD boom, 3185 mm **10'5"** arm, SAE heaped 1.96 m³ **2.56 yd³** bucket, rated capacity of lubricants, coolant, full fuel tank, operator, and standard equipment.

Triple-Grouser Shoes	Operating Weight	Ground Pressure
700 mm **28"**	35748 kg **78,645 lb**	0.59 kg/cm² **8.35 psi**
800 mm **31.5"**	36129 kg **79,483 lb**	0.52 kg/cm² **7.44 psi**
850 mm **33.5"**	36509 kg **80,320 lb**	0.50 kg/cm² **7.03 psi**

WORKING FORCES

	Arm Length	2540 mm 8'4"	3185 mm 10'5"	4020 mm 13'2"
ISO rating	Bucket digging force	229 kN 23300 kgf / **51,370 lb**	200 kN 20400 kgf / **44,970 lb**	200 kN 20400 kgf / **44,970 lb**
	Arm crowd force	193 kN 19700 kgf / **43,430 lb**	165 kN 16800 kgf / **37,040 lb**	139 kN 14200 kgf / **31,310 lb**
SAE rating	Bucket digging force	259 kN 26400 kgf / **58,200 lb**	228 kN 23200 kgf / **51,150 lb**	227 kN 23100 kgf / **50,930 lb**
	Arm crowd force	201 kN 20500 kgf / **45,190 lb**	171 kN 17400 kgf / **38,360 lb**	144 kN 14700 kgf / **32,410 lb**

Component Weights

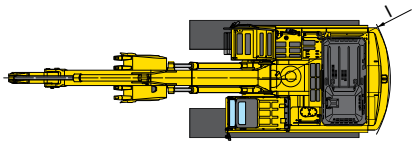
Arm including bucket cylinder and linkage
3185 mm **10'5"** arm assembly ..... 1761 kg **3,882 lb**
4020 mm **13'2"** arm assembly ..... 1988 kg **4,383 lb**
One piece HD boom including arm cylinder
6500 mm **21'3"** boom assembly ..... 3135 kg **6,912 lb**
Boom cylinders x 2 ..... 259 kg **571 lb**
Counterweight ..... 6920 kg **15,255 lb**

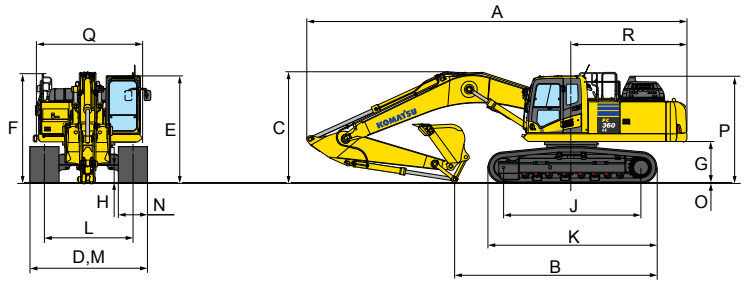
DIMENSIONS

	Arm Length	3185 mm	10'5"	4020 mm	13'2"
A	Overall length	11145 mm	36'7"	11170 mm	36'8"
B	Length on ground (transport)	5935 mm	19'6"	5475 mm	18'0"
C	Overall height (to top of boom)*	3285 mm	10'9"	3760 mm	12'4"
D	Overall width	3440 mm	11'3"		
E	Overall height (to top of cab)*	3160 mm	10'4"		
F	Overall height (to top of handrail)*	3255 mm	10'8"		
G	Ground clearance, counterweight	1185 mm	3'11"		
H	Ground clearance, minimum	498 mm	1'8"		
I	Tail swing radius	3445 mm	11'4"		
J	Track length on ground	4030 mm	13'3"		
K	Track length	4955 mm	16'3"		
L	Track gauge	2590 mm	8'6"		
M	Width of crawler	3440 mm	11'3"		
N	Shoe width	850 mm	33.5"		
O	Grouser height	36 mm	1.4"		
P	Machine height to top of engine cover	3135 mm	10'3"		
Q	Machine upper width **	3145 mm	10'4"		
R	Distance, swing center to rear end	3405 mm	11'2"		

* : Including grouser height

** : Including handrail





BACKHOE BUCKET, ARM AND BOOM COMBINATION

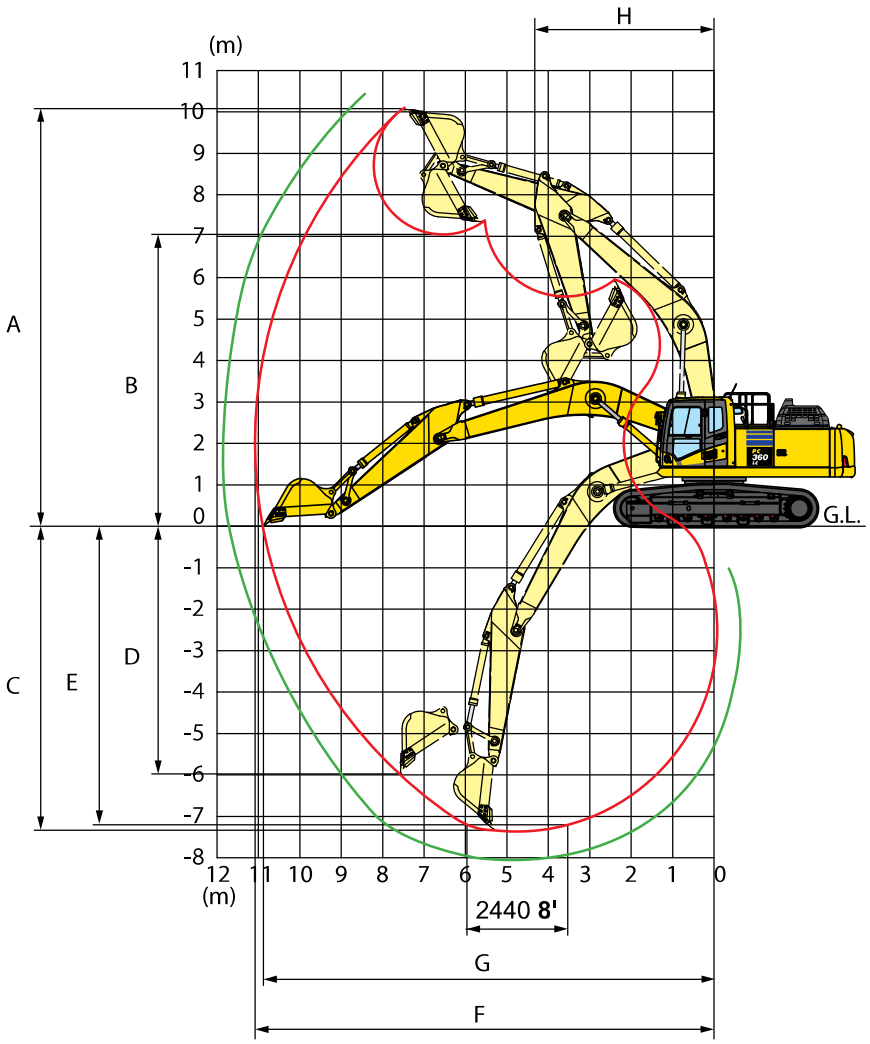
Bucket Type	Bucket Capacity		Teeth	Width		Weight		Tip Radius		6.5 m (21'3") Boom 3.2 m (10'5")	6.5 m (21'3") Boom 4.0 m (13'2")
Komatsu TL	0.93 m³	1.21 yd³	4	762 mm	30"	1097 kg	2418 lb	1674 mm	65.9"	●	●
	1.18 m³	1.54 yd³	4	914 mm	36"	1198 kg	2641 lb	1674 mm	65.9"	●	●
	1.44 m³	1.88 yd³	5	1067 mm	42"	1325 kg	2921 lb	1674 mm	65.9"	●	●
	1.70 m³	2.22 yd³	5	1219 mm	48"	1426 kg	3144 lb	1674 mm	65.9"	●	○
	1.96 m³	2.56 yd³	6	1372 mm	54"	1554 kg	3425 lb	1674 mm	65.9"	○	□
Komatsu HP	0.68 m³	0.89 yd³	3	610 mm	24"	1022 kg	2254 lb	1674 mm	65.9"	●	●
	0.93 m³	1.21 yd³	4	762 mm	30"	1178 kg	2598 lb	1674 mm	65.9"	●	●
	1.18 m³	1.54 yd³	4	914 mm	36"	1358 kg	2993 lb	1674 mm	65.9"	●	●
	1.44 m³	1.88 yd³	5	1067 mm	42"	1439 kg	3173 lb	1674 mm	65.9"	●	●
	1.70 m³	2.22 yd³	5	1219 mm	48"	1555 kg	3429 lb	1674 mm	65.9"	●	□
	1.96 m³	2.56 yd³	6	1372 mm	54"	1701 kg	3750 lb	1674 mm	65.9"	□	⊙
Komatsu HPS	0.68 m³	0.89 yd³	3	610 mm	24"	1112 kg	2451 lb	1674 mm	65.9"	●	●
	0.93 m³	1.21 yd³	4	762 mm	30"	1294 kg	2853 lb	1674 mm	65.9"	●	●
	1.18 m³	1.54 yd³	4	914 mm	36"	1437 kg	3167 lb	1674 mm	65.9"	●	●
	1.44 m³	1.88 yd³	5	1067 mm	42"	1607 kg	3543 lb	1674 mm	65.9"	●	○
	1.70 m³	2.22 yd³	5	1219 mm	48"	1750 kg	3857 lb	1674 mm	65.9"	○	□
	1.96 m³	2.56 yd³	6	1372 mm	54"	1921 kg	4236 lb	1674 mm	65.9"	□	⊙
Komatsu HPX	0.68 m³	0.89 yd³	3	610 mm	24"	1239 kg	2731 lb	1674 mm	65.9"	●	●
	0.93 m³	1.21 yd³	4	762 mm	30"	1421 kg	3133 lb	1674 mm	65.9"	●	●
	1.18 m³	1.54 yd³	4	914 mm	36"	1564 kg	3447 lb	1674 mm	65.9"	●	●
	1.44 m³	1.88 yd³	5	1067 mm	42"	1734 kg	3823 lb	1674 mm	65.9"	●	○
	1.70 m³	2.22 yd³	5	1219 mm	48"	1877 kg	4137 lb	1674 mm	65.9"	○	□
	1.96 m³	2.56 yd³	6	1372 mm	54"	2048 kg	4516 lb	1674 mm	65.9"	□	⊙

● - Used with material weights up to 3,500 lb/yd³ - Quarry/rock/high abrasion applications
□ - Used with material weights up to 2,500 lb/yd³ – General construction
○ - Used with material weights up to 3,000 lb/yd³ – Tough digging applications
⊙ - Used with material weights up to 2,000 lb/yd³ – Light materials applications
X - Not useable

Komatsu recommends the use of buckets sized to machine capacity. Buckets listed in the table above are sized appropriate to the specified material densities. Buckets exceeding recommended sizes may result in reduced performance

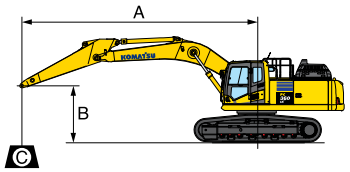
SPECIFICATIONS

WORKING RANGE



	Arm Length	3185 mm	10'5"	4020 mm	13'2"
A	Max. digging height	10210 mm	**33'6"**	10550 mm	**34'7"**
B	Max. dumping height	7110 mm	**23'4"**	7490 mm	**24'7"**
C	Max. digging depth	7380 mm	**24'3"**	8180 mm	**26'10"**
D	Max. vertical wall digging depth	6480 mm	**21'3"**	7280 mm	**23'11"**
E	Max. digging depth for 8' level bottom	7180 mm	**23'7"**	8045 mm	**26'5"**
F	Max. digging reach	11100 mm	**36'5"**	11900 mm	**39'1"**
G	Max. digging reach at ground level	10920 mm	**35'10"**	11730 mm	**38'6"**
H	Min. swing radius	4310 mm	**14'2"**	4320 mm	**14'2"**
SAE rating	Bucket digging force at power max.	200 kN 20400 kg / **44,970 lb**		200 kN 20400 kg / **44,970 lb**	
SAE rating	Arm crowd force at power max.	165 kN 16800 kg / **37,040 lb**		139 kN 14200 kg / **31,310 lb**	
ISO rating	Bucket digging force at power max.	228 kN 23200 kg / **51,150 lb**		227 kN 23100 kg / **50,930 lb**	
ISO rating	Arm crowd force at power max.	171 kN 17400 kg / **38,360 lb**		144 kN 14700 kg / **32,410 lb**	

LIFTING CAPACITY WITH LIFTING MODE



A: Reach from swing center
B: Bucket hook height
C: Lifting capacity
Cf: Rating over front
Cs: Rating over side
⊗ : Rating at maximum reach

Conditions :
- 6500 mm **21' 3"** one-piece boom
- Bucket: None
- Lifting mode: On

Arm: 3185 mm **10'5"** **Shoes:** 800 mm **31.5"** **Unit:** kg lb

A / B	3.0 m 10' Cf	3.0 m 10' Cs	4.6 m 15' Cf	4.6 m 15' Cs	6.1 m 20' Cf	6.1 m 20' Cs	7.6 m 25' Cf	7.6 m 25' Cs	9.1 m 30' Cf	9.1 m 30' Cs	⊗ MAX Cf	⊗ MAX Cs
7.6 m											* 7250	* 7250
25'											* **15900**	* **15900**
6.1 m							* 8890	7600			* 7050	6440
20 '							* **19600**	**16700**			* **15500**	**14200**
4.6 m					* 10740	10260	* 9370	7430			* 7100	5750
15'					* **23600**	**22600**	* **20600**	**16300**			* **15600**	**12600**
3.0 m			* 16210	14630	* 12090	9790	* 10030	7200	8240	5570	* 7380	5390
10'			* **35700**	**32200**	* **26600**	**21500**	* **22100**	**15800**	**18100**	**12200**	* **16200**	**11800**
1.5 m			* 18180	13820	* 13220	9370	10510	6980	8120	5460	7820	5260
5'			* **40000**	**30400**	* **29100**	**20600**	**23100**	**15300**	**17900**	**12000**	**17200**	**11600**
0 m			* 18550	13460	* 13740	9100	10330	6810	8040	5390	7990	5360
0'			* **40900**	**29600**	* **30200**	**20000**	**22700**	**15000**	**17700**	**11800**	**17600**	**11800**
-1.5 m	* 13710	* 13710	* 17720	13380	* 13480	8980	10240	6730			8570	5710
-5'	* **30200**	* **30200**	* **39000**	**29500**	* **29700**	**19800**	**22500**	**14800**			**18800**	**12600**
-3.0 m	* 20540	* 20540	* 15850	13490	* 12300	9010	* 9440	6780			* 8870	6490
-10'	* **45200**	* **45200**	* **34900**	**29700**	* **27100**	**19800**	* **20800**	**14900**			* **19500**	**14300**
-4.6 m	* 15670	* 15670	* 12560	* 12560	* 9590	9210					* 8350	8250
-15'	* **34500**	* **34500**	* **27600**	* **27600**	* **21100**	**20300**					* **18400**	**18100**

Arm: 3185 mm **10'5"** **Shoes:** 850 mm **33.5"** **Unit:** kg lb

A / B	3.0 m 10' Cf	3.0 m 10' Cs	4.6 m 15' Cf	4.6 m 15' Cs	6.1 m 20' Cf	6.1 m 20' Cs	7.6 m 25' Cf	7.6 m 25' Cs	9.1 m 30' Cf	9.1 m 30' Cs	⊗ MAX Cf	⊗ MAX Cs
7.6 m											* 7250	* 7250
25'											* **15900**	* **15900**
6.1 m							* 8890	7630			* 7050	6470
20 '							* **19600**	**16800**			* **15500**	**14200**
4.6 m					* 10740	10300	* 9370	7460			* 7100	5770
15'					* **23600**	**22700**	* **20600**	**16400**			* **15600**	**12700**
3.0 m			* 16210	14690	* 12090	9830	* 10030	7230	8280	5590	* 7380	5410
10'			* **35700**	**32300**	* **26600**	**21600**	* **22100**	**15900**	**18200**	**12300**	* **16200**	**11900**
1.5 m			* 18180	13880	* 13220	9410	10560	7010	8160	5490	7850	5290
5'			* **40000**	**30600**	* **29100**	**20700**	**23200**	**15400**	**18000**	**12100**	**17300**	**11600**
0 m			* 18550	13520	* 13740	9140	10380	6840	8080	5410	8030	5380
0'			* **40900**	**29800**	* **30200**	**20100**	**22800**	**15000**	**17800**	**11900**	**17700**	**11800**
-1.5 m	* 13710	* 13710	* 17720	13450	* 13480	9020	10290	6770			8610	5740
-5'	* **30200**	* **30200**	* **39000**	**29600**	* **29700**	**19900**	**22700**	**14900**			**18900**	**12600**
-3.0 m	* 20540	* 20540	* 15850	13550	* 12300	9050	* 9440	6810			* 8870	6520
-10'	* **45200**	* **45200**	* **34900**	**29800**	* **27100**	**19900**	* **20800**	**15000**			* **19500**	**14300**
-4.6 m	* 15670	* 15670	* 12560	* 12560	* 9590	9260					* 8350	8290
-15'	* **34500**	* **34500**	* **27600**	* **27600**	* **21100**	**20400**					* **18400**	**18200**

Arm: 4020 mm **13'2"** **Shoes:** 800 mm **31.5"** **Unit:** kg lb

A / B	3.0 m 10' Cf	3.0 m 10' Cs	4.6 m 15' Cf	4.6 m 15' Cs	6.1 m 20' Cf	6.1 m 20' Cs	7.6 m 25' Cf	7.6 m 25' Cs	9.1 m 30' Cf	9.1 m 30' Cs	⊗ MAX Cf	⊗ MAX Cs
7.6 m							* 7750	* 7750			* 5610	* 5610
25'							* **17000**	* **17000**			* **12300**	* **12300**
6.1 m							* 7950	7680	* 6550	5740	* 5460	* 5460
20 '							* **17500**	**16900**	* **14400**	**12600**	* **12000**	* **12000**
4.6 m							* 8520	7470	* 7870	5660	* 5470	4980
15'							* **18700**	**16400**	* **17300**	**12400**	* **12000**	**10900**
3.0 m			* 14340	* 14340	* 11020	9870	* 9280	7190	8210	5520	* 5640	4700
10'			* **31600**	* **31600**	* **24300**	**21700**	* **20400**	**15800**	**18100**	**12100**	* **12400**	**10300**
1.5 m			* 16890	13900	* 12370	9350	* 10010	6900	8040	5370	* 5950	4590
5'			* **37200**	**30600**	* **27200**	**20600**	* **22000**	**15200**	**17700**	**11800**	* **13100**	**10100**
0 m	* 8320	* 8320	* 18090	13270	* 13230	8960	10200	6670	7910	5240	* 6480	4640
0'	* **18300**	* **18300**	* **39800**	**29200**	* **29100**	**19700**	**22500**	**14700**	**17400**	**11500**	* **14200**	**10200**
-1.5 m	* 12420	12420	* 17980	13030	* 13400	8740	10050	6530	7840	5180	* 7330	4890
-5'	* **27300**	**27300**	* **39600**	**28700**	* **29500**	**19200**	**22100**	**14400**	**17200**	**11400**	* **16100**	**10700**
-3.0 m	* 17840	* 17840	* 16780	13030	* 12760	8700	* 10020	6510			* 8040	5410
-10'	* **39300**	* **39300**	* **37000**	**28700**	* **28100**	**19100**	* **22000**	**14300**			* **17700**	**11900**
-4.6 m	* 19190	* 19190	* 14360	13230	* 11040	8810	* 8190	6640			* 7850	6480
-15'	* **42300**	* **42300**	* **31600**	**29100**	* **24300**	**19400**	* **18000**	**14600**			* **17300**	**14300**

Arm: 4020 mm **13'2"** **Shoes:** 850 mm **33.5"** **Unit:** kg lb

A / B	3.0 m 10' Cf	3.0 m 10' Cs	4.6 m 15' Cf	4.6 m 15' Cs	6.1 m 20' Cf	6.1 m 20' Cs	7.6 m 25' Cf	7.6 m 25' Cs	9.1 m 30' Cf	9.1 m 30' Cs	⊗ MAX Cf	⊗ MAX Cs
7.6 m							* 7750	* 7750			* 5610	* 5610
25'							* **17000**	* **17000**			* **12300**	* **12300**
6.1 m							* 7950	7720	* 6550	5770	* 5460	* 5460
20 '							* **17500**	**17000**	* **14400**	**12700**	* **12000**	* **12000**
4.6 m							* 8520	7500	* 7870	5690	* 5470	5010
15'							* **18700**	**16500**	* **17300**	**12500**	* **12000**	**11000**
3.0 m			* 14340	* 14340	* 11020	9910	* 9280	7220	* 8220	5550	* 5640	4720
10'			* **31600**	* **31600**	* **24300**	**21800**	* **20400**	**15900**	* **18100**	**12200**	* **12400**	**10400**
1.5 m			* 16890	13960	* 12370	9390	* 10010	6940	8080	5400	* 5950	4610
5'			* **37200**	**30700**	* **27200**	**20700**	* **22000**	**15300**	**17800**	**11900**	* **13100**	**10100**
0 m	* 8320	* 8320	* 18090	13330	* 13230	9000	10250	6710	7950	5270	* 6480	4660
0'	* **18300**	* **18300**	* **39800**	**29400**	* **29100**	**19800**	**22600**	**14700**	**17500**	**11600**	* **14200**	**10200**
-1.5 m	* 12420	* 12420	* 17980	13090	* 13400	8790	10100	6570	7880	5200	* 7330	4910
-5'	* **27300**	* **27300**	* **39600**	**28800**	* **29500**	**19300**	**22200**	**14400**	**17300**	**11400**	* **16100**	**10800**
-3.0 m	* 17840	* 17840	* 16780	13090	* 12760	8740	10020	6540			* 8040	5440
-10'	* **39300**	* **39300**	* **37000**	**28800**	* **28100**	**19200**	**22000**	**14400**			* **17700**	**11900**
-4.6 m	* 19190	* 19190	* 14360	13290	* 11040	8860	8190	6670			* 7850	6520
-15'	* **42300**	* **42300**	* **31600**	**29300**	* **24300**	**19500**	**18000**	**14700**			* **17300**	**14300**

*Load is limited by hydraulic capacity rather than tipping. Ratings are based on ISO standard No. 10567. Rated loads do not exceed 87% of hydraulic lift capacity or 75% of tipping load.

STANDARD EQUIPMENT

- 3 speed travel with auto shift
- Alternator, 90 Ampere, 24V
- AM/FM radio
- Arm holding valve
- Automatic engine warm-up system
- Automatic climate control/air conditioner/heater/defroster
- Auto idle
- Auto idle shut down, programmable
- Auxiliary input (3.5mm jack)
- Batteries, large capacity (2 x 12V)
- Battery master disconnect switch
- Boom holding valves
- Carrier rollers, (2 each side)
- Converter, (2) x 12V
- Counterweight, 6920 kg **15,255 lb**
- Dry type air cleaner, double element
- Electric horn
- Engine, Komatsu SAA6D114E-6
- Engine coolant to -25°C **-13°F**
- EMMS monitoring system
- Engine overheat prevention system
- Extended work equipment grease interval
- Fan guard structure
- Fuel priming pump
- Fuel system pre-filter 10 micron
- Grease sealed track chain
- High back air suspension seat, with heat
- Hydraulic cooling fan (reversible)
- Hydraulic track adjusters
- KOMTRAX® Level 5.0
- Large LCD color monitor, high resolution
- Lock lever
- Mirrors, (LH and RH)
- Operator Protective Top Guard (OPG), Level 1
- Operator identification system
- Pattern change valve (ISO to BH control)
- Power maximizing system
- PPC hydraulic control system
- Pump/engine room partition cover
- Radiator and oil cooler dustproof net
- Rear reflectors
- Rearview monitoring system (1 camera)
- Revolving frame deck guard
- Revolving frame undercovers
- ROPS cab (ISO12117-2)
- Seat belt indicator
- Seat belt, retractable, 76mm **3"**
- Secondary engine shutoff switch
- Service valve
- Skylight
- Slip resistant foot plates
- Starter motor, 11.0kW/24V x 1
- Suction fan
- Thermal and fan guards
- Track frame swivel guard
- Track roller guards, center section
- Track rollers, 8 (each side)
- Track shoes, triple grouser, 800mm **31.5"**
- Travel alarm
- Two boom mode settings
- Working lights, 2 (boom and RH front)
- Working mode selection system

OPTIONAL EQUIPMENT

- Arms
  - 3185 mm **10'5"** arm assembly
  - 3185 mm **10'5"** arm assembly with piping
  - 4020 mm **13'2"** arm assembly
  - 4020 mm **13'2"** arm assembly
- Booms
  - 6500 mm **21'3"** HD boom assembly
  - 6500 mm **21'3"** HD boom assembly with piping
- Cab guards
  - Lower front window guard
  - Full front guard, OPG Level 1
  - Full front guard, OPG Level 2
  - Bolt-on top guard, OPG Level 2
- Counterweight, 7400 kg **16,315 lb** with revolving frame reinforcement for use with super long fronts only
- High pressure in-line hydraulic filters
- Hydraulic control unit, 1 actuator
- Proportional control handles
- Rain visor
- Revolving frame undercovers, heavy duty
- Revolving frame undercovers, severe duty
- Sun visor
- Straight travel pedal
- Track roller guards, full length
- Track shoes, triple grouser, 700 mm **28"**
- Track shoes, triple grouser, 850 mm **33.5"**
- Track shoes, single grouser, 800 mm **31.5"**
- Working lights, front, two additional cab mounted

ATTACHMENT OPTIONS

- Grade control systems
- Hydraulic couplers
- Hydraulic kits, field installed
- Load hold, anti-burst valves
- Material handler front
- Super long fronts
- PSM thumbs
- Rockland thumbs
- Vandalism protection guards with storage box

For a complete list of available attachments, please contact your local Komatsu distributor.

MIX
Paper from responsible sources
FSC® C031303

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KOMATSU®

Note: All comparisons and claims of improved performance made herein are made with respect to the prior Komatsu model unless otherwise specifically stated.

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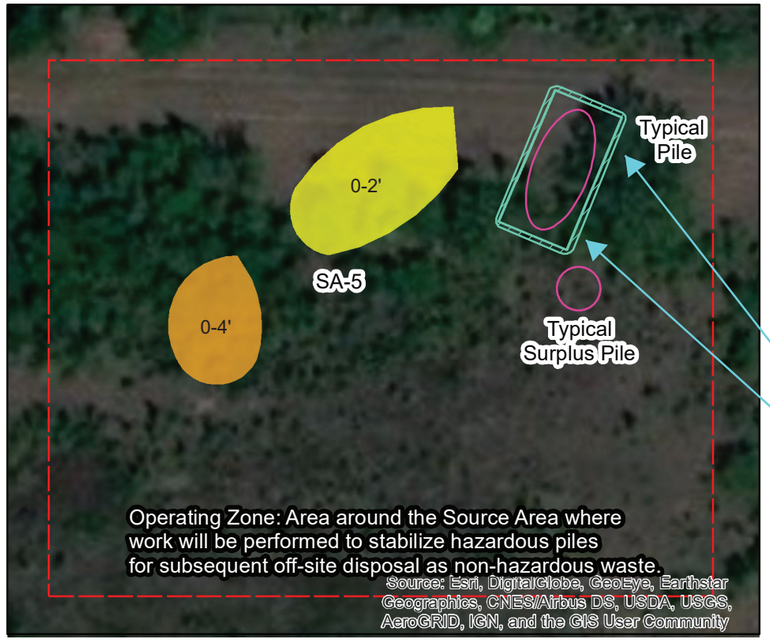
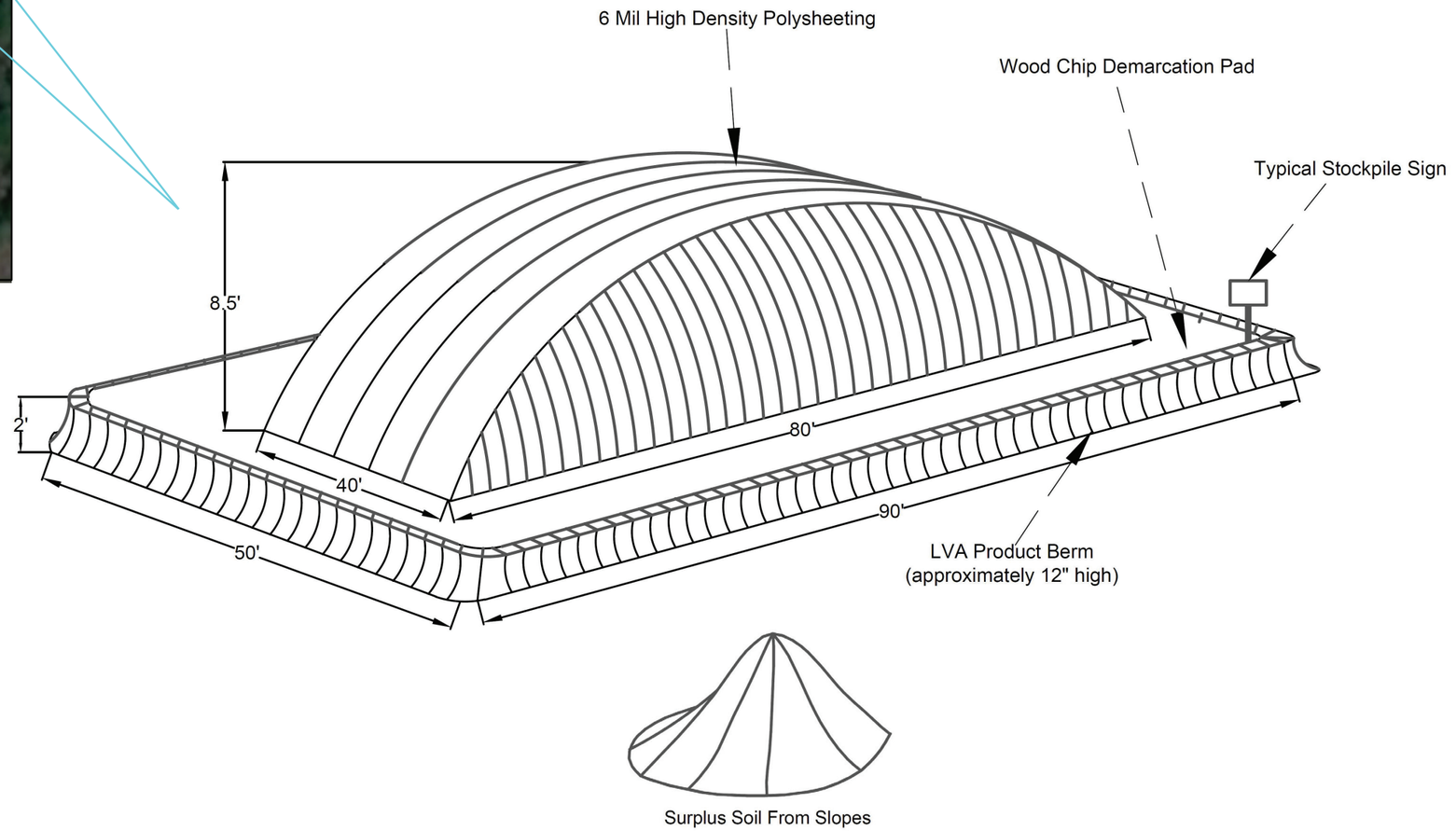


Typical Pile Detail



Surplus Soil From Slopes

IMPACT ENVIRONMENTAL
170 KEYLAND COURT
BOHEMIA, NEW YORK 11716
TEL (631) 269-8800
FAX (631) 269-1599

Scale: 0 25 50 100 Feet

Prepared By: LR | Reviewed By: KK

N W E S

Notes:

Proposed pile locations are approximate and may be adjusted in the field based on Site conditions.

Figure: 11
Source Area
Operating Zone

SOP-27: SOIL TRANSPORT AND OFF-SITE DISPOSAL

1.0 Purpose

The purpose of this standard operating procedure (SOP) is to maintain systematic tracking and control of exported materials from the Site to the disposal facility. All wastes that will be generated from the Site covered under this section will be non-hazardous as defined by 40 CFR Part 261 for toxicity, characteristics and/or listing. All materials that are not specifically listed as non-hazardous will be subject to testing for toxicity or characteristics of reactivity, ignitability and corrosivity. Wastes that are defined as hazardous, are not anticipated for off-site management under the scope of this work plan. Should hazardous wastes that are required to be removed to an off-site hazardous waste treatment storage disposal facility be encountered, contingency measures will be proposed for approval by the USEPA prior to any handling or transport. There will be hazardous waste fill excavated from the Site, but it will be stabilized and rendered non-hazardous prior to offsite transport and management.

2.0 Scope

These procedures apply to all IEC personnel and subcontractors engaged in facility approval, transportation and disposal of non-hazardous soil/fill from Project Sites.

This SOP focuses on site-specific tasks and procedures associated with the approval and disposal of soil/fill and should be used in conjunction with other applicable project SOPs, including the following:

- SOP- Field Documentation
- SOP- Ex-situ Source Area Material Treatment
- SOP - Surface and Subsurface Soil Sampling
- SOP- Sample Handling and Custody
- SOP-Equipment Decontamination Procedures

3.0 Procedures

3.1 Quality Objectives

The data generated from sampling of wastes for offsite management (disposal or beneficial use) will be used to confirm that they do not qualify as a hazardous waste. The limits of action will be those established for the toxicity characteristic leaching procedure. In the case of non-hazardous wastes, testing for total contaminant concentrations may be required in addition to the leaching procedure testing specific to the intended disposal and/or beneficial use facility receiving the waste.

3.2 Non-Hazardous Waste Vetting

Vetting and quality control of proposed non-hazardous waste for offsite management will be performed in accordance with the procedures outlined in this section. In all cases, offsite waste management facilities will be required to have valid permits or authorizations to operate and/or receive wastes.

3.3 Review Staff Qualifications

The review staff will include, at minimum, an Indiana licensed Professional Engineer (referred to herein as the “Review Engineer”), and Environmental Analysis with a minimum of a Bachelor of Arts/Science Degree in environmental, chemical or life science and at least one year of regulatory review and chemical analysis experience. All review staff will be familiar with Federal as well as Indiana codes, rules and regulations pertaining to the classification of wastes and identification and management of hazardous wastes. Wastes under consideration for offsite management will be required to submit a Waste Compliance Package (“WCP”) that includes certified laboratory reports, environmental investigation reports, available site geotechnical reports, a completed waste facility acceptance application and the valid permits, licenses and/or legal authorizations to manage such wastes. Applications will be signed by the Review Engineer to provide and certify the proposed quantity of media, the

physical and chemical characteristics of the media, how the waste was generated, environmental regulatory involvement, and available reports/sample data for media.

3.4 Disposal Facility Approval Process

To secure necessary approval of disposal, a Waste Compliance Package (WCP) must be generated and submitted to the designated disposal facility for review.

This report will include the following:

- Tabulated and laboratory data of each pile,
- Photographic logs
- Detailed notes / sketches (sample locations, cross-section/aerial view) of sampling piles
- Physical characteristics
- Origin location/ history/ background environmental reports/ historical analytical data
- Treatment processing details
- Waste facility acceptance application

Said WCP will be reviewed by an environmental analysist or engineer of the disposal facility and produce facility acceptance terms and conditions for disposal. In all cases, offsite waste management facilities will be required to have valid permits or authorizations to operate and/or receive wastes. Once approval is granted between the generator (ECGP) and the disposal facility, load out and transport will be coordinated.

3.5 Notification

The USEPA will be provided notification 24-hours in advance of approved waste transportation off-site to the selected disposal facility.

3.6 Load Out

The transport of non-hazardous wastes to offsite management facilities must be performed to prohibit loss prevention from accidents or miscommunication. Accidents can be caused due to overloading of transport vehicles, improper planning and or tracking. As such, all aspects of planning and receipt are considered to produce information that has the necessary precision to document loss prevention. All measurements are made by certified weight scales. Loads will be weighed before exiting the Site with waste and at the off-site waste management facility ("Receiving Facility") for added precision. During loading of material, a waste manifest for each load will be provided to act as a transportation charter and receiving facility will certify acceptance of the load/material.

3.7 Manifesting

Trucks scheduled to export non-hazardous waste will be provided with a waste manifest for each load to act as a transportation charter. The manifests will be printed on sequentially numbered five-part carbonless forms consisting of white, yellow, pink, goldenrod and blue sheets (see Transportation Charter). Part 1 of the form will require printing of the Site Owner's (generator's) name and address (East Chicago Gateway Partners), the Site location and address, a description of the material and, if available, information pertaining to the analysis that represents the specific load of material to be transported (e.g. sample or laboratory analysis identification references). Before each loaded truck leaves the Site, the Site Owner, or the Owner's legally designated agent, will sign and date Part 1 of the charter on the top sheet of the multi-part form (white sheet). By signing Part 1, the Site Owner will certify to the following:

> *By signing in the space below, I hereby certify that the waste coming from the above-named Site is being moved with the knowledge and consent of the Site Owner. I have been authorized on behalf of the Site Owner to witness the proper removal, loading and off-site management of the waste, and to evidence the same by signing this transport charter. I understand that by signing this form, I am acknowledging that the*

waste has been tested or demonstrated to be free of contaminants at concentrations in excess of the permitted levels of the Receiving Facility listed on Part 3 of this form. Further, I understand that this form is not evidence of the receipt of the waste at the Receiving Facility. This document bears no form field or area in which to list the weight or volume of waste being transported. Consequently, this form CANNOT be used to evidence the disposal of the waste. Only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of waste to the Receiving Facility. Further, I certify that if the load is rejected at the Receiving Facility, for any reason, I will accept it back to the Site location.

After signing, the waste laden truck will be scaled at the Site scale to generate a gross weight. The weight will be placed, for auditing purposes only, in the material "Description of Non-Hazardous Waste" box in Part 1 prior to leaving the Site. the Site Owner/Agent will remove and retain the bottom sheet of the five-part carbonless form (blue sheet).

Upon signature of Part 1, the Transporter company driver will complete Part 2 of the top sheet (white sheet) of the charter identifying the Transporter name, address and permit # (if applicable), the driver name, driver's license expiration date, vehicle registration state, vehicle license plate index and truck #. When the driver has completed the information required for Part 2, the driver will sign and date a driver certification on the top sheet (white sheet) of the multi-part form at the time of departure from the donor source location. By signing Part 2, the Driver will certify to the following:

By signing in the space below, I hereby certify that the above-named waste was picked up at the location listed in Part 1 above. I understand that I am responsible for any deviation in waste location. Further, by signing this form I, as driver for Hauler, am solely responsible for the amount and weight of waste that is being transported as well as the methods and means for its safe travel.

Upon arrival at the Receiving Facility, the driver will sign and date a certification on the top sheet (white sheet) of the multi-part form (to the right of his/her first signature). By signing, the Driver will certify to the following:

By signing in the space below, I hereby certify that the above-named waste was delivered without incident from the Site listed in Part 1 above to the Receiving Facility listed below and remained secure and unaltered throughout the entire duration of transportation. Further, if the load is rejected, I will immediately return the waste to the Site location presented in Part 1 above.

After signing the top sheet (white sheet) of the multi-part form, the Driver will present the charter to the receiving Facility representative in the scale house. If the representative confirms that Parts 1 and 2 have been adequately completed, then the load will be scaled. If the load is approved, the representative will complete Part 3 of the charter. This includes listing the representative's name that approved the completeness review of the charter Parts and that approved the load. Additionally, the representative of the Receiving Facility will indicate the date of receipt and the time of receipt. Finally, the scale ticket reference number will be listed on the charter.

Upon completing Part 3, the Receiving Facility representative will sign and date a certification on the top sheet (white sheet) of the multi-part form. By signing Part 3, the Receiving Facility representative will certify to the following:

By signing in the space below, I hereby certify that the above-named waste arrived at this Receiving Facility on the date listed. I have advised the Driver listed in Part 2 of this form that this charter can NOT be used to evidence the disposal/beneficial use of the waste; only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of waste to the Receiving Facility.

After signing, the Receiving Facility representative will remove the bottom sheet of the five-part carbonless form (goldenrod sheet) and present it to the driver for his company's use as evidence of having delivered the material to the Receiving Facility. The Receiving Facility will retain the remaining sheets (white, yellow, pink) of the charter at the Site, which will in turn be paired to a numbered two-part weight receipt from the scale. The Receiving Facility representatives will retain a duplicate of the weight ticket for reconciliation, and the pink sheet of the charter. Following reconciliation, the Site owner will be provided with the yellow sheet of the charter and the second part of

the weight ticket. Manifests and weight tickets will be provided as backup in the CMI Reports submitted by the USEPA.
charter on the top sheet of the multi-part form (white sheet). By signing Part 1, the Site Owner will certify to the following:

> *By signing in the space below, I hereby certify that the waste coming from the above-named Site is being moved with the knowledge and consent of the Site Owner. I have been authorized on behalf of the Site Owner to witness the proper removal, loading and off-site management of the waste, and to evidence the same by signing this transport charter. I understand that by signing this form, I am acknowledging that the waste has been tested or demonstrated to be free of contaminants at concentrations in excess of the permitted levels of the Receiving Facility listed on Part 3 of this form. Further, I understand that this form is not evidence of the receipt of the waste at the Receiving Facility. This document bears no form field or area in which to list the weight or volume of waste being transported. Consequently, this form CANNOT be used to evidence the disposal of the waste. Only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of waste to the Receiving Facility. Further, I certify that if the load is rejected at the Receiving Facility, for any reason, I will accept it back to the Site location.*

After signing, the waste laden truck will be scaled at the Site scale to generate a gross weight. The weight will be placed, for auditing purposes only, in the material "Description of Non-Hazardous Waste" box in Part 1 prior to leaving the Site. The Site Owner/Agent will remove and retain the bottom sheet of the five-part carbonless form (blue sheet).

Upon signature of Part 1, the Transporter company driver will complete Part 2 of the top sheet (white sheet) of the charter identifying the Transporter name, address and permit # (if applicable), the driver name, driver's license expiration date, vehicle registration state, vehicle license plate index and truck #. When the driver has completed the information required for Part 2, the driver will sign and date a driver certification on the top sheet (white sheet) of the multi-part form at the time of departure from the donor source location. By signing Part 2, the Driver will certify to the following:

> *By signing in the space below, I hereby certify that the above-named waste was picked up at the location listed in Part 1 above. I understand that I am responsible for any deviation in waste location. Further, by signing this form I, as driver for Hauler, am solely responsible for the amount and weight of waste that is being transported as well as the methods and means for its safe travel.*

Upon arrival at the Receiving Facility, the driver will sign and date a certification on the top sheet (white sheet) of the multi-part form (to the right of his/her first signature). By signing, the Driver will certify to the following:

> *By signing in the space below, I hereby certify that the above-named waste was delivered without incident from the Site listed in Part 1 above to the Receiving Facility listed below and remained secure and unaltered throughout the entire duration of transportation. Further, if the load is rejected, I will immediately return the waste to the Site location presented in Part 1 above.*

After signing the top sheet (white sheet) of the multi-part form, the Driver will present the charter to the receiving Facility representative in the scale house. If the representative confirms that Parts 1 and 2 have been adequately completed, then the load will be scaled. If the load is approved, the representative will complete Part 3 of the charter. This includes listing the representative's name that approved the completeness review of the charter Parts and that approved the load. Additionally, the representative of the Receiving Facility will indicate the date of receipt and the time of receipt. Finally, the scale ticket reference number will be listed on the charter.

Upon completing Part 3, the Receiving Facility representative will sign and date a certification on the top sheet (white sheet) of the multi-part form. By signing Part 3, the Receiving Facility representative will certify to the following:

By signing in the space below, I hereby certify that the above-named waste arrived at this Receiving Facility on the date listed. I have advised the Driver listed in Part 2 of this form that this charter can NOT be used to evidence the disposal/beneficial use of the waste; only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of waste to the Receiving Facility.

After signing, the Receiving Facility representative will remove the bottom sheet of the five-part carbonless form (goldenrod sheet) and present it to the driver for his company's use as evidence of having delivered the material to the Receiving Facility. The Receiving Facility will retain the remaining sheets (white, yellow, pink) of the charter at the Site, which will in turn be paired to a numbered two-part weight receipt from the scale. The Receiving Facility representatives will retain a duplicate of the weight ticket for reconciliation, and the pink sheet of the charter. Following reconciliation, the Site owner will be provided with the yellow sheet of the charter and the second part of the weight ticket. Manifests and weight tickets will be provided as backup in the CMI Reports submitted by the USEPA.

3.8 Load Rejection and Quality Control

Loads rejected due to inadequate or inaccurate execution of the charter Parts 1 and or 2 will be directed back to the Site. At such time, the Receiving Facility representative will mark Part 3 of the top sheet (white sheet) of the charter "rejected" and retain the bottom sheet (goldenrod sheet). The balance of the sheets will be provided back to the driver for use in the return trip to the Site for remedy.

Loads that are rejected from inspection, either while in the truck or after tipping, will immediately be reloaded onto the transport vehicle and returned to the Site. At such time, the Receiving Facility representative will mark Part 3 of the top sheet (white sheet) of the charter "rejected" and retain the bottom sheet (goldenrod sheet). The balance of the sheets will be provided back to the driver for use in the return trip to the Site for remedy. All sheets of the scale ticket will be marked "rejected" as well.

In all cases, rejections will be listed in a log and retained as a corporate record and included in the CMI Reports. Auditing weights will be reviewed to detect discrepancies. If discrepancies of greater than 10% are found, an quality control audit will be performed by the Site Review Engineer or Data Quality Validator (10% is enough to for acceptable error and fuel consumption adjustments). This will require proof of certification of each scale with its respective licensing agency. The audit will continue as necessary until the discrepancies are removed to below 10%, or a reason for such a discrepancy is identified. All information will be provided in the CMI Reports.

4.0 Records

All manifests, scale tickets, WCPs, approval documentation and notifications will be submitted to the USEPA in Quarterly Progress Reports and within the Corrective Measures Implementation Report (Remedial Construction Completed).

5.0 References

None.

6.0 Definitions

None.

7.0 Attachments

Attachment 1: Example Manifest

NON HAZARDOUS WASTE MANIFEST

#

GENERATOR

Site Owner (Generator) Name & Address:
Former DuPont East Chicago -RCRA Closure Site
East Chicago Gateway Partners, LLC
8 The Green - Suite B
Dover, DE 19901

Site Location & Address:
5135 Kennedy Avenue
East Chicago, IN 46312
p/o Lake County Parcel Numbers: 45-03-33-251, 276 and 300

Certification: *By signing in the space below, I hereby certify that the waste coming from the above-named Site is being moved with the knowledge and consent of the Site Owner. I have been authorized on behalf of the Site Owner and waste generator to witness the proper removal, loading and off-site management of the waste, and to evidence the same by signing this transport charter. I understand that by signing this form, I am acknowledging that the waste has been tested or demonstrated to be free of contaminants at concentrations in excess of the permitted levels of the Receiving Facility listed on Part 3 of this form. Further, I understand that this form is not evidence of the receipt of the waste at the Receiving Facility. This document bears no form field or area in which to list the weight or volume of waste being transported. Consequently, this form CANNOT be used to evidence the disposal of the waste. Only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of waste to the Receiving Facility. Further, I certify that if the load is rejected at the Receiving Facility, for any reason, I will accept it back to the Site.*

Description of Non Hazardous Waste - Material/Classification:

Associated Testing (Optional):

Site Owner Authorized Agent Name | Signature of Site Owner/Agent | Shipment Date | Shipment Time

TRANSPORTER

Transporter Name, Address and Permit # (if applicable):

Driver Name (PRINT):

Driver License Expiration Date:

Vehicle License #/State: Truck#:

Certification: By signing in the space below, I hereby certify that the above-named waste was picked up at the location listed in Part 1 above. I understand that I am responsible for any deviation in waste location. Further, by signing this form I, as driver for Hauler, am solely responsible for the amount and weight of waste that is being transported as well as the methods and means for its safe travel.

Certification: *By signing in the space below, I hereby certify that the above-named waste was delivered without incident from the Site listed in Part 1 above to the Receiving Facility listed below and remained secure and unaltered throughout the entire duration of transportation. Further, if the load is rejected, I will immediately return the waste to the Site location presented in Part 1 above.*

Driver Signature for Certification | Date

Driver Signature for Certification | Date

RECEIVING FACILITY

Receiving Facility Name:

Facility Address:

Name of Authorized Recipient:

Date of Receipt:

Time of Receipt:

SCALE TICKET NUMBER:

Certification: *By signing in the space below, I hereby certify that the above-named waste arrived at this Receiving Facility on the date listed. I have advised the Driver listed in Part 2 of this form that this charter CANNOT be used to evidence the disposal/beneficial use of the waste; only a Scale Ticket, issued by the Receiving Facility shall be used to evidence or quantify receipt of waste to the Receiving Facility.*

Name of Receiving Facility Agent | Signature of Receiving Facility Agent | Receipt Date

Attachment C

Laboratory Standard
Operating Procedures

Former DuPont East Chicago Facility

STATE OF ILLINOIS

ENVIRONMENTAL PROTECTION AGENCY
NELAP - RECOGNIZED
ENVIRONMENTAL LABORATORY ACCREDITATION

is hereby granted to

TESTAMERICA CHICAGO

2417 BOND STREET

UNIVERSITY PARK, IL 60484

NELAP ACCREDITED

ACCREDITATION NUMBER #100201

According to the Illinois Administrative Code, Title 35, Subtitle A, Chapter II, Part 186, ACCREDITATION OF LABORATORIES FOR DRINKING WATER, WASTEWATER AND HAZARDOUS WASTES ANALYSIS, the State of Illinois formally recognizes that this laboratory is technically competent to perform the environmental analyses listed on the scope of accreditation detailed below.

The laboratory agrees to perform all analyses listed on this scope of accreditation according to the Part 186 requirements and acknowledges that continued accreditation is dependent on successful ongoing compliance with the applicable requirements of Part 186. Please contact the Illinois EPA Environmental Laboratory Accreditation Program (IL ELAP) to verify the laboratory's scope of accreditation and accreditation status. Accreditation by the State of Illinois is not an endorsement or a guarantee of validity of the data generated by the laboratory.

Celeste M. Crowley
Acting Manager
Environmental Laboratory Accreditation Program

John South
Accreditation Officer
Environmental Laboratory Accreditation Program

Certificate No.: 004379
Expiration Date: 04/30/2019
Issued On: 04/05/2018

State of Illinois
Environmental Protection Agency

Certificate No.: 004379

Awards the Certificate of Approval to:

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

According to the Illinois Administrative Code, Title 35, Subtitle A, Chapter II, Part 186, ACCREDITATION OF LABORATORIES FOR DRINKING WATER, WASTEWATER AND HAZARDOUS WASTES ANALYSIS, the State of Illinois formally recognizes that this laboratory is technically competent to perform the environmental analyses listed on the scope of accreditation detailed below.

The laboratory agrees to perform all analyses listed on this scope of accreditation according to the Part 186 requirements and acknowledges that continued accreditation is dependent on successful ongoing compliance with the applicable requirements of Part 186. Please contact the Illinois EPA Environmental Laboratory Accreditation Program (IL ELAP) to verify the laboratory's scope of accreditation and accreditation status. Accreditation by the State of Illinois is not an endorsement or a guarantee of validity of the data generated by the laboratory.

FOT Name: Drinking Water, Inorganic

Method: SM2320B,20Ed

Matrix Type: Potable Water

Alkalinity

Method: SM2340B,20Ed

Matrix Type: Potable Water

Hardness

Method: SM2510B,20Ed

Matrix Type: Potable Water

Conductivity

Method: SM2540C,20Ed

Matrix Type: Potable Water

Total Dissolved Solids

Method: SM4500Cl-F,20Ed

Matrix Type: Potable Water

Chlorine

Method: SM4500CN-E,20Ed

Matrix Type: Potable Water

Cyanide

Method: SM4500F-C,20Ed

Matrix Type: Potable Water

Fluoride

Method: SM4500H-B,20Ed

Matrix Type: Potable Water

Hydrogen Ion (pH)

Method: SM4500NO2-B,20Ed

Matrix Type: Potable Water

Nitrite

Method: SM4500NO3-F,20Ed

Matrix Type: Potable Water

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: **Drinking Water, Inorganic**

Matrix Type: **Potable Water**

Method: **SM4500P-E,20Ed**

Matrix Type: **Potable Water**

Orthophosphate

Method: **SM4500SO4-E,20Ed**

Matrix Type: **Potable Water**

Sulfate

Method: **SM5310C,20Ed**

Matrix Type: **Potable Water**

Dissolved Organic Carbon

Method: **USEPA180.1**

Matrix Type: **Potable Water**

Turbidity

Method: **USEPA200.7R4.4**

Matrix Type: **Potable Water**

Aluminum
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Copper
Iron
Magnesium
Manganese
Nickel
Silica
Silver
Sodium
Zinc

Method: **USEPA200.8R5.4**

Matrix Type: **Potable Water**

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Copper
Lead
Manganese
Molybdenum
Nickel
Selenium
Silver
Thallium
Zinc

Method: **USEPA245.1R3.0**

Method: **SM4500NO3-F,20Ed**

Nitrate

Total Organic Carbon (TOC)

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Drinking Water, Inorganic

Method: USEPA245.1R3.0

Matrix Type: Potable Water

Mercury

Method: USEPA300.0R2.1

Matrix Type: Potable Water

Chloride
Fluoride
Nitrate
Nitrite
Orthophosphate
Sulfate

Method: USEPA353.2R2.0

Matrix Type: Potable Water

Nitrate

FOT Name: Non Potable Water, Inorganic

Method: SM2320B,1997

Matrix Type: NPW/SCM

Alkalinity

Method: SM2340B,1997

Matrix Type: NPW

Hardness

Method: SM2510B,1997

Matrix Type: NPW/SCM

Specific Conductance

Method: SM2540B,1997

Matrix Type: NPW

Residue (Total)

Method: SM2540C,1997

Matrix Type: NPW

Residue (TDS)

Method: SM2540D,1997

Matrix Type: NPW

Residue (TSS)

Method: SM2540E,1997

Matrix Type: NPW

Residue (% Volatile)

Method: SM2540F,1997

Matrix Type: NPW

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Non Potable Water, Inorganic

Matrix Type: NPW

Method: SM3500Cr-B,2009

Matrix Type: NPW

Chromium VI

Method: SM4500CL⁻-E,1997

Matrix Type: NPW/SCM

Chloride

Method: SM4500Cl-F,2000

Matrix Type: NPW

Chlorine, Total Residual

Method: SM4500Cl-G,2000

Matrix Type: NPW

Chlorine, Total Residual

Method: SM4500CN-E,1999

Matrix Type: NPW/SCM

Cyanide

Method: SM4500CN-G,1999

Matrix Type: NPW/SCM

Cyanide, Available

Method: SM4500F-C,1997

Matrix Type: NPW/SCM

Fluoride

Method: SM4500H-B,2000

Matrix Type: NPW

Hydrogen Ion (pH)

Method: SM4500NH3-G,1997

Matrix Type: NPW/SCM

Ammonia

Method: SM4500NO2-B,2000

Matrix Type: NPW/SCM

Nitrite

Method: SM4500NO3-F,2000

Matrix Type: NPW/SCM

Nitrate

Method: SM2540F,1997

Residue (settleable)

Total Kjeldahl Nitrogen

Nitrate-nitrite (as N)

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: **Non Potable Water, Inorganic** **Method:** **SM4500O-G,2001**

Matrix Type: **NPW**

Oxygen - Dissolved

Method: **SM4500P-E,1999**

Matrix Type: **NPW/SCM**

Orthophosphate — Phosphorus

Method: **SM4500S2-F,2000**

Matrix Type: **NPW/SCM**

Sulfide

Method: **SM4500SO4-E,1997**

Matrix Type: **NPW**

Sulfate

Method: **SM5210B,2001**

Matrix Type: **NPW/SCM**

Biochemical Oxygen Demand (BOD) — Carbonaceous Biochemical Oxygen Demand (CBOI

Method: **SM5220C,1997**

Matrix Type: **NPW/SCM**

Chemical Oxygen Demand (COD)

Method: **SM5310C,2000**

Matrix Type: **NPW/SCM**

Total organic carbon (TOC)

Method: **USEPA120.1,1982**

Matrix Type: **NPW/SCM**

Specific Conductance

Method: **USEPA160.4,1971**

Matrix Type: **NPW/SCM**

Residue (Volatile)

Method: **USEPA1664A**

Matrix Type: **NPW/SCM**

Oil and Grease

Method: **USEPA1664B**

Matrix Type: **NPW/SCM**

Oil & Grease

Method: **USEPA180.1R2.0,1993**

Matrix Type: **NPW**

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: **Non Potable Water, Inorganic**

Matrix Type: **NPW**

Method: **USEPA200.7,1994**

Matrix Type: **NPW/SCM**

Aluminum	Antimony
Arsenic	Barium
Beryllium	Boron
Cadmium	Calcium
Chromium	Cobalt
Copper	Iron
Lead	Magnesium
Manganese	Molybdenum
Nickel	Potassium
Selenium	Silica
Silver	Sodium
Thallium	Tin
Titanium	Vanadium
Zinc	

Method: **USEPA200.8,1994**

Matrix Type: **NPW**

Aluminum	Antimony
Arsenic	Barium
Beryllium	Boron
Cadmium	Calcium
Chromium	Cobalt
Copper	Iron
Lead	Magnesium
Manganese	Molybdenum
Nickel	Potassium
Selenium	Silver
Sodium	Thallium
Tin	Titanium
Vanadium	Zinc

Method: **USEPA218.6R3.3,1994**

Matrix Type: **NPW**

Method: **USEPA180.1R2.0,1993**

Turbidity

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Non Potable Water, Inorganic

Method: USEPA218.6R3.3,1994

Matrix Type: NPW

Chromium VI

Method: USEPA245.1R3.0,1994

Matrix Type: NPW

Mercury

Method: USEPA300.0R2.1,1993

Matrix Type: NPW

Bromide	Chloride
Fluoride	Nitrate
Nitrate-Nitrite (as N)	Nitrite
Orthophosphate	Sulfate

Method: USEPA350.1R2.0,1993

Matrix Type: NPW/SCM

Ammonia

Method: USEPA351.1,1978

Matrix Type: NPW/SCM

Total Kjeldahl Nitrogen

Method: USEPA353.2R2.0,1993

Matrix Type: NPW/SCM

Nitrate	Nitrate-nitrite (as N)

Method: USEPA420.4R1.0,1993

Matrix Type: NPW/SCM

Phenolics

FOT Name: Non Potable Water, Organic

Method: USEPA608

Matrix Type: NPW

4,4'-DDD	4,4'-DDE
4,4'-DDT	Aldrin
alpha-BHC	beta-BHC
Chlordane	delta-BHC
Dieldrin	Endosulfan I
Endosulfan II	Endosulfan sulfate
Endrin	Endrin aldehyde
gamma-BHC (Lindane)	Heptachlor
Heptachlor epoxide	Methoxychlor

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Non Potable Water, Organic

Method: USEPA608

Matrix Type: NPW

PCB-1016	PCB-1221
PCB-1232	PCB-1242
PCB-1248	PCB-1254
PCB-1260	Toxaphene

Method: USEPA624

Matrix Type: NPW

1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane	1,1-Dichloroethane
1,1-Dichloroethene	1,2-Dichlorobenzene
1,2-Dichloroethane	1,2-Dichloropropane
1,3-Dichlorobenzene	1,4-Dichlorobenzene
2-Chloroethylvinyl ether	Acrolein (Propenal)
Acrylonitrile	Benzene
Bromodichloromethane	Bromoform
Bromomethane	Carbon tetrachloride
Chlorobenzene	Chloroethane
Chloroform	Chloromethane
cis-1,3-Dichloropropene	Dibromochloromethane
Dichloromethane (Methylene chloride)	Ethylbenzene
Methyl tert-butyl ether (MTBE)	Tetrachloroethene
Toluene	trans-1,2-Dichloroethene
trans-1,3-Dichloropropene	Trichloroethene
Trichlorofluoromethane	Vinyl chloride
Xylenes (total)	

Method: USEPA625

Matrix Type: NPW

1,2,4-Trichlorobenzene	1,2-Dichlorobenzene
1,3-Dichlorobenzene	1,4-Dichlorobenzene
2,2-Oxybis (1-chloropropane)	2,4,5-Trichlorophenol
2,4,6-Trichlorophenol	2,4-Dichlorophenol
2,4-Dimethylphenol	2,4-Dinitrophenol
2,4-Dinitrotoluene (2,4-DNT)	2,6-Dinitrotoluene (2,6-DNT)
2-Chloronaphthalene	2-Chlorophenol

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Non Potable Water, Organic

Method: USEPA625

Matrix Type: NPW

2-Nitrophenol	2-Methyl-4,6-dinitrophenol
4-Bromophenyl phenyl ether	3,3'-Dichlorobenzidine
4-Chlorophenyl phenyl ether	4-Chloro-3-methylphenol
Acenaphthene	4-Nitrophenol
Anthracene	Acenaphthylene
Benzo(a)anthracene	Benzidine
Benzo(b)fluoranthene	Benzo(a)pyrene
Benzo(k)fluoranthene	Benzo(g,h,i)perylene
Bis(2-chloroethoxy) methane	Benzyl butyl phthalate
Bis(2-ethylhexyl) phthalate	Bis(2-chloroethyl) ether
Dibenz(a,h)anthracene	Chrysene
Dimethyl phthalate	Diethyl phthalate
Di-n-octyl phthalate	Di-n-butyl phthalate
Fluorene	Fluoranthene
Hexachlorobutadiene	Hexachlorobenzene
Hexachloroethane	Hexachlorocyclopentadiene
Isophorone	Indeno(1,2,3-cd) pyrene
Nitrobenzene	Naphthalene
N-Nitrosodi-n-propylamine	N-Nitrosodimethylamine
Pentachlorophenol	N-Nitrosodiphenylamine
Phenol	Phenanthrene
	Pyrene

FOT Name: Solid and Chemical Materials, Inorganic

Method: 1010A

Matrix Type: NPW/SCM

Ignitability

Method: 1311

Matrix Type: NPW/SCM

TCLP (Organic and Inorganic)

Method: 1312

Matrix Type: NPW/SCM

Synthetic Precipitation Leaching Procedure

Method: 6010B

Matrix Type: NPW/SCM

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Solid and Chemical Materials, Inorganic

Method: 6010B

Matrix Type: NPW/SCM

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Magnesium
- Manganese
- Molybdenum
- Nickel
- Potassium
- Selenium
- Silica
- Silver
- Sodium
- Strontium
- Thallium
- Tin
- Titanium
- Vanadium
- Zinc

Method: 6010C

Matrix Type: NPW/SCM

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Magnesium
- Manganese
- Molybdenum
- Nickel
- Potassium
- Selenium
- Silica
- Silver
- Sodium
- Strontium
- Thallium
- Tin
- Titanium
- Vanadium
- Zinc

Method: 6020A

Matrix Type: NPW

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Solid and Chemical Materials, Inorganic

Method: 6020A

Matrix Type: NPW

Antimony
Arsenic
Barium
Beryllium
Boron
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Molybdenum
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

Method: 7196A

Matrix Type: NPW/SCM

Chromium VI

Method: 7199

Matrix Type: NPW

Chromium VI

Method: 7470A

Matrix Type: NPW

Mercury

Method: 7471B

Matrix Type: SCM

Mercury

Method: 9014

Matrix Type: NPW/SCM

Cyanide

Method: 9020B

Matrix Type: NPW/SCM

TOX (Total Organic Halides)

Method: 9034

Matrix Type: NPW/SCM

Sulfides

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Solid and Chemical Materials, Inorganic **Method: 9038**

Matrix Type: NPW

Sulfate

Method: 9040B

Matrix Type: NPW

Hydrogen Ion (pH)

Method: 9040C

Matrix Type: NPW

Hydrogen Ion (pH)

Method: 9045C

Matrix Type: SCM

Hydrogen Ion (pH)

Method: 9045D

Matrix Type: SCM

Hydrogen Ion (pH)

Method: 9050A

Matrix Type: NPW/SCM

Specific Conductance

Method: 9056A

Matrix Type: NPW/SCM

Bromide
Chloride
Fluoride
Nitrate
Nitrite
Phosphate
Sulfate

Method: 9060A

Matrix Type: NPW/SCM

Total Organic Carbon (TOC)

Method: 9066

Matrix Type: NPW/SCM

Phenolics

Method: 9071B

Matrix Type: NPW/SCM

Oil and Grease Extractable

Method: 9095A

Matrix Type: NPW/SCM

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Solid and Chemical Materials, Inorganic

Method: 9095A

Paint Filter

Matrix Type: NPW/SCM

Method: 9095B

Matrix Type: NPW/SCM

Paint Filter

Method: 9251

Matrix Type: NPW/SCM

Chloride

FOT Name: Solid and Chemical Materials, Organic

Method: 8015B

Matrix Type: NPW/SCM

Diesel range organics (DRO)

Gasoline range organics (GRO)

Method: 8015C

Matrix Type: NPW/SCM

Diesel range organics (DRO)

Gasoline range organics (GRO)

Method: 8015D

Matrix Type: NPW/SCM

Diesel range organics (DRO)

Gasoline range organics (GRO)

Method: 8081A

Matrix Type: NPW/SCM

4,4'-DDD

4,4'-DDE

4,4'-DDT

Alachlor

Aldrin

alpha-BHC

alpha-Chlordane

Atrazine

beta-BHC

Chlordane - not otherwise specified

delta-BHC

Dieldrin

Endosulfan I

Endosulfan II

Endosulfan sulfate

Endrin

Endrin aldehyde

Endrin ketone

gamma-BHC (Lindane)

gamma-Chlordane

Heptachlor

Heptachlor epoxide

Isodrin

Kepone

Methoxychlor

Simazine

Toxaphene

Method: 8081B

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Solid and Chemical Materials, Organic **Method: 8081B**

Matrix Type: NPW/SCM

4,4'-DDD	4,4'-DDE
4,4'-DDT	Alachlor
Aldrin	alpha-BHC
alpha-Chlordane	Atrazine
beta-BHC	Chlordane - not otherwise specified
delta-BHC	Dieldrin
Endosulfan I	Endosulfan II
Endosulfan sulfate	Endrin
Endrin aldehyde	Endrin ketone
gamma-BHC (Lindane)	gamma-Chlordane
Heptachlor	Heptachlor epoxide
Isodrin	Kepone
Methoxychlor	Simazine
Toxaphene	

Method: 8082

Matrix Type: NPW/SCM

PCB-1016	PCB-1221
PCB-1232	PCB-1242
PCB-1248	PCB-1254
PCB-1260	

Method: 8082A

Matrix Type: NPW/SCM

PCB-1016	PCB-1221
PCB-1232	PCB-1242
PCB-1248	PCB-1254
PCB-1260	

Method: 8151A

Matrix Type: NPW/SCM

2,4,5-T	2,4,5-TP (Silvex)
2,4-D	2,4-DB
Dalapon	Dicamba
Dichloroprop	Dinoseb
Pentachlorophenol	Picloram

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Solid and Chemical Materials, Organic **Method: 8260B**

Matrix Type: NPW/SCM

1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane
1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane
1,1-Dichloroethane	1,1-Dichloroethene
1,1-Dichloropropene	1,2,3-Trichlorobenzene
1,2,3-Trichloropropane	1,2,4-Trichlorobenzene
1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloropropane (DBCP)
1,2-Dibromoethane (EDB)	1,2-Dichlorobenzene
1,2-Dichloroethane	1,2-Dichloropropane
1,3,5-TCB	1,3,5-Trimethylbenzene
1,3-Dichlorobenzene	1,3-Dichloropropane
1,4-Dichlorobenzene	1,4-Dioxane
1-Chlorohexane	2,2-Dichloropropane
2-Butanone (Methyl ethyl ketone, MEK)	2-Chloro-1,3-butadiene (Chloroprene)
2-Chloroethyl vinyl ether	2-Chlorotoluene
2-Hexanone	2-Methyl-1-propanol (Isobutyl alcohol)
2-Methylnaphthalene	2-Nitropropane
4-Chlorotoluene	4-Methyl-2-pentanone (Methyl isobutyl ketone, MIBK
Acetone	Acetonitrile
Acrolein (Propenal)	Acrylonitrile
Allyl chloride	Benzene
Benzyl chloride	Bromobenzene
Bromochloromethane	Bromodichloromethane
Bromoform	Bromomethane
Carbon disulfide	Carbon tetrachloride
Chlorobenzene	Chlorodibromomethane (Dibromochloromethane)
Chloroethane	Chloroform
Chloromethane	Chloroprene
cis-1,2-Dichloroethene	cis-1,3-Dichloropropene
Dibromomethane	Dichlorodifluoromethane
Dichloromethane (Methylene chloride)	Diethyl ether
Ethanol	Ethyl acetate
Ethyl ether	Ethyl methacrylate
Ethylbenzene	Hexachlorobutadiene
Isopropyl ether	Isopropylbenzene

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Solid and Chemical Materials, Organic

Method: 8260B

Matrix Type: NPW/SCM

- Methacrylonitrile
- Methyl iodide (Iodmethane)
- Methyl methacrylate
- m-Xylene
- n-Butanol
- n-Propylbenzene
- Pentachloroethane
- Propionitrile (Ethyl cyanide)
- sec-Butylbenzene
- t-Butyl alcohol
- Tetrachloroethene
- Toluene
- trans-1,3-Dichloropropene
- Trichloroethene
- Trichlorotrifluoroethane
- Vinyl chloride
- Xylenes (Total)
- m&p-xylene
- Methyl ethyl ketone
- Methyl isobutyl ketone
- Methyl-t-butyl ether
- Naphthalene
- n-Butylbenzene
- o-Xylene
- p-Isopropyltoluene
- p-Xylene
- Styrene
- tert-Butylbenzene
- Tetrahydrofuran
- trans-1,2-Dichloroethene
- trans-1,4-Dichloro-2-butene
- Trichlorofluoromethane
- Vinyl acetate
- Vinylidene chloride

Method: 8270C

Matrix Type: NPW/SCM

- 1,2,4,5-Tetrachlorobenzene
- 1,2-Dichlorobenzene
- 1,3,5-Trinitrobenzene (1,3,5-TNB)
- 1,3-Dinitrobenzene (1,3-DNB)
- 1,4-Dinitrobenzene
- 1,4-Naphthoquinone
- 1-Chloronaphthalene
- 1-Naphthylamine
- 2,3,4,6-Tetrachlorophenol
- 2,4,6-Trichlorophenol
- 2,4-Dimethylphenol
- 2,4-Dinitrotoluene (2,4-DNT)
- 2,6-Dinitrotoluene (2,6-DNT)
- 2-Chloronaphthalene
- 2-Methylnaphthalene
- 1,2,4-Trichlorobenzene
- 1,2-Diphenylhydrazine
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- 1,4-Dioxane
- 1,4-Phenylenediamine
- 1-Methylnaphthalene
- 2,2-Oxybis (1-chloropropane)
- 2,4,5-Trichlorophenol
- 2,4-Dichlorophenol
- 2,4-Dinitrophenol
- 2,6-Dichlorophenol
- 2-Acetylaminofluorene
- 2-Chlorophenol
- 2-Methylpyridine (2-Picoline)

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: **Solid and Chemical Materials, Organic**

Method: **8270C**

Matrix Type: **NPW/SCM**

2-Nitroaniline	2-Naphthylamine
3,3'-Dichlorobenzidine	2-Nitrophenol
3-Methylcholanthrene	3,3'-Dimethylbenzidine
4,6-Dinitro-2-methylphenol	3-Nitroaniline
4-Bromophenyl phenyl ether	4-Aminobiphenyl
4-Chloroaniline	4-Chloro-3-methylphenol
4-Nitroaniline	4-Chlorophenyl phenyl ether
4-Nitroquinoline-1-oxide	4-Nitrophenol
7,12-Dimethylbenz(a)anthracene	5-Nitro-o-toluidine
Acenaphthylene	Acenaphthene
alpha,alpha-Dimethylphenethylamine	Acetophenone
Anthracene	Aniline
Benzidine	Aramite
Benzo(a)pyrene	Benzo(a)anthracene
Benzo(g,h,i)perlyene	Benzo(b)fluoranthene
Benzoic acid	Benzo(k)fluoranthene
Bis(2-chloroethoxy) methane	Benzyl alcohol
Bis(2-ethylhexyl) phthalate	Bis(2-chloroethyl) ether
Carbazole	Butyl benzyl phthalate
Chlorobenzilate	Carbofuran (Furaden)
Diallate	Chrysene
Dibenz(a,j)acridine	Dibenz(a,h)anthracene
Diethyl phthalate	Dibenzofuran
Dimethyl phthalate	Dimethoate
Di-n-octyl phthalate	Di-n-butyl phthalate
Diphenylamine	Dinoseb
Famphur	Ethyl methanesulfonate
Fluorene	Fluoranthene
Hexachlorobutadiene	Hexachlorobenzene
Hexachloroethane	Hexachlorocyclopentadiene
Hexachloropropene	Hexachlorophene
Isodrin	Indeno(1,2,3-cd) pyrene
Isosafrole	Isophorone
m-Cresol (3-Methylphenol)	Kepone
	m-Dinitrobenzene

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Solid and Chemical Materials, Organic

Method: 8270C

Matrix Type: NPW/SCM

- Methapyrilene
- Methyl methanesulfonate
- Methyl parathion
- Naphthalene
- Nitrobenzene
- N-Nitrosodiethylamine
- N-Nitrosodimethylamine
- N-Nitrosodi-n-butylamine (N-Nitrosodibutylamine)
- N-Nitrosodi-n-propylamine
- N-Nitrosodiphenylamine
- N-Nitrosomethylethylamine
- N-Nitrosomorpholine
- N-Nitrosopiperidine
- N-Nitrosopyrrolidine
- O,O,O-Triethyl phosphorothioate
- o-Cresol (2-Methylphenol)
- o-Toluidine
- Parathion
- p-Cresol (4-Methylphenol)
- p-Dimethylaminoazobenzene
- Pentachlorobenzene
- Pentachloronitrobenzene
- Pentachlorophenol
- Phenacetin
- Phenanthrene
- Phenol
- Phorate
- p-Phenylenediame
- Pronamide
- Pyrene
- Pyridine
- Safrole
- Thionazine (Zinophos)

Method: 8270D

Matrix Type: NPW/SCM

- 1,2,4,5-Tetrachlorobenzene
- 1,2,4-Trichlorobenzene
- 1,2-Dichlorobenzene
- 1,2-Diphenylhydrazine
- 1,3,5-Trinitrobenzene (1,3,5-TNB)
- 1,3-Dichlorobenzene
- 1,3-Dinitrobenzene (1,3-DNB)
- 1,4-Dichlorobenzene
- 1,4-Dinitrobenzene
- 1,4-Dioxane
- 1,4-Naphthoquinone
- 1,4-Phenylenediamine
- 1-Chloronaphthalene
- 1-Methylnaphthalene
- 1-Naphthylamine
- 2,2-Oxybis (1-chloropropane)
- 2,3,4,6-Tetrachlorophenol
- 2,4,5-Trichlorophenol
- 2,4,6-Trichlorophenol
- 2,4-Dichlorophenol
- 2,4-Dimethylphenol
- 2,4-Dinitrophenol
- 2,4-Dinitrotoluene (2,4-DNT)
- 2,6-Dichlorophenol
- 2,6-Dinitrotoluene (2,6-DNT)
- 2-Acetylaminofluorene
- 2-Chloronaphthalene
- 2-Chlorophenol
- 2-Methylnaphthalene
- 2-Methylphenol (o-Cresol)
- 2-Methylpyridine (2-Picoline)
- 2-Naphthylamine

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: **Solid and Chemical Materials, Organic**

Method: **8270D**

Matrix Type: **NPW/SCM**

2-Nitrophenol	2-Nitroaniline
3,3'-Dimethylbenzidine	3,3'-Dichlorobenzidine
3-Methylphenol (m-Cresol)	3-Methylcholanthrene
4,6-Dinitro-2-methylphenol	3-Nitroaniline
4-Bromophenyl phenyl ether	4-Aminobiphenyl
4-Chloroaniline	4-Chloro-3-methylphenol
4-Methylphenol (p-Cresol)	4-Chlorophenyl phenyl ether
4-Nitrophenol	4-Nitroaniline
5-Nitro-o-toluidine	4-Nitroquinoline-1-oxide
Acenaphthene	7,12-Dimethylbenz(a)anthracene
Acetophenone	Acenaphthylene
Aniline	alpha,alpha-Dimethylphenethylamine
Aramite	Anthracene
Benzo(a)anthracene	Benzidine
Benzo(b)fluoranthene	Benzo(a)pyrene
Benzo(k)fluoranthene	Benzo(g,h,i)perlyene
Benzyl alcohol	Benzoic acid
Bis(2-chloroethyl) ether	Bis(2-chloroethoxy) methane
Butyl benzyl phthalate	Bis(2-ethylhexyl) phthalate
Carbofuran (Furaden)	Carbazole
Chrysene	Chlorobenzilate
Dibenz(a,h)anthracene	Diallate
Dibenzofuran	Dibenz(a,j)acridine
Dimethoate	Diethyl phthalate
Di-n-butyl phthalate	Dimethyl phthalate
Dinoseb	Di-n-octyl phthalate
Ethyl methanesulfonate	Diphenylamine
Fluoranthene	Famphur
Hexachlorobenzene	Fluorene
Hexachlorocyclopentadiene	Hexachlorobutadiene
Hexachlorophene	Hexachloroethane
Indeno(1,2,3-cd) pyrene	Hexachloropropene
Isophorone	Isodrin
Kepone	Isosafrole
	m-Cresol (3-Methylphenol)

State of Illinois
Environmental Protection Agency

Certificate No.: 004379

Awards the Certificate of Approval

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484

FOT Name: Solid and Chemical Materials, Organic

Method: 8270D

Matrix Type: NPW/SCM

Methapyrilene	m-Dinitrobenzene
Methyl parathion	Methyl methanesulfonate
Nitrobenzene	Naphthalene
N-Nitrosodimethylamine	N-Nitrosodiethylamine
N-Nitrosodi-n-propylamine	N-Nitrosodi-n-butylamine (N-Nitrosodibutylamine)
N-Nitrosomethylethylamine	N-Nitrosodiphenylamine
N-Nitrosopiperidine	N-Nitrosomorpholine
O,O,O-Triethyl phosphorothioate	N-Nitrosopyrrolidine
o-Toluidine	o-Cresol (2-Methylphenol)
p-Cresol (4-Methylphenol)	Parathion
Pentachlorobenzene	p-Dimethylaminoazobenzene
Pentachlorophenol	Pentachloronitrobenzene
Phenanthrene	Phenacetin
Phorate	Phenol
Pronamide	p-Phenylenediame
Pyridine	Pyrene
Thionazine (Zinophos)	Safrole

State of New Jersey

Department of Environmental Protection

Certifies That

EUROFINS FRONTIER GLOBAL SCIENCES LLC

Laboratory Certification ID # WA014

is hereby approved as a

Nationally Accredited Environmental Laboratory

to perform the analyses as indicated on the Annual Certified Parameter List
which must accompany this certificate to be valid

having duly met the requirements of the

Regulations Governing the Certification of Laboratories and Environmental Measurements N.J.A.C. 7:18 et. seq.

and

having been found compliant with the 2009 TNI Standard approved by the

The NELAC Institute

Expires June 30, 2020

NELAP RECOGNIZED TNI ACCREDITATION BODY

Michele M. Potter
Manager

THE GREAT SEAL OF THE STATE OF NEW JERSEY

NJDEP is a NELAP Recognized Accreditation Body

This certificate is to be conspicuously displayed at the laboratory with the annual certified parameter list in a location on the premises visible to the public. Consumers are urged to verify the laboratory's current accreditation status with the State of NJ, NELAP.

New Jersey Department of Environment Protection
Environmental Laboratory Certification Program

Annual Certified Parameter List and Current Status

Effective as of 07/01/2019 until 6/30/2020

Laboratory Name: EUROFINS FRONTIER GLOBAL SCIENCES LLC Laboratory Number: WA014 Activity ID: NLC 190001
11720 NORTH CREEK PKWY NORTH STE 400
BOTHELL WA 98011

Category: BT08 --BT - Lab Developed/Non-Std Methods

Status	Eligible to Report NJ Data	Code	Parameter	Technique	Approved Methods	Primary State
Applied	No	BT08.00001	Methyl Mercury	Cold Vapor Atomic Fluorescence Spectrometry	User Defined FGS-070/CV-GC-AFS	LA

Category: NPW07--Metals

Status	Eligible to Report NJ Data	Code	Parameter	Technique	Approved Methods	Primary State
Certified	Yes	NPW07.02200	Mercury	Purge & Trap Atomic Fluorescence	EPA 1631E	LA
Certified	Yes	NPW07.02250	Methyl Mercury	Purge & Trap Atomic Fluorescence	EPA 1630	LA

Category: NPW08--Metals - ICP, ICP/MS and DCP

Status	Eligible to Report NJ Data	Code	Parameter	Technique	Approved Methods	Primary State
Certified	Yes	NPW08.00130	Aluminum	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.00300	Antimony	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.00450	Arsenic	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.00590	Barium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.00760	Beryllium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.00940	Boron	ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.01110	Cadmium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.01270	Calcium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.01430	Chromium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.01610	Cobalt	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.01770	Copper	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.02110	Iron	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.02290	Lead	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.02490	Magnesium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.02660	Manganese	Digestion, ICP/MS	EPA 200.8	LA

New Jersey Department of Environment Protection
Environmental Laboratory Certification Program

Annual Certified Parameter List and Current Status

Effective as of 07/01/2019 until 6/30/2020

Laboratory Name: EUROFINS FRONTIER GLOBAL SCIENCES LLC Laboratory Number: WA014 Activity ID: NLC 190001
11720 NORTH CREEK PKWY NORTH STE 400
BOTHELL WA 98011

Category: NPW08--Metals - ICP, ICP/MS and DCP

Status	Eligible to Report NJ Data	Code	Parameter	Technique	Approved Methods	Primary State
Certified	Yes	NPW08.02830	Molybdenum	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.02990	Nickel	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.03200	Potassium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.03390	Selenium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.03650	Silver	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.03810	Sodium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.04030	Thallium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.04190	Tin	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.04280	Titanium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.04510	Vanadium	Digestion, ICP/MS	EPA 200.8	LA
Certified	Yes	NPW08.04690	Zinc	Digestion, ICP/MS	EPA 200.8	LA

Category: SCM06--Metals

Status	Eligible to Report NJ Data	Code	Parameter	Technique	Approved Methods	Primary State
Certified	Yes	SCM06.00690	Methyl Mercury	Cold Vapor Atomic Fluorescence Spectrometry	User Defined EPA 1630	LA

Michele M. Potter, Manager

KEY: AE = Air and Emissions, BT = Biological Tissues, DW = Drinking Water, NPW = Non-Potable Water, SCM = Solid and Chemical Materials

State of New Jersey
Department of Environmental Protection

PHILIP D. MURPHY
Governor

SHEILA Y. OLIVER
Lt. Governor

Office of Quality Assurance
401 E. State Street
PO Box 420, Mail Code 401-02D
Trenton, NJ 08625-0420
Tel #: (609) 292-3950
Fax#: (609) 7777-1774

CATHERINE R. McCABE
Commissioner

June 3, 2019

Dear Laboratory Manager:

Your fiscal year 2020 (FY20) laboratory certification renewal application has been processed and a Certificate and Annual Certified Parameter List (ACPL) that reflects the current status of your facility are enclosed. If there are any discrepancies, please contact your Laboratory Certification Officer to verify information and make arrangements for a new ACPL. If the Office of Quality Assurance does not receive documentation of any discrepancies before July 10, 2019 this ACPL will be considered final and any changes received thereafter will be treated as a modification application. Effective with the receipt of this letter, your facility's certification status is valid through June 30, 2020. Both the ACPL and Certificate must be conspicuously displayed at your facility in a location on the premises that is visible to the public.

As always, we are available to discuss any comments or questions. Please do not hesitate to contact your laboratory certification officer or me.

Sincerely,

Michele M. Potter
Manager

Enclosures: ACPL; Certificate

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JOHN BEL EDWARDS
GOVERNOR

CHUCK CARR BROWN, PH.D.
SECRETARY

State of Louisiana

DEPARTMENT OF ENVIRONMENTAL QUALITY
ENVIRONMENTAL SERVICES

Read Receipt Requested

AI No. 83654
Activity No. ACC20190001
LELAP Lab ID # 03073
Accreditation Year FY 2020
Renewal due FY 2021

Mr. Dave Wunderlich
Eurofins Frontier Global Sciences LLC
11720 N Creek Pkwy N Ste 400
Bothell, Washington 98011-8244

Re: Scope of Accreditation

Dear Mr. Wunderlich:

On May 24, 2019, the Louisiana Environmental Laboratory Accreditation Program (LELAP) received a request for an amendment to your Scope of Accreditation. LELAP amends the Scope issued June 25, 2018 to include the parameters requested. Additions are highlighted in the attached scope. LELAP removes Total Phosphorus by EPA 200.8, EPA 1638, and FGS-054/ICP-MS; and Chromium VI by SM 3500-Cr B, 21st ED in the non-potable water matrix. LELAP also removes Total Phosphorus by EPA 1638 and FGS-054/ICP-MS; and Chromium VI by EPA 7196A in the solid chemical materials matrix.

The Louisiana Department of Environmental Quality's laboratory accreditation program, in accordance with Louisiana Administrative Code, Title 33, Part I, Subpart 3, Laboratory Accreditation, accredits this laboratory for Fiscal Year 2020. This accreditation does not constitute an endorsement of the suitability of the listed methods for any specific purpose. Accreditation of the environmental laboratory does not imply that a product, process, system, or person is approved by LELAP. The laboratory is accredited for the methods as identified on the application for accreditation; if the methods are partially identified on the application for accreditation, the laboratory is accredited for the versions listed on the current application or referenced in the laboratory standard operating procedure.

National Environmental Laboratory Accreditation Program (NELAP) accreditation is granted only for those methods/analytes for which "NELAP" is indicated as the type of accreditation. "STATE" is indicated as the type of accreditation for those methods/analytes for which accreditation by the Louisiana Environmental Laboratory Accreditation Program (LELAP) is granted. Accreditation is dependent on the laboratory's successful ongoing compliance with regulations as outlined in the Louisiana Administrative Code, Title 33, Part I, Subpart 3, Laboratory Accreditation, and with the standards adopted by the NELAP Accreditation Council.

The accreditation certificate is the property of the State of Louisiana. Should your accreditation be suspended or revoked, your laboratory must return the certificate of accreditation to the department and delete any electronic copies until your accreditation status is restored.

LAC 33:I.5313.A and/or the 2009 TNI Standard require that the laboratory report include all relevant information. Therefore, the certificate number shall be placed in the upper right corner of all laboratory reports. If the test report includes results of any test for which the laboratory is not accredited, the unaccredited results must be clearly identified as such.

We request that you examine the scope of accreditation attachment for accuracy and completeness. If you find that an analyte for which you expected to be accredited is not listed, please examine your records to ensure that:

1. You have met the requirements for successful participation in proficiency test studies as outlined in LAC 33:I.4711 and in the 2009 TNI Standard.

2. In the case of accreditation by recognition, the requested analyte must be listed for the requested method and matrix on both the certificate issued by the Primary Accreditation Body ***and*** on the Louisiana application form.

If after reviewing this information, the scope and/or certificate are inaccurate, please notify us immediately.

If you have any questions, please contact your assigned assessor Mr. Joseph P Kieffer, Environmental Scientist at 225-219-3302.

Sincerely,

Cheryl Sonnier Nolan
Administrator
Public Participation and Permit Support Services Division

17 June 2019
Date

CSN:KHW:jk

STATE OF LOUISIANA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Is hereby granting a Louisiana Environmental Laboratory Accreditation to

Eurofins Frontier Global Sciences LLC
11720 N Creek Pkwy N Ste 400
Bothell, Washington 98011-8244

Agency Interest No. 83654
Activity No. ACC20190001

According to the Louisiana Administrative Code, Title 33, Part I, Subpart 3, LABORATORY ACCREDITATION, the State of Louisiana formally recognizes that this laboratory is technically competent to perform the environmental analyses listed on the scope of accreditation detailed in the attachment.

The laboratory agrees to perform all analyses listed on this scope of accreditation according to the Part I, Subpart 3 requirements and agrees to adapt to any changes in the requirements. It also acknowledges that continued accreditation is dependent on successful ongoing compliance with the applicable requirements of Part I and the 2009 TNI Standard by which the laboratory was assessed. Please contact the Department of Environmental Quality, Louisiana Environmental Laboratory Accreditation Program (LELAP) to verify the laboratory's scope of accreditation and accreditation status.

Accreditation by the State of Louisiana is not an endorsement or a guarantee of validity of the data generated by the laboratory. Accreditation of the environmental laboratory does not imply that a product, process, system, or person is approved by LELAP. To be accredited initially and maintain accreditation, the laboratory agrees to participate in two single-blind, single-concentration PT studies, where available, per year for each field of testing for which it seeks accreditation or maintains accreditation as required in LAC 33:I.4711.

Cheryl Sonnier Nolan
Administrator
Public Participation and Permit Support Services Division

Issued Date: 17 June 2019

Effective Date: July 1, 2019
Expiration Date: June 30, 2020
Certificate Number: 03073

STATE OF LOUISIANA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Eurofins Frontier Global Sciences LLC
AI Number: 83654
Activity No. ACC20190001
Expiration Date: June 30, 2020

Effective Date: July 1, 2019

11720 N Creek Pkwy N Ste 400, Bothell, Washington 98011-8244

Certificate Number: 03073

Air Emissions

Analyte	Method Name	Method Code	Type	AB
1095 - Mercury	EPA 30B	10404203	NELAP	LA
3974 - Total Vapor Phase Mercury	EPA 30B	10404203	NELAP	LA
1095 - Mercury	FGS-136/CVAFS	60039909	NELAP	LA

Non Potable Water

Analyte	Method Name	Method Code	Type	AB
1000 - Aluminum	EPA 200.8	10014401	NELAP	LA
1005 - Antimony	EPA 200.8	10014401	NELAP	LA
1010 - Arsenic	EPA 200.8	10014401	NELAP	LA
1015 - Barium	EPA 200.8	10014401	NELAP	LA
1020 - Beryllium	EPA 200.8	10014401	NELAP	LA
1025 - Boron	EPA 200.8	10014401	NELAP	LA
1030 - Cadmium	EPA 200.8	10014401	NELAP	LA
1550 - Calcium hardness as CaCO3	EPA 200.8	10014401	NELAP	LA
1040 - Chromium	EPA 200.8	10014401	NELAP	LA
1050 - Cobalt	EPA 200.8	10014401	NELAP	LA
1055 - Copper	EPA 200.8	10014401	NELAP	LA
1075 - Lead	EPA 200.8	10014401	NELAP	LA
1090 - Manganese	EPA 200.8	10014401	NELAP	LA
1100 - Molybdenum	EPA 200.8	10014401	NELAP	LA
1105 - Nickel	EPA 200.8	10014401	NELAP	LA
1140 - Selenium	EPA 200.8	10014401	NELAP	LA
1150 - Silver	EPA 200.8	10014401	NELAP	LA
1165 - Thallium	EPA 200.8	10014401	NELAP	LA
1755 - Total hardness as CaCO3	EPA 200.8	10014401	NELAP	LA
1185 - Vanadium	EPA 200.8	10014401	NELAP	LA
1190 - Zinc	EPA 200.8	10014401	NELAP	LA
1000 - Aluminum	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1005 - Antimony	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1010 - Arsenic	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1015 - Barium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1020 - Beryllium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1025 - Boron	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1030 - Cadmium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1035 - Calcium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1550 - Calcium hardness as CaCO3	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1040 - Chromium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1050 - Cobalt	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1055 - Copper	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1070 - Iron	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1075 - Lead	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1085 - Magnesium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1090 - Manganese	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1100 - Molybdenum	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1105 - Nickel	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1125 - Potassium	EPA 200.8, Rev.5.5	10014809	NELAP	LA

Non Potable Water

Analyte	Method Name	Method Code	Type	AB
1140 - Selenium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1150 - Silver	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1155 - Sodium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1160 - Strontium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1165 - Thallium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1175 - Tin	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1180 - Titanium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1755 - Total hardness as CaCO3	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1185 - Vanadium	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1190 - Zinc	EPA 200.8, Rev.5.5	10014809	NELAP	LA
1205 - Methyl Mercury	EPA 1630	10122608	NELAP	LA
1010 - Arsenic	EPA 1632	10123203	NELAP	LA
1000 - Aluminum	EPA 1638	10124002	NELAP	LA
1005 - Antimony	EPA 1638	10124002	NELAP	LA
1010 - Arsenic	EPA 1638	10124002	NELAP	LA
1015 - Barium	EPA 1638	10124002	NELAP	LA
1020 - Beryllium	EPA 1638	10124002	NELAP	LA
1025 - Boron	EPA 1638	10124002	NELAP	LA
1030 - Cadmium	EPA 1638	10124002	NELAP	LA
1035 - Calcium	EPA 1638	10124002	NELAP	LA
1040 - Chromium	EPA 1638	10124002	NELAP	LA
1050 - Cobalt	EPA 1638	10124002	NELAP	LA
1055 - Copper	EPA 1638	10124002	NELAP	LA
1070 - Iron	EPA 1638	10124002	NELAP	LA
1075 - Lead	EPA 1638	10124002	NELAP	LA
1085 - Magnesium	EPA 1638	10124002	NELAP	LA
1090 - Manganese	EPA 1638	10124002	NELAP	LA
1100 - Molybdenum	EPA 1638	10124002	NELAP	LA
1105 - Nickel	EPA 1638	10124002	NELAP	LA
1125 - Potassium	EPA 1638	10124002	NELAP	LA
1140 - Selenium	EPA 1638	10124002	NELAP	LA
1150 - Silver	EPA 1638	10124002	NELAP	LA
1155 - Sodium	EPA 1638	10124002	NELAP	LA
1160 - Strontium	EPA 1638	10124002	NELAP	LA
1165 - Thallium	EPA 1638	10124002	NELAP	LA
1175 - Tin	EPA 1638	10124002	NELAP	LA
1180 - Titanium	EPA 1638	10124002	NELAP	LA
1185 - Vanadium	EPA 1638	10124002	NELAP	LA
1190 - Zinc	EPA 1638	10124002	NELAP	LA
1010 - Arsenic	EPA 1640	10124400	NELAP	LA
1030 - Cadmium	EPA 1640	10124400	NELAP	LA
1040 - Chromium	EPA 1640	10124400	NELAP	LA
1050 - Cobalt	EPA 1640	10124400	NELAP	LA
1055 - Copper	EPA 1640	10124400	NELAP	LA
1075 - Lead	EPA 1640	10124400	NELAP	LA
1105 - Nickel	EPA 1640	10124400	NELAP	LA
1150 - Silver	EPA 1640	10124400	NELAP	LA
1190 - Zinc	EPA 1640	10124400	NELAP	LA
1045 - Chromium VI	EPA 7196A	10162400	NELAP	LA
1095 - Mercury	EPA 1631E	10237204	NELAP	LA
1550 - Calcium hardness as CaCO3	SM 2340 B, 20th ED	20046202	NELAP	LA
1755 - Total hardness as CaCO3	SM 2340 B, 20th ED	20046202	NELAP	LA
1550 - Calcium hardness as CaCO3	SM 2340 B-97, Online Edition	20046600	NELAP	LA
1755 - Total hardness as CaCO3	SM 2340 B-97, Online Edition	20046600	NELAP	LA
1045 - Chromium VI	SM 3500-Cr B-97, Online Edition	20066200	NELAP	LA

Non Potable Water

Analyte	Method Name	Method Code	Type	AB
1045 - Chromium VI	SM 3500-Cr B-2011	20066266	NELAP	LA
1000 - Aluminum	FGS-054/ICP-MS	60039307	NELAP	LA
1005 - Antimony	FGS-054/ICP-MS	60039307	NELAP	LA
1010 - Arsenic	FGS-054/ICP-MS	60039307	NELAP	LA
1015 - Barium	FGS-054/ICP-MS	60039307	NELAP	LA
1020 - Beryllium	FGS-054/ICP-MS	60039307	NELAP	LA
1025 - Boron	FGS-054/ICP-MS	60039307	NELAP	LA
1030 - Cadmium	FGS-054/ICP-MS	60039307	NELAP	LA
1035 - Calcium	FGS-054/ICP-MS	60039307	NELAP	LA
1040 - Chromium	FGS-054/ICP-MS	60039307	NELAP	LA
1050 - Cobalt	FGS-054/ICP-MS	60039307	NELAP	LA
1055 - Copper	FGS-054/ICP-MS	60039307	NELAP	LA
1070 - Iron	FGS-054/ICP-MS	60039307	NELAP	LA
1075 - Lead	FGS-054/ICP-MS	60039307	NELAP	LA
1085 - Magnesium	FGS-054/ICP-MS	60039307	NELAP	LA
1090 - Manganese	FGS-054/ICP-MS	60039307	NELAP	LA
1100 - Molybdenum	FGS-054/ICP-MS	60039307	NELAP	LA
1105 - Nickel	FGS-054/ICP-MS	60039307	NELAP	LA
1125 - Potassium	FGS-054/ICP-MS	60039307	NELAP	LA
1140 - Selenium	FGS-054/ICP-MS	60039307	NELAP	LA
1150 - Silver	FGS-054/ICP-MS	60039307	NELAP	LA
1155 - Sodium	FGS-054/ICP-MS	60039307	NELAP	LA
1160 - Strontium	FGS-054/ICP-MS	60039307	NELAP	LA
1165 - Thallium	FGS-054/ICP-MS	60039307	NELAP	LA
1175 - Tin	FGS-054/ICP-MS	60039307	NELAP	LA
1180 - Titanium	FGS-054/ICP-MS	60039307	NELAP	LA
1185 - Vanadium	FGS-054/ICP-MS	60039307	NELAP	LA
1190 - Zinc	FGS-054/ICP-MS	60039307	NELAP	LA
1095 - Mercury	FGS-069/CVAFS	60039501	NELAP	LA
1205 - Methyl Mercury	FGS-070/CV-GC-AFS	60039705	NELAP	LA

Solid Chemical Materials

Analyte	Method Name	Method Code	Type	AB
1205 - Methyl Mercury	EPA 1630	10122608	NELAP	LA
1095 - Mercury	EPA 1631B	10122802	NELAP	LA
1000 - Aluminum	EPA 1638	10124002	NELAP	LA
1005 - Antimony	EPA 1638	10124002	NELAP	LA
1010 - Arsenic	EPA 1638	10124002	NELAP	LA
1015 - Barium	EPA 1638	10124002	NELAP	LA
1020 - Beryllium	EPA 1638	10124002	NELAP	LA
1025 - Boron	EPA 1638	10124002	NELAP	LA
1030 - Cadmium	EPA 1638	10124002	NELAP	LA
1035 - Calcium	EPA 1638	10124002	NELAP	LA
1040 - Chromium	EPA 1638	10124002	NELAP	LA
1050 - Cobalt	EPA 1638	10124002	NELAP	LA
1055 - Copper	EPA 1638	10124002	NELAP	LA
1070 - Iron	EPA 1638	10124002	NELAP	LA
1075 - Lead	EPA 1638	10124002	NELAP	LA
1085 - Magnesium	EPA 1638	10124002	NELAP	LA
1090 - Manganese	EPA 1638	10124002	NELAP	LA
1100 - Molybdenum	EPA 1638	10124002	NELAP	LA
1105 - Nickel	EPA 1638	10124002	NELAP	LA
1125 - Potassium	EPA 1638	10124002	NELAP	LA

Solid Chemical Materials

Analyte	Method Name	Method Code	Type	AB
1140 - Selenium	EPA 1638	10124002	NELAP	LA
1150 - Silver	EPA 1638	10124002	NELAP	LA
1155 - Sodium	EPA 1638	10124002	NELAP	LA
1160 - Strontium	EPA 1638	10124002	NELAP	LA
1165 - Thallium	EPA 1638	10124002	NELAP	LA
1175 - Tin	EPA 1638	10124002	NELAP	LA
1180 - Titanium	EPA 1638	10124002	NELAP	LA
1185 - Vanadium	EPA 1638	10124002	NELAP	LA
1190 - Zinc	EPA 1638	10124002	NELAP	LA
1000 - Aluminum	FGS-054/ICP-MS	60039307	NELAP	LA
1005 - Antimony	FGS-054/ICP-MS	60039307	NELAP	LA
1010 - Arsenic	FGS-054/ICP-MS	60039307	NELAP	LA
1015 - Barium	FGS-054/ICP-MS	60039307	NELAP	LA
1020 - Beryllium	FGS-054/ICP-MS	60039307	NELAP	LA
1025 - Boron	FGS-054/ICP-MS	60039307	NELAP	LA
1030 - Cadmium	FGS-054/ICP-MS	60039307	NELAP	LA
1035 - Calcium	FGS-054/ICP-MS	60039307	NELAP	LA
1040 - Chromium	FGS-054/ICP-MS	60039307	NELAP	LA
1050 - Cobalt	FGS-054/ICP-MS	60039307	NELAP	LA
1055 - Copper	FGS-054/ICP-MS	60039307	NELAP	LA
1070 - Iron	FGS-054/ICP-MS	60039307	NELAP	LA
1075 - Lead	FGS-054/ICP-MS	60039307	NELAP	LA
1085 - Magnesium	FGS-054/ICP-MS	60039307	NELAP	LA
1090 - Manganese	FGS-054/ICP-MS	60039307	NELAP	LA
1100 - Molybdenum	FGS-054/ICP-MS	60039307	NELAP	LA
1105 - Nickel	FGS-054/ICP-MS	60039307	NELAP	LA
1125 - Potassium	FGS-054/ICP-MS	60039307	NELAP	LA
1140 - Selenium	FGS-054/ICP-MS	60039307	NELAP	LA
1150 - Silver	FGS-054/ICP-MS	60039307	NELAP	LA
1155 - Sodium	FGS-054/ICP-MS	60039307	NELAP	LA
1160 - Strontium	FGS-054/ICP-MS	60039307	NELAP	LA
1165 - Thallium	FGS-054/ICP-MS	60039307	NELAP	LA
1175 - Tin	FGS-054/ICP-MS	60039307	NELAP	LA
1180 - Titanium	FGS-054/ICP-MS	60039307	NELAP	LA
1185 - Vanadium	FGS-054/ICP-MS	60039307	NELAP	LA
1190 - Zinc	FGS-054/ICP-MS	60039307	NELAP	LA
1095 - Mercury	FGS-069/CVAFS	60039501	NELAP	LA
1205 - Methyl Mercury	FGS-070/CV-GC-AFS	60039705	NELAP	LA

Biological Tissue

Analyte	Method Name	Method Code	Type	AB
1095 - Mercury	EPA 1631B	10123009	NELAP	LA
1010 - Arsenic	EPA 1632	10123203	NELAP	LA
1005 - Antimony	EPA 1638	10124002	NELAP	LA
1010 - Arsenic	EPA 1638	10124002	NELAP	LA
1015 - Barium	EPA 1638	10124002	NELAP	LA
1020 - Beryllium	EPA 1638	10124002	NELAP	LA
1025 - Boron	EPA 1638	10124002	NELAP	LA
1030 - Cadmium	EPA 1638	10124002	NELAP	LA
1040 - Chromium	EPA 1638	10124002	NELAP	LA
1050 - Cobalt	EPA 1638	10124002	NELAP	LA
1055 - Copper	EPA 1638	10124002	NELAP	LA
1070 - Iron	EPA 1638	10124002	NELAP	LA

Biological Tissue

Analyte	Method Name	Method Code	Type	AB
1075 - Lead	EPA 1638	10124002	NELAP	LA
1085 - Magnesium	EPA 1638	10124002	NELAP	LA
1090 - Manganese	EPA 1638	10124002	NELAP	LA
1100 - Molybdenum	EPA 1638	10124002	NELAP	LA
1105 - Nickel	EPA 1638	10124002	NELAP	LA
1125 - Potassium	EPA 1638	10124002	NELAP	LA
1140 - Selenium	EPA 1638	10124002	NELAP	LA
1150 - Silver	EPA 1638	10124002	NELAP	LA
1155 - Sodium	EPA 1638	10124002	NELAP	LA
1160 - Strontium	EPA 1638	10124002	NELAP	LA
1165 - Thallium	EPA 1638	10124002	NELAP	LA
1175 - Tin	EPA 1638	10124002	NELAP	LA
1180 - Titanium	EPA 1638	10124002	NELAP	LA
1185 - Vanadium	EPA 1638	10124002	NELAP	LA
1190 - Zinc	EPA 1638	10124002	NELAP	LA
1005 - Antimony	FGS-054/ICP-MS	60039307	NELAP	LA
1010 - Arsenic	FGS-054/ICP-MS	60039307	NELAP	LA
1015 - Barium	FGS-054/ICP-MS	60039307	NELAP	LA
1020 - Beryllium	FGS-054/ICP-MS	60039307	NELAP	LA
1025 - Boron	FGS-054/ICP-MS	60039307	NELAP	LA
1030 - Cadmium	FGS-054/ICP-MS	60039307	NELAP	LA
1035 - Calcium	FGS-054/ICP-MS	60039307	NELAP	LA
1040 - Chromium	FGS-054/ICP-MS	60039307	NELAP	LA
1050 - Cobalt	FGS-054/ICP-MS	60039307	NELAP	LA
1055 - Copper	FGS-054/ICP-MS	60039307	NELAP	LA
1070 - Iron	FGS-054/ICP-MS	60039307	NELAP	LA
1075 - Lead	FGS-054/ICP-MS	60039307	NELAP	LA
1085 - Magnesium	FGS-054/ICP-MS	60039307	NELAP	LA
1090 - Manganese	FGS-054/ICP-MS	60039307	NELAP	LA
1100 - Molybdenum	FGS-054/ICP-MS	60039307	NELAP	LA
1105 - Nickel	FGS-054/ICP-MS	60039307	NELAP	LA
1125 - Potassium	FGS-054/ICP-MS	60039307	NELAP	LA
1140 - Selenium	FGS-054/ICP-MS	60039307	NELAP	LA
1150 - Silver	FGS-054/ICP-MS	60039307	NELAP	LA
1155 - Sodium	FGS-054/ICP-MS	60039307	NELAP	LA
1160 - Strontium	FGS-054/ICP-MS	60039307	NELAP	LA
1165 - Thallium	FGS-054/ICP-MS	60039307	NELAP	LA
1175 - Tin	FGS-054/ICP-MS	60039307	NELAP	LA
1180 - Titanium	FGS-054/ICP-MS	60039307	NELAP	LA
1185 - Vanadium	FGS-054/ICP-MS	60039307	NELAP	LA
1190 - Zinc	FGS-054/ICP-MS	60039307	NELAP	LA
1095 - Mercury	FGS-069/CVAFS	60039501	NELAP	LA
1205 - Methyl Mercury	FGS-070/CV-GC-AFS	60039705	NELAP	LA

TEST AMERICA QUALITY ASSURANCE MANUAL

HAS BEEN REDACTED – 217 PAGES

Quality Assurance Manual

TestAmerica Chicago
2417 Bond Street
University Park, IL 60484
Phone: 708-534-5200
Fax: 708-534-5211

www.testamericainc.com

Table 21-2.

Example: Schedule of Routine Maintenance

Instrument	Procedure	Frequency
Mercury Analyzer	Check tubing for wear Fill rinse tank with 10% HCl Fill reductant bottle with 10% Stannous Chloride	Daily Daily Daily
ICP	Check pump tubing Check fluid level in waste container Check torch Check sample spray chamber for debris Check nebulizer Check entrance slit for debris Check/Refill recirculator	Daily Daily Daily Monthly Monthly Yearly by Service Rep. Monthly
ICP MS	Check pump tubing Change pump tubing Check torch Check / clean nebulizer Clean cones Check air filters Check multiplier voltages & do cross calibration Check/Change vacuum pump oil Check chiller water level/Refill	Daily As required Weekly As required As required As required Weekly Monthly Monthly
UV-Vis Spectrophotometer	Clean ambient flow cell Precision check/alignment of flow cell Wavelength verification check	As required As required Annually
Auto Analyzers	Clean sampler Check all tubing Clean inside of colorimeter Clean pump well and pump rollers Clean wash fluid receptacle Clean optics and cells	As required As required As required As required As required As required
HP / Agilient GC/MS	Pump oil-level check Pump oil changing Analyzer bake-out Analyzer cleaning Resolution adjustment Change multiplier Change filaments	Monthly Annually As required As required As required As required As required

Instrument	Procedure	Frequency
Gas Chromatograph	Compare standard response to previous day or since last initial calibration Check temp. of detector, inlet, column oven Septum replacement Check system for gas leaks (with SNOOP-MS VOA) Check for loose/frayed wires and insulation Bake injector/column Change/remove sections of guard column Replace connectors/liners Change/replace column(s)	Daily Daily As required W/cylinder change as required As Required As Required As Required As Required As Required
Electron Capture Detector (ECD)	Detector wipe test (Ni-63) Detector cleaning	Semi-annually As required
Flame Ionization Detector (FID)	Detector cleaning	As required
Autosamplers GC/MS & GC Volatiles	Check lines Change filters Replace Needles Check Gaskets Re-calibrate Replace Sensors	As required As required As required As required As required As required
Autosamplers GC/MS Semivolatiles	Replace Syringe	As required
Concentrators GC/MS & GC Volatiles	Change Trap Replace Lines	As required As required
Balances	Class 1 traceable weight check Clean pan and check if level Field service	Daily, when used Daily At least Annually
Conductivity Meter	KCl calibration Conductivity cell cleaning	Daily, applicable standards As required
Turbidimeter	Check light bulb	Daily, when used
Deionized/Distilled Water	Conductivity Point Sources Daily conductivity check Check deionizer light Monitor for VOA's System cleaning Replace cartridge & large mixed bed resins	Water Quality SOP *UP-QA-035* Daily Daily As required As required As required
Drying Ovens	Temperature monitoring Temperature adjustments	Daily As required
Refrigerators/ Freezers	Temperature monitoring Temperature adjustment Defrosting/cleaning	Continuous As required As required
pH/Specific Ion Meter	Calibration/check slope Clean electrode	Daily As required
BOD Incubator	Temperature monitoring Coil and incubator cleaning	Continuous As required
Water baths	Temperature monitoring Water replaced	Daily As needed

Table 22-1.

Standard Sources and Preparation *(ISO17025 5.9.1)*

Instrument	Source	How Received	Stock Storage	Preparation	Intermediate & Working Standard Storage	Frequency
ICP	Environmental Express; Inorganic Ventures; Ultra; High Purity	Custom Prepared Solutions	Room Temperature (Standards with Ag protect from light)	Working standards from stock	Room Temperature	Daily
ICPMS	Environmental Express; Inorganic Ventures; Ultra; High Purity	Custom Prepared Solutions	Room Temperature (Standards with Ag protect from light)	Working standards from stock	Room Temperature	Daily
CVAA	Inorganic Ventures; Ultra	1000 ppm solutions	Room Temperature	Working standards from stock	Room Temperature	Daily
GC	Restek; Ultra	Solutions and Neat	Refrigerate or Room Temperature (per manufacturer)	Working standards from stock	Refrigerate	As needed or every 6 months
GC (Herbicide)	ChemService Restek	Solutions and Neat	Refrigerate or Room Temperature (per manufacturer)	Working standards from stock	Refrigerate	As needed or every 6 months
TOC	JT Baker; Macron	Solid	Refrigerate	Working standards from stock	Refrigerate	Daily
Volatile Organics	Accustandard; Ultra; Restek;	Ampoule/ Solutions and Neat	Freezer (-10°C) Refrigerate (per manufacturer)	Working standards from stock	Freezer Refrigerate (per manufacturer)	Bi-weekly; Gas, 2-CEVE-weekly Acrolein-3 day (Per SOP)
Semi-Volatile Organics (GC/MS)	Restek; Supleco	Ampoule/ Solutions and Neat	Freezer (-10°C); Refrigerate or Room Temperature (per manufacturer)	Working standards from stock	Freezer	As needed or every 6 months
Anions_Ion Chromatography	ERA; RICCA	Solutions	Refrigerate or Room Temperature (per manufacturer)	Working standards from stock	N/A	Daily
CR+6_Ion Chromatography	ERA; Ultra Scientific	Solutions	Refrigerate or Room Temperature (per manufacturer)	Working standards from stock	Refrigerate	Daily
AQ2 Seal	ERA RICCA Macron; Fisher	Solutions, Salts	Refrigerate or Room Temperature (per manufacturer)	Working standards from stock	Refrigerate	Daily
PC Titrate	ERA RICCA JT Baker	1000 ppm Solutions; Salts	Refrigerate or Room Temperature (per manufacturer)	Working standards from stock	Room Temperature or Refrigerate	Daily

Appendix 3: Summary of Calibration and QC Procedures for GC Organics

Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]
SW8081A SW8081B SW8082	Minimum five-point initial calibration for all target analytes[2]	Initial calibration prior to sample analysis. Perform instrument re-calibration once per year minimum.	Linear regression correlation coefficient $r^2 \geq 0.99$, $r \geq 0.995$. RSD of CF ≤ 20%	Correct problem then repeat initial calibration
SW8082A SW8151A	Initial calibration verification (ICV) must be from a 2nd source	Once immediately following initial calibration	All target analytes within 15% of expected value Within 20% for 8081B/8082A	Correct problem then repeat initial calibration
	Continuing calibration verification (CCV)	Non-IS Methods: Before sample analysis, every 12 hours, and at the end of the analysis sequence. IS Methods: Before sample analysis, every 12 hours or per specified Project QAPP/ Program frequency.	All analytes within 15% of expected value and within the RT Window. Average of all analytes 15%. Within 20% for 8081B/8082A	Repeat CCV once, if it again fails criteria, identify and correct problem, repeat initial CCV (re-calibrate if necessary) and re-analyze all samples since last successful CCV.
	Breakdown check (Endrin and DDT)[1]	Before sample analysis	Degradation ≤15% for either Endrin or DDT.	Inlet/column maintenance; repeat breakdown check and re-analyze all samples since last successful breakdown check.
	Method blank	One per analytical prep batch, not to exceed 20 samples in a batch.	No analytes detected RL values between the RL and MDL will be evaluated and flagged with a 'J'	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One per prep batch, not to exceed 20 samples in a batch.	Statistical Control Limits	Re-prep and analyze the LCS and all samples in the affected analytical batch
	Surrogate(s)	Every sample, spike, standard, and method blank	Statistical Control Limits	Check system, re-inject, re-extract
	MS/MSD	One per batch per matrix, if insufficient sample for MS/MSD, then a LCS/LCSD will be analyzed.	Statistical Control Limits	None (LCS is used to determine if data is acceptable).
	Second-column confirmation	100% for all positive results	Same as for initial or primary column analysis	Same as for initial or primary column analysis. If the relative % difference of results between the 2 columns is greater than 40%, a comment should be placed in LIMS.
	Retention time window calculated for each analyte (see section 9 for how to calculate RTWs).	System set-up, with each new column or major instrument maintenance. Update the mid-RTW at the start of the run or daily. (as needed)	Each analyte of the LCS, MS/MSD and CCV must be within the calculated RTW.	Correct the problem and re-process or re-analyze samples. If questions, see the supervisor or technical director.
	MDL verification	Minimum – yearly	Detectible	Re-evaluate MDL standard used and MDL
SW8081A SW8081B SW8082 SW8082A	Internal Standards	Every sample/standard and blank	Retention time ±30 seconds from retention time of the mid-point std. in the CCV/ICAL (sample/standard). EICP area within -50% to +100% of ICAL mid-point std for the CCV and samples.	Refer to corrective action section of method SOP.

1 --8081A only; 2 – Method 8082, a five-point calibration is only analyzed for Aroclors 1016 and 1260 unless specified in program or project QAPP.

3 - This is a summary of the acceptance criteria, refer to the method SOP for specific or more information; 4 - All abnormalities must be noted on the data, the benchsheet and in LIMS.

Appendix 3: Summary of Calibration and QC Procedures for GC Organics

Method	QC Check	Frequency	Acceptance Criteria[3]	Corrective Action[4]
EPA608 608.3	Minimum three-point (preferably five) initial calibration for all target analytes	Initial calibration prior to sample analysis. Perform instrument re-calibration once per year minimum.	**RSD of CF ≤ 10%** Linear regression - correlation coefficient $r^2 > 0.990$, $r \geq 0.995$.	Correct problem then repeat initial calibration
	Initial calibration verification (ICV) must be from a 2nd source.	Immediately following initial calibration	All analytes within 15% of expected value	Correct problem then repeat initial calibration
	Continuing calibration verification (CCV)	Before sample analysis, after every 10 samples, and at the end of the analysis sequence.	All analytes within **15% of expected value** and within the RTW.	Repeat CCV once, if it again fails criteria, identify and correct problem, repeat initial CCV (re-calibrate if necessary) and re-analyze all samples since last successful CCV.
	Breakdown check (Endrin and DDT)	Before sample analysis	Degradation ≤15% for either Endrin or DDT.	Inlet/column maintenance; repeat breakdown check and re-analyze all samples since last successful breakdown check.
	Method blank	One per analytical prep batch, **not to exceed 10 samples in a batch**.	No analytes detected ≥ RL values between the RL and MDL will be evaluated and flagged with a 'J'	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank
	LCS (QC check standard)	One per prep batch, **not to exceed 10 samples in a batch.**	Method Control Limits	Re-prep[7] and analyze the LCS and all samples in the affected analytical batch
	Surrogate(s)	Every sample, spiked sample, standard, and method blank	Method Control Limits	Check system, re-inject, re-extract
	MS	One per batch per matrix, 10%, if insufficient sample for MS, then an additional LCS will be analyzed.	Method Control Limits	All target compounds should be reported, and any compounds that are outside criteria must be within criteria in the LCS.
	Second-column confirmation	100% for all positive results	Same as for initial or primary column analysis	Same as for initial or primary column analysis. If the relative % difference of results between the 2 columns is greater than 40%, a comment should be placed in LIMS.
	Retention time window calculated for each analyte (see section 9 for how to calculate RTWs).	System set-up, with each new column or major instrument maintenance. Update the mid-RTW at the start of the run or as needed.	Each analyte of the LCS, MS/MSD and CCV must be within the calculated RTW.	Correct the problem and re-process or re-analyze samples. If questions, see the supervisor or technical director.
	Internal Standards	Every sample/standard and blank	Retention time ±30 seconds from retention time of the mid-point std. in the CCV/ICAL (sample/standard). EICP area within -50% to +100% of ICAL mid-point std for the CCV and samples.	Refer to corrective action section of method SOP.
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL; see Technical Director.

3 - This is a summary of the acceptance criteria, refer to the method SOP for specific or more information.
4 - All abnormalities must be noted on the data, the benchsheet and in LIMS.

Appendix 3: Summary of Calibration and QC Procedures for GC/MS Organics

Method	QC Check	Frequency	Acceptance Criteria[2]	Corrective Action[3]
SW8260B SW8270C SW8270D	Check of mass spectral ion intensities[1], i.e., Tune	Prior to initial calibration or Continuing calibration verification, every 12 hours	Refer to criteria listed in the method SOP for Tune criteria, including DDT, Benzidine and Pentachlorophenol requirements for 8270.	Retune the instrument and verify (instrument maintenance may be needed).
SW8260B	Minimum five-point initial calibration for all target analytes	Initial calibration prior to sample analysis. Perform instrument re-calibration as necessary and after major instrument maintenance.	SPCCs average RF ≥ 0.30 or 0.1 depending on the compound and %RSD for RFs for CCCs ≤ 30% and all other target analytes	Correct problem then repeat initial calibration
SW8270C			SPCCs average RF ≥ 0.050 and %RSD for RFs for CCCs ≤ 30%	Correct problem then repeat initial calibration
			option (if %RSD is > 15%)–linear regression $r^2 \geq 0.990$, $r \geq 0.995$.	Refer to individual SOP for corrective action procedure.
SW8270D			All analytes < 20% RSD, up to 10% of analytes can be > 20% RSD Most analytes must meet minimum RF's (see Table 4 in 8270D SOP)	Correct problem then repeat initial calibration
SW8260B SW8270C SW8270D	Initial calibration verification (ICV) must be from a 2nd source.	Immediately following five-point (minimum) initial calibration and before samples are analyzed.	All analytes within 30% of expected value	Correct problem then repeat ICV, if criteria fails it may be necessary to repeat initial calibration or report outlier with PM/QA approval and qualification (NCM required).
	Relative Retention time window	Each sample	Relative retention time (RRT) of the analyte within 0.06 RRT units of the RRT of the internal standard	Correct problem then reprocess or re-analyze all samples analyzed since the last retention time check
SW8260B	Continuing calibration verification (CCV)	Daily, before sample analysis and every 12 hours of analysis time	SPCCs average RF ≥ 0.30 or 0.1 depending on the compound; and	Correct problem then repeat CCV, if criteria is met, repeat associated samples. If criteria is not met, it may be necessary to repeat initial calibration and re-analyze all samples since last successful CCV.
SW8270C			SPCCs average RF ≥ 0.050; and	
SW8260B SW8270C			CCCs: ≤20% difference (when using RFs) or drift (when using least squares regression).	
SW8270D			All analytes < 20% RSD, up to 10% of analytes can be > 20% RSD Most analytes must meet minimum RF's (see Table 4 in 8270D SOP)	
SW8260B SW8270C SW8270D	Method blank	One per analytical prep batch	No analytes detected ≥ RL values between the RL and MDL will be evaluated and flagged with a 'J' ; (Common lab contaminants cited in SOP < 3x RL)	Correct problem then re-prep[5] and analyze method blank and all samples processed with the contaminated blank. Common lab contaminants < 3x RL will be narrated.

Method	QC Check	Frequency	Acceptance Criteria[2]	Corrective Action[3]
SW8260B SW8270C	Internal Standards	Every sample/standard and blank	Retention time ±30 seconds from retention time of the mid-point std. in the CCV/ICAL (sample/standard). EICP area within -50% to +100% of ICAL mid-point std for the CCV and samples.	Refer to corrective action section of method SOP.
SW8270D			Retention time ±30 seconds from retention time of the mid-point std. in the CCV/ICAL (sample/standard). EICP area within -50% to +100% of ICAL mid-point standard Area based on CCV	Refer to corrective action section of method SOP.
SW8260B SW8270C SW8270D	LCS for all target analytes	Volatiles: one per tune per 12 hour sequence. Semivolatiles: One per prep batch, not to exceed the 20 samples in a batch.	Statistical Control Limits	Refer to corrective action section of method SOP.
	MS/MSD	One set per batch of 20 samples per matrix, if insufficient sample for MS/MSD, then a LCS/LCSD will be analyzed.	Statistical Control Limits	None (the LCS is used to evaluate and determine if the batch is acceptable).
	Surrogate(s)	Every sample, spike, standard, and blank	Statistical Control Limits	Refer to corrective action section of method SOP.
SW8260B	pH check	All 8260 water samples All low level 5035 soils are prepped in sodium sulfate (refer to the method SOP for exceptions).	pH ≤2.	If the pH is > 2, then comment the data, in the PIPE database, and LIMS.
SW8260B	Residual chlorine check (samples suspected of coming from a chlorinated waste stream)	Each sample from a suspected chlorinated waste stream.	Residual chlorine should be negative.	If the residual chlorine is positive, then comment in LIMS via an NCM.
	MDL verification	Minimum – yearly	Detectible	Re-evaluate MDL standard used and MDL;

1 – SW8260B requires BFB; SW8270C and SW8270D requires DFTPP
2 - This is a summary of the acceptance criteria, refer to the method SOP for specific or more information.
3 - All abnormalities must be noted on the data, the bench sheet and in LIMS.

Appendix 3: Summary of Calibration and QC Procedures for GC/MS Organics

Method	QC Check	Frequency	Acceptance Criteria[1]	Corrective Action[2]
EPA624 624.1 EPA625 625.1	Check of mass spectral ion intensities (i.e. Tune) 624-BFB; 625-DFTPP	Prior to initial calibration or Continuing calibration verification every 24 hours (624/625) every 12 hours (624.1/625.1)	Refer to criteria listed in the method SOP for Tune requirements including DDT, Benzidine and Pentachlorophenol criteria for 625.	Retune instrument and verify instrument maintenance may be needed.
	625 Minimum of Three - point initial calibration for all target analytes. 624: Minimum of Four – point initial calibration for all target analytes.	Initial calibration prior to sample analysis. Perform instrument re-calibration once per year minimum.	%RSD < 35%	If the calibration is not considered linear by %RSD, then correct problem then repeat initial calibration
	Relative Retention time window	Each sample	Retention time (RT) of the analyte within 30 seconds of the RT (± 0.25 min. RTW is used) of the target.	Correct problem then reprocess or re-analyze all samples analyzed since the last retention time check
	Continuing calibration verification (CCV)	Daily, before sample analysis	All calibration analytes within "Range of Q" of expected value. (Method Control Limits)	Correct problem then repeat initial calibration and re-analyze all samples since last successful CCV.
	Method blank	624: One per tune 625:One per prep batch (not to exceed 20 samples per batch).	No analytes detected ≥ RL values between the RL and MDL will be evaluated & flagged with a 'J'; (Common lab contaminants cited in SOP < 3x RL)	Correct problem then re-prep[5] and analyze method blank and all samples processed with the contaminated blank. Common lab contaminants < 3x RL will be narrated.
	LCS for all analytes in method specified spike list.	624: One per tune 625: One per prep batch (not to exceed 20 samples per batch)	Method Control Limits (Range of P)	Refer to the corrective action section of the Method SOP
	MS for all analytes in method specified spike list.	One per batch of 20 per matrix, if insufficient sample for MS, then a duplicate LCS will be analyzed.	Method Control Limits (Range of P)	None (the LCS is used to evaluate and determine if the batch is acceptable).
	Surrogate(s)	Every sample, spiked sample, standard, and method blank	Statistical Control Limits	Refer to the corrective action section of the Method SOP
	Internal Standards	Every sample/standard	Retention time ±30 seconds from retention time of the mid-point std. in the CCV/ICAL (sample/standard). EICP area within -50% to +100% of ICAL mid-point std for the CCV and –50% to +100% of the prior CCV for the samples.	Refer to the corrective action section of the Method SOP
EPA624 624.1	pH check	All 624 samples	pH should be ≤ 2. (Unless un-preserved samples are received.)	If the pH is > 2, then comment in LIMS via an NCM.
EPA624 624.1	Residual chlorine check (NC samples or samples suspected of coming from a chlorinated waste stream)	All samples from NC or a suspected chlorinated waste stream.	Residual chlorine should be negative.	If the residual chlorine is positive, then comment the data, in the PIPE database, and LIMS.
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

1 - This is a summary of the acceptance criteria, refer to the method SOP for specific or more information. 2 - All abnormalities must be noted on the data, the benchsheet and in LIMS.

Appendix 3: Summary of Calibration and QC Procedures for GC Organics

Method	QC Check	Frequency	Acceptance Criteria[1]	Corrective Action[2]
SW8015B[3] SW8015C SW8015D	Minimum five-point initial calibration for all target analytes	Initial calibration prior to sample analysis. Perform instrument re-calibration once per year minimum.	RSD of CF ≤ 20% Linear – least squares regression $r^2 \geq 0.990$, $r \geq 0.995$	Correct problem then repeat initial calibration
	Initial calibration verification (ICV), must be from a 2nd source.	Immediately following five-point initial calibration	All analytes within 15% of expected value Within 20% for 8015C/8015D	Correct problem then repeat initial calibration
	LCS for all analytes	One per prep batch, not to exceed 20 samples in a batch.	Statistical Control Limits	Re-prep and analyze the LCS and all samples in the affected analytical batch
	Continuing calibration verification (CCV)	Before sample analysis, after every 10 samples, and at the end of the analysis sequence	All analytes within 15% of expected value and within the RTW. Within 20% for 8015C/8015D	Repeat CCV, if criteria fails, correct problem then repeat initial CCV (re-calibrate if necessary) and re-analyze all samples since last successful CCV.
	Method blank	One per analytical prep batch, not to exceed 20 samples in a batch.	No analytes detected ≥ RL values between the RL and MDL will be evaluated and flagged with a 'J'	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank
	Surrogate	Every sample, spiked sample, standard, and method blank	Statistical Control Limits	Check system, re-analyze, re-prep
	MS/MSD	One per batch per matrix, if insufficient sample for MS/MSD, then a LCS/LCSD will be analyzed.	Statistical Control Limits	None (LCS is used to determine if data is acceptable).
	GC/MS confirmation.	At the clients request or analyst judgment.		
	Retention time window calculated for each analyte (see section 9 for how to calculate RTWs).	System set-up, with each new column or major instrument maintenance. Update the mid-RTW as the start of the run or daily. (as needed)	Each analyte of the LCS, MS/MSD and CCV must be within the calculated RTW.	Correct the problem and re-process or re-analyze samples. For questions, see the supervisor or technical director.
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL
SW8015B SW8015C SW8015D – GRO	pH Check	All water samples after analysis.	pH should be less than 2.	If pH is > 2, then place a comment on the benchsheet and in LIMS.

1 - This is a summary of the acceptance criteria, refer to the method SOP for specific or more information.
2 - All abnormalities must be noted on the data, the benchsheet and in LIMS.
3 - For GRO and DRO, see state specific SOP/Method for acceptance criteria. If there is not a specific method for that state, then follow the acceptance criteria in this table.

Appendix 3: Summary of Calibration and QC Procedures for Method SW6010B / SW6010C / 6010D

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
SW6010B SW6010C SW6010D	Initial calibration (one to three standards for each element- and a blank)	Daily initial calibration prior to sample analysis.	>/= 0.995 (6010B/6010D) >/= 0.998 (6010C)	Re-calibrate
	Curve high-standards read-back S1 / S2 6010B/6010C	Daily after curve	+/- 5% of known concentration	Re-calibrate, re-run samples for affected elements
	Linear Range Check Standard 6010D	Daily	+/- 10% of known concentration	If LRC fails, sample concentrations can not exceed the high standard of the curve.
	Second-source calibration verification (ICV)	Daily after initial calibration	All analytes within 10% of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Second-source calibration verification – Low Level (ICVL) 6010C / 6010D	Daily after mid-range ICV (Conc. = RL Level)	All analytes +/-30% (6010C) +/- 20% (6010D) of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration blank (ICB)	After ICV	+/- RL (6010B / 6010C) +/- ½ RL (6010D)	Correct problem then re-analyze for affected elements; may report results >10X contamination level or non-detects if biased high
	CRI (2X RL)	At the beginning of an analytical run	50-150%	NA
	MRL (at RL)	At the beginning of an analytical run	70-130% (Project Specific)	Per QAPP
	Interference check solution (ICSA) 6010B/6010C/6010D	At the beginning of an analytical run	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- RL	Correct problem; re-analyze ICSA; re-analyze all affected samples; may report non-detects if biased high.
	Interference check solution (ICSB) 6010B / 6010C	At the beginning of an analytical run	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- RL	Correct problem; re-analyze ICSB; re-analyze all affected samples; may report non-detects if biased high.
	Method Blank	One per prep batch of </= 20 samples	+/- RL < /2 RL per QAPP	Correct problem, re-prep and re-analyze the method blank and all samples for affected elements; may report results >10X contamination level or non-detects if biased high
	LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	Correct problem, then re-prep and analyze the LCS and all samples for affected elements; may report non-detects if biased high.
	Method duplicate	One per prep batch per matrix upon request	</= 20 RPD	Repeat
	MS/MSD	One per prep batch per matrix	+/- 25% of known concentration	None
	Dilution test (SD)	Each new sample matrix	5x dilution must agree within 10% (6010B / 6010C); 20%	Perform post digestion spike addition upon request

			(6010D) of the original determination	
Method 6010B 6010C 6010D	**QC Check**	**Frequency**	**Acceptance Criteria**	**Corrective Action**
	Post digestion spike addition (PDS)	When dilution test fails for some programs	Recovery within 25% of expected results	None
	Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analytical sequence	All analytes within 10% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.
	Second-source calibration verification – Low Level (CCVL) 6010C only	After mid-range CCV (Conc. = RL Level)	All analytes within 30% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.
	Continuing Calibration blank (CCB)	After each CCV	+/- RL	Correct problem and re-analyze affected elements of bracketed samples; may report results >10X contamination level or non-detects if biased high
	Internal Standard	All samples and QC	50 – 150%	Re-analyze sample at a dilution
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Method SW6020A / 6020B

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
SW6020A SW6020B	Initial calibration (one to three standards for each element- and a blank)	Daily initial calibration prior to sample analysis.	r >/= 0.998 (6020A) r >/= 0.995 (6020B)	Re-calibrate
	Curve high-standards read-back S1 6020A / 6020B	Daily after curve	+/- 5% of known concentration	Re-calibrate, re-run samples for affected elements
	Linear Range Check Standard 6020B		+/- 10% of know concentration	If LRC fails, sample concentrations can not exceed the high standard of the curve.
	Second-source calibration verification (ICV)	Daily after initial calibration	All analytes within 10% of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Second-source calibration verification – Low Level (ICVL) 6020A / 6020B	Daily after mid-range ICV/ICB (Conc. = RL Level)	All analytes within 30% of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration blank (ICB)	After ICV	+/- RL (6020A) +/- ½ RL(6020B)	Correct problem then re-analyze for affected elements; may report results >10X contamination level or non-detects if biased high
	CRI (2X RL)	At the beginning of an analytical run	50-150%	NA
	MRL (at RL)	At the beginning of an analytical run	70 – 130% (Project Specific)	Per QAPP
	Interference check solution (ICSA) 6020A / 6020B	At the beginning of an analytical run and every 12 hours	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- RL	Correct problem; re-analyze ICSA; re-analyze all affected samples; may report non-detects if biased high.
	Interference check solution (ICSB) 6020A	At the beginning of an analytical run and every 12 hours	+/- 20% of expected value of spiked elements. Non-spiked elements: +/- RL	Correct problem; re-analyze ICSB; re-analyze all affected samples; may report non-detects if biased high.
	Method Blank	One per prep batch of </= 20 samples	+/- RL < ½ RL per QAPP	Correct problem, re-prep and re-analyze the method blank and all samples for affected elements; may report results >10X contamination level or non-detects if biased high
	LCS	One per prep batch of </= 20 samples	+/- 20% of known concentration	Correct problem, then re-prep and analyze the LCS and all samples for affected elements; may report non-detects if biased high.
	Method duplicate	One per prep batch per matrix upon request	</= 20 RPD	Repeat
	MS/MSD	One per prep batch per matrix	+/- 25% of known concentration	None
	Dilution test (SD)	Each new sample matrix	5x dilution must agree within 10% (6020A); 20% (6020B) of the original determination	Perform post digestion spike addition upon request

Method 6020A cont.	QC Check	Frequency	Acceptance Criteria	Corrective Action
	Post digestion spike addition (PDS)	When dilution test fails for some programs	Recovery within 25% of expected results	None
	Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analytical sequence	All analytes within 10% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.
	Second-source calibration verification – Low Level (CCVL) 6020A	After mid-range CCV/CCB (Conc. = RL Level)	All analytes within 30% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.
	Continuing Calibration blank (CCB)	After each CCV	+/- RL	Correct problem and re-analyze affected elements of bracketed samples; may report results >10X contamination level or non-detects if biased high
	Internal Standard	All samples and QC	30 – 150%	Re-analyze sample at a dilution
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Method SW7196A

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
SW7196A	Initial calibration (5 standards and a blank)	Initial calibration prior to sample analysis.	r ≥ 0.995	Correct problem then repeat initial calibration
	Second-source calibration verification (ICV)	Immediately following initial calibration	All analytes within 10% of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration Blank (ICB)	After ICV	+/- RL	Correct problem then proceed; may report results >10X contamination level or non-detects if biased high
	Method blank	One per batch of 10 samples - waters One per batch of 20 samples - solis	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank. may report results >10X contamination level or non-detects if biased high
	LCS - soluble	One per batch of 10 samples - waters One per batch of 20 samples - solis	+/- 20% of known conc. (3060A prep) +/- 15% of known conc. (waters)	Re-prep, re-analyze all affected samples. ; may report non-detects if biased high.
	LCS – insoluble (3060A soil prep)	One per batch of 20 samples	+/- 20% of known conc. (3060A prep)	Re-prep, re-analyze all affected samples. ; may report non-detects if biased high.
	Matrix duplicate	One per batch upon request	</= 20 RPD	Repeat once
	MS/MSD - soluble	One pair per 10 samples - waters One pair per 20 samples - soils	+/- 25% of known conc. (3060A prep) +/- 15% of know conc. (waters)	Persistent interference indicates the need to evaluate matrix further for reducing agents.
	MS/MSD – insoluble (3060A soil prep)	One pair per batch of 20 samples	+/- 25% of known conc. (3060A prep)	Persistent interference indicates the need to evaluate matrix further for reducing agents.
	Post Digestion Spike (3060A soil prep)	One per batch of 20 samples	+/- 15% of known conc. (3060A prep)	If check indicates interference, dilute and re-analyze sample. Persistent interference indicates the need to evaluate matrix further for reducing agents.
	Continuing calibration verification (CCV)	Beginning and after every 10 samples and at the end of the analysis sequence	All analytes within 10% of expected value	Correct problem and re-analyze all samples since last successful calibration; may report non-detects if biased high.
	Continuing Calibration Blank (CCB)	After every CCV	+/- RL	Correct problem and re-analyze all samples since last successful calibration. May report results >10X contamination level or non-detects if biased high

Appendix 3: Summary of Calibration and QC Procedures for Method SW7470A / SW7471B

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
SW7470A SW7471B	Calibration curve – minimum 5 standards and blank	Quarterly, monthly, or daily – see individual SOP	r ≥ 0.995	Recalibrate
	Initial Calibration Verification – mid-level, second-source required (ICV)	Immediately following initial calibration and daily at the beginning of each analytical sequence.	±10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration Blank (ICB)	After ICV	+/- RL	Correct problem then proceed; may report results >10X contamination level or non-detects if biased high
	Method blank	One per batch of 20 or fewer samples	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank. may report results >10X contamination level or non-detects if biased high
	CRA (at RL level)	One per batch of 20 or fewer samples	No established limits	None
	LCS	One per batch of 20 or fewer samples	+/- 20% of known concentration	Correct problem, re-prep and repeat LCS, MB and all samples in the batch; may report non-detects if the LCS is biased high.
	Matrix duplicate	One per matrix per batch of 20 or fewer samples as requested	</= 20 RPD	Repeat once
	MS/MSD	One pair per matrix per batch of 20 or fewer samples	+/- 25% of known concentration	None
	Continuing calibration verification (CCV)	Beginning, every 10 samples, and at end of sequence	±20% of known concentration	Correct problem then repeat CCV, CCB and all samples since last successful CCB; may report non-detects if biased high.
	Continuing Calibration Blank (CCB)	After every CCV	+/- RL	Correct problem then repeat CCV,CCB and all samples since last successful CCB; may report results >10X contamination level or non-detects if biased high
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Cyanide

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
SW9010B SW9010C SW9014 SM4500CNE	Initial calibration (6 standards (9014); 7 standards (4500CNE) and a calibration blank)	Initial daily calibration prior to sample analysis.	r ≥ 0.995 y-intercept < abs. value of RL	Correct problem then repeat initial calibration
	Distilled standards 9010B / 9010C (one high and one low)	Once per calibration – Only when curve is not distilled	+/- 10% of known concentration (high) +/- 25% of known concentration (low)	Correct problem then repeat distilled standards and related samples
	Second-source calibration verification (ICV)	Immediately following initial daily calibration	+/- 10% of known concentration	Correct problem. Repeat, then repeat initial calibration if necessary
	Initial Calibration Blank (ICB)	Following ICV	+/- RL	Correct problem. Repeat, then repeat initial calibration, ICV and ICB if necessary; may report non-detects if CCV is biased high
	Method blank	One per prep batch of 20 or fewer samples	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank; may report non-detects and results >10X the contamination level.
	LCS	One per prep batch of 20 or fewer samples	+/- 15% of known concentration +/- 10% for Drinking Waters	Re-prep, re-analyze affected samples; may report non-detects if biased high
	Matrix duplicate (optional if MS/MSD performed)	One per matrix per prep batch of 20 or fewer samples upon request	</= 20 RPD </= 10 RPD for Drinking Waters	None
	MS/MSD	One per matrix per prep batch	+/- 25% of known concentration +/- 15% for Drinking Waters	None unless both spike recoveries very low, then PDS
	Post Digestion Spike (PDS)	When both MS and MSD recoveries are very low	+/- 15% of known concentration	None
	Continuing calibration verification (CCV)	After every 10 readings and at the end of the analysis sequence	+/- 10% of known concentration	Correct problem then re-read the CCV, CCB and all samples since last successful CCV/CCB; may report non-detects if CCV is biased high
	Continuing Calibration Blank (CCB)	After every CCV	+/- RL	Correct problem then re-read the CCV, CCB and all samples since last successful CCV/CCB; may report non-detects and results >10X the contamination level.
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Mercury

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
EPA245.1 ~~EPA245.5~~	Calibration curve – minimum 5 standards and blank	Quarterly, monthly, or daily – see individual SOP	r ≥ 0.995	Recalibrate
	Initial Calibration Verification – mid-level, second-source required (ICV)	Immediately following initial calibration and daily at the beginning of each analytical sequence.	±5% of known conc. (245.1) ~~±10% of known conc. (245.5)~~	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration Blank (ICB)	After ICV	+/- RL	Correct problem then proceed; may report results >10X contamination level or non-detects if biased high
	CRA	One per calibration	No established limits	None
	Method blank	One per batch of 20 or fewer samples	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank. may report results >10X contamination level or non-detects if biased high
	LCS	One per batch of 20 or fewer samples	+/- 15% of known concentration	Correct problem, re-prep and repeat LCS, MB and all samples in the batch; may report non-detects if the LCS is biased high.
	Matrix duplicate	One per matrix per batch of 20 or fewer samples as requested	</= 20 RPD	Repeat once
	MS/MSD	One pair per matrix per batch of 20 or fewer samples	+/- 30% of known concentration	None
	Continuing calibration verification (CCV)	Beginning, every 10 samples, and at end of sequence	±10% of known concentration	Correct problem then repeat CCV, CCB and all samples since last successful CCB; may report non-detects if biased high.
	Continuing Calibration Blank (CCB)	After every CCV	+/- RL	Correct problem then repeat CCV,CCB and all samples since last successful CCB; may report results >10X contamination level or non-detects if biased high
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for ICP Method 200.7

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
EPA200.7	Initial calibration (three standards for each element- and a blank)	Daily initial calibration prior to sample analysis.	>/= 0.995	Re-calibrate
	Curve high-standards read-back	Daily after curve	+/- 5% of known concentration	Re-calibrate, re-run samples for affected elements
	Second-source calibration verification (ICV)	Daily after initial calibration	All analytes within 5% of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration blank (ICB)	After ICV	+/- RL	Correct problem then re-analyze for affected elements; may report results >10X contamination level or non-detects if biased high
	CRI (2X RL)	At the beginning of an analytical run	50-150%	NA
	Interference check solution (ICSA)	At the beginning of an analytical run	+/- 20% of expected value of spiked elements or < 2X RL	Correct problem; re-analyze ICSA; re-analyze all affected samples; may report non-detects if biased high.
	Interference check solution (ICSB)	At the beginning of an analytical run	+/- 20% of expected value of spiked elements or < 2X RL	Correct problem; re-analyze ICSB; re-analyze all affected samples; may report non-detects if biased high.
	Method Blank	One per prep batch of </= 20 samples	+/- RL < ½ RL per QAPP	Correct problem, re-prep and re-analyze the method blank and all samples for affected elements; may report results >10X contamination level or non-detects if biased high
	LCS	One per prep batch of </= 20 samples	+/- 15% of known concentration	Correct problem, then re-prep and analyze the LCS and all samples for affected elements; may report non-detects if biased high.
	Method duplicate	One per 10 or fewer samples per matrix	</= 20 RPD	Repeat
	MS	One per 10 or fewer samples per matrix	+/- 30% of known concentration	None
	Dilution test	One per 10 or fewer samples per matrix	5x dilution must agree within 10% of the original determination	Perform post digestion spike addition
	Post Digestion Spike (PDS)	Performed when Dilution test fails	+/- 15% of known concentration	Narrate
	Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analytical sequence	All analytes within 10% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.
	Continuing Calibration blank (CCB)	After each CCV	+/- RL	Correct problem and re-analyze affected elements of bracketed samples; may report results >10X contamination level or non-detects if biased high
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for ICP/MS Method 200.8

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
EPA200.8	Initial calibration (one to three standards for each element- and a blank)	Daily initial calibration prior to sample analysis.	>/= 0.995	Re-calibrate
	Curve high-standards read-back	Daily after curve	+/- 5% of known concentration	Re-calibrate, re-run samples for affected elements
	Second-source calibration verification (ICV)	Daily after initial calibration	All analytes within 10% of expected value	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration blank (ICB)	After ICV	+/- RL	Correct problem then re-analyze for affected elements; may report results >10X contamination level or non-detects if biased high
	CRI (2X RL)	At the beginning of an analytical run and every 12 hours	50-150%	NA
	Interference check solution (ICSA)	At the beginning of an analytical run and every 12 hours	+/- 20% of expected value of spiked elements or < 2X RL	Correct problem; re-analyze ICSA; re-analyze all affected samples; may report non-detects if biased high.
	Interference check solution (ICSB)	At the beginning of an analytical run and every 12 hours	+/- 20% of expected value of spiked elements or < 2X RL	Correct problem; re-analyze ICSB; re-analyze all affected samples; may report non-detects if biased high.
	Method Blank	One per prep batch of </= 20 samples	+/- RL < ½ RL per QAPP	Correct problem, re-prep and re-analyze the method blank and all samples for affected elements; may report results >10X contamination level or non-detects if biased high
	LCS	One per prep batch of </= 20 samples	+/- 15% of known concentration	Correct problem, then re-prep and analyze the LCS and all samples for affected elements; may report non-detects if biased high.
	Method duplicate	One per 10 or fewer samples per matrix	</= 20 RPD	Repeat
	MS	One per10 or fewer samples per matrix	+/- 30% of known concentration	None
	Dilution test	Each new sample matrix	5x dilution must agree within 10% of the original determination	Perform post digestion spike addition
	Continuing Calibration Verification (CCV)	After every 10 readings and at the end of the analytical sequence	All analytes within 10% of expected value	Correct problem and re-analyze affected elements of bracketed samples; may report non-detects if biased high.
	Continuing Calibration blank (CCB)	After each CCV	+/- RL	Correct problem and re-analyze affected elements of bracketed samples; may report results >10X contamination level or non-detects if biased high
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Gravimetric Analyses

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
SM2540 C (TDS) SM2540D (TSS) SM2540B (TS) EPA160.4 (TVS) ASTM D482-87 (Ash) ASTM D2974 (FOC) SM2540 G (Moisture) ASTM D5057 (Density)	LCS (applicable methods only: TDS; TSS; TS)	Applicable to some gravimetric testing - one per batch of 20 or fewer samples	+/- 20% of known concentration	Repeat LCS, MB and all samples in batch; May report non-detects if LCS is biased high.
	Method blank (if applicable – except for ASTM D5057)	One per batch of 20 or fewer samples	+/- RL < ½ RL per QAPP	Repeat MB, LCS and all samples in batch; May report non-detects and samples > 10X the contamination level.
	Duplicate (optional if MS/MSD performed)	10% of samples	</=20 RPD	None
	MS/MSD	Applicable to some gravimetric testing - one pair per set of 20 or fewer samples (except for ASTM D5057 and 160.4)	+/- 25% of known concentration	None
	MDL verification (applicable methods only: TDS; TSS; TS)	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Titrimetric Analyses

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
SM2320B Alkalinity forms SM4500 S2F Sulfide SM5220C COD SM4500Cl_F Cl_2 Res.	LCS	One per batch of 20 or fewer samples	± 20% of known concentration ± 15% SM2320B	Correct problem and repeat LCS, MB and all samples in the batch; May report non-detects if the LCS is biased high.
	Method blank	One per batch of 20 or fewer samples	No analyte detected > report limit	Correct problem and repeat MB, LCS and all samples in the batch; May report non-detects and samples >10X the contamination level
	Duplicate (optional if MS/MSD performed; Not performed for Sulfide)	One per batch of 20 or fewer samples	±20%	None
	MS/MSD (Not performed for SM2320B; SM4500Cl_F)	Available for some titrimetric tests at one pair per batch of 20 or fewer samples.	+/- 25% of known concentration	None
	Standardization	Per specific SOP	NA	NA
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Spectrophotometric Analyses

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
EPA 350.1* SM4500NH3G; NH_3. SM4500ClE*: 9251 Cl^-. SM3500CrB* Cr+6. SW9038: SO_4^{-2}. SM5310C 9060A: TOC. $SM4500NO_2B$ Nitrite EPA 353.2* $SM4500NO_3F$ Nitrate 9066* EPA 420.4* Phenols SM4500P Phosphorus EPA 351.1 SM4500NH3G TKN	Calibration curve – minimum 5 standards and blank	Quarterly or daily – see individual SOP	r ≥ 0.995 y-intercept < abs. value of RL	Recalibrate
	Initial Calibration Verification – mid-level, second-source required (ICV)	Immediately following initial calibration and daily at the beginning of each analytical sequence.	±10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration Blank (ICB)	After ICV	+/- RL	Correct problem then proceed; may report results >10X contamination level or non-detects if biased high
	Method blank	One per batch of 20 or fewer samples One per 10 samples for 9066; 420.4	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank. may report results >10X contamination level or non-detects if biased high
	LCS	One per batch of 20 or fewer samples One per 10 samples for 9066; 420.4	+/- 20% of known concentration +/- 10% for * methods +/- 15% for Chloride methods	Correct problem, re-prep and repeat LCS, MB and all samples in the batch; may report non-detects if the LCS is biased high.
	Matrix duplicate (optional if MS/MSD performed)	One per matrix per batch of 20 or fewer samples as requested	</= 20 RPD </+ 10 RPD for * methods </= 30 RPD for soils	Repeat once
	MS/MSD	One pair per matrix per batch of 20 or fewer samples One per 10 samples for 353.2; 9060A; SM5310C; 9251	+/- 25% of known concentration +/- 10% for * methods	None
	Continuing calibration verification (CCV)	Beginning, every 10 samples, and at end of sequence	±10% of known concentration	Correct problem then repeat CCV, CCB and all samples since last successful CCB; may report non-detects if biased high.
	Continuing Calibration Blank (CCB)	After every CCV	+/- RL	Correct problem then repeat CCV,CCB and all samples since last successful CCB; may report results >10X contamination level or non-detects if biased high
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Electrometric Analyses

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
SM5210B; BOD; CBOD; EPA120.1: SM2510B; SW9050A: Cond. SM4500OG DO. SM4500FC; F- SW9040B/C, SW9045C/D: pH.	Calibration Curve – minimum of 5 standards and blank	Initial Calibration before each batch (where applicable)	R ≥ 0.995.	Recalibrate
	Initial Calibration Verification (second source) (ICV)	Immediately after initial calibration and daily at beginning of analytical sequence (where applicable)	±10% of known concentration	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration Blank	With ICV (where applicable)	+/- RL	Correct problem then proceed; may report results >10X contamination level or non-detects if biased high
	Method blank	One per batch of 20 or fewer samples (where applicable)	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank; may report results >10X contamination level or non-detects if biased high.
	LCS	One per batch of 20 or fewer samples (where applicable)	±20% of known concentration	Correct problem, re-prep and repeat LCS, MB and all samples in the batch; may report non-detects if the LCS is biased high.
	MS/MSD	Each batch (where applicable)	± 20%	None
	Duplicate	When spike not available	±20%	None
	Continuing Calibration verification (CCV)	Beginning, every 10 samples, and end of batch (where applicable)	±10% of known concentration	Correct problem then repeat CCV, CCB and all samples since last successful CCB; may report non-detects if biased high.
	Continuing Calibration blank	With each CCV (where applicable)	+/- RL	Correct problem then repeat CCV,CCB and all samples since last successful CCB; may report results >10X contamination level or non-detects if biased high
	Calibration checks	Alternate pH buffers every 10 readings. Read-back DO calibration bottle. Conductivity standards must bracket samples in each range.	pH buffers +/- 0.2 SU DO bottle +/- 0.5 mg/L Cond. stds. After samples, <10% drift	Re-calibrate and re-read samples since last in-control check.
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Ion Chromatographic Analyses

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
EPA300; SW9056A Bromide Chloride Fluoride Nitrate Nitrite Sulfate O-Phosphate EPA 218.6 SW7199 CR+6	Calibration Curves	Initial calibration. Perform instrument re-calibration once per month minimum.	R ≥ 0.995.	Recalibrate
	Initial Calibration verification (ICV), second source	Immediately following initial calibration and daily before the analytical sequence	+/- 10% of known concentration +/- 5% for 218.6	Correct problem then repeat initial calibration; may report non-detects if biased high.
	Initial Calibration Blank	After ICV	+/- RL	Correct problem then proceed; may report results >10X contamination level or non-detects if biased high
	Method blank	One per batch of 20 or fewer samples	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank; may report results >10X contamination level or non-detects if biased high.
	LCS	One per batch of 20 or fewer samples	+/-10% of known concentration for 300.0, 218.6; 7199 +/- 20% for 9056	Correct problem, re-prep and repeat LCS, MB and all samples in the batch; may report non-detects if the LCS is biased high.
	MS/MSD	One pair per batch of 20 or fewer samples (9056A) One pair per batch of 10 or fewer samples (300.0)	+/- 20% of known concentration +/- 10% for 218.6; 7199	None, control batch on LCS
	Duplicate	One per batch of 20 or fewer samples upon request Note: Not required for 218.6; 7199	</= 20 RPD (300.0) </= 15 RPD (9056A)	None
	Continuing calibration verification (CCV)	After every 10 readings and at the end of the analytical sequence	+/- 10% of known concentration +/- 5% for 218.6	Correct problem then repeat CCV, CCB and all samples since last successful CCB; may report non-detects if biased high.
	Continuing Calibration blank (CCB)	After every CCV	+/- RL	Correct problem then repeat CCV,CCB and all samples since last successful CCB; may report results >10X contamination level or non-detects if biased high
	Retention time window	Based on RTs of ICV anions	+/- 5% drift	Evaluate data
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Oil & Grease Analyses

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
9071B 1664A 1664B HEM SGT-HEM	Method blank	One per batch of 20 or fewer samples	+/- RL < ½ RL per QAPP	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank; may report results >10X contamination level or non-detects if biased high.
	LCS	One per batch of 20 or fewer samples	1664A, 1664B 78-114% for HEM, 64-132% for SGT-HEM 9071B 80 – 120% for HEM & SGT-HEM	Correct problem, re-prep and repeat LCS, MB and all samples in the batch; may report non-detects if the LCS is biased high.
	MS/MSD	One pair per batch of 20 or fewer samples as available. (Note:additional sample bottles need to be submitted by the client for water samples for MS/MSD analysis)	1664A, 1664B 78-114% for HEM, 64-132% for SGT-HEM 9071B 75 – 125% for HEM & SGT-HEM	None, use LCS
	MDL verification	Minimum yearly	Detectible	Re-evaluate MDL standard used and MDL

Appendix 3: Summary of Calibration and QC Procedures for Physical Analyses

Method	QC Check	Frequency	Acceptance Criteria	Corrective Action
SW1010A D-92: Flash Point.				
	STD - n-Decane (Flashpoint)	One per batch of 20 or fewer samples – applicable for flash point only	Statistical limits	Re-analyze
SW9095A: Paint Filter. SM 2540 F: Settleable Solids.	Duplicate	One for each batch of 20 or fewer samples Note: (Duplicates are not performed for Flashpoint or Paint Filter when samples are non-detect)	Report results	None

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1 Revision Log:

Revision: 06	**Effective Date:** This version	
Section	**Justification**	**Changes**
Cover	Required change	Changed company name from Frontier Global Sciences to Eurofins Frontier Global Sciences.
All	Formatting requirement per LOM SOP-LAB-201	Reformatted document to new corporate specifications.
9.2	Updated	Added an interference
10	Updated	Included additional chemicals and associated hazards
12.7	Required	Changed tissue handling procedure
13	Required	Added computer hardware and software
14	Updated	Updated standard and reagent preparation steps
16.1	Update	Updated lamp current setting
17.2	Updated	Added a more applicable algorithm
18.2	Update	Updated control limits
15.1, 17.2, 19.1.2, 20.1	Required	Added calibration factor
App B and C	Update	Updated Appendices B and C
App D	Required	Added Instrument Maintenance and Troubleshooting

2 Reference:

2.1 Buck scientific 200 A AAS manual, August 1998.

2.2 Crecelius, E.A.;Bloom, N.S et al. Speciation of Selenium and Arsenic in Natural Waters and Sediments, Volume 2: Arsenic Speciation. Final Report. Prepared for Electric Power Research Institute, Palo Alto, CA by Old Dominion University, Norfolk, VA, 1986.

2.3 Method 1669, "Method for Sampling Ambient Water for Determination of Metals at EPA Ambient Criteria Levels," U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Engineering and Analysis Division (4303), 401 M Street SW, Washington, DC 20460, April 1995 with January 1996 revisions.

2.4 Bloom, N.S, Ultra-Clean Aqueous Sample Collection and Preservation, FGS-008, 1995, also EPA Method 1669.

2.5 EPA Method 1632, “Inorganic Arsenic in water by Hydride Generation Quartz Furnace Atomic Absorption”, U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division (EAD), Revision A, January 2001.

2.6 Chemical Hygiene Plan, Eurofins Frontier Global Sciences, current version.

2.7 National Environmental Laboratory Accreditation Conference, NELAC Standard September 8, 2009.

2.8 Department of Defense Quality Systems Manual for Environmental Laboratories, prepared by DoD Environmental Quality Workgroup, Final Version 4.2, October 2010.

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3 Cross Reference:

Document	Document Title
SOP FGS-007	Cleaning of Sampling Equipment and Bottles
SOP FGS-008	Ultra Clean Aqueous Sample Collection
SOP FGS-038	Data Review and Validation
SOP FGS-059	Determination of Total Reducible Arsenic in Water
SOP FGS-094, App F	Standard Operating Procedure Training Record
SOP FGS-099	Waste Disposal Procedure for Client Sample Waste
SOP FGS-140	pH Meter Calibration and Analysis
SOP FGS-144	Manual Integration
SOP FGS-145	Oven Digestion Procedure for Sediment, Plant and Animal Tissue
SOP FGS-147	Frequency of Testing for Lot Acceptance

4 Purpose:

4.1 This standard operating procedure (SOP) describes the method for determining total and species specific arsenic in water and solid extract samples by Hydride Generation Cryogenic Trapping Gas Chromatography Atomic Absorption Spectrophotometry (HG-CT-GC-AAS).

5 Scope:

5.1 Hydride generation cryogenic trapping gas chromatography atomic absorption spectrophotometry (HG-CT-GC-AAS) is used for sensitive species specific determination of arsenite [As(III)], arsenate [As(V)], *monomethylarsonic acid*- [MMA], and *dimethylarsinic acid* [DMA]. This method can also be used for the determination of total inorganic arsenic [TIAs] at very low concentration levels (below 0.10 µg/L) in situations where the method detection limit of the automated HG-AFS system ("Millennium", Eurofins Frontier SOP FGS-059 "Determination of Total Reducible Arsenic in Water and Solid Extracts by Hydride Generation – Atomic Fluorescence Spectrometry") is not sufficiently low. This SOP will also cover sample handling and storage procedures.

5.2 This SOP describes a method of the determination of arsenic species in aqueous, and solid matrices (biological tissue, plant tissue, nutraceutical, etc.).

6 Basic Principles:

6.1 In this technique arsenic species are selectively volatilized from solution by controlling the pH of the sample solution and reducing them to their corresponding. The arsines are purged from the solution and trapped in a cooled 'U' tube. Heating the column re-volatilizes the arsines and allows for chromatographic separation based on boiling points. Once separated, the arsines are carried into a quartz furnace with a flame where they are atomized and detected via atomic absorption spectrophotometry.

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7 Reference Modifications:

	FGS 022.06	Method 1632
Prep./Analysis Blanks	Continuing Calibration Blanks and Method Blanks must be < PQL.	Continuing Calibration Blanks and Method Blanks must be < MDL.
OPR (LCS) for Tissue Samples	LCS (SDS) per 10 (1 OPR (SDS) per 10)	1 OPR (SDS) per 10
MD	Not required, added at the request of the client.	None
Instrument Calibration	Calibration is based on a minimum 5-point non-zero calibration curve with a correlation coefficient (R) > 0.995 using a Linear regression calibration, (y=kx+m) or CF RSD <20%	Calibration is based on a 3 or more non-zero point calibration with a calibration factor (CF) RSD <20%.

8 Definitions:

8.1 Analytical Run – the continuous analysis of one or more batches. An analytical run requires a calibration curve, ICV, ICB, and CCV/CCB every ten samples. An analytical run must conclude with a CCV/CCB.

8.2 Batch – no more than 20 client samples grouped for preparation. 1 MBLK, 1 LCS (or BS/BSD) and 1 MS/MSD are prepared *per 10* samples.

8.3 Calibration Standards (CAL) – a series of standards that will be used to calibrate the instrument, made from a PDS. A calibration blank plus at least five different concentrations are required, beginning with one at PQL concentration.

8.4 Certified Reference Material (CRM) – a standard of known composition that is certified by a recognized authority and representing a sample matrix. It is used to verify the accuracy of a method.

8.5 Control Limit (CL) – the limit of the range of acceptability for the quality control samples

8.6 Initial Calibration Verification (ICV) – a standard used to check initial calibration and is prepared from a SDS. This standard is run at mid-level concentration and verifies instrument calibration. It is always followed by an ICB.

8.7 Initial and Continuing Calibration Blank (ICB and CCB) for evaluation of instrument drift, sensitivity, and contamination. ICB must be analyzed directly after the ICV, and the CCBs every 10 samples immediately after CCVs. ICB and CCBs must individually be less than one-half of the Practical Quantitation Limit.

8.8 Field Blanks for water samples: Analyze the field blank(s) shipped with each set of samples. “A set of samples” are samples collected from the same site at the same time, to a maximum of 10 samples. Analyze the blank immediately before analyzing the samples in the batch.

8.8.1 Field Blank (FB): A sample of reagent water placed in a sample container in the field and used to demonstrate that samples have not been contaminated by sample collection or transport activities.

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8.8.2 Travel or Trip Blank (TB) – reagent water placed in a sample container in the laboratory and treated as a sample in all respects, including exposure to site conditions.

8.8.3 Filter Blank: If the samples are filtered for the determination of dissolved As and/or As species, the field blank shall be filtered as well.

8.9 Equipment Blank (EB): A sample of reagent water placed in a sample container prior to using the equipment to collect samples, used to demonstrate that the sampling equipment is free from contamination.

8.9.1 Bottle blanks: Eurofins Frontier is performing bottle testing according to EFGS-147 of cleaned sample bottles before sending them out to clients. The bottles are filled with reagent water and acidified with HCl to a pH<2 (1.5 ml of concentrated HCl/L) and allowed to stand for a minimum of 48 hours before an aliquot is analyzed for TIAs. The bottles must test lower than the ½ PQL.

8.9.2 Analysis of equipment blanks shall be performed on 5% of the equipment cleaned by Eurofins Frontier Geosciences before any equipment is sent out to the client. The equipment blank must test lower than the ½ PQL

8.10 Laboratory Control Sample (LCS) and Laboratory Control Sample Duplicate (LCSD), is equivalent to OPR based on EPA 1632, is a sample containing known concentrations of the analytes of interest that is taken through the entire preparation and analysis process in the same manner as the samples to monitor complete method performance. A Certified Reference Material (CRM) is preferred as the LCS, but a blank spiked sample also meets the requirement.

8.11 Method Duplicate (MD) – a second separate sample, taken from the same source sample and analyzed in the laboratory separately *at the request of the client*. A MSD may be used as a duplicate.

8.12 Matrix Spike (MS) and Matrix Spike Duplicate (MSD) – a representative sample is selected and spiked with a SDS at one to five times the ambient concentration or at one to five times the MRL, whichever is greater These QC samples will indicate sample matrix effects on the analytes of interest. For this method, aqueous samples are not digested therefore the analytical spike and analytical duplicate spike are considered the matrix spike and matrix spike duplicate.

8.13 May: This action, activity, or procedural step is optional.

8.14 May Not: This action, activity, or procedural step is prohibited.

8.15 Method Blank (MBLK), Preparation Blank (PB), and BLK in LIMS – an aliquot of reagent water that is treated as a sample throughout the preparation and analysis processes, and is a control for system cleanliness. For tissue samples corn oil is used as reference matrix.

8.16 Method Detection Limit (MDL) – the limit derived from an exercise as described in 40 CFR, Part 136, Appendix B. The exercise produces a defined value that is the minimum concentration that can be measured and reported with 99% confidence that the analyte concentration is greater than zero from a given matrix.

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8.17 Ongoing Precision Recovery (OPR) - A method blank spiked with known quantities of analytes from a secondary source at 30 ng/L, or a known certified reference material. Its purpose is to assure that the results produced by the laboratory remain within the limits specified in the referenced methods for precision and accuracy. *See LCS*.

8.18 Practical Quantization Limit (PQL) – the minimum concentration that can be reported quantitatively. The PQL is often described as 1-10 times higher than MDL. FGS defines the PQL as the lowest concentration that can achieve an acceptable recovery (*50-150% for TIAs, 30-170% for Arsenite, 60-140% for MMA and 40-160% for DMA)* from the reproducibility of ten replicate sample preparations. The PQL is the upper Control Limit for the ICB, CCB, and MBLK (Prep blank); i.e. these QC standards must be lower in concentration than PQL. In LIMS, the PQL is given the term MRL.

8.19 Quality control sample (QCS)—A sample containing all or a subset of the analytes at known concentrations. The QCS is obtained from a source external to the laboratory or is prepared from a source of standards different from the source of calibration standards. It is used to check laboratory performance with *test materials prepared external to the normal preparation process. This sample is analyzed within a batch as an LCS and is performed on a quarterly basis*.

8.20 Primary Dilution Standard (PDS) – a standard that is used to make a series of calibration standards for this method. It is prepared from a SSS of arsenic.

8.21 Stock Standard Solution (SSS) – a standard of analyte that is purchased from a certified source for the preparation of working standards.

8.22 Secondary Dilution Standard (SDS) – a sample of standard from an alternate SSS, used to prepare the ICV, CCV, MS, and MSD standards, and for IDOC/CDOC.

8.23 Shall: This action, activity, or procedure is required.

8.24 Should: This action, activity, or procedure is suggested, but not required.

9 Interferences:

9.1 If water is allowed to condense in the trap, multiple and irregular peaks occur.

9.2 *If water vapor condenses on the transfer line the resulting condensation will result in interferences*.

9.3 It has been observed that free chlorine (as contained in some batches of HCl) may suppress the signals.

9.4 High concentrations of other metals may interfere. Excessive foaming may cause interferences.

9.5 When an unusually concentrated sample is encountered, check for carryover.

10 Safety Precautions, Pollution Prevention and Waste Handling:

10.1 Personnel will don appropriate laboratory attire according to the Chemical Hygiene Plan. This includes, but is not limited to, laboratory coat, safety goggles and nitrile gloves under clean gloves.

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10.2 The toxicity or carcinogenicity of reagents used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be as low as reasonably achievable. Chemists should refer to the MSDS (Material Safety Data Sheets) for each chemical they are working with.

10.3 All personnel handling environmental samples known to contain or to have been in contact with human waste should be immunized against known disease-causative agents. Eurofins Frontier will reimburse the expense of Hepatitis A and B immunizations for any laboratory staff member who desires this protection.

10.4 Hydrochloric acid (HCl) – corrosive, liquid and mist cause severe burns to all body tissue. Wear protective clothing, goggles, and gloves. Always handle in fume hood.

10.5 Sodium hydroxide (NaOH) – very corrosive and toxic, harmful if swallowed, inhaled, or absorbed through skin. It is extremely destructive to tissue of the mucous membranes, eyes, and skin. Wear protective clothing, goggles, and gloves. Handle in well-ventilated area.

10.6 Potassium Hydroxide (KOH) – corrosive, liquid and mist cause severe burns to all body tissue. Wear protective clothing, goggles, and gloves.

10.7 Sodium borohydride, ($NaBH_4$) – very toxic, do not breathe dust, vapor, mist, or gas. Avoid skin contact. Corrosive to skin, eyes, and mucous membranes. Boron affects the Central Nervous System (CNS). Keep away from acids, as it will react violently, liberating hydrogen. Wear protective clothing, goggles and gloves. Handle in well-ventilated area.

10.8 Tris Buffer, Tris-HCl (tris(hydroxymethyl)aminomethane hydrochloride) – Avoid skin contact, eye contact and inhalation.

10.9 Ascorbic Acid – Avoid skin contact, eye contact and inhalation.

10.10 Helium (He) – If inhaled, Helium can be an asphyxiant.

10.11 Hydrogen (H) – If inhaled, Hydrogen can be an asphyxiant

10.12 Liquid Nitrogen (N2) – If inhaled, Argon can be an asphyxiant. Contact with cryogenic liquid can cause burns and frostbite to occur.

10.13 Argon (Ar) – If inhaled, Argon can be an asphyxiant. Contact with rapid expanding gas can cause burns and frostbite to occur.

10.14 Air – Although not directly harmful, air can indirectly cause serious problems by accelerating combustion. Because a violent explosion could occur, never use air in the hydride generation apparatus.

10.15 See Eurofins Frontier Global Sciences Chemical Hygiene Plan (CHP) for general information regarding employee safety, waste management, and pollution prevention.

10.16 Pollution prevention information can be found in the current Eurofins Frontier Global Sciences Chemical Hygiene Plan (CHP), which details and tracks various waste streams and disposal procedures.

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10.17 All laboratory waste is accumulated, managed, and disposed of in accordance with all federal, state, and local laws and regulations. Any waste generated by this procedure should be disposed of according to SOP FGS-099 "Waste Disposal Procedure for Client Sample Waste," which provides instruction on dealing with laboratory and client waste.

11 Personnel Training and Qualifications:

11.1 An analyst must perform an initial demonstration of capability (IDOC) that includes four replicates of a secondary source before being qualified to analyze samples without supervision. Continuing DOC will be maintained and monitored via performance on CRMs and other QC samples, as well as obtaining acceptable results on proficiency testing exercises.

11.2 The analyst/laboratory technician must have read this SOP and other relevant SOPs and have the training documented on the applicable form(s). The analysis may be questioned on SOP by supervisor(s) and/or trainers.

11.3 Training is documented by the employee and supervisor, and is kept on file in the QA Office. The employee must read, understand, and by signing the training document, agree to perform the procedures as stated in all Standard Operating Procedures (SOPs) related to this method.

11.4 Reading of the SOP must be documented on the correct form such as "Standard Operating Procedure Training Record," Appendix F in FGS-094, the last page of this SOP, Appendix E "Standard Operating Procedure Training Record" or a similar document."

11.5 All employees must also, on a yearly basis, read the Quality Manual (QM), and complete the yearly Ethics training.

11.6 All training documents including IDOCs, CDOCs, SOP reading, Initial QA orientation, and Ethics training are stored by the Quality Assurance Manager in the employees training file for ten years after the employee is no longer working for Eurofins Frontier Global Sciences.

11.7 Chemical Safety Training, Compressed Gas Training, Chemical Hygiene Plan documentation, and Shipping of Hazardous goods, are stored by the Health and Safety Officer for ten years after the employee is no longer working for Eurofins Frontier Global Sciences.

12 Sample Collection, Preservation, and Handling:

12.1 Aqueous samples (250 mL is recommended) must be collected in previously cleaned or tested low HDPE, Teflon, or PETG bottles (cleaned according to Eurofins Frontier SOP FGS-007). Collecting or storing samples for arsenic speciation in HNO_3-cleaned bottles may oxidize As(III) to As(V). For clean sampling techniques see Eurofins Frontier SOP FGS-008 "Ultra-Clean Aqueous Sampling Collection".

12.2 If samples are to be analyzed for dissolved elements, they shall be filtered through a pre-cleaned 0.45-µm filter in the field to follow EPA requirements. If this is not possible, Frontier recommends that the samples shall be filtered at the laboratory within 48-hours of sample collection and prior to preservation.

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12.2.1 For Arsenic speciation (As^{3+}, As^{5+}) water samples, preservation must be performed in the field to reduce changes in As speciation that may occur during transport and storage. Water samples are acidified to pH <2 with hydrochloric acid (1.5 mL of concentrated HCl/L sample) and stored in polyethylene bags at 0-4°C from the time of collection until analysis.

12.2.2 If As species are not target analytes, the samples may be preserved upon receipt by the laboratory. The sample shall then be acidified to pH <2 with hydrochloric acid (1.5 mL of concentrated HCl/L sample) and stored in polyethylene bags at ambient temperature until analysis.

12.2.3 Store the preserved sample for a minimum of 48 hours to allow the As adsorbed on the container walls to completely dissolve in the acidified sample.

12.3 Samples that will be reported for regulatory compliance purposes, for clients located in the State of Louisiana, or clients that must meet LELAP (Louisiana Environmental Laboratory Accreditation Program) requirements, their samples will be stored at 0-4°C for at least 48 hrs before sample preparation.

12.4 The holding time for aqueous samples is 28 days from the time of collection until the time of analysis.

12.5 An alternate preservation method to the EPA 1632 procedure is:

12.5.1 To quick-freeze samples and store at –80 °C (on dry ice or in a cyrogenic freezer) until analysis.

12.6 Tissue sample preservation - The tissue sample must be frozen in the sampling container at less than -18 °C or freeze-dried and stored at room temperature. The holding time for tissue samples is 2 years.

12.7 Solid biological tissue samples must be handled as designated by Eurofins Frontier Global Sciences SOP, FGS 145 “Oven Digestion Procedure for Sediment, Plant and Animal Tissue samples for Arsenic and Selenium Speciation”.

13 Apparatus and Equipment:

13.1 LIMS

13.2 Data Acquisition Software

13.3 Network Chromatography Interface

13.4 The apparatus needed for speciation analysis of arsenic is shown in principle in EPA Method 1632 Figure 1.

13.5 Reaction Vessel

13.6 GC Trap and Column

13.7 Atomizer

13.8 Detector

13.9 Connections: Either friction-fit or threaded tubing connectors.

13.10 Recorder: Any multi-range chart recorder or integrator.

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13.11 Flow-meter

13.12 Syringe with needle.

13.13 Pipettes: Calibrated variable pipettes with a range of 5 µL – 10 mL. Used to make solutions and sample dilutions. *Pipettes are to be calibrated weekly according to SOP FGS-003 and FGS-155*.

14 Reagents and Standards:

14.1 Reagent Water: 18-MΩ ultra pure deionized water starting from a pre-purified (distilled, R.O., etc.) source is used.

14.2 Arsenite (As(III)) solution - A stock solution can be purchased directly. The working standard is prepared by serial dilution.

14.2.1 Dilutions that are made daily must be entered into LIMS on the day of preparation and must be discarded at the end of analysis.

14.3 Arsenate (As(V)) Solution - A stock solution can be purchased directly.

14.3.1 Dilutions that are made daily must be entered into LIMS on the day of preparation and must be discarded at the end of analysis.

14.4 Monomethyl Arsenic (MMAs) Solution - A working standard is prepared by diluting monosodium acid methane arsonate sesquihydrate. A second source standard is prepared by diluting disodium methyl arsenate. The working standard is prepared by serial dilution. The stock solution is stable for 10 years; all further dilutions must be remade daily.

14.4.1 This stock solution shall be entered into LIMS on the day of preparation and any working solutions made from this stock solution must be prepared, documented and discarded at the analysis day.

14.5 Dimethyl Arsenic (DMAs) Solution - A stock solution is prepared by dissolving cacodylic acid sodium salt trihydrate. A second source standard is prepared by diluting dimethylarsinic acid. The working standard is prepared by serial dilution. The stock solution is stable for 10 years; all further dilutions must be remade daily.

14.5.1 This stock solution shall be entered into LIMS on the day of preparation and any working solutions made from this stock solution must be prepared, documented and discarded at the analysis day.

14.6 Sodium hydroxide (NaOH) pellets - Analytical grade

14.7 Potassium Hydroxide - Trace metal grade

14.8 Tris(hydroxymethyl)–aminomethane hydrochloride - reagent grade

14.8.1 TRIS Buffer - Dissolve tris (hydroxymethyl)-aminomethane hydrochloride and sodium hydroxide in reagent water and dilute.

14.8.1.1 *Alternate TRIS Buffer - Dissolve tris (hydroxymethyl)-aminomethane hydrochloride and potassium hydroxide in reagent water and dilute*.

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14.9 Sodium borohydride ($NaBH_4$) – reagent grade. This is the major source of the instrument blank. Therefore, every new lot number must be analyzed for As according to FGS-022.

14.9.1 Borohydride solution – Dissolve $NaBH_4$ and NaOH in reagent water, and dilute. This solution is stable for about 8-10 hrs when kept covered in an ice-bath or stored in the refrigerator. This solution must be discarded at the end of analysis.

14.10 Hydrochloric acid (HCl) – trace-metal grade, concentrated, pre-analyzed and found free of measurable arsenic. It should not contain free chlorine (see 6.2). This reagent shall be entered into LIMS and the expiration date is set to the same as the manufacturer's expiration date.

14.11 Corn oil – Reference matrix from tissue samples. This corn oil must be entered into LIMS and the expiration date is set to 1 year. The corn oil shall be stored at ambient temperature.

14.12 Helium gas

14.13 Hydrogen gas

14.14 Air

14.15 Liquid Nitrogen

14.16 Quality control sample (QCS)—The QCS must be prepared from a source different from that used to produce the calibration standards. River/reagent water and marine water that contain certified concentrations of total As may be purchased. Certified reference materials for As species are not currently available. The calibration standards and acceptable instrument performance must be verified with the analyses of a QCS on a quarterly basis. *This sample is analyzed within a batch as an LCS and is performed on a quarterly basis.*

15 Calibration:

15.1 A calibration curve is determined daily from analysis of at least three different standards for arsenite (AsIII) or inorganic arsenic. The first calibration point must be at or less than the method specific PQL The correlation coefficient for this curve must be greater than or equal to 0.995 *or the %RSD must be less than 20%* in order to continue with analyses. Quantitation is based on peak area (PA).

16 Procedure:

16.1 Instrument Start Up: Turn on power. Turn on the cuvette heating. Turn on all gases and adjust the pressure. Set lamp current. To light the flame, all gases are turned on and a flame is brought to both furnace ends. After the furnace has warmed up, the hydrogen flow is reduced slowly until the flame ignites inside the cuvette (a "pop" is heard). Allow lamp to warm up and then check that the baseline is stable prior to calibration.

16.2 After the lamp has warmed up and the flame has stabilized, immerse the column in liquid N_2, adjust the helium flow, and zero the detector by turning the "absorbance" knob. If further adjustments have to be made (e.g. lamp or wave length adjustments),

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refer to manufacturer's manual (2.1) Absorbance settings cannot be altered at any time during analysis.

16.3 Determination of Total Inorganic Arsenic: With the helium flow in the bypass position, place sample or an aliquot into the reaction vessel. Add HCl (14.10.1) to reaction vessel and replace top. Raise the Dewar flask filled with liquid nitrogen so that the trap is immersed. Switch helium flow to purge position. Slowly inject of borohydride solution (14.9.1) through the silicon rubber septum using a syringe. Purge the system. Remove the liquid nitrogen from the GC column and begin heating the GC column.

16.4 Arsenite Determination: Arsenite is determined separately from 16.3 by varying the pH so that only As(III) reacts. The procedure is similar to that in 16.3 except that TRIS buffer (14.8.1) is used in place of the HCl, and less borohydride solution (14.9.1) is injected through the septum.

16.5 Methyl and Di-methyl Arsenic Determination: The methylated species are determined separately from inorganic arsenic although the procedure is exactly the same as the determination of inorganic arsenic with the following exceptions (16.3). The exceptions are that less HCl is used and DMAs standards should be run to condition the curve before the calibration curve is analyzed.

16.6 Refer to EFGS-038, current revision for data review

16.7 See Appendix A for an easily assessable table for each Arsenic species.

17 Calculations:

17.1 The calibration curve is regular linear regression with an intercept (y=kx+m).

Results are calculated using following equation:

C_s (µg/L or µg/g) = [(PA – b) /m] • D • F/I

C_s = sample concentration (µg/L or µg/g)

PA = peak area of sample

m = slope of the calibration curve.

b = intercept of the calibration curve.

D – dilution of sample

I - initial volume or mass (L or g)

F - final volume (L)

17.2 An alternate calibration curve is calibration factor with an RSD <20%:

Results are calculated using following equation:

C_s (µg/L or µg/g) = PA/CF • D • F/I

C_s = sample concentration (µg/L or µg/g)

PA = peak area of sample

CF = calibration factor

D – dilution of sample

I - initial volume or mass (L or g)

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F - final volume (L)

17.2.1 For each species of interest, calculate the mean calibration factor, the standard deviation and the relative standard deviation of the mean. % RSD=100 * (Standard deviation/mean of the calibration factor).

17.3 The calculation for the true value of a standard made from a solid is as follows:

MW (amu) • final volume (mL) / MW_A = C (ppm)

MW= molecular weight of the solid standard (amu)

MW_A= molecular weight of the analyte of interest

C= concentration of the standard (ppm)

18 Statistical Information/Method Performance:

18.1 The Method Detection Limit (MDL) is determined according to 40 CFR Part 136 Section B. Ten replicates (9 degrees of freedom) spiked 3-10 times the expected MDL are run. The standard deviation (s) is taken from the resulting data and the MDL is calculated as follows: MDL=2.821*s. This value should not be interpreted as the method reporting limit.

18.2 The Practical Quantitation Limit (PQL) is the reporting limit for this method and is included as the lowest calibration point (2003 NELAC regulation 5.5.5.2.2.1.h.3). The PQL is determined by 10 replicates of an applicable matrix spike with a concentration that must fall within the control limits for the lowest calibration standard, which is between *50-150% for TIAs, 30-170% for Arsenite, 60-140% for MMA and 40-160% for DMA*.

18.3 Using clean handling techniques and reagents tested low for As content, the Method Detection Limit (MDL) is between 0.003 and 0.020 μg/L, depending upon the species, for a 15-mL water sample.

18.4 Current LODs and PQLs are stored at: General and Admin\Quality Assurance\MDLs & PQLs.

19 Quality Assurance/Quality Control:

19.1 Calibration Curve - The calibration curve is determined daily, and may be determined more often if ongoing calibration standards fall outside of accepted limits, see Table 3.

19.1.1 If a linear regression curve model is used, the minimum acceptable correlation coefficient for the calibration curve is 0.995.

19.1.2 If a calibration factor curve model is used, the minimum RSD is <20%.

19.2 Calibration Verification: Initial calibration (ICV) verification with a second source standard is analyzed immediately after the calibration. Following the ICV, a continuing calibration verification standard (CCV) is analyzed after every 10 samples and at the end of the analytical run. For acceptance range see Table 3.

19.3 Calibration blank: Initial calibration blank (ICB) verification is analyzed immediately after the initial calibration verification. Following the ICB, a continuing calibration blank (CCB) is analyzed after the continuing calibration verification. ICB/CCB recoveries must be

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less than the PQL. Each analytical batch for the analysis must have at least one preparation blank per 10 samples and treated exactly the same as samples.

19.4 Per Eurofins Frontier Global Sciences internal Quality Control Standards, the preparation blank for the batch and the absolute value of the associated ICB/CCBs must be less than the PQL for the samples to be reportable.

19.4.1 The preparation blanks and the absolute value of the ICB/CCBs must be less than the MDL in Table 2 below for the associated samples to be reported for regulatory compliance purposes, for clients located in the State of Louisiana, or clients that must meet LELAP (Louisiana Environmental Laboratory Accreditation Program) requirements.

Table 2 (EPA 1632 Table 1)

Analyte	Water MDL (µg/L)	Water RL (µg/L)	Tissue MDL (µg/L)	Tissue Water RL (µg/L)
Inorganic Arsenic (As^{+3} +As^{+5})	0.003	0.01	0.03	0.10
Arsenite (As^{+3})	0.003	0.01	0.02	0.10
Monomethylarsonic acid (MMA)	0.004	0.01	0.01	0.05
Dimethylarsinic acid (DMA)	0.02	0.05	0.04	0.10

19.5 Duplicates: A matrix duplicate may be analyzed per client request. Maximum acceptable relative deviation must be less than or equal to MS/MSD RPD listed in Table 3.

19.6 Matrix Spikes: For every 10 samples, at least one set matrix spike/matrix spike duplicates shall be performed. The spiking levels must be spiked at least one to five times the background concentration. For acceptable recoveries for MS/MSD see Table 3.

19.7 For every set of 10 samples, an OPR (SDS at 30ng/L or CRM) must be analyzed. For acceptable recoveries for CRMs or OPR, see Table 3.

19.8 Report results for each As species in a sample or in field blanks at or above the MRL (PQL) in µg/L or µg/g, to three significant figures. Report results for each As species in samples below the MRL (PQL) as less than the value of the MRL (PQL).

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19.9 Quality control criteria from method 1632 A Table 3:

Table 3

Analyte	OPR	ICV/CCV	MS/MSD % Rec.	MS/MSD %RPD
TIAs	50-150%	80-120%	50-150%	<35%
As3+	30-170%	70-130%	30-170%	<35%
MMA	60-140%	80-120%	60-140%	<25%
DMA	40-160%	70-130%	40-160%	<40%

20 Corrective Action

20.1 Calibration:

20.1.1 If the correlation coefficient is less than 0.995, a calibration factor model is applied (%RSD <20%), and vice-a-versa. If both model types are out of control, analysis must be halted, the reason investigated, rectified and the instrument has to be recalibrated, prior to running any samples.

20.2 Initial calibration verification (ICV): If the ICV is outside the acceptance criteria, it has to be rerun, if still outside, new working standards have to be diluted, the instrument recalibrated and the ICV rerun.

20.3 Laboratory Control Standard (LCS): If recovery falls outside the acceptance criteria, re-analyze once to confirm and then halt further analysis of the batch. Investigate cause of problem and re-calibrate.

20.4 Relative Percentage Deviation (RPD):

20.4.1 Aqueous samples: If a RPD is outside the acceptance criteria and cannot be qualified, the reason has to be investigated and a third aliquot analyzed.

20.4.2 Leaches, digestions etc.: If a RPD is outside the acceptance criteria, the reason has to be investigated and additional aliquots (analytical duplicates) analyzed. If the RPD of the leachates/digestions is still out, but the RPD of the analytical spike duplicates are within the control limits the analysis will be carried on.

20.5 Matrix spike recoveries:

20.5.1 Aqueous samples: If a matrix spike is outside the acceptance criteria and cannot be qualified, the reason has to be investigated and a second aliquot analyzed.

20.5.2 Leaches, digestions etc.: If a matrix spike is outside the acceptance criteria, the reason has to be investigated and a second aliquot analyzed. The sample must

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be stirred and well homogenized before a portion of the sample is measured out for the leach/digestion process.

20.5.3 If the matrix spike recovery of the leachates/digestions is still outside the acceptance criteria, analytical spikes have to be preformed. Speciation samples might not have to be re-extracted. The data should be flagged and noted that the matrix has a strong oxidizing/reducing potential.

20.6 The determined mean concentration from three analyses of the QCS must be within ± 10% of the stated QCS value. If the QCS is not within the required limits, an immediate second analysis of the QCS is recommended to confirm unacceptable performance. If the calibration standards and/or acceptable instrument performance cannot be verified, the source of the problem must be identified and corrected before proceeding with further analyses. The QCS is performed on a minimum of a quarterly basis and is treated as an LCS and analyzed before any client samples.

20.7 When the initial result of the analyzed sample is above the calibration curve, a blank sample shall be analyzed after to verify that there is no carryover of analyte taken place.

20.8 If a method blank is slightly elevated and is reanalyzed for confirmation, low level samples shall also be reanalyzed to confirm the low reported value.

21 List of Attachments

Appendix A: Analysis Procedure for Each Arsenic Species

Appendix B: Suggested Arsenic Calibration Curve (Can be modified based on client needs)

Appendix C: Example of an Analytical Sequence

Appendix D: Instrument troubleshooting and Maintenance

Appendix E: Example - Standard Operating Procedure Training Record

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Appendix A

Analysis Procedure for Each Arsenic Species

Arsenic Species	Sample Aliquot	pH Control (added prior to NaBH4)
Total Inorganic Arsenic	15 mL	HCl
Arsenite	15 mL	TRIS buffer
Methyl Arsenic	15 mL	HCl
Di-methyl Arsenic	15 mL	HCl

Arsenate Concentration is determined by subtracting As (III) from that of the total inorganic Arsenic.

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Appendix B

Suggested Arsenic Calibration Curve (Can be modified based on client needs)

Calibration curve	Concentration	Working Standard (*)10ppb As (15 mL final volume)	Control Range (%Rec)
SEQ-CAL1 (BLANK)	0.0 ug/L	0.0 uL	
SEQ-CAL2	0.010 ug/L	15.0 uL	See Table 3 (sec 19.9) - OPR
SEQ-CAL3	0.015 ug/L	22.5 uL	
SEQ-CAL4	0.025 ug/L	37.5 uL	
SEQ-CAL5	0.050 ug/L	75.0 uL	
SEQ-CAL6	0.125 ug/L	187.5 uL	
SEQ-CAL7	0.250 ug/L	375.0 uL	
(**) ICV	0.100 ug/L	(**)150.0 uL	See Table 3 (sec 19.9) - ICV

(*) Primary Working Standard: The 10 ppb primary working standard is prepared by serial dilution in 18 MΩ ultra pure deionized water. Dilute 100 uL of 1000 ppm Primary Standard into 10 mL final volume, it becomes 100 ppb. Then dilute 20 uL of 100 ppb standard into 20 mL final volume.

(**) Secondary working Standard: The 10 ppb secondary working standard is prepared exactly same as above from 2nd source.

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Appendix C

Example of an Analytical Sequence

Batch run sequence: Water/Tissues
ICV
ICB
OPR1
OPR2
MBLK1
MBLK2
Sample #1
Sample #2
Sample #3
Sample #4
Sample #5
Sample #6
CCV1
CCB1
Sample #7
Sample #8
Sample #9
Sample #10
MS1
MSD1
Sample #11
Sample #12
Sample #13
Sample #14
CCV2
CCB2
Sample #15
Sample #16
Sample #17
Sample #18
Sample #19
Sample #20
MS2
MSD2
CCV3
CCB3

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Appendix E: Example - Standard Operating Procedure Training Record

By signing this document, I the employee, certifies to have read, understood and agreed to follow the test method and quality procedure as described in this procedure.

Reading of SOP FGS-022.06:
Determination of Arsenic Species in Various Matrices by Hydride Generation Cryogenic Trapping Gas Chromatography Atomic Absorption Spectrophotometry.

SOP name and Revision number

Employee name (print)

Employee name (sign) Date:

Supervisor name (sign) Date:

Initial SOP Training (leave blank if not applicable)

Initial reading of method and training	Initials	Date	Supervisor
1. Read method			
2. Observe the method			
3. Detailed review of method and associated literature			
4. Supervised practice of method with trainer			
5. Unsupervised practice of the method with trainer			
6. Review of work with trainer and/or peer-review			
7. IDOC to determine precision and accuracy			
8. Determination of blanks			

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Attachment D

Community Participation Plan

Former DuPont East Chicago Facility

Community Participation Plan

Former DuPont East Chicago Facility, Indiana

USEPA ID: IND 005174354

August 8, 2019

Prepared for:

East Chicago Gateway Partners, LLC
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Prepared by:

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IE Project #11300

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Figure 1 – Property Areas

Exhibit 1 – Community Contacts

Exhibit 2 - Project Team Contacts

ACRONYMS AND ABBREVIATIONS

°C	Degree Celsius
°F	Degree Fahrenheit
AOC	Area of Concern
AMSL	Above Mean Sea Level
BERA	Baseline Ecological Risk Assessment
BGS	Below Ground Surface
CA	Corrective Action
CAO	Corrective Action Objectives
CMS	Corrective Measure Study
CMI	Corrective Measures Implementation
CSM	Conceptual Site Model
DCRG	DuPont Corporate Remediation Group
DQO	Data Quality Objective
ECGP	East Chicago Gateway Partners, LLC
FEMA	Federal Emergency Management Agency
GPS	Global Positioning System
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
IAC	Indiana Administrative Code
IDEM	Indiana Department of Environmental Management
IRM	Interim Remedial Measures
ISCF	In-Situ Chemical Fixation
ISCR	In-Situ Chemical Reduction
ISS	In-Situ Stabilization

MCL	Maximum Contaminant Level
PID	Photo Ionization Detection
PM	Project Manager
PRB	Permeable Reactive Barrier
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility investigation
RSL	Remedial Screening Level
SA	Source Area
SWMU	Solid Waste Management Unit
TSCA	Toxic Substances Control Act
US	United States
USMAIL	U.S. Mail Carrier Service
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
WMU	Waste Management Units
WP	Work Plan

INTRODUCTION OVERVIEW

This Community Participation Plan sets forth the requirements for provision of notice to the local residents, workers, media companies, public agencies and other interested parties ("the Community") for the Resource Conservation and Recovery Act ("RCRA") corrective measures being performed at the Former DuPont East Chicago Facility located at 5215 Kennedy Avenue, East Chicago Indiana ("the Facility"). Additionally, this plan establishes means and methods for the Community to examine the data generated during performance of the Project and will encourage participation through questions and comments in performance review. Where required, the plan provides the procedures for informational meetings, public comment input and consideration, and other public participation events involving communication with the Community.

The scope and design of the corrective measures comply with the RCRA Administrative Order on Consent (Docket No. RCRA-05-2019-003) executed between the United States Environmental Protection Agency, Region 5, E.I. du Pont Nemours and Company (DuPont), Chemours Company FC, LLC (Chemours) and East Chicago Gateway Partners, LLC, et al. on November 16, 2018. The corrective measures were selected by the USEPA in the Final Decision and Response to Comments document issued on July 18, 2018 with respect to the Conceptual Site Model and Remedial Action Objectives.

This Community Participation Plan is being submitted as part of the Corrective Measures Work Plan for review and approval by the USEPA Region 5. Approval of the Corrective Measures Work Plan will define the full operational and administrative scope of the remediation at the former DuPont Facility's environmental contamination. These efforts will be defined herein as, "the Project".

Goals of the Community Participation Plan

One goal of the Community Participation Plan is to ensure compliance with USEPA Guidance under RCRA, as well as City, County and State regulations in all communications. It is essential the Community know that all required Corrective Measures are done within the authority and oversight of the USEPA RCRA program and any development and construction be done under any municipal, County or State laws and regulations. Another goal of the plan is to enlist the support of the Community. The overarching goal of the Project is for the betterment of the City of East Chicago. Turning a blighted and unusable Property into a positive part of the Community is paramount. The Community Participation Plan will do that by keeping the community well informed; providing explanations about technical activities; and ensuring opportunities for Community input and participation.

Finally, it is a goal of the activities presented in the Community Participation Plan to help ensure public safety both on and off the Property.

Community Participation Plan Scope and Purpose

The scope of this Community Participation Plan was developed in accordance with the RCRA Public Participation Manual issued by USEPA on January 11, 2017. Performance of the plan will represent a joint effort between the East Chicago Gateway Partners, LLC (ECGP), Impact Environmental (remediation contractor for ECGP), the United States Environmental Protection Agency ("USEPA"), the Indiana Department of Environmental Management ("IDEM"), E. I. du Pont de Nemours and Company, and the Chemours Company FC, LLC ("DuPont"), collectively the "Project Team". The Project Team will operate and maintain community outreach and two-way communication during the process of remediation, construction and development.

Maintaining a clear channel of open communication with the Community is essential to the success of the remediation and redevelopment of the Property. Direct communication with the Community must use language that is easily understandable with plain-language explanations of technical terminology. Toward this goal, information will be presented in both English and Spanish, either as translated text or through an onsite interpreter present at meetings. Where practical, detailed engineering concepts will be presented with accompanying diagrams and visual renderings for clarity.

The plan is intended to be adaptable to adjust to the schedule of technical activities as well as to the Community-based requirements. Finally, the plan provides a means for the Community to be educated on the Project and to be able to receive answers to questions or comments with respect to the performance of the Project.

The goals for the project can be described from the perspective of both the Community and the Project Team as follows:

- The Community must get information on the Project in a language and format that can be easily understood.
- The Community must be aware of the schedule of activities associated with the performance of the Project and when scheduled goals are or are not met.
- The Community must have access to data to demonstrate that the Project is being safely performed.
- The Community must have answers to questions regarding the safety and efficacy of the Project.
- The Community must have the ability to apply for grants to study the safety and efficacy of the Project.
- The Community must have the ability to have adequate responses to complaints generated from the performance of the Project.
- The Community must have input on any contingencies or modifications to the Project.
- The Project Team must provide performance data for the project for examination by the Community.
- The Project Team must provide regular updates, including informational meetings, of the progress of the Project to the Community.

- The Project Team must perform self-assessment and planning exercises to identify adjustments necessary to educate, inform and protect the Community.

DUPONT FACILITY HISTORY

Facility Background

The Property is approximately 440 acres in size and bound on the north by the Riley Park neighborhoods and various commercial properties, the south by the East Branch of the Grand Calumet River, the east by commercial properties (including the City of East Chicago Solid Waste Transfer Station), and the west by Kennedy Avenue and the former USS Lead Refinery. Currently most of the Property remains vacant, fenced and unused. The Property has been divided into the following six areas as mentioned in previous site investigations and reports and is presented in Figure 1.

The Redevelopment Area: This area consists of approximately 155 acres and encompasses the former manufacturing area located within the central and western portion of the Property. Future industrial and/or commercial use is anticipated for this area.

The Open Area: This area consists of approximately 50 acres and includes an approximately 25-acre solid waste landfill. The former landfill operated during historical manufacturing operations however discontinued use in 2002. A majority of the landfill consists of inert filter cake derived from waste water treatment systems on the Property. North of the landfill location is approximately 25 acres of wooded areas and wetlands.

The Buffer Zone: This area is located within the Redevelopment Area directly east of the open and redevelopment area and separates these portions from the adjacent natural area. The buffer zone area is approximately 200 feet wide and extends across the width of the Property oriented north to south occupying approximately 20 acres. Buffer area is intended to provide additional protection to the natural area and its resources. Vegetation and habitat management will continue to support the health of the natural area. The buffer zone area has undergone various IRM to mitigate the migration of contamination into the natural area.

The Natural Area: This area is approximately 172 acres and has remained undeveloped retaining its unique dune and swale habitat. The natural area is managed by The Nature Conservancy for habitat and wildlife preservation and is protected from future development.

The Active Manufacturing Area (Leased Area): This area consists of approximately 30 acres leased and managed by WR Grace Industries. This area is the only remaining portion of the Facility that maintains manufacturing operations. These operations consist of manufacturing silica products and has remained nearly unchanged for 110 years.

The Annex Area: This area is approximately 10 acres in size and consists primarily of wetlands. This parcel has not been previously investigated due to ownership discrepancies and is situated along the

northeastern boundary of the Property. An investigative work plan focusing on this area has been approved and is currently scheduled to being in 2019.

Demographics of East Chicago

As of the census of 2010, there were 29,698 people, 10,724 households, and 7,197 families residing in the city. The population density was 2,107.7 inhabitants per square mile. There were 12,958 housing units at an average density of 919.7 per square mile. Population has been on a steady decrease since 1970 at which time the population was over 46,000.

The racial makeup of the city was 42.9% African American, 35.5% White, 0.6% Native American, 0.1% Asian, 18.1% from other races, and 2.8% from two or more races. 15,105 people, or 50.9% of the population identified as Hispanic or Latino (a majority being of Puerto Rican descent).

There were 10,724 households of which 40.8% had children under the age of 18 living with them, 27.9% were married couples living together, 31.4% had a female householder with no husband present, 7.7% had a male householder with no wife present, and 32.9% were non-families. 29.0% of all households were made up of individuals and 9.5% had someone living alone who was 65 years of age or older. The average household size was 2.75 and the average family size was 3.42.

The median age in the city was 30.9 years. 31.4% of residents were under the age of 18; 9.7% were between the ages of 18 and 24; 25.4% were from 25 to 44; 22.2% were from 45 to 64; and 11.3% were 65 years of age or older. The gender makeup of the city was 46.8% male and 53.2% female.

Land Use

The land use to the north and northeast of the Property is residential. The homes are one or two-story single-family dwellings, typically 1,200 to 1,500 square feet in size with detached garages or outbuildings.

The land use to the northwest of the Property is industrial, consisting predominantly of vacant lots and petroleum bulk petroleum storage facilities (tank farm).

The land use to the south of the Property is industrial, consistent of production, development facilities and petroleum bulk petroleum storage facilities (tank farm).

The land use to the east of the Property is commercial and industrial, consisting of an airport and air transportation-related support facilities and solid waste recycling operations.

The land use to the west of the Property is commercial and industrial, consisting of a USEPA Superfund Site (USS Lead), development facilities, bulk petroleum transport facilities, and solid waste recycling operations.

DESCRIPTION OF THE RCRA CORRECTIVE ACTION

The RCRA Process

Congress enacted RCRA, an amendment of the Solid Waste Disposal Act, in 1976 to address the safe management and disposal of the high volumes of municipal and industrial solid waste generated nationwide. RCRA goals are to protect human health and the environment, conserve energy and natural resources, reduce waste and insure environmentally sound waste management methods.

RCRA continues to evolve as congress amends the statute to reflect changing needs. Amendments to RCRA have occurred several times since 1976, most significantly in 1984. The 1984 amendments called the Hazardous and Sold Waste Amendments, specifically expanded the scope and requirements of RCRA. Subtitle C of RCRA establishes a regulatory program to manage hazardous waste from cradle-to-grave and ensure that hazardous waste management permitting protects human health and the environment. These regulations govern permitting for the generation, transportation, treatment storage and disposal of hazardous waste. Where permits are issued for these activities, the RCRA plan for closing and cleaning the facilities, through corrective measures, is clearly defined and understood to follow a general process.

Once corrective measures are complete, the USEPA can terminate the corrective action order. Decisions regarding completion of corrective measures can be made for specific portions of the Property (zones) or for a specified operable unit or release. USEPA policy is for the public to have an opportunity to review and comment on matters relating to the corrective action.

The RCRA Closure of the Property

The Facility historically operated as a chemical manufacturing facility for Grasselli Corporation from 1892 to 1929 and subsequently by DuPont from 1929 until the Facility was closed in the mid-1980s. DuPont maintained the property until the Facility was transferred to Chemours in 2015 and was sold to ECGP in 2018. The Facility entered the RCRA Corrective Action Program in 1997.

Below is a brief table that provides a list of the RCRA Corrective Action Program milestones for the Property achieved under ownership of Dupont and Chemours.

RCRA Corrective Action Program Milestones

RCRA Process Milestone	Owner/Party	Purpose	Year
RCRA 3008 (h) Administrative Order on Consent	USEPA/ DuPont	Enforcement Order based on discovery of a release	1997
Current Conditions Report	DuPont/ CH2M2 Hill	Identify and define Facility contamination	1997
Phase I RCRA Facility Investigation (RFI)	DuPont/ DuPont Corporate Remediation Group (DCRG)	Identify and define Facility contamination	2002
Installation of PRB Wall - Interim Remedial Measure (IRM)	DuPont/ DCRG	IRM to mitigate migration of contaminated groundwater off-Facility	2002
Current Human Exposure Under Control - Environmental Indicator (EI)	DuPont/ DCRG/ USEPA	Human exposure designated as "under control" by USEPA	2004
Phase II RFI	DuPont/ DCRG	Identify and define Facility contamination	2005
Migration of Contaminated Groundwater Under Control	DuPont/ DCRG/ USEPA	Migration of contaminated groundwater designated as under control	2005
Human Health Risk Assessment (HHRA)	DuPont/ Pioneer Technologies Corporation	Identify human health risks associated with exposure to Facility contamination	2011
Baseline Ecological Risk Assessment (BERA)	DuPont/ Parsons	Identify ecological risks associated with exposure to Facility contamination	2012
Buffer Zone IRM Excavations	DuPont/ Parsons/ Summit	Excavate, treat and dispose on-Facility contaminated soils within the Buffer Zone Area	2013 - 2016
Corrective Measures Study	DuPont / Parsons	Evaluate and propose final remedial actions	2015
Final Decision Response to Comments	USEPA/ Chemours/ ECGP	USEPA selected final remedies	2018
RCRA 3008 (h) Administrative Order on Consent for Corrective Measures	USEPA/ ECGP/ Chemours/ Dupont	USEPA Enforcement Order to complete selected remedies	2018

DuPont Facility Environmental History

Former operations and waste management practices were investigated at the Property during closure of various industrial processes at the former DuPont facility, as per RCRA requirements. Throughout the 1980s and 1990s, soil and groundwater investigations and operational assessments identified the presence of on-site soil and on-site and off-site groundwater contamination from the operation of the DuPont facility. The principle contaminants were inorganic metals that included arsenic and lead.

Subsequent investigations performed from the 2000s to the early 2010s further defined and prioritized the environmental risks of the detected contaminants. As a result of these investigations, immediate protective measures ("interim remedial measure") were performed by DuPont. This included the installation of a 2,000-foot long permeable reactive barrier wall parallel to the northern boundary of the Property designed to prevent groundwater contamination from migrating off-site. Additionally, 76,256 cubic yards of arsenic and lead impacted fill were excavated and sequestered from the Natural and Buffer Areas to prevent it from contaminating ground and surface water quality. In 2015, a corrective measures study was conducted to evaluate what additional remedial approaches and technology applications would achieve the RCRA corrective action objectives. It was determined that an additional 61,780 cubic yards of arsenic and lead contaminated soils in the Redevelopment and Lease Areas would require excavation and disposal to protect groundwater, and that the remaining contaminated surface fill would be capped with permeable and non-permeable covers to prevent exposures. The study also determined that the existing groundwater contamination would be treated with chemical remediation techniques, performed in-place, throughout the Property.

In the summer of 2018, USEPA issued the Final Decision and Response to Comments document designating the final corrective measures based on the recommendations in the 2015 CMS, the 2016 addendum to the CMS for the Leased Area and public comment.

In November of 2018, the USEPA issued a RCRA 3008 (h) Administrative Order on Consent for Corrective Measures Implementation Order ("Consent Order"). This document obligates respondents (DuPont and ECGP to satisfy the environmental cleanup requirements provided in the Final Decision and Response to Comments. This Consent Order obligates the respondents to satisfy the environmental cleanup requirements. Moreover, the Consent Order identified that a portion of land that is approximately 9-acres in size, identified as the "Annex Area" had been erroneously omitted from the RCRA program. This past omission obligates respondents to start the RCRA process to investigative and, if necessary, remediate this area and its contamination. Currently, it is understood that the investigative work in the Annex Area will be performed by DuPont. These activities are scheduled to start in the Summer of 2019.

In May of 2019, A Natural Area and Buffer Zone Assessment for 2014-2018 prepared by DuPont concluded that the natural resource conditions of the water, sediment and soil of the Natura Area were improved. The report recommends that further evaluation of the Natural Area, inclusive of the Buffer Zone, is not warranted and that monitoring be performed in the future.

In June of 2019, the Corrective Measures Implementation Work Plan will be submitted by ECGP to the USEPA for review and approval. Corrective Measures activities will start upon approval of the work plan by the USEPA.

Selected Corrective Measures – USEPA Final Decision Response to Comments Document

Various fill/soil and groundwater remediation treatment techniques and technologies were evaluated and proposed for use at the Facility given the associated CAOs and remedial cleanup goals presented in the 2015 Corrective Measures Study by Parsons dated March 2015. These technologies were evaluated for their efficiency in achieving overall protection of human health and the environment, attaining media cleanup standards, controlling Source Area releases, and complying with applicable standards for waste management. Additionally, short-term and long-term effectiveness, feasibility and costs were factored. The CMS mixed and matched the selected treatment techniques and technologies into 5 separate packaged alternatives. USEPA selected the proposed CMS "Alternative 4" containing final corrective measures to achieve short-term and long-term remedial goals. After a public comment period the final corrective measure and remedies were issued in the Final Decision Response to Comment Document July 18, 2018 and are as follows:

Cap and Cover

Prohibit direct contact exposures to contaminants in the fill through the utilization of engineering controls. The engineering controls included maintaining pavement and foundations in the Lease area and by constructing and maintaining a permeable barrier cover in the Open Area and Redevelopment Area.

Source Area Excavation/ Treatment/ Off-Site Disposal

Excavate fill with concentrations of Arsenic greater than 1,000 mg/kg "hot-spots"or, Source Areas for off-site disposal. These locations are known to be major sources of the detected groundwater contamination. Modeling predicts that this removal of the Source Areas will result in the decreased arsenic concentrations in the groundwater. In addition, excavation and off-site disposal of Lead contaminated fill to a depth 2 feet below ground surface in the Lease Area. These corrective measures will mitigate direct human contact and achieve a residual target cancer risk and exposure factors across the Property.

In-situ Treatment of Saturated Source Area Fill

Treat impacted in-situ saturated soil within arsenic Source Area excavations (below the water table) to reduce arsenic leaching characteristics to further reduce source concentrations.

In-Situ Treatment of Groundwater

Create enhanced microbial sulfate reduction injection treatment zones along the plume flow paths and construct permeable reactive biological barrier walls with a perpendicular orientation to intercept the plume and reduce arsenic solubility. The combination of Source Area remediation and treatment zones transecting plume flow paths is intended to rapidly reduce arsenic concentrations in groundwater, reduce

the flux of arsenic to the treatment barriers thus extending their longevity, and to convert existing forms of arsenic in saturated fill/soils into forms that are less soluble and therefore less mobile.

Final Closure of the Onsite Landfill

Proceed with final closure of the landfill as required and approved by the Indiana Department of Environmental Management. Final closure effort should meet or exceed the requirements of Title 329 of Indiana Administrative Code (IAC), Article 10, Rule 37.

Institutional Controls

The Property owner is required to maintain controls including compliance with industrial zoning, a security fence, and compliance health and safety requirements during corrective measures. In addition, deed restrictions will be required to prevent non-industrial use of the property consistent with the Cleanup Plan, prevent the installation of on-site drinking water wells and to notify any future workers or developers of the potential for vapor intrusion risks. The deed restrictions were added to title and tendered to the USEPA in February of 2019.

Financial Assurance

The total estimated cost of the proposed remedy is calculated at $26.6M. The Project Team has posted performance bonds equal to this amount held by the USEPA to provide financial assurance to verify the Corrective Measures will be implemented over the next 30 years.

Overview of Corrective Measures Implementation Process

The overall approach of this Corrective Measures Implementation (CMI) Work Plan is to complete the required tasks for the design, construction and operation of the corrective measures concurrently with the process necessary for redevelopment of the Facility. For proper implementation of corrective measures and redevelopment to occur with long-term sustainable effects, supplemental studies, surveys and investigations will be required. In general, studies will rely upon previously collected data to model or conclude new information, surveys will rely upon non-intrusive field activities and investigations will rely upon intrusive field activities. These information gathering mechanisms will provide means for remedial design optimization and redevelopment constructability planning. This approach will result in a phased and sequenced remedial design and construction. Remedial construction “Phase I” will focus on short-term remedial objectives related to soil remediation and preliminary groundwater treatment. Remedial construction “Phase II” will focus on long-term remedial objectives related to full scale treatment of groundwater and the landfill closure.

Remedial Construction Phase I

The remedial design, construction and development implementation components that will be addressed under the scope of Remedial Construction Phase I include the following:

- Remedial Design and Construction:

- Survey Work
- Groundwater Baseline Event
- Preliminary Groundwater Treatment
- Source Area Soil Excavation, Treatment and Disposal
- In-Situ Stabilization of Saturated Source Area Soil
- Permeable Barrier Cover Importation, Specification and Construction
- Remedial Groundwater Performance Monitoring

- Development Related Activities:

  - Clearing and Grubbing
  - Concrete Survey and Slab/Foundation Removal
  - Geotechnical Investigation
  - Gary Road Access and Construction
  - Landfill Investigation and Beneficial Reuse Determination Study
  - Ground Improvement and Site Preparation
  - Low Void Aggregate (LVA) Processing and Manufacturing

Remedial Construction Phase II

The remedial design, construction and development implementation components that will be addressed under the scope of Remedial Construction Phase II include the following:

- Remedial Design and Construction:
  - Full- Scale Groundwater Treatment and Monitoring
  - Biowall Construction
  - Facility Landfill Closure
  - Hydrogeologic Study/ Fate and Transport Assessment
  - Remedial Groundwater Performance Monitoring

- Development Related Activities:
  - Clearing and Grubbing
  - Ground Improvement and Site Preparation
  - Low Void Aggregate (LVA) Processing and Manufacturing
  - Building Design and Construction
  - Stormwater Systems and Hydraulic Controls
  - Facility Access Controls
  - Building Engineering Controls/ Vapor Barrier

SUMMARY OF COMMUNITY COMMUNICATIONS AND CONCERNS

The Community

The Community not only represents the local interests of residents, workers and public industries, but also other interested parties that include representatives of consumer, environmental, faith, and minority associations; trade, industrial, agricultural, and labor organizations; public health, scientific, and professional societies; civic associations; public officials; and governmental and educational associations. A contact list for each of these types of entities is provided for use and continual update as Exhibit 1 Community Contacts.

The Project Team

The Project Team includes East Chicago Gateway Partners, LLC, Impact Environmental, the United States Environmental Protection Agency, the Indiana Department of Environmental Management, E. I. du Pont de Nemours and Company, and the Chemours Company FC, LLC. A contact list for each of these types of entities is provided for use and continual update as Exhibit 2 - Project Team Contacts.

Community Participation History

Public participation as part of the RCRA corrective action process has included the release of investigative and remedial scoping documents and the occurrence of Public Meetings. Public Meetings were held at the East Chicago Public Library located at 1008 W Chicago Avenue, East Chicago, Indiana. Overall, participation from the community has been at a high-level (USEPA RCRA Public Participation Manual 2017), and all the meetings have involved strong question and answer interchange. The following summarizes the recent public participation in the Project.

- In August and September 2014, the USEPA made the Natural Area Statement of Basis available for public review and comment.
- November 27th, 2017 the USEPA made the Western Portion (Redevelopment, Leased and Open Areas) Statement of Basis available for public review and comment.
- Public comment period lasted from November 27th, 2017 until March 12th, 2018; written comments were received.
- January 10th, 2018 Public Meeting lead by USEPA on Statement of Basis.
- March 7th, 2018 Public Meeting lead by USEPA on Statement of Basis.
- June 11th – June 18th, 2019, community interviews were performed to identify concerns regarding the investigation and remediation of the Property and to determine the effectiveness of the participation measures as part of the USS Lead/Former DuPont East Chicago Facility CIP update.
- Since 2016, USEPA RCRA staff have participated in numerous Public Meetings associated with the nearby off-property USS Lead Superfund Site; the most recent having been held on April 7th, 2018.
- A meeting with the East Chicago Mayor at City Hall and tour of Property occurred on March 14th, 2019.

- Facility tour and meeting on development with representatives from United States Senator, Todd Youngs Office and the Indiana Economic Development Corporation took place on March 27th, 2019.
- Facility tour and meeting on development with representatives from Northwest Indiana Forum took place on March 27th, 2019.
- East Chicago Gateway Partners introduced as the new owners of the Property at the Lake County Economic Development Corporation Annual meeting on March 21st, 2019.

Likely Concerns of the Community

The community concerns have been gathered based on several resources including, 2010 USEPA interviews, public comments responses to Statement of Basis, discussions with local leaders and articles in the Northwest Indiana Times. These concerns include:

- Lead, arsenic and other contaminants of concern causing exposures through air, soil/fill and groundwater.
- Environmental justice issues.
- The remediation being performed on an expedited schedule.
- Traffic safety.
- Security to prevent unauthorized access onto the Property.
- Previous confusion about information regarding the Property.
- Previous issues with the availability of information on the Property.

The Project Team has reviewed the comments made during the Public Meetings and has opted to pursue some comments made by public participants within the proposed Corrective Measures Implementation Work Plan. These are presented as follows:

Comment	Date/Type of Comment	Work Plan Response
Need to recapture the value of contaminated media on the Property.	Public comment for Final Decision Public Meeting; written comments received from the Statement of Basis public comment period.	Plan includes methodology to determine possibility of beneficial use of waste on the Property as an aggregate component in building materials.
Impacts of groundwater contamination upon Riley Park residents.	Public comment for Final Decision Public Meeting; written comments received from the Statement of Basis public comment period.	Initial groundwater treatment will be conducted during the Remedial Construction Phase I and a full-scale groundwater treatment will be implemented in the Remedial Construction Phase II.
Security and perimeter fence continuity.	Public comment for Final Decision Public Meeting; written comments received from the Statement of Basis public comment period.	A video surveillance plan of the Property with real-time remote monitoring is being developed.
Containment of soil/fill on the Property.	Written comments received from the Statement of Basis public comment period.	A vehicle tire wheel wash, among other measures, is being installed and will be used for all vehicles involved in the corrective measures.

The highest Community concerns appear to be related to exposure to sitewide contaminants, particularly, arsenic. As expressed in various public forums and in the media, this concern is most related to groundwater contamination. A lessor degree of exposure concerns relates to the presence of elevated concentrations of arsenic and lead in the soil at specific locations on the Property. These contaminated soils are classified as hazardous waste based upon toxicity as determined by leachability testing and represent a recognized source of contamination for groundwater.

Community Based Redevelopment

The Property owner, ECGP, has begun planning and design work for the construction of warehouse facilities. The design will include one or more large buildings (1,100,000 square feet) with associated loading docks and parking lots. Such a design will dovetail with the Corrective Measures required under the Final Decision Response. In particular, the barrier cover that is required by the Corrective Measures can be designed to have the geotechnical qualities to support such structures.

The ECGP redevelopment project will be called, "The East Chicago Logistics Center". Phase 1 of the project will involve expedited construction of a 1.1 million square-foot warehouse and will be followed by support warehouse space in future phases, as remediation progresses.

ECGP representative have met with officials from the City of East Chicago on several occasions to discuss planning and permitting for the East Chicago Logistics Center. Many of the particulars are pending approval of the Corrective Measures Work Plan. The logistics center is intended to benefit from the Property's proximity to Interstates 90 and 65, the Gary International Airport, and the skilled local workforce. The East Chicago Logistics Center is expected to create over 300 construction jobs, 1,000 permanent careers, and 1,000 city-wide multiplier jobs. In addition, it will grow the East Chicago tax base.

COMMUNICATION ACTION MEASURES

Passive Measures

Repositories

The USEPA has set up the predetermined information repository at the East Chicago Public Library and online. In addition, ECGP has set up a website www.ecgpdev.com to provide information to the community as well as an updated calendar of ground disturbances and other events scheduled on the Property. These are considered passive communication action measures as Community users need to pursue this information for it to be obtained.

Repository locations

Location 1: The Robert A. Pastrick Branch of the East Chicago Public Library, 1008 W. Chicago Avenue, East Chicago, Indiana (telephone number 219-397-5505). The library keeps the following hours of operation:

- Monday – Thursday 9AM – 8PM
- Friday and Saturday 9AM – 5PM
- Sunday - Closed
- Not open for Federal or State Holidays

Location 2: The USEPA Region 5 Records Center, Ralph Metcalfe Federal Building, 7th Floor, 77 West Jackson Boulevard, Chicago, Illinois (telephone number (312) 353-2000).

- The Metcalfe Federal Building is open weekdays (except Federal Holidays) from 6AM to 6PM. The Record Center is open from 8:15 AM to 4:45 PM.
- Main entrances to the building are located on the north (Jackson Blvd. side) and the west (Clark Street side). Entrance for the disabled is through a double-doorway on the Jackson Blvd. side, which has two call-buttons if there is any need for assistance.
- Photo-identification is required to enter the building. Everyone (e.g., visitors, general public, non-federal workers) entering the building will be screened by a metal detector. All bags and other items must through an x-ray scan. Building security is monitored by the uniformed guards of the Federal Protective Service.
- All USEPA visitors entering the USEPA office spaces will be issued a visitor's badge by the badge office attendant or floor receptionist. Visitors must be accompanied by a USEPA employee. Upon exiting the building, visitors must return their badge to the attendant or receptionist.

Location 3: The on-line virtual repositories locations:

- USEPA Website https://www.epa.gov/hwcorrectiveactionsites/dupont-facility-east-chicago-current-documents-reports-and-graphics

- The ECGP Website https://www.ECGPdev.com

Of note is that the ECGP site can retain and share information from other non-public sessions upon request, subject to availability and legal considerations as determined by the Project Team.

Fact Sheets

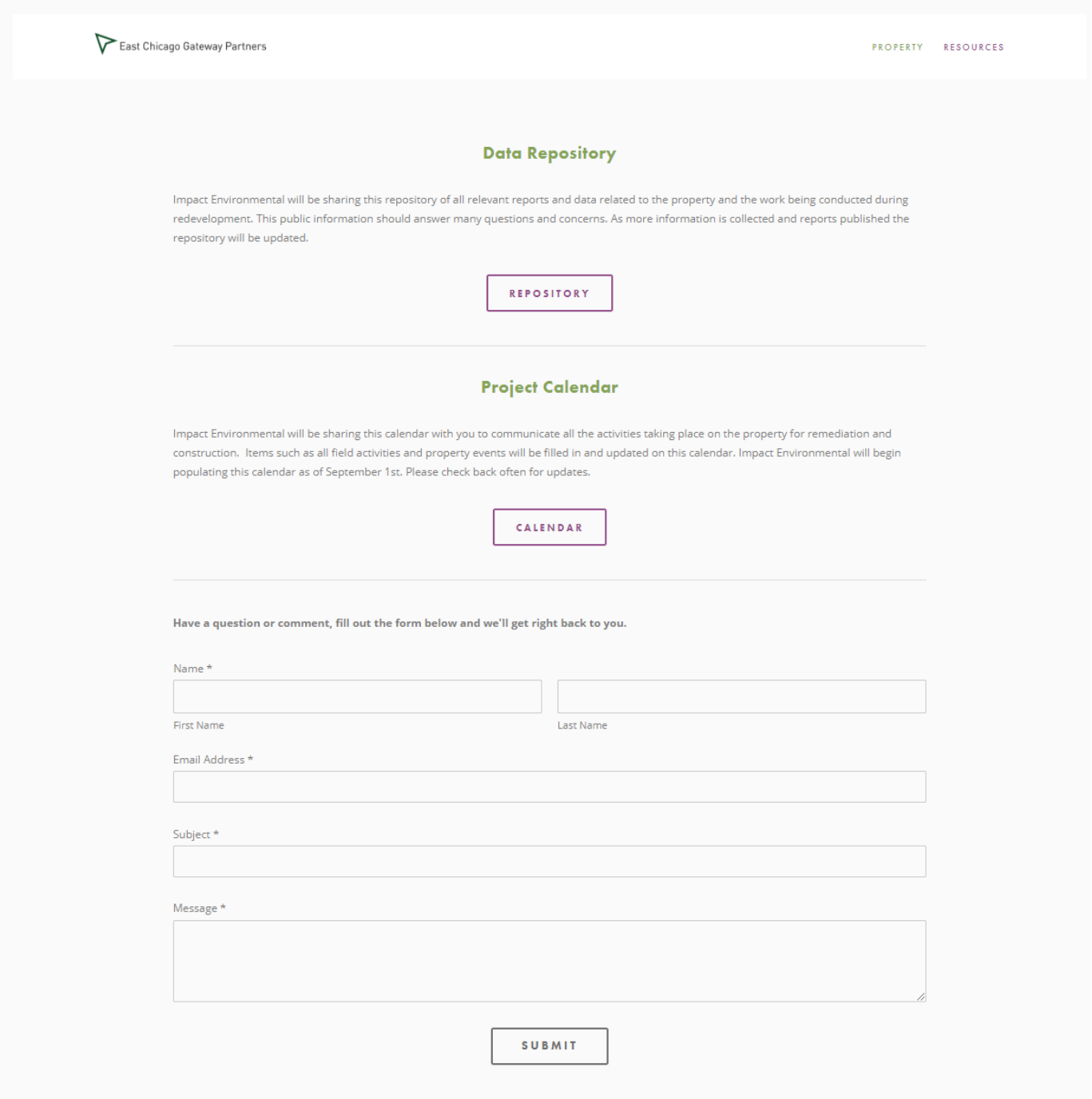
Letter-sized (8.5 x 11 inch), double sided printed sheets with updated information about the Property and the Corrective Measures will be provided to act as a quick-reference guide for the Project. The sheets will provide Project-related information in an easy-to understand format. Fact sheets will be produced throughout the project design and cleanup process to promote understanding of the individual elements of the remedy. These sheets will be made conspicuously available at all repositories and will be available as a hand-out in large quantities for informational meetings. Large numbers of copies will also be provided upon request by any member of the Community. They will be produced in English and Spanish.

Interactive Website

A database of information will be available on the website www.ecgpdev.com. On the website there is a calendar of scheduled ground disturbance work and development activities that will be available and updated regularly. There will also be a form to contact ECGP with concerns or comments (see below). Questions and/or comments from the Community to the Project Team can be made at any time utilizing the internet using the ECGP portal that includes a "Question and Comment" page. Online users can fill out an auto-response page that accepts questions and comments.

All questions and comments will be reviewed by the Project Team (minimally the ECGP Project Manager and the USEPA Project Manager). Where an answer is prompted, an answer to the question will be provided in either: 1) correspondents where a return address is provided; or 2) in the subsequent Public Outreach Report that will restate the question and provide an answer. Where comments are made, the comment will be restated and addressed in the subsequent Public Outreach Report. The Project Team reserves the right to bundle similar questions and comments for a more generalized response, where appropriate.

Interactive Website Screen Capture



*Comments will be returned in a timely manner. The USEPA maintains a public database of documents at the East Chicago Public Library as well.

Online Events Calendar

Important milestone dates that effect the stakeholders will also be maintained on the ECGP website and will include such dates as:

- 6/15/19 Permit Submittals
- 7/27/19 Calumet Day Celebration
- 8/15/19 Investigation & Surveying Begins
- 9/15/19 Start-Up of Earth Disturbance
- 10/1/19 Controlled Burn Event in Natural Area Performed by the Nature Conservancy
- 4/15/20 Earthen Protective Barrier Construction Start
- 4/22/20 East Chicago Earth Day Celebration

Keeping the Community in-the-know on issues is important to reducing concerns from the sights and sounds that may emanate from the Property during remediation and development. This will allow all parties involved to stay focused on important matters and dates rather than reacting to the kind of concerns that come from miscommunication.

Active Measures

Active communication action measures deliver the message and content to the Community. These activities and techniques are presented below. Additionally, a table that captures scheduled and triggered instances for each type of activity or event is provided at the end of the section. To encourage outreach and continued two-way dialogue with the Community, the Project Team will implement a variety of active activities and techniques that will be assessed internally and externally to ensure efficacy. The activities and techniques are endorsed in the RCRA Public Participation Manual and are reactive to address project changes and technology changes.

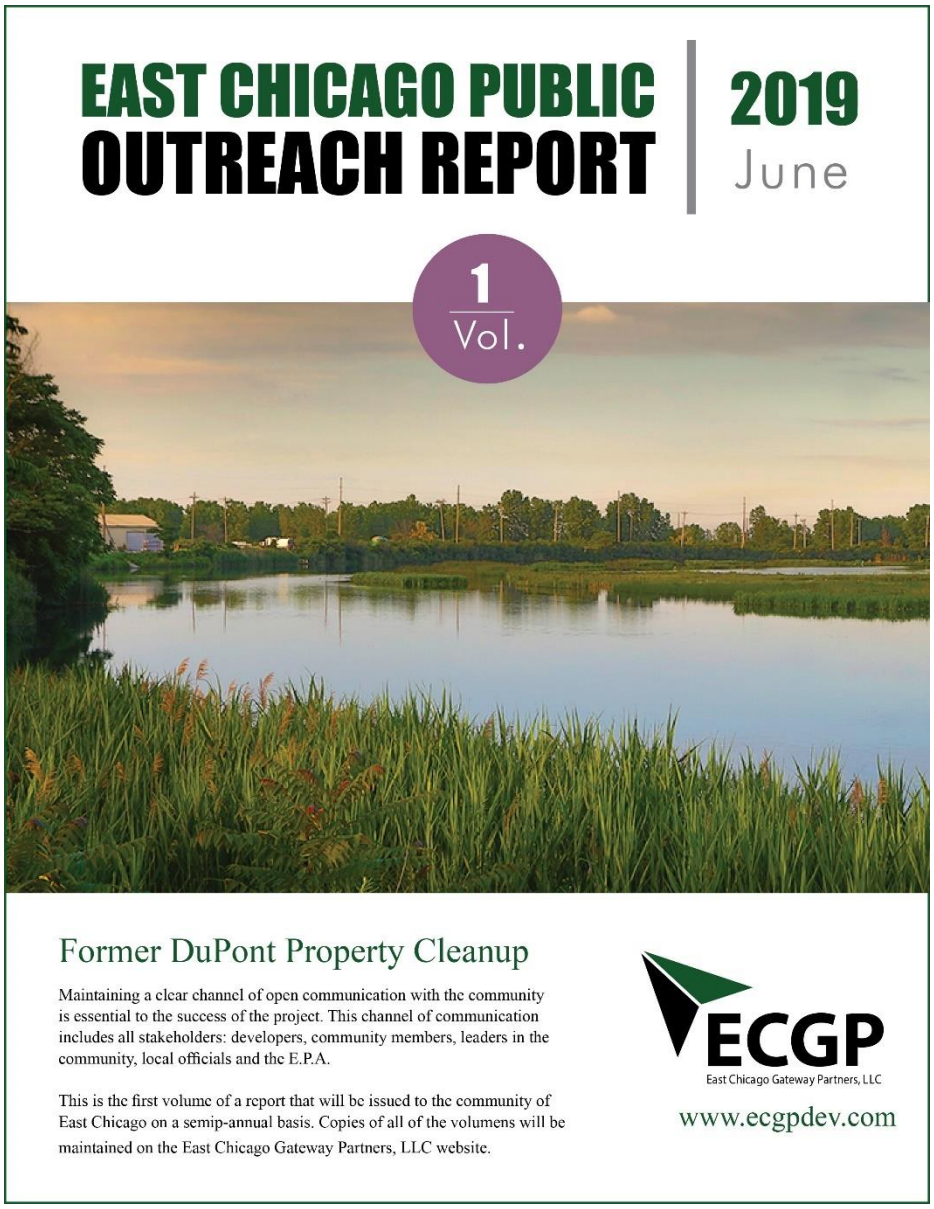
Written Questions or Comments

Questions and/or comments from the Community to the Project Team can be made at any time utilizing the USMAIL or parcel service. All questions and comments will be reviewed by the Project Team (minimally the ECGP Project Manager and the USEPA Project Manager). Where an answer is prompted, an answer to the question will be provided in either: 1) correspondents where a return address is provided; or 2) in the subsequent Public Outreach Report that will restate the question and provide an answer. Where comments are made, the comment will be restated and addressed in the subsequent Public Outreach

Report. The Project Team reserves the right to bundle similar questions and comments for a more generalized response, where appropriate.

Public Outreach Reports

Progress reports and newsletters keep the public informed and up-to-date. A Semi-annual Public Outreach Report will be issued by the Property owners (ECGP) to update Corrective Measure progress, present Reportable Metrics (see below), provide Self-Assessment and Planning adjustments, provide notice of upcoming informational meetings, present any changes to the scope of the Corrective Measures and provide for any explanation of significant differences, address public comment received by the Project Team (across all media). A presentation of the typical cover for such a publication is provided below.



Mass Mailers

Mass mailers will be sent using the US Postal Service commercial marketing mail, "*Every Door Direct Mail"* service. The service covers entire zip codes and can be adjusted and customized to approach commercial and residential buildings and homes. The mass mailer will be on a standard Postcard size sheet. Mailers will be clearly distinguishable with the name of the recipient legible on the mailer envelope. This adjustment is necessary as previous information mailed reportedly looked like "junk mail" and was often reported discarded. Mailers will be in English on one side and Spanish on the other.

With the assistance from the USEPA and Community leaders, the mailing list will be consistently updated. Through that list, the channel of communication from the Project Team will be delivered. Not only will the Corrective Measures be communicated but the redevelopment benefits to the City of East Chicago will be explained. The community outreach will be monitored and reported to the USEPA on a quarterly basis as and included within Public Outreach Reports prepared by Impact Environmental (see **Public Outreach Reports** above). In addition to the USPS direct mail service to local residents and businesses, the mass mailers will be provided to interested parties that include representatives of consumer, environmental, faith, and minority associations; television and radio, trade, industrial, agricultural, and labor organizations; public health, scientific, and professional societies; civic associations; public officials; and governmental and educational associations provided in the Community Contacts (Exhibit 1).

Flyposting

Flyposting or bill posting is a marketing tactic involving the placement of advertising posters in legal places such as the Property fence line, public billboard locations, private property spaces authorized by the owner and Community posting venues. Modern printing techniques enable the posters to feature full-color designs, halftones, and photographs, making them popular for increasing viewer interest and deliver content on Property-related events. The posters will have stylized in content in English and Spanish presenting important information on the progress of the Project, any necessary safety concerns that need to be conveyed or notification of informational meetings.

Informational Meetings

Informational meetings with the community will be held annually in June, or as prompted by the list of events presented in the Active Communication Measures Schedule (below), at a time and location that is easily accessible and functionally appropriate (for size and the content of presentation). The informational meetings will be inclusive, promote open communication that includes active-listening, will present honest information, and will be responsive. Notice of the meetings will be presented through the passive measures and in active measures (mailers, flyposting and the Community Outreach Reports).

Like all the communication venues being provided under this Community Participation Plan, it will be presented in a manner as to avoid any bias in content or participation by any individual or group of peoples based upon age, race, resident status, ethnicity or religion. Participation will not require a sign-in or a presentation of credentials for participants to take part in asking questions or making comments.

Environmental Justice

Environmental justice issues will be properly considered during the decision-making and community involvement process regarding cleanup actions at the Facility. ECGP will ensure that all people, regardless of race, color, national origin, or income, have equal access to public information during cleanup of the Facility, and are afforded the same level of protection from environmental and health hazards as is required by EPA.

Public Outreach Events

ECGP will have representation at environmental themed events as they are scheduled throughout the Corrective Measures activities. Where possible, ECGP will secure a booth or dedicated location at the event to provide information to the Community about the Facility, its Corrective Measure activities and redevelopment. This will include an attractive display of flypostings, distribution of current and back issues of the Community Outreach Reports, distribution of Fact Sheets, signup for inclusion on the Community Contacts list and information on upcoming informational meetings. Additionally, representatives of ECGP will be at the event to answer questions from members of the Community. At a minimum, ECGP will partake in the City of East Chicago, Earth Day Event held in April of each year (starting in 2020).

Observation Area

Due to expected heavy vehicle traffic at the Project onset and the presence of an increased contaminant exposure potential during hot spot excavation and off-site transport, an Observation Area for the Community to view the Property will not be initially available. It is expected that as the Project progresses and the contaminated surface areas of the Property have been covered with the required earthen protective barrier, an Observation Area will be possible, and safe. At this time, it is expected that such an area would be located along Kennedy Avenue and would include parking for a minimum of 25 vehicles, including 3 buses, a means to view the extent and progress of remedial activities and an informational billboard setup that presents some of the technical aspects of the completed and planned remedial efforts. The area would be open for adults and properly supervised minors and will require execution of a waiver of liabilities with the Project Team. Where Community is accessing this area for educational purposes, a Project Team representative can be made available to guide the visit and answer questions.

Final decisions with respect to the need to provide for such an area will be driven by Community comment and the Project Team's ability to create an area that has adequate safety measures to prohibit exposures to Property-related contaminants.

Active Communication Measures Schedule

Fact Sheets	Routine Event	Event Prompt
Responses to Questions & Comments	On-Demand	Not Event Prompted

Fact Sheets	Routine Event	Event Prompt
Mass Mailers	Annual; March	Changes to CMI Implementation Work Plan; Completed Corrective Measure activities; Proposed Interim Remedial Measures
Community Outreach Event	Annually on East Chicago Earth Day; April	As Environmental Themed Events are Scheduled in the Community
Community Outreach Reports	Semi-Annually; June and December	Not Event Prompted
Informational Meetings	July	Changes to CM Implementation Work Plan; Completed CM activities; Proposed Interim Remedial Measures; Poor Community Assessment Grade
Flyposting	Annually; September	2 Weeks Before any Public Meeting; New or Predictive Safety Concerns
Observation Area	Not Scheduled Yet (potentially, on-demand)	As Property Becomes Safe for Visitors; Updated in Community Outreach Reports

Self-Assessment of Participation Activities

The Project Team must be able to assess the need for changes to the Community Participation Plan as the Project continues. The self-assessment is intended to increase the likelihood of successful public outreach by aligning Community participation goals with the ongoing ability to implement a strategy.

A self-assessment section will be included in each Public Outreach Report. The section will include subsections as follows:

Record Keeping

Maintain a running list of Public Participation activities and goals that were performed in the past and continue to add to the running list and provide with public notifications and Public Outreach Reports.

Shortfall Identification

Assess if goals were adequately met; determine which goals, if any, were not accounted for by past activities; note any major strengths or weaknesses of past activities. Adjust for technology changes that provide new opportunities to enhance Public Participation. Adjust as necessary for regulatory changes that apply to the Project.

Adjustments

Make adjustments to plan to compensate for any identified shortfalls. Document adjustments and provide the information in Public Outreach Reports.

Reportable Metrics

Community health information that is collected before and during the performance of Project-related activities will be summarized in a Public Outreach Reports. Such data will include the following.

Security

The number of unauthorized access incidents will be compiled. This will include break-ins; acts of vandalism and trespassing.

Traffic

The number of licensed vehicle failure incidents will be compiled. This will include instances where the facility transportation plan is not followed, accidents, moving violation citations issued by law enforcement and incidents causing hazardous substance releases.

Air Quality

The number of times where air quality was measured to be compromised due to Project-related activities. This will include instances of dust detection or chemical detection events detected at perimeter community air monitoring stations above the Community Air Monitoring Plan (part of the CMI Work Plan) action levels.

Injuries

The number of times where injuries are reported on the Property. This will include injuries and incidents where employees or visitors sustain minor or major injuries from Project-related activities.

Water Quality

Upon implementation of the long-term groundwater monitoring and maintenance program (post remediation), the number of times where water quality was measured to be compromised due to Project-related activities. This will include instances of water contamination of heavy metals at concentrations above ambient groundwater quality standards.

Community Assessment of Participation Activities

Getting feedback from the Community on how well the Community Participation Plan is designed and being executed will be done by the Project Team. This maintains two-way lines of communication between the Community and the Project Team. This will be performed by the annual issuance of a performance survey that will be issued by mail to the Assessment list. The survey will prompt recipients for feedback that will allow the Project Team to make modifications or remedy deficiencies as noted.

Actions or changes made to the Community Participation Plan that are based upon comments received from the survey will be highlighted in subsequent Public Outreach Reports.

In that the survey includes a means to grade the perceived performance of the Project Team for both remedial performance and participation criteria, it will be a goal of the Project Team to maintain a “C” grade or better. Failure to maintain a “C” grade or better will result in an internal action by the Project Team to add to or omit activities in attempt to raise that grade in subsequent surveys. Continuance of a “C” grade for more than two surveys will prompt a Public Meeting whereby the issue is addressed and the Community can be solicited for ideas on how best to improve conditions to a higher grade (i.e. C+, B, B+, A-, A or A+).

Figure 1

Site Areas Map

Former DuPont East Chicago Facility



Figure 1 – Site Areas

Exhibit 1

Community Contacts

Former DuPont East Chicago Facility

Community Contacts				
Organization	**Address**	**Municipality**	**Zip Code**	**Phone #**
Public Service/Community Centres				
East Chicago Public Library	1008 W Chicago Ave	East Chicago	46312	(219) 397-5505
East Chicago Public Library	2401 E Columbus Drive	East Chicago	46312	(219) 397-2454
McGuire Memorial Library	4321 Fir Street	East Chicago	46312	(219) 392-7230
151st Street Library Center	4925 Gladiola Avenue	East Chicago	46312	(219) 397-3241
Hammond Public Library	564 State Street	Hammond	46320	(219) 931-5100
The Univesity Library	2200 169th Street	Hammond	46323	(219) 989-2224
151st Street Library Center	4925 Gladiola Avenue	East Chicago	46312	(219) 397-3241
Ivy Tech Community College	410 E Columbus Drive	East Chicago	46312	(219) 392-3600
Carrie Gosch Elementary School	455 E 148th Street	East Chicago	46312	(219) 391-4172
George Washington Elementary School	1401 E 144th Street	East Chicago	46312	(219) 391-4169
Indiana Harbor Catholic School/Lighthouse Academies	3916 Pulaski St	East Chicago	46312	(219) 378-7450
Purdue University Northwest Hammond Campus	2200 169th Street	Hammond	46323	(219) 989-2400
East Chicago Urban Enterprise Academy (ECUEA)	1402 E Chicago Ave	East Chicago	46312	(219) 392-3650
Joseph L. Block Middle School	2700 Cardinal Dr	East Chicago	46312	(219) 391-4084
East Chicago Central High School	1100 W Columbus Drive	East Chicago	46312	(219) 391-4100
Ivy Tech Community College	410 E Columbus Drive	East Chicago	46312	(219) 392-3600
Communities in Schools of East Chicago	100 W Chicago Avenue	East Chicago	46312	(219) 378-9114
Munster Community Park Social Center	8751 Lions Club Drive	Munster	46321	(219) 836-7275
Block Stadium	1601 E 144th Street	East Chicago	46312	(219) 381-6000
Bessie Owens Recreation Center	4001 Alexander Avenue	East Chicago	46312	(219) 391-8478
Indian Harbor East Chicago Lions Club	4233 Homerlee Avenue	East Chicago	46312	(219) 902-6459
The church of st raphael the archangel	8751 Lions Club Drive	Munster	46321	(219) 798-3331
Columbian Club of East Chicago	1104 Knights of Columus Drive	East Chicago	46312	(219) 398-6700

Community Contacts				
Organization	**Address**	**Municipality**	**Zip Code**	**Phone #**
Knights of Columbus	3916 173rd Street	Hammond	46323	(219) 845-9760
Biological Sciences; chemistry; civil engineering; construction engineering and management technology - Environmental Health and Safety				
St. Catherine Hospital	4321 Fir Street	East Chicago	46312	(219) 392-1700
Lake Nursing and Rehabilitation	5025 McCook Avenue	East Chicago	46312	(219) 397-0380
Okolocha Medical Clinic	701 E Chicago Avenue	East Chicago	46312	(219) 398-0700
Immanel Family Health Center	915 W Chicago Avenue	East Chicago	46312	(219) 397-6000
St. Margaret Mercy	2001 E Columbus Dr	East Chicago	46312	(219) 378-9284
Franciscan Health	5454 Hohman Ave	Hammond	46320	(219) 932-2300
St. Joseph's Carmalite Home	4840 Grasselli Street	East Chicago	46312	(219) 397-1085
Martin Luther King Center	4802 Melville Avenue	East Chicago	46312	(219) 391-8481
Boys and Girls Clubs NW Indiana	2009 E 138th Street	East Chicago	46312	(219) 398-1344
Foundation of East Chicago	100 W Chicago Avenue, #B,	East Chicago	46312	(219)-392-4225
Home Builders Association of Northwest Indiana	800 E 86th Avenue	Merriville	46410	(888) 812-2944
Northwestern Idniana Building and Construction Trades	6570 Ameriplex Drive	Portage	46368	(219) 762-2951
Habitat for Humanity of Northwest Indiana	3777 Colfax Avenue	Gary	46408	(219) 923-7265
Hijos De Borinquen Association	1411 Broadway Street	East Chicago	46312	(219) 354-0741
Lakeshore Chamber of Commerce	5246 Hohman Avenue	Hammond	46320	(219) 931-1000
East Chicago Urban Enterprise Association c.	PO Box 378, East Chicago	East Chicago	46312	(219) 392-3660
East Chicago Business Development	4444 Railroad Avenue	East Chicago	46312	(219) 391-8205
Lakeshore Public Media	8625 Indiana Place	Merrillville	64410	(219) 756-5656
Faith-Based				
Our Lady of Perpedual Help Church	7132 Arizona Avenue	Hammond	46323	(219) 844-3438

Community Contacts				
Organization	**Address**	**Municipality**	**Zip Code**	**Phone #**
Holy Trinity Hungarian Roman Catholic Church	4759 McCook Ave	East Chicago	46312	(219) 397-1907
Saint Patrick's Roman Catholic Church	3802 Grand Boulevard	East Chicago	46312	(219) 398-1036
Our Lady of Guadalupe Church	3510 Deodar St	East Chicago	46312	(219) 398-0253
Saint Stanislaus Roman Catholic Church	808 W. 150th st	East Chicago	46312	(219) 398-2341
Peace Protestant Reformed Church	14864 101st Ave	Dyer	46311	(219) 440-3967
Calvary United Protestant Church	425 N Orchard Dr	Park Forest, IL	60466	(708) 748-6261
Iglesia Del Nazareno E Chicago Church	919 W Chicago Ave, East Chicago 46312	East Chicago	46312	(219) 398-4388
Beth AME Church	6155 Ray Ave, Hammond	Hammond	46230	(219) 931-6122
Congregation B'nai Isreal Temple	400 North Edglawn Drive	East Chicago	46312	630-892-2450
Congregation Beth Shalom Synagogue	3433 Walters Ave	Northbrook , IL	60062	(847) 498-9160
Chabad Lubavitch of Northwest Indiana	1113 Ridge Rd	Munster	46321	(219) 513-0327
Al-Amin Mosque	3702 W 11th Ave	Gary	46404	(219) 949-1854
Illiana Islamic Association	9608 Spring St	Highland	46322	(212) 924-2940
Gary Masjid Mosque	1473 W 15th Ave	Gary	46407	(219) 885-3018
First Baptist Church Hammond	473 Sibley St,	Hammond	46320	(219) 932-0711
Macedonia Baptist Church	4901 Melville Ave	East Chicago	46312	(219) 397-1678
First Baptist Church East Chicago	4911 McCook Ave	East Chicago	46312	(219) 398-0758
Friendship Missionary Baptist Church	4756 Melville Ave	East Chicago, IN	46312	(219) 397-1107
Second Baptist Church	3939 Deodar St	East Chicago	46312	(219) 398-4322
New Starlight Baptist Church	3839 Guthrie St	East Chicago	46312	(219) 398-1493
Tabernacle Baptist Church	3715 Butternut St	East Chicago	46312	(219) 398-2943
Hessville Baptist Church	6423 Arizona Ave	Hammond	46323	(219) 844-6523
New Community Baptist Church	5461 Calumet Ave	Hammond	46320	(219) 931-8407
New Hope Missionary Baptist Church	1117 Merrill St	Hammond	46320	(219) 932-5954
Mt. Zion Baptist Church	1047 Kenwood St	Hammond	46320	(219) 931-4337

Community Contacts				
Organization	**Address**	**Municipality**	**Zip Code**	**Phone #**
Holy Trinity Croatian Church	4754 Carey St	East Chicago	46312	(219) 398-3061
The Cross Church	455 E 148th St	East Chicago	46312	(219) 397-0023
East Chicago Church of Indiana	4429 Olcott Ave	East Chicago	46312	(219) 354-0710
St Mark AME Zion	4200 Alder St	East Chicago	46312	(219) 398-4653
St Stanislaus Church	808 W 150th St	East Chicago	46312	(219) 398-2341
St. Mary's Church	802 W 144th St	East Chicago	46312	(219) 398-2409
Antioch Missionary Baptist Church	3902-06 Alexander Ave	East Chicago	46312	(219) 398-2589
St George Serbian Church	4021 Elm St	East Chicago	46312	(219) 397-0240
Greater Destiny Bible Church	1920 E Columbus Dr	East Chicago	46312	(219) 398-2006
Harvest Apostolic Church	502 W 142nd St	East Chicago	46312	(219) 397-1112
Goodwill Christian Church	5119 Indianapolis Blvd	East Chicago	46312	(219) 397-6771
St. Nicholas Parish	4309 Olcott Ave	East Chicago	46312	(219) 398-3760
The church of st raphael the archangel	8751 Lions Club Dr	Munster	46321	(219) 798-3331
Art and Cultural Counsels				
Arts Alliance Illinois	70 East Lake, Suite 420	Chicago, IL	60601	(312) 855-3105
South Shore Arts	1040 Ridge Rd	Munster	46321	(219) 836-1839
Arts & Business Council of Chicago	100 S State St 4th Floor	Chicago, IL	60611	(312) 372-1876
News/Media Outlets				
NWI Times	601 W. 45th Avenue	Munster, IN	46321	(219) 933-3249
	Andrew Steele	(219)-933-3241	ew.steele@nwi.com	
	Lauren Cross	(219)-933-3206	en.cross@nwi.com	
	Sarah Reese	(219) 933-3351 a	h.reese@nwi.com	
Chicago Post-Tribune	posttribuneservice@tribpub.com			(219) 318-1111
Indiana Public Media	1229 E 7th St	Bloomington	47405	RADIO: (812) 855-1357
Indiana Public Media	1230 E 7th St	Bloomington	47405	TV: (812) 855-5900

Community Contacts				
Organization	**Address**	**Municipality**	**Zip Code**	**Phone #**
Inside Indiana Business	1630 North Meridian Street, Suite 400	Indianapolis	46202	(317) 472-7355
Daily Herald	155 E. Algonquin	Arlington Heights, IL	60005	(847) 427-4300
The Journal Gazette	600 W. Main St	Fort Wayne	46802	(260) 461-8773
Radio Stations				
Indiana 105.5 FM	2755 Sager Road	Valparaiso	46383	(219) 462-6111
Lakeshore Public Radio (NPR)	8625 Indiana Place	Merrillville	46410	(219) 756-5656
WBEZ 91.5 FM	848 E Grand Ave	Chicago IL	60611	(312) 948-4600
WJOB Network	7150 Indianapolis Blvd	Hammond	46324	(219) 845-1100
Environmental Action and Conservation Groups				
The Nature Conservancy	8 S Michigan Ave	Chicago, IL	60603	(312) 580-2100
National Wildlife Federation	11100 Wildlife Center Drive	Reston, VA	20190	media@nwf.org
Hoosier Environmental Council	3951 N Meridian St # 100	Indianapolis	46208	(317) 685-8800
TV/Cable Stations				
ABC 7 Chicago	190 North State Street	Chicago Illinois	60601	(312) 750-7777
Community Groups				
East Chicago Calumet Coalition	Not published for privacy and security purposes.			
Calumet Lives Matter	Not published for privacy and security purposes.			
Community Strategy Group	Not published for privacy and security purposes.			
Housing and Urban Development Entities				
East Chicago Housing Authority (ECHA)	Main Office: 4444 Railroad Ave.	East Chicago	46312	(219) 397-9974
Economic Authorities				
City of East Chicago Planning & Economic Development Department	4525 Indianapolis Boulevard	East Chicago	46312	(219) 391-8205
Lakeshore Chamber of Commerce	5246 Hohman Avenue Suite 100	Hammond	46320	(219) 937-8778

Community Contacts				
Organization	**Address**	**Municipality**	**Zip Code**	**Phone #**
Hammond Economic Development	5925 Calumet Avenue	Hammond	46320	(219) 853-6508
Industry Representatives				
ArcelorMittal Indiana Harbor (metal refinery)	3210 Watling St	East Chicago	46312	(219) 399-1200
American Precision Services (machinist)	7110 W 21st Ave	Gary	46406	(219) 977-4451
Allard Truck Rental	8820 Indianapolis Blvd	Highland	46322	(219) 838-0200
Actin Inc (demolition contractor)	1102 E Columbus Dr	East Chicago	46312	(219) 397-5020
Eichhorn & Eichhorn, LLP	2929 Carlson Dr #100	Hammond	46323	(219) 931-0560
CliftonLarsonAllen LLP	833 West Lincoln Highway, Suite 315W	Schererville 46375	46375	(219) 864-7300
Horseshoe Casino	777 Casino Center Drive	Hammond	46320	(219) 473-6109
Calumet Lumber c.	402 E. Chicago Avenue	East Chicago	46312	(219) 397-2345
REGIONAL Federal Credit Union	7144 Kennedy Avenue	Hammond	46323	(219) 989-7203
Professional Locomotive Services	4949 Huish Dr	East Chicago	46312	(219) 398-9123
Van Til's Supermarket	2635 169th Street	Hammond	46323	(219) 844-5415
First Midwest Bank	10322 Indianapolis Blvd	Highland	46322	(708) 385-4162
Ameristar East Chicago Casino Hotel	777 Resorts Blvd.	East Chicago	46312	(219) 378-3306
Northern Indiana Public Service Co. (NIPSCO)	1500 165th Street	Hammond	46320	(219) 853-4405
BP Whiting Business Unit	PO Box 710	Whiting	46394	(219) 473-7700
Grant Writers				
Foundations of East Chicago General Operating Grants	100 W. Chicago Avenue	East Chicago	46312	(219) 392-4225
Resident List - East Chicago Zip Code 46312				
Note: The residential contact list is not published for privacy and security purposes.				

Exhibit 2

Project Team Contacts

Former DuPont East Chicago Facility

Project Team Contacts

Project Team	Title	Organization	Telephone Number	E-mail Address
Jennifer Dodds	Project Manager	EPA, Region 5	Office: (312) 886-1484	dodds.jennifer@epa.gov
Richard Parish	Project Administrator	ECGP	Office: (631) 805-8900	rich@impactenvironmental.com
Kevin Kleaka	Project Manager	Impact Environmental	Office: (631) 269-8800 x129	kkleaka@impactenvironmental.com
Daniel Fruhauf	Assistant Project Manager	Impact Environmental	Office: (631) 269-8800 x141	dfruhauf@impactenvironmental.com
Chris Tripoli	Field Operations Manager	Impact Environmental	Mobile: (201) 268-5686	ctripoli@impactenvironmental.com
Michael Bluight	Quality Assurance Manager	Impact Environmental	Office: (516) 269-8800 x118	mbluight@impactenvironmental.com
Xin Yuan	Quality Control Manager	Impact Environmental	Office: (516) 269-8800 x111	xyuan@impactenvironmental.com
Mr. John Smith	Field Team Leader	Impact Environmental	Mobile: (570) 817-2636	jsmith@impactenvironmental.com