FEASIBILITY STUDY
FORMER MANUFACTURING PLANT AREA
SHERWIN-WILLIAMS/HILLIARDS CREEK SITE

GIBBSBORO, CAMDEN COUNTY, NEW JERSEY
ADMINISTRATIVE ORDER INDEX NO. II CERCLA-02-99-2035

Prepared for:

The Sherwin-Williams Company
101 Prospect Avenue
Cleveland, Ohio

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Prepared by:

The ELM Group, Inc.
345 Wall Street, Research Park
Princeton, NJ 08540-1518
www.Explore**ELM**.com

565477

EXECUTIVE SUMMARY

Pursuant to Administrative Order on Consent (AOC) Index No. II CERCLA-02-99-2035, The Sherwin-Williams Company (Sherwin-Williams) is submitting to the United States Environmental Protection Agency Region 2 (EPA) this Feasibility Study (FS) for the Former Manufacturing Plant (FMP) area of the Sherwin-Williams/Hilliards Creek Site, located in Gibbsboro, Camden County, New Jersey. The FMP FS follows the February 2018 *"Former Manufacturing Site Remedial Investigation Report, Soil, Sediment, Surface Water, Pore Water and Vapor Intrusion, Sherwin-Williams/Hilliards Creek Superfund Site, Former Manufacturing Plant Area"* (FMP RIR, the March 2018 Baseline Ecological Risk Assessment, and October 2017 Human Health Risk Assessment. The FMP area was incorporated into the Hilliards Creek Site in 2007, and the Hilliards Creek Site was listed on the National Priorities List (NPL) in 2008.

The objective of this FS is to evaluate alternatives for the remediation of soil, sediment, soil gas and surface water at the FMP and, based on site conditions and regulatory criteria, evaluate the alternatives according to seven criteria set forth in the National Contingency Plan (NCP). Based on the evaluation of alternatives presented in this FS, and consideration of two additional criteria, the EPA will present alternatives, as well as the preferred remedy, in a Proposed Plan. Following a period of public comment on the Proposed Plan, the EPA will issue a Record of Decision (ROD) finalizing selection of the remedy for the FMP.

This FS evaluates remedial alternatives for both the FMP and the "Eastern Off-Property Area", located east of United States (U.S.) Avenue from the FMP. The environmental media addressed at the FMP are surface and subsurface soils, sediment, surface water, and soil gas that may represent risks to building occupants. Within, but separate from, the soil medium is an area of Light Non-Aqueous Phase Liquid (LNAPL) for which remedial alternatives are also evaluated. The environmental medium of concern for the Eastern Off-Property Area is LNAPL found in the saturated soil matrix.

At EPA's direction, remedial alternatives for groundwater will be included in a future, separate FS. However, one of the Applicable or Relevant and Appropriate Requirements (ARARs) for soil is to remove or contain sources of groundwater contamination to the extent practicable. A similar ARAR exists for LNAPL. Therefore, the evaluation of the remedial alternatives for soil at the FMP includes an assessment of whether sources of groundwater contamination are controlled, and whether LNAPL will be removed or contained to the extent practicable. The evaluation of remedial alternatives for the Eastern Off-Property Area includes an assessment of whether the LNAPL has been removed or contained to the extent practicable.

The FMP is a large area that, for purposes of this FS, has been divided into five separate study areas:

1. Former Main Plant: This is the northwest part of the site. It includes the former Tank Farm B subarea (the current location of the 7 Foster Avenue building), the building slab of the former 6 East Clementon Road building, the parking area west of the 2 and 4 Foster Avenue buildings, the 10 Foster Avenue building, and the Silver Lake conveyance system, which is located beneath the parking area.

2. The Former Resin Plant and Tank Farm A: This is the area immediately north of Foster Avenue and west of United States (U.S.) Avenue. The area includes the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings and the building slab from the former "red barn".

3. The Seep Area: This is the area south of Foster Avenue, west of U.S. Avenue and east of Hilliards Creek. This area includes the 1 and 5 Foster Avenue buildings.

4. Upper Hilliards Creek: This is Hilliards Creek and its floodplain beginning at Foster Avenue and ending at West Clementon Road. To the east is the Seep Area and to the west are residential properties B-1 through B-8, which have been the subject of a prior remedial action.

5. The Former Lagoon Area. This is the area where the former wastewater lagoons were located. It is south of the Seep Area, east of Hilliards Creek and west of U.S. Avenue. The cemetery is immediately south of this area.

The Eastern Off-Property Area consists of seven properties located east of U.S. Avenue from the FMP: the former tavern/service station property at the corner of U.S. Avenue and Berlin Road that is currently vacant, and the properties located along U.S. Avenue designated as E-1, E-7, E-8, E-9, E-10 and E-11 in the "*Residential Properties Remedial Investigation Report*" (Weston, 2015).

Silver Lake and the portion of Hilliards Creek south of West Clementon Road will be included in the future Waterbodies Unit FS.

This FS is based upon information collected by Sherwin-Williams under oversight of the EPA Remediation Branch and specific information collected in 2003–2004 by Sherwin-Williams under the oversight of the EPA Removal Branch. During these time periods, an extensive investigation of soil, sediment surface water, pore water, soil gas and indoor air was conducted, providing a detailed understanding of Site conditions. Based on the information collected during the investigations, a Human Health and Risk Assessment (HHRA) was prepared.

Sherwin-Williams provided to EPA the results of the investigations in the FMP RIR. The FMP RIR compared the results of the investigation to established criteria to determine if the nature and extent of contamination had been adequately defined. These criteria are:

- Soil samples were compared to the New Jersey Department of Environmental Protection (NJDEP) Residential Direct Contact Soil Remediation Standards (RDCSRS). Comparison to the NJDEP Impact to Groundwater Soil Remediation Standards (IGWSRS) was not conducted in the RIR, but compliance with these standards is evaluated for the soil remedial alternatives in the FS.

- Surface water and pore water sample results were compared to the NJDEP chronic surface water criteria for fresh water (FW2) aquatic protection, NJDEP's ecological screening criteria, or applicable federal screening levels.

- Sediment samples were compared to the NJDEP Lowest Effects Level (LEL) for freshwater sediment as updated in NJDEP's March 2009 Ecological Screening Criteria.

- Soil gas and indoor air samples were compared to the NJDEP Non-Residential Soil Gas Screening Levels (NRSGSL) and Non-Residential Indoor Air Screening Levels (NRIASL), respectively.

A Baseline Ecological Risk Assessment (BERA) was conducted for sediment and soil in Upper Hilliards Creek and soil in the Former Lagoon Area. Based on the BERA results, Preliminary Remediation Goals (PRGs) were developed for sediment and soil in these areas.

Sherwin-Williams conducted additional studies at the FMP following submission of the RIR. Additional groundwater monitoring wells have been installed and additional groundwater samples have been collected. Sherwin-Williams also conducted an extensive study of the nature and extent of the LNAPL, its potential for recoverability and evidence of degradation processes. The results of these investigations were provided to EPA in the *"LNAPL Investigation Report, Former Manufacturing Plant Area, Gibbsboro, New Jersey"* (LNAPL Report; EHS, 2018a and 2018b). Finally, additional sub slab sampling has been conducted at property E-1 on the Eastern Off-Property Area. The results of these post-RIR studies are included, as appropriate, in evaluating alternatives for soil and LNAPL.

The understanding of Site conditions used to evaluate remedial alternatives has been developed from the RIR, the LNAPL Report, the ongoing groundwater RI, and the BERA. Key findings are summarized below.

Light Non-Aqueous Phase Liquid

LNAPL is found in the subsurface in the former Resin Plant/Tank Farm A and Seep Areas on the FMP, and on the Eastern Off-Property Area. LNAPL is also present beneath Foster Avenue and U.S. Avenue. Key findings regarding the LNAPL as presented in the LNAPL Report that apply to all locations where the LNAPL is present are:

- The LNAPL consists primarily of degraded mineral spirits. It contains some benzene and naphthalene, along with volatile organic compound (VOC) and semi-volatile organic compound (SVOC) tentatively identified compounds (TICs). In some locations where the LNAPL is present, benzene and/or naphthalene is found in soil at concentrations greater than the RDCSRS.

- The vast majority of LNAPL is trapped in the soil pores of the fine-grained sands beneath the water table and, even under high pressures, the LNAPL cannot be removed from the soil pores.

- The LNAPL is present at low saturation levels. As such, it is generally neither mobile nor recoverable. Localized recovery is ongoing in the Seep Area, but the recovery volumes are decreasing. No recovery efforts or measurements of saturation have been conducted beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings.

- The LNAPL is undergoing biodegradation. This is documented by the presence of methane and other vapors in the soil beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings. Biodegradation rates for the LNAPL are likely limited by the absence of important nutrients such as nitrate/nitrite and sulfate/sulfide.

- The LNAPL is the source of dissolved-phase VOCs and SVOCs in groundwater. However, the extent to which dissolved-phase VOCs and SVOCs are present at concentrations greater than the NJDEP Groundwater Quality Standards (GWQS) is

stable, and there is conclusive evidence that the dissolved-phase constituents are undergoing biodegradation.

Former Main Plant Area

- The majority of the area is currently covered by an impermeable cap consisting of buildings and associated parking areas that prevents direct contact with constituents in soil.

- South of Foster Avenue, near the 7 Foster Avenue building:

    - Arsenic, lead and PAHs are found at concentrations greater than the RDCSRS in surface and subsurface soil.

    - Pentachlorophenol is found at concentrations greater than the RDCSRS in soil samples collected south of the 7 Foster Avenue building.

    - There is no evidence of LNAPL on this portion of the FMP.

- North of Foster Avenue and west of the 2 and 4 Foster Avenue buildings:

    - Arsenic, lead and/or PAHs are found at concentrations greater than the RDCSRS from the surface (0.0' – 0.5') to approximately five to six feet bgs throughout much of the area. Arsenic is found at concentrations greater than the RDCSRS at depths of up to 15 feet below ground surface (bgs) beneath the southern and southeastern portion of the 6 East Clementon Road building slab.

    - PCBs, primarily aroclor 1260, are found at concentrations greater than the RDCSRS at depths of up to six feet bgs in locations adjacent to and west of the Silver Lake conveyance system. PCBs are found at concentrations greater

than 50 mg/kg at three locations near the center of the Silver Lake conveyance system.

- There is evidence of LNAPL on the west side of the 2 Foster Avenue building, where naphthalene was found at concentrations greater than the RDCSRS.

- Arsenic is present at a concentration greater than the NJDEP GWQS in shallow monitoring well MPMW0049, located south of the 6 East Clementon Road building slab, and MPMW0032, located north of Foster Avenue and east of the Silver Lake conveyance system.

Former Resin Plant/Tank Farm A Area

- The Former Resin Plant/Tank Farm A area is the presumed source of the LNAPL present in this area and the Seep Area south of Foster Avenue.

- The majority of the area is covered with an impermeable cap consisting of the 2 and 4 Foster Avenue buildings, 3 U.S. Avenue building and associated parking areas. A soil cover is present in the northeast portion of the area.

- The shallowest depth at which constituents are present at concentrations greater than the RDCSRS is 3.5' – 4.0' bgs, and the majority of exceedances of the RDCSRS are associated with the presence of LNAPL in the saturated zone.

- The LNAPL and associated constituents in soil gas are the primary focus of remedial alternatives for this area. In addition to the general conclusions regarding all of the LNAPL at the FMP, the following specific conclusions are applicable to the LNAPL in this area:

    - The LNAPL extends horizontally from the former stacks located adjacent to Silver Lake to the north and west, along U.S. Avenue to the east, and to Foster Avenue to the south;

- Based on the presence of methane in soil gas, the LNAPL is likely present beneath a portion of the 4 Foster Avenue and 3 U.S. Avenue building, and all of the 2 Foster Avenue building;

- In locations where soil borings and groundwater wells have been installed, the LNAPL extends vertically from the water table (approximately 10' bgs) to as deep as 25 feet bgs. No soil sampling has been conducted beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings. Therefore, the depth and thickness of the LNAPL in those areas cannot be definitively established. However, since former Tank Farm A is the presumed source of the LNAPL, it is expected that the vertical distribution beneath the buildings is similar to that in former Tank Farm A.

- The only well in this area in which measurable LNAPL is currently observed is MW-11. It is generally observed as a sheen, and no recovery is conducted. As discussed above, no soil or groundwater sampling has been conducted beneath the 2 and 4 Foster Avenue or 3 U.S. Avenue buildings.

Seep Area

The Seep Area is the location where interim actions were previously conducted to mitigate and prevent discharges to Upper Hilliards Creek. In addition to the general conclusions applicable to all of the LNAPL at the FMP, the following specific conclusions are applicable to the Seep Area:

- The LNAPL in the Seep Area extends from Foster Avenue in the north to U.S. Avenue in the east, to Upper Hilliards Creek to the west, near Foster Avenue and beneath the 5 Foster Avenue building. No soil sampling has been conducted beneath the 1 Foster Avenue building, but based on other data, some LNAPL may be present beneath the southeast corner of the building.

- Vertically, the LNAPL within the Seep Area is first encountered at the water table and extends approximately five feet into the saturated zone.

- The key difference between the LNAPL in the Seep Area and the LNAPL in the Former Resin Plant/Tank Farm A Area is that the LNAPL in the Seep Area is more accessible. The depth to the LNAPL is shallower in the Seep Area than within the former Resin Plant/Tank Farm A Area, and based on the current understanding of its distribution, the LNAPL in the Seep Area is not extensively present under buildings, while in the Former Resin Plant/Tank Farm A Area, the LNAPL is present beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings.

- LNAPL recovery is ongoing within a small area of the Seep Area, but recovery volumes are declining.

Former Lagoon Area

- The primary constituent found in soil at a concentration greater than the RDCSRS in the Former Lagoon Area is pentachlorophenol.

- The highest concentrations of pentachlorophenol are located in the northwest portion of the former lagoon area, where pentachlorophenol concentrations in saturated soil ranged from 140 mg/kg to 650 mg/kg.

- Pentachlorophenol is also found in groundwater at concentrations greater than the NJDEP GWQS in shallow groundwater monitoring wells installed in the same area.

- VOC and SVOC TICs are present in groundwater at concentrations greater than the interim specific GWQS, but no apparent source of the TICs in soil has yet been identified.

Upper Hilliards Creek

There are three media in Upper Hilliards Creek for which alternatives are evaluated in this FS: (1) soil, (2) sediment, and (3) surface water. Conditions in each that are relevant to the alternatives evaluation are summarized below.

Soil

- Arsenic, lead and PAHs are the constituents found most frequently in Upper Hilliards Creek at concentrations greater than the RDCSRS. Arsenic and lead are the constituents found most frequently in surface soil (0' – 1') at concentrations greater than PRGs.

- The vertical extent of these constituents in the Upper Hilliards Creek floodplain ranges from approximately two feet to as deep as six to eight feet bgs in locations immediately adjacent to the stream. There are a number of locations where sampling was terminated prior to achieving vertical delineation, and a Pre-Design Investigation (PDI) will be necessary to better define the vertical extent in these locations.

- The Upper Hilliards Creek area also includes a small area along the eastern fence lines of residential properties B-4 through B-7, located along West Clementon Road. In this limited area, arsenic and lead are found at concentrations greater than the RDCSRS in shallow soils.

Sediment

- The BERA concluded that three primary constituents, arsenic, lead and cyanide, contribute to ecological risks. These constituents are also found throughout Upper Hilliards Creek, and their vertical extent ranges from approximately two to seven feet.

- There is low potential for toxicity to benthic organisms.

- PRGs were developed to protect the most sensitive terrestrial and aquatic-dependent wildlife receptors.

Surface Water

Lead was found in the southernmost sampling location at a concentration greater than the surface water standard.

Eastern Off-Property Area

The shallowest interval at which site-related constituents were found at concentrations greater than the RDCSRS on the Eastern Off-Property Area was 12.5'–13.0' bgs. Therefore, there is no current or expected exposure to these constituents by residents or workers. Additionally, sub-slab soil gas sampling has found no evidence of vapor intrusion below any structure. However, the LNAPL composition and thickness beneath the former tavern/service station is similar to that in the former Resin Plant/Tank Farm A Area, but no soil gas sampling has been conducted on this property. Therefore, it is possible that some methane and/or petroleum vapors may be present on this property.

In addition to the general conclusions applicable to the LNAPL in the FMP, the following specific conclusions are applicable to the Eastern Off-Property Area:

- The LNAPL extends across U.S. Avenue from approximately Residential Property E-1, located at the northeast corner of U.S. Avenue and Berlin-Haddonfield Road, to Property E-11, located across U.S. Avenue from the southern portion of the Seep Area.

- The vertical thickness of the LNAPL is relatively small in comparison to the former Resin Plant/Tank Farm A and Seep Areas. The LNAPL thickness in the former Resin Plant/Tank Farm A area ranged from approximately ten to fifteen feet, while in the Seep Area it was as thick as six to seven feet. In the Eastern Off-Property Area, the LNAPL thickness is estimated at approximately two to four feet. The exception to this

general condition is the former tavern/service station where the LNAPL thickness is approximately six to eight feet.

- The LNAPL is present exclusively at and beneath the water table, at depths ranging from approximately ten to approximately 17 feet bgs, depending upon the ground surface and groundwater elevations.

Based on the understanding of Site conditions, Remedial Action Objectives (RAOs) were developed for all media:

Soil

- Prevent potential current and future unacceptable risks to human and ecological receptors resulting from uptake of soil contaminants by plants, ingestion of contaminated soil and food items by humans and ecological receptors, and physical contact with contaminated soil.

- Minimize migration of Site-related contaminants in the soil to sediment, surface water and groundwater.

Sediment

- Prevent potential current and future unacceptable risks to human and ecological receptors resulting from uptake of sediment contaminants by plants, ingestion of contaminated sediment and food items by humans and ecological receptors, and physical contact with contaminated sediment.

- Minimize migration of Site-related contaminants in the sediment to surface water.

Surface Water

- Prevent potential current and future unacceptable risks to human and ecological receptors resulting from uptake of surface water contaminants by plants, ingestion of

contaminated surface water and food items by humans and ecological receptors, and physical contact with contaminated surface water.

- Minimize transport of Site-related contaminants in surface water.

LNAPL

- Remove or treat where practicable or contain where removal or treatment is not practicable.

- Prevent potential current and future unacceptable risks to human and ecological receptors resulting from direct contact with LNAPL.

- Minimize transport of LNAPL-related COCs in groundwater.

Methane and Vapor Intrusion

- Prevent potential current and future unacceptable risks to human receptors resulting from inhalation of volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) originating in LNAPL.

- Prevent potential current and future risks to human health and structures resulting from the presence of methane in soil gas.

All RAOs are applicable to the FMP, while the RAOs for LNAPL and, potentially, methane and vapor intrusion, are applicable to the Eastern Off-Property Area.

A series of remedial alternatives to achieve the RAOs were developed for each medium, as presented below. Note that as part of a technology screening evaluation, a detailed evaluation of thermal technologies for the possible application to the LNAPL was conducted. Based on this evaluation it was concluded that, although thermal treatment could be applied in portions of the former Resin Plant/ Tank Farm A Area, there are significant

implementability difficulties and short-term effectiveness concerns that prevent its application near roadways or on the Eastern Off-Property Area. Therefore, this technology was not carried into the detailed evaluation of alternatives.

FORMER MAIN PLANT

Soil

- Soil Alternative 1 – No Action
- Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
- Soil Alternative 3 – Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
- Soil Alternative 4 – Extensive Excavation to Depth and Institutional Controls

Sediment

- Sediment Alternative 1 – No Action
- Sediment Alternative 2 - Targeted Removal of Surface Sediment with Contaminants Greater than PRGs, Capping and Natural Recovery
- Sediment Alternative 3 – Removal of All Sediment with Contaminants Greater than PRGs

Surface Water

- Surface Water Alternative 1- No Action
- Surface Water Alternative 2 – Institutional Controls

EASTERN OFF-PROPERTY AREA

- Alternative EOP1 – No Action
- Alternative EOP2 – LNAPL Bioremediation and Contingent Soil Gas Removal
- Alternative EOP3 – Extensive Excavation to Depth

Each remedial alternative was evaluated, based on criteria specified in the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). The CERCLA criteria used in this FS to evaluate the alternatives are:

1. Overall protection of human health and the environment;
2. Compliance with Applicable, Relevant or Appropriate Requirements (ARARs);
3. Long-term effectiveness and permanence;
4. Reduction of toxicity, mobility and volume through treatment;
5. Short-term effectiveness;
6. Implementability; and
7. Cost.

The first two of these criteria are considered "threshold criteria" that any remedy must meet in order to be selected. The next five criteria are "balancing criteria" for comparison of alternatives. Two other criteria, "State Acceptance" and "Community Acceptance", will be evaluated by the EPA following public comment on the Proposed Plan.

The analyses conducted in this FS support the following conclusions regarding the remedial alternatives.

FORMER MANUFACTURING PLANT

Soil

Soil Alternatives 3 and 4 fully meet the two threshold criteria of "Protection of Public Health and the Environment" and "Compliance with ARARs". Both alternatives protect human and ecological receptors from direct contact exposure to constituents in soil, prevent transport of contaminated soil in surface water, remove sources of groundwater contamination, remove or contain LNAPL to the extent practicable and prevent risks due to soil vapors.

Soil Alternatives 3 and 4 also score the same for the balancing criterion "Long-Term Effectiveness and Permanence", since both will provide long-term protection of public health and the environment.

However, Soil Alternative 4 ranks lower than Soil Alternative 3 in four of the five balancing criteria: "Reduction of Toxicity, Mobility and Volume Through Treatment", "Short-Term Effectiveness", "Implementability", and "Cost":

- Reduction of Toxicity, Mobility and Volume Through Treatment: Alternative 4 would physically remove the vast majority of the LNAPL, but no treatment would occur. Alternative 3 would stimulate the already robust biological degradation of the LNAPL, reducing its toxicity, mobility and volume through biological treatment.

- Short-Term Effectiveness: Implementation of Soil Alternative 4 would require that more than eight times as much soil be removed from the Site than would be required under Soil Alternative 3. This translates to approximately 25,000 more truck trips through the community to remove soil and import backfill. Soil Alternative 4 would require four additional years to complete than Soil Alternative 3, resulting in a longer period of impacts to the community. Excavation depths for Soil Alternative 4 are

much greater than those for Soil Alternative 3, creating potential risks to U.S. Avenue and Foster Avenue during construction. The extensive excavation that would be required under Soil Alternative 4 would also place at risk the workers conducting the remedial action.

- Implementability: The volume of soil removed under Soil Alternative 4 is much greater than under Soil Alternative 3, so the implementability difficulties are much greater. In particular, the depth of the excavations that would be conducted under Soil Alternative 4 would result in the need to install substantial soil stability measures to protect roadways and workers, the need to manage much larger volumes of contaminated groundwater and stabilize larger volumes of saturated soil prior to transport.

- Cost: The cost for Soil Alternative 4 ($87 million) is estimated to be more than three times the cost of Soil Alternative 3 ($24 million).

Sediment

Sediment Alternatives 2 and 3 meet the threshold criteria of "Protection of Public Health and the Environment" and "Compliance with ARARs". Both alternatives protect human and ecological receptors from direct contact exposure to constituents in sediment and prevent transport of contaminated sediment in surface water. Sediment Alternatives 2 and 3 score similarly in all balancing criteria except "Cost". The cost for Sediment Alternative 3 ($1.8 million) is slightly greater than the cost of Sediment Alternative 2 ($1.6 million).

Surface Water

Both alternatives will meet the two threshold criteria if soil and sediment source control actions are implemented. Surface Water Alternative 1, No Action would not have short-term impacts on the community and would be less expensive to implement.

EASTERN OFF-PROPERTY AREA

All alternatives, including Alternative EOP1, No Action, meet the threshold criterion of "Protection of Public Health and the Environment". Constituents are present at concentrations greater than the RDCSRS only at depths well below those the building occupants or construction workers would encounter, and there is no evidence of vapor intrusion at any occupied building. However, only Alternatives EOP2 and EOP3 also achieve the second threshold criterion of "Compliance with ARARs" since they are the only alternatives that would remove or treat LNAPL to the extent practicable.

Alternatives EOP2 and EOP3 score the same with regard to the balancing criterion of "Long-Term Effectiveness and Permanence", since both will provide long-term protection of public health and the environment.

However, Alternative EOP3 scores much lower than Alternative EOP2 in four of the five balancing criteria: "Reduction of Toxicity, Mobility and Volume Through Treatment", "Short-Term Effectiveness", "Implementability", and "Cost":

- Reduction of Toxicity, Mobility and Volume Through Treatment: While Alternative EOP3 would remove all LNAPL, Alternative EOP2 would stimulate the already robust biological degradation of the LNAPL, reducing its toxicity, mobility and volume through biological treatment.

- Short-Term Effectiveness: Implementation of Alternative EOP3 would require that approximately 81,000 CY of soil be excavated across 3 acres at a depth of approximately 16 feet. Of this 81,000 CY, approximately 25,000 CY would be disposed off-site and the remainder would be reused. The structures would be moved and stored during the remediation period, and the residents and office workers would be relocated for an extended period of time. The depth of the excavation immediately adjacent to U.S. Avenue would create serious risks to the roadway.

- Implementability: Alternative EOP2 has significant implementability issues, including the need to install and maintain a network of injection locations on the former tavern/service station for a period of ten years, install and operate soil gas recovery wells along U.S. Avenue, conduct multiple rounds of injections on the residential properties, and install piping and utilities beneath U.S. Avenue. However, these issues are far more manageable than those associated with Alternative EOP3, in which soil would be excavated to depths approaching 20 feet, with the excavations extending approximately four feet into the saturated zone. Five residences and one office building would need to be moved and reconstructed, and the residents and workers would need to be relocated during the remediation and reconstruction process.

- Cost: The cost for Soil Alternative EOP3 ($18.5 million) is estimated to be almost four times the cost of Soil Alternative EOP2 ($5 million).

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LIST OF ACRONYMS

ACO	Administrative Consent Order
AMSL	above mean sea level
AO	Administrative Order
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
ARRCS	Administrative Requirements for the Remediation of Contaminated Sites (N.J.A.C. 7:26C)
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BLL	blood lead level
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CCC	Criterion Continuous Concentration
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CKD	cement kiln dust
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
CY	cubic yard
dL	deciliter
DLUR	Division of Land Use Regulation
DO	dissolved oxygen
DOT	Department of Transportation
DPE	dual-phase extraction
E&S	erosion and sedimentation
EO	Executive Order
EOP	Eastern Off-Property
EPA	United States Environmental Protection Agency
EPH	extractable petroleum hydrocarbons
ERA	Ecological Risk Assessment
ERT	Environmental Response Team
ESC	ecological screening criteria
ESNR	ecologically sensitive natural resources
EUSA	East of U.S. Avenue

FEMA	Federal Emergency Management Administration
FMP	Former Manufacturing Plant
FPR	free product recovery
f_{oc}	organic carbon fraction
FS	Feasibility Study
ft/day	feet per day
ft/mi	feet per mile
ft/yr	feet per year
ft^2	square feet
FW2	chronic surface water criteria for fresh water
FWPCA	Federal Water Pollution Control Act
g/cm^3	grams per cubic centimeter
GC/MS	gas chromatography/mass spectrometry
GIS	geographic information system
gph	gallons per hour
gpm	gallons per minute
GWQS	Ground Water Quality Standard
HI	Hazard Index
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
IGWSRS	Impact to Groundwater Soil Remediation Standard
Kg	kilogram
L	liter
LEL	Lowest Effects Level
LNAPL	Light Non-Aqueous Phase Liquid
LOE	lines of evidence
LOEC	lowest observed effect concentration
MCL	Maximum Contaminant Level
MIP	membrane interface probe
mg	milligram
MNR	Monitored Natural Recovery
MTBE	methyl-tert-butyl ether
mV	millivolt

NAAQS	National Ambient Air Quality Standard
NAVD	North American Vertical Datum
NCP	National Contingency Plan
NFA	North of Foster Avenue
ND	non-detect
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJPDES	New Jersey Pollutant Discharge Elimination System
NOEC	no observed effect concentration
NOEL	No Observed Effect Level
NPL	National Priorities List
NRDCSRS	Non-Residential Direct Contact Soil Remediation Standard
NRIASL	Non-Residential Indoor Air Screening Levels
NRSGSL	Non-Residential Soil Gas Screening Levels
NSZD	natural source zone depletion
O&M	operations and maintenance
ORP	oxidation-reduction parameter
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbons
PAR	Pathways Analysis Report
PCB	polychlorinated biphenyls
PCP	pentachlorophenol
PDI	Pre-Design Investigation
PEC	Probable Effects Concentration
PID	photoionization detector
PP	Proposed Plan
PRG	Preliminary Remediation Goal
PRM	Potomac-Raritan-Magothy aquifer
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RDCSRS	Residential Direct Contact Soil Remediation Standard
RI	Remedial Investigation
RIR	Remedial Investigation Report
ROD	Record of Decision
RSGL	Residential Soil Gas Screening Levels
RSL	Regional Screening Level

SCSR	Site Characterization Summary Report
SFA	South of Foster Avenue
Sherwin-Williams	The Sherwin-Williams Company
SI	Site Investigation
SLERA	Screening Level Ecological Risk Assessment
SQG	sediment quality guidelines
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
SWQS	Surface Water Quality Standard
T&D	transportation and disposal
TAL	Target Analyte List
TBC	To Be Considered
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TIC	tentatively identified compound
TOC	total organic compound
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
TSS	total suspended solids
U.S.	United States
UCL	upper confidence limit
µg	microgram
UHC	Upper Hilliards Creek
UNDV	Undeveloped Area
USACE	United States Army Corps of Engineers
USFWS	United States Fish & Wildlife Service
UV	ultraviolet
VI	Vapor Intrusion
VISL	Vapor Intrusion Screening Levels
VOC	volatile organic compound
WOE	weight-of-evidence
WQIP	water quality indicator parameters
WRA	Well Restriction Area
XRF	X-Ray Fluorescence

1.0 INTRODUCTION

Pursuant to Administrative Order on Consent (AOC) Index No. II CERCLA-02-99-2035, The Sherwin-Williams Company (Sherwin-Williams) is submitting to the United States Environmental Protection Agency Region 2 (EPA) this Feasibility Study (FS) for soil, sediment and surface water at the Former Manufacturing Plant (FMP) area of the Sherwin-Williams/Hilliards Creek Site (Hilliards Creek Site) located in Gibbsboro, Camden County, New Jersey (Figure 1). The FMP FS follows the *"Remedial Investigation Report, Soil, Sediment, Surface Water, Pore Water and Vapor Intrusion, Sherwin-Williams Hilliards Creek Superfund Site, Former Manufacturing Plant Area"* (FMP RIR) (Weston, 2018). The FMP area became part of the Hilliards Creek Site in 2007, and the Hilliards Creek Site was listed on the National Priorities List (NPL) in 2008.

In addition to the FMP RIR, one other document and one submittal provided to the EPA are cited in this FS:

- *"Former Manufacturing Plant, Shallow/Intermediate Monitoring Wells, Remedial Investigation, Groundwater Exceedances Map (NJDEP Groundwater Quality Standards)"; (Figure 2, Shallow Groundwater Exceedance Figure)*, provided to EPA on January 15, 2018

- *"LNAPL Investigation Report, Former Manufacturing Plant Area, Gibbsboro, New Jersey"* (LNAPL Report; EHS, 2018a)

Figure 2 summarizes all of the exceedances of the NJDEP groundwater quality standards (GWQS) in shallow and intermediate groundwater sampling conducted at the FMP since 2009, when the groundwater RI began, through 2017. Included on this figure are the results of both shallow and intermediate groundwater monitoring wells, and the shallow and intermediate grab samples collected in 2012.

Although remedial alternatives for groundwater are not evaluated in this FS (see below), Figure 2 presents locations where constituents are present in groundwater at concentrations greater than established standards. Based on these data, locations can be identified where soil remediation may be needed to address potential sources of groundwater contamination.

The LNAPL Report summarizes the results of the RI and supplemental data gathered to support conclusions regarding the nature and extent of the LNAPL, its mobility and recoverability, potential mechanisms responsible for natural source zone depletion (NSZD), and its potential to act as a source of vapor intrusion (VI) and groundwater impacts.

As stated above, remedial alternatives for groundwater are not evaluated in this FS. A separate RIR for groundwater will be prepared and submitted to EPA in the future and, based on the nature and extent of contaminants in groundwater, a separate FS will be developed.

1.1. Purpose and Organization of Report

The FMP RIR presented the nature and extent of contamination in soil, sediment, surface water, pore water, soil gas and indoor air throughout the FMP. The FMP RIR documented that the nature and extent of constituents in soil, sediment, surface water, pore water, soil gas and indoor air at the FMP were adequately characterized to support the development of this FS and ultimately a Record of Decision (ROD) for the Site. Documents supporting the RIR include the "*Human Health Risk Assessment for the Former Manufacturing Plant Area of the Sherwin-Williams/Hilliards Creek Site"* (HHRA) (Gradient, 2017), which evaluated human health risk based on exposure to contaminated media, and the *"Baseline Ecological Risk Assessment (BERA) for the Former Manufacturing Plant Area of the Sherwin-Williams/Hilliards Creek Site"* (Gradient, 2018), which evaluated the potential for impact to ecological receptors from contaminated media. A summary of the HHRA and BERA results is presented in this FS.

The objective of this FS is to evaluate alternatives for the remediation of soil, sediment, and surface water at the FMP and the adjacent Eastern Off-Property Area. LNAPL is present in some locations within the FMP and the Eastern Off-Property Area, and alternatives for remediation of the LNAPL and soil gas vapors associated with the LNAPL are included as needed. As discussed below, the alternative evaluation considers Site conditions and regulatory criteria, and evaluates the alternatives according to seven criteria specified by regulation.

Based on the evaluation of alternatives presented in this FS, the EPA will present alternatives, as well as the preferred remedy, in a Proposed Plan (PP). Following a period of comment on the PP, the EPA will issue a ROD finalizing selection of the remedy.

According to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Section 121, remedial actions must:

- Be protective of human health and the environment;
- Attain Applicable or Relevant and Appropriate Requirements (ARARs), or provide grounds for invoking a waiver;
- Be cost-effective;
- Utilize permanent solutions and alternative treatment technologies to the maximum extent practicable; and
- Satisfy the preference for treatment that reduces contaminant mobility, toxicity, and volume as principal elements, or provide explanations otherwise.

In this FS, remedial alternatives have been developed and evaluated based on the required CERCLA evaluation criteria:

1. Overall protection of human health and the environment;

2. Compliance with ARARs;

3. Long-term effectiveness and permanence;

4. Reduction of toxicity, mobility and volume through treatment;

5. Short-term effectiveness;

6. Implementability; and

7. Cost.

The first two of these criteria are considered "threshold criteria" that any selected remedy must meet. The next five criteria are "balancing criteria" for comparison of alternatives. Two other criteria, State Acceptance and Community Acceptance, will be evaluated by the EPA following public comment on the Proposed Plan.

The environmental media at the FMP for which remedial alternatives are included in this FS are soil, sediment, and surface water. Note that part of the evaluation of alternatives for soil includes alternatives to address the LNAPL and soil gas vapors. Saturated soil in which LNAPL is present is the medium of concern for the Eastern Off-Property Area.

1.2. Report Organization

The format for this FS is based on EPA's "*Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA"* (EPA, 1988a). This FS is presented in the following sections:

- Section 1 identifies the purpose of the FS and provides background information.

- Section 2 describes the environmental setting of the FMP, provides the Site history and presents the nature and extent of contamination at the FMP.

- Section 3 summarizes ARARs, provides remedial action objectives (RAOs) and identifies and screens remedial technologies to address the contaminated media at the FMP.

- Section 4 provides a detailed development and analysis of remedial alternatives retained from the screening process and a comparative analysis of remedial alternatives for each medium.

- Section 5 provides a list of references.

2.0 SITE HISTORY AND SETTING

A detailed discussion of the Site ownership history, disposal activities, prior investigations and prior removal actions at the FMP are presented in the RIR. The following is a brief summary of that information.

2.1. Site Description

The FMP is an area in the Sherwin-Williams / Hilliards Creek Site, one of three sites in Gibbsboro and Voorhees, New Jersey that are undergoing investigation and remediation by Sherwin-Williams. The other two sites are the Route 561 Dump Site, and the U. S. Avenue Burn Site (Figure 3).

For purposes of the FS, the FMP has been divided into five study areas and the Eastern Off-Property Area (Figure 4):

1. Former Main Plant: This area includes the former Tank Farm B area (the location of the current 7 Foster Avenue building), the building slab of the former 6 East Clementon Road building, the parking area west of the 2 and 4 Foster Avenue

buildings, the 10 Foster Avenue building, and the Silver Lake conveyance system, (which is located beneath the parking area). This is the area in which the majority of the historic paint manufacturing activities were conducted.

2. The Former Resin Plant/Tank Farm A: This is the area immediately north of Foster Avenue and west of United States (U.S.) Avenue. The area includes the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings. The former Tank Farm A area is presumed to be the source of the LNAPL found at the FMP.

3. The Seep Area: This is the area south of Foster Avenue, west of U.S. Avenue and east of Hilliards Creek. This area includes the 1 and 5 Foster Avenue buildings. The Seep Area has been the subject of historic interim actions to control LNAPL discharges to Hilliards Creek.

4. Upper Hilliards Creek: This is Hilliards Creek and its floodplain beginning at Foster Avenue and ending at West Clementon Road. To the east is the Seep Area and to the west are residential properties B-1 through B-8, which have been the subject of a prior remedial action. As discussed in the RIR, the portion of Upper Hilliards Creek from Foster Avenue to approximately the northern portion of the Former Lagoon Area was channelized at some time between 1940 and 1943.

5. The Former Lagoon Area: The Former Lagoon Area lies between the Seep Area and the cemetery. The former wastewater lagoons are first observed in aerial photographs from 1951 and were closed under NJDEP oversight in 1979. Wastewater from the manufacturing operations was placed in the lagoons, and sludge from the lagoons was periodically transferred to the Burn Site for disposal.

The Eastern Off-Property Area consists of seven parcels. One is the location of the former tavern/service station that is now a vacant lot. Also included are the properties referred to as E-1, E-7, E-8, E-9, E-10 and E-11 in the Residential Properties Remedial Investigation

Report (Weston, 2015). Six of these properties are residences, and E-7 is an office that has been converted from a residence.

Silver Lake, located just north of the FMP, and that portion of Hilliards Creek soil of West Clementon Road, will be addressed in the FS for the Waterbodies Unit.

2.2. Site History

A detailed discussion of the site history is presented in the RIR and was based on a review of numerous historical references. The following summarizes the information provided in the FMP RIR.

The FMP was a paint, varnish and lacquer manufacturing plant from the early 1850s until 1978. The plant was first operated by John Lucas & Co., Inc. (Lucas) and subsequently by Sherwin-Williams. The plant closed permanently in 1978, and the factory property was sold in 1981 to Robert K. Scarborough (Scarborough), who redeveloped the former manufacturing facility property. The former plant site is currently utilized as an office and light industrial park and is called The Paint Works Corporate Center (The Paint Works) and is owned by Brandywine Realty Trust (Brandywine).

John Lucas purchased a small mill site along with the adjacent lake (Silver Lake) in April 1852 and formed the company John Lucas & Co. The primary paint manufacturing operations at that time consisted of color production and color grinding in various oils. In 1857, John Lucas enlarged the business and expanded production by grinding white lead and colors in oils. During the latter part of the 1850s, Lucas manufactured white zinc colored paints, chrome greens, chrome yellows, and Chinese and Prussian blues.

Paint production increased over time from the 1870s into the 1890s. Operations included dry color production, varnish production, color grinding, and ready mixed oil paints and canning. Varnishes were manufactured using mixing kettles and ovens in the area now known as the Former Resin Plant area.

The holding tanks for various oils and driers used for color grinding were located in the former Tank Farm A area. The tanks were installed in the late 1880s. The tanks were also used to store ready-mixed paint.

In 1901 the John Lucas Co. continued after John Lucas's death; additional buildings were constructed, and additional paint manufacturing operations were added. The new operations included dry color manufacturing and lacquer manufacturing.

Sherwin-Williams purchased the John Lucas Co. in 1930. The dry color operation closed, and the ready-mixed paints were relocated. The main manufacturing at the plant consisted of three separate operation areas identified as: dye making, oil paint making and paint making.

Between 1950 and 1977, wastewater generated from the manufacturing process was treated and disposed in the former lagoon area located in the southern portion of the site. Wastewater was discharged by gravity from the former facility to a lift station and subsequently pumped into a 27,000-gallon concrete holding basin. Alum was added to the wastewater, and then the wastewater was gravity fed from the basin of Lagoon 1 for coagulation and settling. The wastewater was then transferred to Lagoons 2, 3, and 4 for biological treatment. Sludge was removed periodically from the lagoons and transferred to the landfill area of the United States Avenue Burn Site.

Sherwin-Williams closed the manufacturing facility on September 1, 1978, and in 1981 sold the majority of the property to Scarborough, who developed the former manufacturing area into The Paint Works Corporate Center. Scarborough sold The Paint Works Corporate Center to Brandywine in 1997. Brandywine is the current owner.

2.3. Investigation and Interim Measure Summary

Investigative activities and interim measures have been performed at the FMP since the late 1970s. The majority of the work has been performed by Sherwin-Williams since 1991 under the oversight of either the NJDEP or the EPA Removal or Remediation Branches. Previous

interim measures at the FMP included a removal action in 1979 to remove sludge material and contaminated soil from the Former Lagoon Area and a number of measures beginning in the 1980s and continuing to the present designed to address and prevent discharges from the Seep Area. Beginning in 2016, Sherwin-Williams has implemented interim measures designed to mitigate vapor intrusion into the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings.

A detailed discussion of the previous investigations and interim measures is provided in the FMP RIR. The following summarizes the information from the FMP RIR.

2.3.1. Site Investigation Summary

The first investigation of the FMP was conducted by Sherwin-Williams in the Former Lagoon Area. This investigation was performed under the oversight of the NJDEP to characterize topographic features, subsurface conditions and volumes of waste and residual materials.

Scarborough conducted an investigation of the Seep Area in 1986 in response to observations of seeps in the parking area near the 1 and 5 Foster Avenue buildings. Scarborough also conducted an investigation in 1988 of the former service station/tavern.

From 1991 until 2000, Sherwin Williams conducted five phases of remedial investigation of the FMP, previously referred to as The Paint Works Corporate Center, which included the former Tank Farm A, Tank Farm B and Seep Areas, as well as the former service station/tavern, located at the corner of U.S. Avenue and Berlin Road. Sherwin-Williams performed these RI activities under an Administrative Consent Order (ACO) with NJDEP dated September 20, 1990. NJDEP terminated the ACO in 2001.

In 1998, the Removal Branch of the EPA collected soil and sediment samples along Hilliards Creek in the stretch between Foster Avenue and West Clementon Road.

In 2003 and 2004, Sherwin-Williams conducted a geophysical investigation of the FMP to identify subsurface utilities, historic features and possible transport pathways for free

product, and performed a soil screening and confirmatory sampling program to delineate the extent of the residual petroleum product present at the FMP. These activities were conducted under the oversight of the EPA Removal Branch.

Sherwin-Williams entered into AOC Index No. II CERCLA-02-99-2035 with EPA Remedial Branch in 1999. Pursuant to this AOC, Sherwin-Williams prepared the Revised Work Plan for RI/FS Activities, Gibbsboro, New Jersey (2003 RI Work Plan), which was approved by EPA in 2004. Field activities for the RI of Hilliards Creek commenced in 2005. In 2007, the EPA Remedial Branch requested that Sherwin-Williams prepare a RI Work Plan for the FMP, and the FMP became part of the Hilliards Creek Site.

Ten sampling events were conducted at the FMP or Eastern Off-Property Area as part of the RI:

1. 2005: Hilliards Creek Strategic Sampling;

2. 2006: Hilliards Creek Phase 2 Sampling;

3. 2009 – 2010: FMP Strategic Sampling;

4. 2012: FMP Phase 2/Shallow and Intermediate Soil and Groundwater Screening/ Investigatory Trenching;

5. 2014: Sherwin-Williams Sampling at 6 East Clementon Road;

6. 2015: Soil Sampling North of Hilliards Creek and South of West Clementon Road Residential Properties;

7. 2015: EPA Environmental Response Team (ERT) Sampling at 6 East Clementon Road and North of Resin Plant;

8. 2015: United States Avenue Residential Property Soil Sampling;

9. 2016: Extractable Petroleum Hydrocarbon and Hexavalent Chromium Sampling; and

10. 2017: Supplemental U.S. Avenue Residential Property Soil Sampling.

The scopes of each of these sampling events are presented in the FMP RIR. These events included soil, sediment, surface water and pore water sampling, as well as geophysical surveys. Figure 6 presents all RI soil sampling locations.

Groundwater sampling has been ongoing at the FMP as part of the RI. Soil samples have been collected during groundwater monitoring well installations, and the results of this soil sampling was included in the RIR.

Numerous sub-slab and indoor air sampling events have been conducted at and around the FMP buildings from 2008 through 2016. Ongoing methane monitoring is being conducted the in 2 and 4 Foster Avenue and 3 U.S. Avenue buildings. The sub-slab and indoor air sampling results from the FMP were presented in the FMP RIR.

Sub-slab sampling was also conducted at the Eastern Off-Property Area:

- Sub-slab sampling results from sampling conducted by the EPA in 2008 and 2009 on the Eastern Off-Property Area were presented in the Residential Properties RIR.

- EPA collected sub-slab samples at properties E-7, E-8, E-9 and E-11 in August 2015 as part of a larger sub-slab and indoor air sampling program. The samples were analyzed for VOCs by EPA Method TO-15.

- Sherwin-Williams collected one sub-slab sample and a duplicate at Property E-1 in April 2018. The samples were analyzed for VOCs by EPA Method TO-15 and for

methane by EPA Method 3C. The results were provided to EPA in a June 2018 Technical Memorandum.

To support the BERA, sampling was conducted in August and September 2017 along the upper portion of Hilliards Creek. This sampling consisted of collecting additional surface (0.0' – 0.5') soil samples, soil invertebrates, sediment samples for chemistry and toxicity testing, surface water and pore water samples, and benthic and forage fish samples.

In 2017 and 2018, Sherwin-Williams conducted a supplemental investigation focused on the LNAPL. This program was proposed in the LNAPL Investigation Work Plan (EHS, 2017), which was approved by EPA on July 25, 2017. The investigation included lateral and vertical delineation of LNAPL impacts using membrane interface probe (MIP) and conventional soil samples, as well as collection of microbial samples, LNAPL transmissivity testing, and laboratory pore fluid and mobility testing. A Phase 2 investigation was conducted that consisted of the placement of BioTraps™ in select wells to evaluate dissolved-phase biodegradation of the LNAPL constituents. The results of the investigation were provided to EPA in the LNAPL Report EHS, 2018a).

2.3.2. Interim Measure Summary

Interim measures conducted at the FMP have consisted of measures designed to remove residuals from the former lagoons and measures to control and mitigate discharges of LNAPL from the Seep Area into Hilliards Creek. These actions were performed under the direction of either the NJDEP or the EPA Removal Branch and are discussed in the FMP RIR. The following summarizes the information provided in the FMP RIR.

In October – December 1979, Sherwin-Williams, under the direction and supervision of the NJDEP, removed approximately 8,100 cubic yards of sludge material from the former Lagoon Area. These lagoon closure activities were approved by the NJDEP in 1981.

Discharges from the Seep Area were first observed in 1986, and Scarborough performed several short-term actions in 1986-1987. Sherwin-Williams undertook a series of subsequent actions to address the potential for LNAPL discharges to Hilliards Creek, including:

- In 1996, Sherwin-Williams conducted a soil removal and storm water sewer line replacement project. As part of this project, the storm water sewer serving the 1 Foster Avenue building was replaced, and soil between the 5 Foster Avenue building and Hilliards Creek was removed and replaced. Approximately 66 tons of soil and 14,000 gallons of an oil/water mixture were sent off site for disposal.

- Sherwin-Williams installed a free product recovery/soil vapor extraction (FPR/SVE) system in the seep area in 1997. The system operated continuously from 1997 through 2008, and on a reduced basis from December 2008 until June 2010. Operation of the FPR/SVE system was terminated in 2010 after several years of declining product recovery rates.

- In 2002 – 2003, Sherwin-Williams conducted two response actions to address discharges at the Seep Area. From April–June 2002, measures were implemented to recover and collect free product that was observed in the storm water system, the rip-rap channel leading to Hilliards Creek, and Hilliards Creek. These actions included installation of adsorbent booms, pipe jetting to clear obstructions in the storm sewer, and use of pumps to recover accumulated product. In May 2003, following heavy rains, Sherwin-Williams implemented measures to recover and collect product discharges from the storm drain system. Approximately 2,100 gallons of product/ water mixture were collected and disposed.

- In 2003, Sherwin-Williams conducted additional interim measures under the direction of the EPA Removal Branch. These activities include the installation of a product interceptor trench parallel to Hilliards Creek in a location between the 1 and

5 Foster Avenue building, and removal of a former pump house and removal of soil from an area southwest of the 1 Foster Avenue building. Product recovered in the interceptor trench was routed to the FPR/SVE system for collection and disposal.

Currently, Sherwin-Williams is conducting manual product recovery activities. The product recovery activities are conducted quarterly, except for one location located in the Seep Area, where monthly activities are performed.

From 1998 until 2010, when operation of the FPR/SVE system was terminated, a total of 138,087 gallons of product/water mixture had been recovered (based on the volumes reported on waste manifests). Between 2010 and the end of 2017, a total of 2,735 gallons of product were recovered by manual methods. During the period of manual recovery, annual recovery rates have declined from 920 gallons in 2011 to approximately 125 gallons in 2017 and 150 gallons in 2018.

2.4. Nature and Extent of Contamination

The FMP RIR contains a comprehensive discussion of the nature and extent of Site-related constituents in soil, sediment, surface water, and pore water. The FMP RIR also contains a preliminary discussion of the fate and transport of the LNAPL, which has been further developed in the LNAPL Report.

Additionally, two other documents, the HHRA and BERA, were prepared that evaluated the potential human and ecological risks associated with exposure to the constituents found at the FMP:

- The HHRA identifies those exposure scenarios where the presence of Site-related constituents in soil, sediment, surface water and/or groundwater was conservatively estimated to result in: (a) a hazard quotient (HQ) greater than 1 for non-carcinogenic health effects, (b) an excess lifetime cancer risk of one-in-one-million (10^{-6}) to one-

in-ten-thousand (10^{-4}) for carcinogenic health effects, or (c) a child blood lead level of 5 micrograms per deciliter (µg/dL) for lead exposure.

Risks to commercial workers from vapor intrusion were evaluated for eight buildings: 1 Foster Avenue, 2 Foster Avenue, 4 Foster Avenue, 5 Foster Avenue, 7 Foster Avenue, 10 Foster Avenue, 6 East Clementon Road (no longer present), and 3 U.S. Avenue).

- The BERA identifies those exposure areas where the calculated HQ was greater than 1 for the most sensitive ecological receptor resulting from exposure to Site-related constituents.

As discussed in Section 1, two other documents are relied upon in this FS to establish the nature and extent of contamination:

- The LNAPL Report provides data and analysis regarding the composition of the LNAPL, its horizontal and vertical distribution, its potential mobility and recoverability, and evidence of natural processes that are degrading the LNAPL and dissolved-phase organic compounds.

- Figure 2 identifies those locations where constituents are present in groundwater at concentrations greater than established standards. This FS does not include an evaluation of remedial alternatives for groundwater (these will be provided in a subsequent FS for groundwater), but the groundwater data are used to identify potential locations where soil remediation may be needed to address sources of groundwater contamination.

It is not the intent of this FS to reproduce the entirety of the FMP RIR and LNAPL Report, but rather to provide adequate information regarding the nature and extent, and fate and transport, of Site-related constituents, to support the evaluation of remedial alternatives. Therefore, this section provides a summary of the FMP RIR, LNAPL Report and groundwater

results, and references selected data presentation figures from the RIR and LNAPL Report, as well as Figure 2.

The referenced documents incorporate the use of screening levels for the purpose of determining the nature and extent of Site-related contamination. Soil, sediment, pore water, surface water and groundwater sampling results were compared to established standards and benchmarks to determine if Site-related contamination had been adequately delineated.

The media-specific screening criteria that have been used are:

- The FMP RIR compared soil sample results to the NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS, N.J.A.C. 7:26D). The RDCSRS were applied to all soil locations, regardless of land use. As discussed in subsequent sections of this FS, Preliminary Remediation Goals (PRGs) have been developed for surface soil in ecological habitat areas in the Former Lagoon Area and the Hilliards Creek floodplain (see Appendix A). The NJDEP Impact to Groundwater Soil Remediation Standards (IGWSRS) are also applicable in some instances.

  Constituent concentrations in soil were subsequently compared to ecological soil screening levels as part of the Screening Level Ecological Risk Assessment (SLERA). Based on the results of the SLERA, a BERA was conducted and, based on the results of the BERA, site-specific PRGs for surface soil (0.0' – 1.0') were calculated (see Appendix A).

- Groundwater results are compared to the NJDEP GWQS. If a NJDEP GWQS had not been promulgated, the EPA Maximum Contaminant Levels (MCLs) were used for comparison.

- The FMP RIR compared surface water and pore water sample results to the NJDEP chronic surface water criteria for fresh water (FW2) aquatic protection, if available. Note that there is no chronic surface water standard for silver, so the acute standard

was used for comparison. If there was no surface water standard, NJDEP's ecological screening criteria were used. If constituents still did not have a screening level available from either of these sources, then EPA's Criterion Continuous Concentration (CCC) promulgated under Section 304(a) of the Clean Water Act were used to establish a screening level.

- The FMP RIR compared sediment samples to the NJDEP Lowest Effects Level (LEL) for freshwater sediment as updated in March 2009 Ecological Screening Criteria. The BERA used the Probable Effect Concentrations (PECs) as initial criteria for comparison. Based on the BERA results, site-specific PRGs were developed and have been applied as cleanup criteria in sediment.

- Indoor air and soil gas samples were compared to the NJDEP Non-Residential Indoor Air Screening Levels (NRIASL) and Non-Residential Soil Gas Screening Levels (NRSGSL), respectively.

- Sub-slab samples collected by EPA on the Eastern Off-Property Area and reported in the Residential RIR were compared to the NJDEP Residential Soil Gas Screening Levels (RSGSL).

The FMP RIR primarily used the analytical soil data and X-Ray Fluorescence (XRF) results collected as part of the RI to define the nature and extent of contamination at the FMP. The XRF results were used to provide screening level estimates of the average concentrations of arsenic and lead. Additionally, soil screening data collected in 2003 under the oversight of the EPA Removal Branch were used to assist in defining the extent of LNAPL. The FMP RIR also included a summary of the results of the geophysical investigation conducted under the direction of both the EPA Removal and Remediation Branches.

This FS incorporates all of the analytical and XRF data from the FMP RIR as well as the results of the BERA sampling, the Draft LNAPL Report and the shallow groundwater results

collected to date as the basis for developing and evaluating remedial alternatives. Sections 2.4.1 through 2.4.7 summarize the nature and extent of contamination in each of the five subareas and the Eastern Off-Property Area based on the FMP RIR, groundwater technical memo, BERA sampling, and LNAPL Report, as applicable.

2.4.1. Light Non-Aqueous Phase Liquid: Former Resin Plant/Tank Farm A, Seep and Eastern Off-Property Areas

Both the RIR and the LNAPL Report presented discussions of the nature and extent of the LNAPL. The RIR based the interpretation of the horizontal and vertical extent of the LNAPL on analytical soil results, including total petroleum hydrocarbons (TPH) and extractable petroleum hydrocarbons (EPH), the results of field screening using a hydrophobic dye, photoionization detector (PID) results, and soil gas measurements. The LNAPL Report included these lines of evidence, but also included more detailed evaluations, including ultraviolet (UV) fluorescence, core photography, results of membrane interface probes (MIP), and partitioning calculations for the vapor, aqueous and sorbed phases.

In addition to evaluating the horizontal and vertical extent of the LNAPL (see Figure 6-14 from the LNAPL Report for estimated extent; presented in Appendix B), the LNAPL Report also included the results of several other investigation and characterization activities:

- Petrochemical analyses of the residual LNAPL were conducted to quantitatively determine the residual saturation levels. These results provide a basis to predict the recoverability and mobility of the LNAPL.

- Imbibition testing (application of high-pressure water to the soil cores) was conducted to evaluate the ability of water to displace the residual LNAPL in the soil cores. The results provide a basis to predict whether enhanced hydraulic recovery methods such as dual phase extraction would be effective in removing the LNAPL.

- An evaluation of several lines of evidence, including methane, carbon dioxide and petroleum vapors in the vadose zone, a biogenic heat signature in groundwater

within the residual LNAPL area, a thriving microbial population, and geochemical conditions suitable for anaerobic biodegradation, was performed to assess whether NSZD mechanisms were degrading the LNAPL.

- Bio-Traps™ baited with Carbon-13 (^{13}C) were deployed in select monitoring wells to better understand the microbial populations present in the subsurface and confirm earlier conclusions that biodegradation of the LNAPL and dissolved-phase constituents was occurring.

The data presented in the RIR and the supplemental evaluations performed in the Draft LNAPL Report support several conclusions regarding the LNAPL at the FMP and Eastern Off-Property Area, as discussed below. Relevant figures and tables from the LNAPL Report are provided in Appendix B for review and reference.

- The LNAPL is best described as a degraded mineral spirit. It contains some benzene and naphthalene, along with volatile organic compound (VOC) and semi-volatile organic compound (SVOC) tentatively identified compounds (TICs). Table 6-3 from the LNAPL Report provides a summary of the composition of the LNAPL. In some locations where the LNAPL is present, benzene and/or naphthalene is found in soil at concentrations greater than the RDCSRS. These locations are discussed for each individual area.

- As a result of previous LNAPL recovery efforts, ongoing NSZD mechanisms and the fluctuation of the water table, the vast majority of the remaining LNAPL is trapped in the soil pores of the fine-grained sands beneath the water table. As such, the LNAPL is not, on a site-wide basis, either recoverable or mobile.

- The LNAPL is present at low saturation levels, providing additional support for the conclusion that it is neither mobile nor recoverable. Localized recovery is ongoing in the Seep Area, but the recovered volumes are small and continue to decrease. No

recovery efforts or measurements of saturation have been conducted beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings. Figure 6-6 from the LNAPL Report provides a summary of the measured saturation levels.

- Even at high pressures, water is unable to displace the LNAPL from the soil pores. Therefore, use of hydraulically-enhanced recovery methods is not likely to be successful. Table 6-9 from the LNAPL Report summarizes the results of imbibition testing.

- The LNAPL is undergoing biodegradation. This is documented by the presence of methane and other vapors in the soil beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings (see Figure 5). Studies in the literature document LNAPL degradation rates ranging from several hundred to several thousand gallons per acre per year (see Section 8.1 of the LNAPL Report). Even at the low end of this range, these rates greatly exceed the mass of LNAPL that is recovered on an annual basis at the site (approximately 90 gallons in 2017). Based on the flux of methane and soil gas measured at the site, it is probable that actual degradation rates exceed the low end of the degradation rate range cited in the literature. The current biodegradation rates for the LNAPL are likely limited by the absence of important nutrients such as nitrate/nitrite and sulfate/sulfide and could be increased if these nutrients were present.

- The LNAPL is the source of dissolved-phase VOCs and SVOCs (Figure 2). However, the extent to which dissolved-phase VOCs and SVOCs are present at concentrations greater than the GWQS is stable, and there is conclusive evidence that the dissolved-phase constituents are undergoing biodegradation.

Additional detail on the distribution and characteristics of the LNAPL specific to the former Resin Plant/Tank Farm A and Seep Areas at the FMP and the Eastern Off-Property Area is provided in the discussion of site conditions in those areas, below.

2.4.2. Former Main Plant FS Study Area

The Former Main Plant FS Study Area (Figure 4) includes the 7 Foster Avenue building, located south of Foster Avenue and west of Hilliards Creek (the former Tank Farm B area), and, north of Foster Avenue, the existing 6 E. Clementon Road building slab, the 10 Foster Avenue building, and the parking areas for the 10 Foster Avenue and 2 and 4 Foster Avenue buildings. The Silver Lake conveyance system is located beneath the parking area in the center of this area. Figure 6 shows the locations of all soil samples collected in this area during the RI.

Site conditions important to consider in identifying and evaluating remedial alternatives are:

- The majority of the area is currently covered by an impermeable cap consisting of the 2, 4, 7 and 10 Foster Avenue and 3 U.S. Avenue buildings, the 6 East Clementon Road building slab, and the associated parking areas. The asphalt cover in the parking areas consists of approximately a four-inch base layer and a two-inch top layer. Areas not covered by an impermeable cap are the landscaped areas and the lawn between the 7 Foster Avenue building and Hilliards Creek, some small landscaped areas located throughout the parking areas, and areas on both sides of Foster Avenue at its intersection with West Clementon Road.

- South of Foster Avenue, near the 7 Foster Avenue building (Figures 2, 7 and 8):

    - PAHs are found at concentrations greater than the RDCSRS from the surface (0.0' – 0.5') to up to ten feet bgs. Based on the aerial photograph review, this area, including the location of the 7 Foster Avenue building, was filled at some point between 1943 and 1951, so the PAHs are likely the result of the filling activity.

    - Arsenic and lead are found at concentrations greater than the RDCSRS in surface soil to depths up to six feet bgs.

- Pentachlorophenol is found at concentrations greater than the RDCSRS in soil samples collected from the 2' to 8' intervals at location MPSB0207, located in the parking area south of the 7 Foster Avenue building.

- There is no evidence of LNAPL on this portion of the FMP.

- Pentachlorophenol was found at relatively low concentrations (approximately 0.8 µg/L) in comparison to the GWQS (0.3 µg/L) in shallow and intermediate monitoring wells MPMW0011/MPMW0012, located in the southern parking area of the 7 Foster Avenue building.

- Arsenic, lead and PAHs are present at concentrations greater than their respective IGWSRS in soil in the unsaturated zone. However, the majority of the locations are covered with an impermeable cap. Also, PAHs and lead are considered immobile chemicals under NJDEP guidance (NJDEP, 2008). Since lead and PAHs are not present in groundwater, the IGWSRS are not applicable.

- Benzene was also found in intermediate monitoring well MPMW0012 at a concentration greater than the GWQS, but it is unlikely that the benzene is associated with a source located in the immediate vicinity, as shallow monitoring well MPMW0011 did not contain benzene at a concentration greater than the GWQS.

- Pentachlorophenol was found at concentrations greater than the GWQS in shallow monitoring wells MW-17 and MW-18, located in the parking area north of the 7 Foster Avenue building.

- North of Foster Avenue and west of the 2 and 4 Foster Avenue buildings (Figures 2, 9 and 10):

- Arsenic, lead and/or PAHs are found at concentrations greater than the RDCSRS from the surface (0.0' – 0.5') to approximately five to six feet bgs throughout much of the area. Arsenic is found at concentrations greater than the RDCSRS at depths of up to 15 feet bgs beneath the southern portion of the 6 East Clementon Road building slab.

- PCBs, primarily aroclor 1260, are found at concentrations greater than the RDCSRS at depths of up to six feet bgs in locations adjacent to and west of the Silver Lake conveyance system. PCBs are found at concentrations greater than 50 mg/kg at three locations near the center of the Silver Lake conveyance system: MPSB0143, MPSM0144, and ERTSB012.

- Lead, PAHs and PCBs are considered immobile chemicals pursuant to NJDEP guidance and are not found in groundwater.

- There is evidence of LNAPL on the west side of the 2 Foster Avenue building, near location MPSB0107, where naphthalene was found at concentrations greater than the RDCSRS.

- Arsenic is present at a concentration greater than the GWQS in shallow monitoring well MPMW0049, located south of the 6 East Clementon Road building slab, and MPMW0032, located north of Foster Avenue and east of the Silver Lake conveyance system.

- Benzene and VOC/SVOC TICs are present at concentrations greater than the GWQS in shallow monitoring well MW-15, located in the parking lot adjacent to the 2 Foster Avenue building. These same constituents were found at concentrations greater than the GWQS at shallow/intermediate groundwater screening location MPSB0107, located immediately adjacent to the 2 Foster Avenue building.

2.4.3. Former Resin Plant/Tank Farm A Area

The Former Resin Plant/Tank Farm A Area (Figure 4) is the presumed source of the LNAPL present in this area and the Seep Area south of Foster Avenue. Much of this area is covered with an impermeable cap consisting of the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings, the slab of the former "red barn" building, the parking area north of the 2 Foster Avenue building and east of the 4 Foster Avenue building, and the U.S. Avenue sidewalk. Areas not covered by an impermeable cap are the small landscaped areas around the 2 and 4 Foster Avenue buildings, the area immediately east of the historic smokestacks, located in the northernmost portion of the Former Resin Plant area, and the area between the former red barn slab and U.S. Avenue.

- In addition to the characteristics of the LNAPL applicable to all of the LNAPL at the FMP and Eastern Off-Property Area, there are conditions applicable to the LNAPL in this area:
    - The LNAPL extends horizontally from the former stacks located adjacent to Silver Lake in the northwest portion of the area, to U.S. Avenue to the east, and to Foster Avenue to the south;
    - Based on the presence of methane and other petroleum vapors in soil gas (Figure 5), the LNAPL is likely present beneath a portion of the 4 Foster Avenue, and all of the 3 U.S. Avenue building and 2 Foster Avenue building;

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  - In locations where soil borings and groundwater wells have been installed, the LNAPL extends vertically from the water table (approximately 10' bgs) to as deep as 25 feet bgs. No soil sampling has been conducted beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings. Therefore, the depth and thickness of the LNAPL cannot be definitively established in those areas. However, since former Tank Farm A is the presumed source of the LNAPL, it is expected that the vertical distribution beneath the buildings is similar to that in former Tank Farm A.

  Figure 12 provides the interpreted extent of LNAPL on the FMP, including the former Resin Plant/Tank Farm A Area.

- Naphthalene and benzene are found in soil at concentrations greater than the RDCSRS (Figure 11). These constituents are associated with the LNAPL, which is found at depths ranging from approximately 8 feet bgs to 17 feet bgs (see Figures 4-1 and 6-10A from the LNAPL Report, Appendix B).

- The LNAPL is a source of benzene, naphthalene and VOC/SVOC TICs in shallow and intermediate groundwater, as shown by MW-11, MW-12, and MW-24 (Figure 2). The LNAPL is also likely responsible for the presence of arsenic found in groundwater at concentrations greater than the GWQS (wells MW-11 and MW-12; see Figure 2). Although the LNAPL is not a source of arsenic, its presence does create reducing conditions that tend to mobilize naturally-occurring arsenic present in the soil matrix.

- Naphthalene was found in indoor air in the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings and adjacent parking areas at concentrations greater than the NRIASLs (Figure 5). As discussed in the RIR, it is not certain that the naphthalene originates with the LNAPL, but any remedy designed to address methane in the

subsurface will also remove the naphthalene in soil gas that may be the source of the naphthalene in indoor air.

2.4.4. Seep Area

The Seep Area is the location where interim actions were previously conducted to mitigate and prevent discharges to Upper Hilliards Creek.

- In addition to the general conclusions applicable to all of the LNAPL at the FMP and the Eastern Off-Property Area, the following conclusions regarding the LNAPL are applicable to the Seep Area:

    - The LNAPL in the Seep Area extends from Foster Avenue in the north to U.S. Avenue in the east, to Upper Hilliards Creek to the west, near Foster Avenue and (Figure 12). The LNAPL is likely present beneath the 5 Foster Avenue building. However, based on the absence of any soil gas impacts beneath the 1 Foster Avenue building slab and the absence of LNAPL in soil borings immediately north of the building, it is unlikely that LNAPL is present beneath the 1 Foster Avenue building. This will be confirmed as part of a PDI.

    - Vertically, the LNAPL within the Seep Area is first encountered at the water table (approximately one-foot bgs in the 1 and 5 Foster Avenue parking area and deeper along the slopes adjacent to Foster Avenue and U.S. Avenue), and typically extends approximately three feet (and in some cases five feet) into the saturated zone (see Figures 4-1 and 6-10E from the LNAPL Report, Appendix B).

    - Benzene and naphthalene are present in soil at concentrations greater than the RDCSRS where the LNAPL is present (Figure 13, MPSB0047; MW-13). Both constituents are found exclusively in the saturated zone.

- The LNAPL is a source of naphthalene, benzene and VOC/SVOC TICs in groundwater (Figure 2, MW-13R and MPMW0009).

- The key difference between the LNAPL in the Seep Area and the LNAPL in the Former Resin Plant/Tank Farm A area is that the LNAPL in the Seep Area is generally more accessible. It is not found at the depths observed in the Former Resin Plant/Tank Farm A area, and, based on the current understanding of the LNAPL distribution. is not extensively present beneath large buildings, such as is the case in the former Resin Plant/Tank Farm A Area.

- PAHs are present at concentrations greater than the RDCSRS in some locations immediately below asphalt parking areas and roadways.

2.4.5. Former Lagoon Area

The primary constituent found in soil at a concentration greater than the RDCSRS in the former Lagoon Area is pentachlorophenol (Figure 14). PAHs are found at concentrations greater than the RDCSRS in isolated locations.

The highest concentrations of pentachlorophenol are located in a relatively small area in the northwest portion of the former Lagoon Area in borings MPSB0049 and MPSB0203. At depths from 2 to 6 feet bgs, pentachlorophenol concentrations ranged from 140 mg/kg to 650 mg/kg. In other locations, the majority of the pentachlorophenol concentrations were less than 10 mg/kg, with a maximum concentration of 23 mg/kg.

The pentachlorophenol is, in general, present in the saturated zone, and is found at concentrations greater than the RDCSRS as deep as 20 feet bgs (MPSB0068). Shallow groundwater levels in the former Lagoon Area range from approximately 81 feet NAVD to 84 NAVD during high water levels. As such, except in locations where the soil has been mounded, groundwater is encountered at depths of approximately four feet bgs. As shown on Figure 15, detections of pentachlorophenol are almost exclusively at and below four feet

bgs. Therefore, the IGWSRS for pentachlorophenol (0.3 mg/kg) is not applicable to the vast majority of the former Lagoon Area. There are exceptions to this general statement, including MPSB0049, MPSB0056, MPSB0122, and MPSB0123.

Pentachlorophenol is found in groundwater at concentrations significantly greater than the GWQS in shallow groundwater monitoring wells MPMW0027 and MPMW0101 (Figure 2).

VOC and SVOC TICs are found at concentrations greater than the interim specific GWQS in the majority of the shallow and intermediate groundwater monitoring wells in the former Lagoon Area (Figure 2). Based on a review of the analytical data for the soil samples collected in the former Lagoon Area (see Table 3 from the RIR), there is no readily apparent source of the VOC and SVOC TICs. This will be further investigated as part of a PDI.

2.4.6. Upper Hilliards Creek

Upper Hilliards Creek (Figure 4) lies between the Seep Area and the 7 Foster Avenue building and parking area, which is part of the Main Plant FS Study Area. Also included in the Upper Hilliards Creek area is an area east of residential properties B-4 through B-7, where remediation activities have previously been conducted. The remedial actions addressed the constituents present on the residential properties at concentrations greater than the RDCSRS, but sampling conducted in support of those activities found constituents at concentrations greater than the RDCSRS east of these properties.

There are three media in Upper Hilliards Creek for which alternatives are evaluated in this FS: (1) soil, (2) sediment, and (3) surface water. Conditions in each that are relevant to the alternatives evaluation are summarized below.

2.4.6.1. Soil

Arsenic, lead and PAHs are the constituents found most frequently in Upper Hilliards Creek at concentrations greater than the RDCSRS (Figures 16 and 17). Arsenic and lead are the constituents found most frequently in surface soil (0'–1') at concentrations greater than

PRGs (Figure 21). Based on the distribution of these constituents in soil, they are present as a result of stream channelization (northern portion of Upper Hilliards Creek), or the deposition of sediment from Upper Hilliards Creek onto the floodplain.

Based on the distribution of arsenic and lead (see Figures 18 and 19), the horizontal extent of constituents is defined by approximately the 80-foot North American Vertical Datum (NAVD) contour within the Upper Hilliards Creek floodplain. In the northern portion of Upper Hilliards Creek, constituents within the floodplain are contiguous with constituents present in the Former Main Plant area to the west and the Seep Area to the east.

Based on the vertical extent of arsenic and lead, the depth at which delineation to the RDCSRS is achieved in the Upper Hilliards Creek floodplain ranges from approximately two feet bgs, typically at the most eastern and western sampling locations, to as deep as six to eight feet bgs in locations immediately adjacent to the stream. There are a number of locations where sampling was terminated prior to achieving vertical delineation, and a PDI will be necessary to better define the vertical extent in these locations.

The horizontal and vertical extent to which constituents exceed the PRGs and RDCSRS along the eastern fence lines of residential properties B-4 through B-7 is limited (Figure 18). The arsenic and lead are typically found only in the 0.0'–0.5' interval, and are vertically delineated by samples in the 2.5'–3.0' interval. Horizontally, delineation is achieved approximately 50 feet from the eastern fence line. Additional sampling will likely be conducted as part of a PDI to better refine the horizontal extent.

2.4.6.2. Sediment

The RIR found a number of constituents, including pesticides, PAHs, PCBs and metals, at concentrations greater than the Ecological Screening Criteria (ESC) in sediment in Upper Hilliards Creek (Figure 20). These constituents were found in sediment throughout Upper Hilliards Creek, and their vertical extent ranged from two to seven feet.

Based on the BERA, three primary constituents were identified as contributing to ecological risks in sediment: arsenic, lead and cyanide. These constituents are also found throughout Upper Hilliards Creek, and their vertical extent ranges from approximately two to seven feet (Figure 20).

2.4.6.3. Surface Water

Barium, cyanide and iron were the constituents found at concentrations greater than the surface water standards as part of the RI sampling (Figure 21). Lead was detected in one location, HCDW005, at a concentration greater than the surface water standard. The results of the BERA sampling were similar, except that barium was not detected at a concentration greater than the surface water standard.

2.4.7. Eastern Off-Property Area

The presence of LNAPL in the saturated zone is the only medium for which an evaluation of remedial alternatives is required in the Eastern Off-Property Area. Site-related constituents are not present in unsaturated soils at concentrations greater than the RDCSRS, and sampling conducted by the EPA has found no soil gas at concentrations greater than screening levels beneath the structures located in this area. These findings were reflected in the HHRA, where no cancer or non-cancer risks exceeded EPA's targets for any receptor.

In addition to the general conclusions regarding LNAPL presented earlier, the following conclusions are specific to the Eastern Off-Property Area:

- The LNAPL extends across U.S. Avenue from approximately Residential Property E-1, located at the northeast corner of U.S. Avenue and Berlin-Haddonfield Road, to Property E-11, located across U.S. Avenue from the southern portion of the Seep Area (Figure 22).

- The LNAPL extends to the southeast to the fence line of the U.S. Avenue Burn Site (Figure 22).

- The vertical thickness of the LNAPL is, in general, relatively small in comparison to the former Resin Plant/Tank Farm A and Seep Areas. The LNAPL thickness in the former Resin Plant/Tank Farm A area ranged from approximately ten to fifteen feet, while in the Seep Area it was thick as six to seven feet. In the Eastern Off-Property Area, the LNAPL thickness is estimated at approximately two to four feet.

- The exception to the general conclusion regarding the thickness of the residual LNAPL in the Eastern Off-Property Area is the former tavern/service station, where, based on the CPT/MIP results at locations CPT-MIP-32, CPT-MIP-33 and CPT-MIP-35 (LNAPL Report Appendix B, page 281), the LNAPL thickness is five to seven feet.

- The LNAPL is present exclusively at and beneath the water table, at depths ranging from approximately ten to approximately 17 feet below ground surface, depending upon the ground surface and groundwater elevations.

- The shallowest depth at which any constituent is found at a concentration greater than the RDCSRS is 10.0' – 10.5' bgs. Naphthalene, the primary constituent associated with the LNAPL, is present at concentrations greater than the RDCSRS at this interval at location MPSB0352 (Figure 23). This is below the depth at which any resident would contact the naphthalene and below the depth that any construction worker would be expected to contact the naphthalene. As such, there is effectively a soil cap of a minimum of ten feet thick across the Eastern Off-Property Area.

- Sampling conducted by the EPA in 2008, 2009 and 2016, and Sherwin-Williams in 2018, found no constituents in soil gas at concentrations greater than screening levels on the Eastern Off-Property Area (see Figure 24).

- The LNAPL is the source of benzene and VOC/SVOC TICs found in intermediate and shallow groundwater in MW-26, MW-27, MPMW0008, MPMW0025, MPMW0042,

and MPMW0044 (Figure 2). The dissolved-phase organic constituents are undergoing biodegradation.

2.4.8. Human Health Risk Assessment

The HHRA characterized the potential risk to human health from exposure to soil, sediment, surface water and vapor intrusion at the FMP. For purposes of the HHRA, the FMP was divided into four exposure areas: (1) North of Foster Avenue (NFA; the Former Main Plant and Resin Plant/Tank Farm A areas), (2) South of Foster Avenue (SFA; the Seep Area), (3) East of United States Avenue (EUSA); and (4) the Undeveloped Area (UNDV; the Former Lagoon Area and parts of Upper Hilliards Creek). These exposure areas were selected because the receptors and expected exposure parameters were predicted to be similar.

Receptors evaluated for risks associated with soil, sediment and surface water were the Construction Worker, Utility Worker, Outdoor Worker, child, adolescent and adult Recreator, and child and adult Resident. Exposure pathways evaluated for soil were incidental soil ingestion, dermal contact with soil, and inhalation of vapors and particulates that might be emitted from soil. Sediment exposure pathways were ingestion and dermal contact. The surface water exposure pathway was dermal contact while wading.

Risks to commercial workers from vapor intrusion were evaluated for eight buildings: 1, 2, 4, 5, 7 and 10 Foster Avenue, 6 East Clementon Road (no longer present) and 3 U.S. Avenue. Results of indoor air sampling were screened against health-based values that are protective of commercial workers. Results of sub-slab sampling were screened against criteria protective under assumed conservative soil gas to indoor air transport assumptions.

The HHRA found that cancer risks for the Utility, Construction and Outdoor Workers were within EPA's target range in all four FMP exposure areas. Additionally, non-cancer risks for the Utility and Outdoor Workers were within EPA's target hazard index (HI) in the four exposure areas. The non-cancer risk for the Construction Worker exceeded EPA's HI in the NFA, SFA and UNDV.

Cancer risks for the adult and child resident exceeded EPA's target risk range in the NFA, SFA and UNDV. Non-cancer hazards for the child Resident exceeded EPA's target HI in the NFA, SFA and UNDV. Non-cancer hazards to the adult Resident exceeded EPA's target HI in the UNDV. It is noted that there are no residents occupying the NFA, SFA or UNDV.

Sediment exposures to the child, adolescent and adult Recreators in the UNDV, which includes Upper Hilliards Creek, were evaluated assuming that the chromium was: (a) all hexavalent chromium (Cr^{+6}), the carcinogenic form of chromium, and (b) 5% Cr^{+6}, based on sampling conducted at the FMP. Assuming 100% Cr^{+6}, cancer and non-cancer risks for all Recreators exceeded EPA's target risk range and HI. Assuming 5% Cr^{+6}, cancer risks for the adolescent Recreator were within EPA's target range, but the non-cancer risk for the adolescent Recreator was greater than 1. Cancer and non-cancer risks for child and adult Recreators exceeded the target risk range and HI.

Risks due to exposure to lead were evaluated by modeling to evaluate whether the probability of a blood lead level (BLL) greater than 5 µg/L was greater than 5%. The 5% probability threshold was exceeded in NFA, SFA and UNDV for the child Resident, the Construction Worker and Outdoor Worker in the SFA, and the Construction Worker in the UNDV. Exposure to soil was the contributor to the exceedance of the BLL criteria in the UNDV. The 5% threshold was exceeded in the combined UNDV+UHC for the child Recreator, as a result of exposure to both soil and sediment.

Based on a comparison of indoor air sampling results with EPA and NJDEP screening levels values established for the protection of commercial workers, and sub-slab screening values derived from the indoor air screening levels, it was concluded that there may be a potential for risk to occupants of the 2 and 4 Foster and 3 U.S. Avenue buildings. However, based on site observations and the potential for background sources, it was uncertain that the concentrations observed in indoor air were the result of vapor intrusion.

2.4.9. Baseline Ecological Risk Assessment

The primary purpose of the BERA is to estimate the likelihood and magnitude of risks to ecological receptors in those portions of the FMP that serve as ecological habitat. The BERA considered an exposure area called "Upper Hilliards Creek". This included the aquatic and terrestrial habitat within Hilliards Creek between Foster Avenue and West Clementon Road. The aquatic habitat is the stream, while the terrestrial habitat includes the Upper Hilliards Creek floodplain and adjacent forested areas, and the Former Lagoon Area. In total, the exposure area is approximately 17 acres in size, with approximately 0.4 acres of stream.

Representative ecological groups were identified and surrogate wildlife species were chosen to represent each group. These species are: the American Robin, Northern Bobwhite, Bald Eagle, Red-Tailed Hawk, Short-tailed Shrew, Meadow Vole, Red Fox, Raccoon, Mallard, Great Blue Heron. Spotted Sandpiper, Mink and Muskrat.

The BERA evaluated potential ecological risks to these receptors based on exposure to metals, PCBs, PAHs, pesticides, semi-volatile organic compounds (SVOCs) and volatile organic compounds (VOCs). Exposure to these constituents was examined in soil, sediment, surface water, pore water and tissue. Additionally, 28-day sediment toxicity testing was conducted to evaluate the potential for toxicity to benthic invertebrates.

The BERA concluded:

- Risks to benthic invertebrates are low.

- Arsenic, lead and manganese may pose an unacceptable risk to aquatic life. Exceedances of risk-based benchmarks were observed in pore water, surface water and fish tissue. Concentrations of these metals in Upper Hilliards Creek were higher than in background locations.

- Arsenic, barium lead and zinc may pose an unacceptable risk to the plant community.

- Arsenic in soil may represent an unacceptable risk to soil invertebrates.

- Arsenic and lead may pose an unacceptable risk to wildlife. Small wildlife that primarily consume terrestrial invertebrates such as the American Robin and Short-Tailed Shrew were identified as the most sensitive terrestrial receptors due to their size, small home range and dietary preferences. The Spotted Sandpiper was identified as the most sensitive aquatic receptor due to its small home range, small size and high rate of incidental sediment ingestion. The BERA noted that risks were driven by localized elevated COPC concentrations within and near Hilliards Creek, and that upland areas farther away from Hilliards Creek were expected to pose minimal risks to wildlife.

2.4.10. Derivation of Soil and Sediment PRGs

Presented in Appendix A and summarized in Table 1 are the ecological PRGs for soil and sediment derived from the BERA results. Although the RIR compared the sediment data to the NJDEP ESC, and the BERA compared results to the PECs, neither the ESC nor PECs are cleanup criteria. The values derived in Appendix A are those used in this FS to determine the need for, and the areas and volumes of, sediment and soil remediation.

Ecological PRGs were derived following New Jersey Department of Environmental Protection (NJDEP) guidance for the determination of risk-based remediation goals (NJDEP, 2015). These are consistent with the risk management section (Step 8) of the United States Environmental Protection Agency's (EPA) Superfund ecological risk assessment guidance (EPA, 1997).

Benthic invertebrate PRGs were developed using the results of the sediment toxicity testing that was conducted as part of the BERA. The aquatic-dependent and terrestrial wildlife PRGs were developed using food chain models and Site-specific information (*e.g.*, tissue concentration data) that was collected as part of the BERA. Terrestrial wildlife PRGs were developed using site-specific tissue data from all of Hilliards Creek. Site-specific surface

water PRGs were not developed because the NJDEP Water Quality Standards are considered ARARs for Upper Hilliards Creek.

PRGs for Protection of Benthic Invertebrates

Background sediment toxicity samples did not result in significant toxicity. None of the Upper Hilliards Creek sediment samples resulted in significant toxicity. Further, mean weight and mean biomass results were significantly greater in samples collected from UHC when compared to background samples. However, some samples collected from Middle Hilliards Creek and Lower Hilliards Creek did show toxicity, and these results were used, along with the results from Upper Hilliards Creek, to develop benthic PRGs for all of Hilliards Creek.

Sediment PRGs were developed for three primary COPCs: arsenic, cyanide, and lead. These three COPCs were found most frequently above sediment benchmarks, and their presence was highly correlated with the presence of other COPCs. Therefore, by addressing these three COPCs, it can be expected that all other COPCs would be addressed.

Site-specific benthic PRGs for sediment were developed using the sediment data and toxicity data for all of Hilliards Creek collected for the BERA as follows:

1. The highest concentration of a COPC at which no effect was observed in the toxicity bioassays (a no observed effect concentration [NOEC]); or

2. The lowest concentration of a COPC at which minimal or low toxicity was observed in the toxicity bioassays (a lowest observed effect concentration [LOEC]).

The BERA found that survival was the endpoint where statistically significant reductions in comparison to the control were observed.

Based on this analysis, the following PRGs for benthic invertebrates were developed:

- **Arsenic:** The LOEC for As survival was 20.5 mg/kg for UHC.

- **Lead:** The LOEC for Pb survival was 593 mg/kg for UHC.

- **Cyanide**: The LOEC for CN- survival was 20 mg/kg for UHC.

PRGs for Protection of Aquatic-Dependent Wildlife

The BERA concluded that the most sensitive aquatic wildlife receptor was the Spotted Sandpiper. This aquatic surrogate wildlife receptor has HQs that are an order of magnitude higher than those of other aquatic surrogate wildlife receptors, has the highest modeled exposure to benthic organisms (100% of its diet), has the highest incidental sediment ingestion rate (10%), and is sensitive to the primary COPCs. Therefore, for the development of wildlife sediment PRGs, the Spotted Sandpiper was selected, given that it is the most sensitive surrogate aquatic wildlife receptor, and PRGs developed using this surrogate receptor will be protective of other aquatic-dependent wildlife. Sediment PRGs for protection of aquatic-dependent wildlife were developed using the BERA food web models (Gradient, 2016a), consistent with NJDEP guidance (NJDEP, 2015).

The wildlife sediment PRGs, based on the most sensitive aquatic wildlife receptor (the Spotted Sandpiper) for each key COPC are:

- **Arsenic:** The PRG for As is estimated as 17 mg/kg

- **Lead:** The PRG for Pb is estimated as 176 mg/kg

- **Cyanide:** The PRG for CN- is estimated as 4 mg/kg

As noted in the BERA and Appendix A, there are a number of assumptions inherent in the food web modeling used to develop the aquatic-dependent wildlife PRGs that result in conservative PRGs. These include the assumption that the diet of the Spotted Sandpiper will consist of 100% benthic invertebrates from the Site, it would also consume sediment at 10%

of the food ingestion rate, and there would be 100% bioaccessibility of all COPCs in both food and sediment.

PRGs for the Protection of Terrestrial Wildlife

The BERA found that the most sensitive terrestrial surrogate wildlife receptors were the American Robin and Short-Tailed Shrew. These receptors have HQs that are similar to or an order of magnitude higher than those of other terrestrial surrogate wildlife receptors, have the highest modeled exposure to soil invertebrates (100% of its diet), have substantial incidental soil ingestion rates (2.4-10.4%), small home ranges, and are sensitive to the primary COPCs. Thus, for the development of wildlife PRGs, the American Robin and Short-Tailed Shrew were selected, given that they are the most sensitive terrestrial surrogate wildlife receptors, and PRGs developed using these surrogate receptors will be protective of other terrestrial wildlife. Wildlife PRGs were developed using the BERA food web models, consistent with the NJDEP guidance (NJDEP, 2015).

The wildlife soil PRGs based on the most sensitive terrestrial wildlife receptors for each key COPC are:

- **Arsenic:** The lowest PRG for As is estimated as 12 mg/kg (based on the Short-Tailed Shrew). This value is below the site-specific 95% upper confidence level (UCL) background soil concentration; thus, the background value of 17 mg/kg for As was selected as the PRG (Table A.10).

- **Lead:** The lowest PRG for Pb is estimated as 91 mg/kg (based on the Short-Tailed Shrew). This value is also below the site-specific 95% UCL background soil concentration; thus, the background value of 213 mg/kg for Pb was selected as the PRG (Table A.10).

- **Cyanide:** The lowest PRG for CN- is estimated as 4 mg/kg (based on the American Robin). This value is also below the site-specific 95% UCL background soil

concentration; thus, the background value of 58 mg/kg for CN- was selected as the PRG (Table A.10).

Similar to the derivation of the PRGs for the aquatic-dependent wildlife, there are several assumptions inherent in the food web modeling for the terrestrial wildlife that result in conservative PRGs. These include the assumptions that the diets consist of 100% terrestrial invertebrates from the Site, and complete bioaccessibility of the COPCs in the food source and soil.

Selection of Ecological PRGs

The derived sediment concentrations for protection of the Spotted Sandpiper, the surrogate for aquatic-dependent wildlife, were selected as the ecological PRGs for sediment, since these values are lower than the values for protection of benthic organisms. The soil concentrations derived for protection of terrestrial wildlife were all below the Site-specific 95% upper confidence limit (UCL) background concentration. Therefore, background concentrations were selected at the ecological PRGs for protection of terrestrial wildlife. The PRGs for soil and sediment are set forth on Table 1.

Distribution of Constituents at Concentrations Greater than PRGs

Figure 25 presents the extent to which constituents are found in Upper Hilliards Creek sediment at concentrations greater than the PRGs. Figure 26 presents the extent to which constituents are found in surface soil (less than one foot) at concentrations greater than the PRGs within the areas of ecological habitat at the Site.

2.5. Environmental Setting

The RIR presented a detailed discussion of the environmental setting of the FMP. Presented in this section is a summary of the key findings in the RIR.

2.5.1. Land Use

The FMP is a large parcel of land with a variety of land uses including commercial properties and ecological habitat. North of Foster Avenue, the land use is commercial. Commercial properties, as well as a large area of undeveloped land, are south of Foster Avenue (Figure 4).

In the northern part of the site are the Former Main Plant, and Former Resin Plant and former Tank Farm A subareas, which consist of commercial properties and parking areas. North of the Former Main Plant is Silver Lake and north of the Former Resin Plant and former Tank Farm A is an undeveloped parcel of land.

South of Foster Avenue and west of Hilliards Creek is the former Tank Farm B area, now the location of the 7 Foster Avenue building. South of Foster Avenue and east of Hilliards Creek is the Seep Area. The Seep Area consists of commercial buildings and a parking area.

South of the Seep Area is the Former Lagoon Area, which is currently undeveloped.

Upper Hilliards Creek begins at Foster Avenue and terminates at West Clementon Road. The northeast portion of the Upper Hilliards Creek subarea consists of approximately 350 feet of a grassy stream bank beginning at Foster Avenue and extending to the southwest corner of 1 Foster Avenue. From this location to West Clementon Road, the stream bank is natural and undeveloped.

As shown on Figures 27 and 28, both sides of Upper Hilliards Creek beginning at approximately the southwest corner of the 1 Foster Avenue building and ending at West Clementon Road are either NJDEP-mapped wetlands or a Federal Emergency Management Administration (FEMA) mapped flood zone. Based on this mapping, this area is likely to remain undeveloped.

2.5.2. Topography

The FMP slopes gradually from northeast to southwest with the Former Main Plant, Former Resin Plant and former Tank Farm A study area at higher elevations than the Seep Area, former lagoon area and Upper Hilliards Creek.

The site topography has been altered by fill placement in the southwest portion of the Former Main Plant study area (see 1951 aerial photographs in Appendix A of the RIR). As shown in aerial photographs, fill was placed in the current location of the 7 Foster Avenue building, and along West Clementon Road, where residential properties were constructed. Fill was also placed in the former lagoon area as part of the lagoon closure, which may have raised the elevation of the area above what existed prior to the lagoon construction.

An exception to the general trend of a gradual slope from northeast to southwest is the change in elevation from the north side of Foster Avenue in the Former Main Plant and Resin Plant/Tank Farm A study areas to the south side of Foster Avenue where the Seep Area is located. There is a decline of approximately 8 to 10 feet in elevation from Foster Avenue to the Seep Area parking lot in this location.

2.5.3. Geology

The FMP is situated within the New Jersey Coastal Plain Physiographic Province. The New Jersey Coastal Plain extends from the Fall Line in the west, to the Atlantic Ocean in the east, and from the Raritan Bay in the northeast, to the Delaware Bay in the southwest (Figure 29).

The Coastal Plain is comprised of a southeast-dipping wedge of Cretaceous to Quaternary unconsolidated sand, silt, clay, and gravel deposits which unconformably overlie pre-Cretaceous bedrock. The quaternary deposits are typically horizontal unconsolidated deposits and unconformably overlie gently (10 to 60 feet per mile [ft/mi]) southeast dipping Tertiary and Cretaceous sediments (Zapecza, 1989). The thickest unconsolidated deposits (approximately 6,500 feet) are located in southernmost Cape May County.

The geologic units and lithologic descriptions for the entire New Jersey Coastal Plain are presented in Figure 30. Throughout the Coastal Plain the majority of the geologic units consist primarily of fine to coarse quartz sand, although there are also discrete geologic units where clay predominates.

According to mapping provided by the NJDEP, the FMP lies entirely within the outcrop area of the lower Kirkwood Formation. The younger Cohansey Formation outcrops approximately 1,000 feet south southeast of the site. Vertically, the investigation of the FMP has extended to the Hornerstown and Navesink Formations.

The lower Kirkwood Formation consists of an upper sand facies and a lower clay facies (Owens *et al*., 1998). The upper facies is described generally as fine- to medium-grained sand, light yellow to white, locally very micaceous, gravelly, and stained by iron oxides in the near surface. The lower facies is described as a clay and clay-silt, dark gray, micaceous, with wood fragments, lignitized twigs, and other plant debris. The Vincentown Formation is described as fine- to coarse-grained quartz sand, gray, glauconitic, and brown, clayey, very fossiliferous, glauconite and quartz calcarenite (Zapecza, 1989).

Based on the boring logs for the site, the native soil beneath the FMP is fine- to coarse-grained (predominantly fine- to medium-grained) sand, white, gray, brown, yellow, orange, containing trace to some clay, silt, and gravel, locally micaceous. These are interpreted to belong to the upper sand facies of the lower Kirkwood Formation.

2.5.4. Hydrogeology

The New Jersey Coastal Plain consists of 15 regional hydrogeologic units: nine aquifers (seven major, two minor) and six confining units (Zapecza, 1989). The major aquifers include the Kirkwood-Cohansey aquifer system, Atlantic City 800-foot sand, Wenonah-Mount Laurel aquifer, Englishtown Aquifer, Upper Potomac-Raritan-Magothy (PRM) aquifer, Middle PRM aquifer, and Lower PRM aquifer. The minor aquifers include the Piney Point and Vincentown aquifers. The named confining beds are the Composite, Marshalltown-

Wenonah, and the Merchantville-Woodbury confining beds. Unnamed confining beds separate the Kirkwood-Cohansey aquifer from the Atlantic City 800-foot sand, and the Upper, Middle, and Lower PRM aquifers.

Groundwater is encountered at depths of approximately 10 to 12 feet bgs in areas of the FMP located north of Foster Avenue and east of U.S. Avenue. Within the Seep Area, groundwater is typically encountered at a depth of 1 to 2 feet bgs, but it can occasionally rise to essentially ground surface. Groundwater is encountered at depths of approximately 5 to 10 feet within the former Lagoon Area.

Shallow (0' – 15' bgs) and intermediate (15' – 25' bgs) groundwater flow are influenced by Hilliards Creek, Bridgewood Lake and White Sand Branch (located south of the FMP in the Burn Site), which act as localized discharge locations. Groundwater flow measured on August 18, 2017 is shown on Figure 31. This figure was previously provided to the EPA in the "*Technical Memorandum Summarizing the Results of Groundwater Sampling at 16 Newly Installed Wells and Proposal for Additional Monitoring Well Installation and Sampling*", (Sherwin-Williams, 2018).

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section identifies ARARs and RAOs, and screens the remedial technologies that can potentially meet ARARs and RAOs. RAOs and technologies are identified based on ARARs, Site-related COCs, risks as identified by the HHRA and BERA, the environmental media of concern, and estimates of the quantities of media to be addressed.

3.1. Applicable or Relevant and Appropriate Requirements

Remedial actions under CERCLA are required to meet Federal and State ARARs (unless waived under specific conditions). CERCLA Section 121(d)(2)(A) specifies that Superfund Remedial Actions must meet Federal standards, requirements or limitations that are determined to be legally ARARs, and that State ARARs must be met if they are more stringent than the Federal requirements. CERCLA Section 121(d)(4) identifies six specific

circumstances under which ARARS may be waived (EPA, 1988b). A standard can be Applicable or Relevant and Appropriate, but not both.

- ***Applicable*** requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (EPA, 1988b).

- ***Relevant and Appropriate*** requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (EPA, 1988b).

CERCLA also recognizes other guidelines as "To Be Considered (TBC)." These include non-promulgated advisories or guidance issued by Federal or State government that are not legally binding and do not have the status of potential ARARs. TBCs may be considered along with ARARs and may be used in determining cleanup levels (EPA, 1988b).

EPA defines three types of ARARs: Chemical-Specific, Location-Specific, and Action-Specific:

- **Chemical-Specific ARARs:** usually either health- or risk-based numerical values or methodologies that establish the acceptable amount or concentration of a chemical that may remain in or be discharged to the environment. Where more than one requirement addressing a contaminant is determined to be an ARAR, generally the requirement that should be used is the one that is the most stringent. Note, however, that in some cases, a less stringent requirement is more well-suited to the

circumstances at a site, such that a more stringent requirement will not be deemed to be relevant and appropriate under the circumstances.

- **Location-Specific ARARs:** generally restrict certain activities or limit concentrations of hazardous substances solely because of geographical or land use concerns. Examples include standards and requirements for addressing wetlands, historic places, floodplains, or sensitive ecosystems and habitats.

- **Action-Specific ARARs:** usually are restrictions on the conduct of certain activities or the operation of certain technologies at a particular site. Examples include regulations concerning the design, construction, and operating characteristics of a treatment system or a landfill.

ARARs and TBCs for the FMP areas are summarized in the following sections.

3.1.1. Chemical-Specific ARARs

Federal

Federal Safe Drinking Water Act-Maximum Contaminant Levels (40 CFR 141.11-.16 and .60-.63). Defines the quality criteria for public drinking water supplies, except private wells.

National Ambient Air Quality Standards (NAAQSs) (40 CFR 50). Establishes air quality standards for specific criteria pollutants, including lead.

New Jersey State

New Jersey Air Pollution Control Rules (N.J.A.C. 7:27). Governs actions that may result in emissions of contaminants into the ambient atmosphere.

Ground Water Quality and Surface Water Standards (N.J.A.C. 7:9). Regulates activities respecting protection and enhancement of ground water and surface water resources.

Remediation Standards (N.J.A.C 7:26D). Establishes the minimum standards for the remediation of soil, contaminated groundwater and surface water.

3.1.2. Location-Specific ARARs

Federal

Endangered Species Act (16 USC 1531 *et seq*.). Requires that action be performed to conserve endangered species or threatened species.

Section 404 - Clean Water Act, as it pertains to wetlands. Prohibits discharge of dredged or fill material into wetlands adjacent to navigable waters without a permit.

Fish and Wildlife Coordination Act (16 USC 661 *et seq*.). Requires actions to protect fish or wildlife when diverting, channeling, or modifying a stream.

Federal Water Pollution Control Act (FWPCA) (33 USC 1521 *et seq*.). Requires a permit from USACE and consideration by both the EPA and the USFWS before an application to dredge and fill may be enacted.

National Historic Preservation Act. Establishes a program for the preservation of historic properties in the United States.

New Jersey State

New Jersey Endangered Plant Species Program (N.J.A.C. 7:5C). Identifies the official list of endangered plant species and establishes the program for maintaining and updating the list.

New Jersey Freshwater Wetlands Protection Act Rules (N.J.A.C 7:7A). Constitutes the rules governing the implementation of the Freshwater Wetlands Protection Act and the New Jersey Water Pollution Control Act as it relates to freshwater wetlands.

New Jersey Flood Hazard Area Control (N.J.A.C 7:13). Sets forth the requirements governing activities in the flood hazard area or riparian zone of a regulated water.

New Jersey Division of Fish, Game, and Wildlife Rules (N.J.A.C 7:25). Supplements the statutes governing fish and game laws in the State of New Jersey.

3.1.3. Action-Specific ARARs

Federal

RCRA Land Disposal Restrictions (40 CFR 268). Identifies hazardous wastes that are restricted from land disposal and identifies those circumstances under which otherwise prohibited waste may continue to be land disposed.

Toxic Substance Control Act (TSCA) regulations for the cleanup and disposal of PCB remediation waste (40 CFR 761.61). Defines the approaches that may be used to remediate and dispose of PCB-containing environmental media.

Department of Transportation (DOT) Rules for Hazardous Materials Transport (49 CFR 107, 171.1-172.604). Defines requirements for the safe and effective transportation of hazardous materials in commerce.

Occupation Safety and Health Standards and Safety and Health Regulations for Construction (29 CFR 1910 and 1926). Establishes occupational safety and health standards.

New Jersey State

Discharges of Petroleum and Other Hazardous Substances (N.J.A.C 7:1E). Sets forth guidelines and procedures to be followed in the event of a discharge of hazardous substance, and defines hazardous substance in New Jersey.

New Jersey Worker and Community Right-to-Know Regulations (N.J.A.C 7:1G). Establishes procedures by which employers provide chemical inventory reporting to inform employees and communities of the potential hazards in the work place.

New Jersey Storm Water Management Rules (N.J.A.C 7:8). Establishes stormwater management requirements to prevent contamination of waterways via stormwater discharge.

New Jersey Water Pollution Control Act Regulations (N.J.A.C 7:14). Prohibits the discharge of any pollutant into the waters of the State without a valid permit.

New Jersey Pollutant Discharge Elimination System Rules (N.J.A.C 7:14A). Establishes the framework under which NJDEP regulates the discharge of pollutants to the surface and groundwaters of the State.

Regulations Governing the Certification of Laboratories and Environmental Measurements (N.J.A.C 7:18). Establishes procedures for laboratories to obtain and maintain certifications and perform sample analysis to ensure analytical and data environmental measurements are of known and defensible quality.

New Jersey Solid Waste Rules (N.J.A.C 7:26). Governs the registration, operation, maintenance, and closure of sanitary landfills, other solid waste facilities, and solid waste transportation operations in the State of New Jersey.

New Jersey Recycling Rules (N.J.A.C 7:26A). Describes the requirements for operating recycling centers and the conduct of recyclable materials generators and transporters.

New Jersey Technical Requirements for Site Remediation (N.J.A.C 7:26E). Establishes the minimum technical requirements for the remediation of contaminated sites.

New Jersey Hazardous Waste Rules (N.J.A.C 7:26G). Identifies the minimum national standards for the acceptable management of hazardous waste in New Jersey.

New Jersey Air Pollution Control Rules (N.J.A.C 7:27). Identifies activities that require obtaining an air permit for construction/operation.

New Jersey Noise Control Rules (N.J.A.C 7:29). Prohibits the generation of certain types of noise at specific times and establishes methods to determine compliance.

New Jersey Brownfield and Contaminated Site Remediation Act (P.L. 1997, C. 278). Enabling legislation for development of remediation standards necessary to protect public health and safety and the environment from discharged hazardous substances and for mandating cleanup of contaminated sites.

Soil Erosion and Sediment Control Act (P.L. 1975, C. 251). Requires that a certified Soil Erosion and Sediment Control Plan be submitted to and approved by the local Soil Conservation District for any construction project that will disturb more than 5,000 ft^2.

3.1.4. TBCs

Federal

EPA's 1985 "Policy on Floodplains and Wetlands Assessments for CERCLA Actions". Requires that CERCLA actions meet the substantive requirements of Floodplain Management Executive Order (EO 11988) and Protection of Wetlands Executive Order (EO 1990).

Fish and Wildlife Coordination Act Advisories. Advisories on the effects of pollutants and other activities on wildlife, including migratory birds and fish, and wildlife habitat authorized under the Fish and Wildlife Coordination Act.

Executive Order 11988 Floodplain Management. Requires federal agencies to avoid to the extent possible long- and short-term adverse impacts associated with the occupancy and

modification of floodplains, and avoid support of floodplain development wherever there is a practicable alternative.

Executive Order 11990 Protection of Wetlands. Requires federal agencies to provide leadership and take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands.

New Jersey State

NJDEP "NJDEP Ecological Screening Criteria." March 2009. Provides ESC to be used as screening values in ecological assessments.

NJDEP "Ecological Evaluation Technical Guidance," Version 2.0, August 2018. Provides guidance on conducting ecological evaluations and implementing Risk Management Decisions for ecologically sensitive natural resources.

Administrative Requirements for the Remediation of Contaminated Sites (N.J.A.C 7:26C).

NJDEP Site Remediation Program, "Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria", Version 1.0, September 24, 2012. Guidance on alternate methods to achieve compliance with applicable remediation standards.

NJDEP Site Remediation Program, "Monitored Natural Attenuation Technical Guidance", Version 1.0, March 2012.

NJDEP Site Remediation Program, "Presumptive and Alternative Remedy Technical Guidance", Version 2.0, August 2013.

NJDEP, "Guidance for the Evaluation of Immobile Chemicals for the Impact to Ground Water Pathway", June 2008.

NJDEP Site Remediation Program, "Technical Guidance on the Capping of Sites Undergoing Remediation", Version 1.0, July 2014.

NJDEP Guidance Document, "Capping of Inorganic and Semivolatile Contaminants for the Impact to Groundwater Pathway", Version 1.0, March 2014.

New Jersey Department of Transportation (NJDOT) Standard Specifications – Soil Erosion and Sediment Control Measures (1996). NJDOT standards are typically used to develop the appropriate plans for sediment and soil erosion control required under New Jersey Soil Conservation Act.

New Jersey Soil Cleanup Criteria for Chromium, September 2008, Revised April 2010.

3.2. Remedial Action Objectives

Table 2 presents the currently-identified remedial action goals for soil, sediment surface water and groundwater for the FMP Site.

The soil remediation objectives include the direct contact remediation standards for human health protection, site-specific PRGs for wildlife protection, and the impact to groundwater criteria. These soil remediation objectives are:

- The Residential Direct Contact Soil Remediation Standards (RDCSRS);
- The Non-Residential Direct Contact Soil Remediation Standards (NRDCSRS);
- The Impact to Groundwater Soil Remediation Standards (IGWSRS);
- Preliminary Remediation Goals (PRGs) for wildlife protection; and
- Standards established pursuant to TSCA for the remediation of PCBs.

Key considerations for each standard or criterion include:

- Where a constituent is left in place at a concentration greater than the RDCSRS, institutional controls in the form of a Deed Notice are required. The Deed Notice identifies the locations and depths where constituents are present in soil at concentrations greater than the RDCSRS, limits the land use of the area, and specifies the procedures and notifications that must be followed if intrusive activities are conducted within the area of the Deed Notice. If constituents are left in place at concentrations greater than the RDCSRS and the land use is residential, engineering controls must also be applied consistent with NJDEP technical guidance.

- Where a constituent is left in place at a concentration greater than the NRDCSRS, a Deed Notice and engineering controls are required. NJDEP guidance states that "…*a cap is a barrier over contaminated media that mitigates exposure to potential receptors.*" The guidance further states, "*As with any selected remedial action, the capping must be protective of human health and the environment.*"

- The IGWSRS apply to soil in the unsaturated zone. There are default IGWSRS, but there are also provisions for establishing site-specific values, and NJDEP guidance provides for modeling to show that there will be no groundwater impact for conditions where the constituent is present in unsaturated soil above the water table and the constituent is not present in groundwater. NJDEP guidance also identifies a category of constituents (immobile chemicals) for which, if present in the unsaturated zone, and not present in groundwater, the IGWSRS are not applicable. Where inorganic constituents are present in soil at concentrations greater than the IGWSRS, capping is allowed. However, the cap must meet specific requirements, including being impermeable.

- The PRGs pertain to the top 12" for soil in areas of ecological habitat and the top 6" for sediment.

- Where PCBs are present at concentrations greater than 50 mg/kg, cleanup regulations pursuant to 40 CFR 761.61 apply.

For purposes of this FS, the following conclusions regarding the different soil criteria have been applied:

- The soil PRGs are applicable to the top one foot of soil within the Former Lagoon Area and the Hilliards Creek floodplain.

- Pursuant to NJDEP guidance, the RDCSRS and NRDCSRS are generally not applicable to Ecologically Sensitive Natural Resources (ESNRs) such as the Hilliards Creek flood plain and the former Lagoon Area, since human exposures are not expected to be the same as in developed uplands areas. However, a formal mechanism to preserve the ESNRs in perpetuity and prevent development of these is required. This may include a Deed Notice or a conservation easement.

- The RDCSRS and NRDCSRS are applicable to all soil beneath the Former Main Plant, Resin Plant/Tank Farm A, Seep Area and Eastern Off-Property Area. For those alternatives where constituents would remain at a concentration greater than the RDCSRS, a Deed Notice is included. For those alternatives where constituents would remain at a concentration greater than the NRDCSRS, a Deed Notice and engineering controls are included.

- The IGWSRS are applicable to unsaturated soil in all portions of the FMP. However, for purposes of this FS, the following limitations on the applicability of the IGWSRS have been used:

    - Throughout the Hilliards Creek floodplain and the Seep Area, groundwater levels fluctuate such that the top of the water table is very near, or at, the surface. As such, the soil in these areas can be considered to be saturated and the IGWSRS are not applicable.

- Lead, PAHs (except for naphthalene) and PCBs are considered by NJDEP to be "immobile chemicals". Therefore, unless these constituents are present in an area in groundwater at concentrations greater than the GWQS, the IGWSRS are not applicable.

- Impermeable caps are present across the majority of the Former Main Plant and Former Resin Plant/Tank Farm A areas. With few exceptions, the constituents present at concentrations greater than the default IGWSRS are inorganics and semivolatile organic compounds that are allowed to be capped pursuant to NJDEP guidance. Therefore, under alternatives where the impermeable cap is to remain, compliance with the IGWSRS is achieved.

- For alternatives where an impermeable cap will not or cannot be installed, and constituents may remain in unsaturated soil at concentrations greater than the default IGWSRS, Site-specific values will be developed or the alternative will include removal of the soil containing the constituent at concentrations greater than the IGWSRS.

3.2.1. Remedial Action Objectives

RAOs are media- or unit-specific goals developed for the protection of human health and the environment, based on the current and intended future use at each site. The RAOs for soil, sediment and surface water at the FMP based on the results of the RI, HHRA and BERA are:

Soil

- Prevent potential current and future unacceptable risks to human and ecological receptors resulting from uptake of soil contaminants by plants, ingestion of contaminated soil and food items by humans and ecological receptors, and physical contact with contaminated soil.

- Minimize migration of Site-related contaminants in the soil to sediment, surface water and groundwater.

Sediment

- Prevent potential current and future unacceptable risks to human and ecological receptors resulting from uptake of sediment contaminants by plants, ingestion of contaminated sediment and food items by humans and ecological receptors, and physical contact with contaminated sediment.

- Minimize migration of Site-related contaminants in the sediment to surface water.

Surface Water

- Prevent potential current and future unacceptable risks to human and ecological receptors resulting from uptake of surface water contaminants by plants, ingestion of contaminated surface water and food items by humans and ecological receptors, and physical contact with contaminated surface water.

- Minimize transport of Site-related contaminants in surface water.

LNAPL

- Remove or treat where practicable or contain where removal or treatment is not practicable.

- Prevent potential current and future unacceptable risks to human and ecological receptors resulting from direct contact with LNAPL.

- Minimize transport of LNAPL-related COCs in groundwater.

Methane and Vapor Intrusion

- Prevent potential current and future unacceptable risks to human receptors resulting from inhalation of VOCs and SVOCs originating in LNAPL.

- Prevent potential current and future risks to human health and structures resulting from the presence of methane in soil gas.

3.3. General Response Actions/Estimation of Areas and Volumes

3.3.1. Soils

Pursuant to EPA guidance, the total estimated soil areas and in-place volumes where constituents are present at levels exceeding RIR screening criteria (RDCSRS) and the soil PRGs for the FMP were estimated (Table 3). These estimates are based on the data presented in the RIR, the RDCSRS and the PRGs that have been developed. As discussed further, for each alternative that has been evaluated, soil areas and volumes that would be addressed will vary depending on the nature and components of each alternative.

3.3.2. LNAPL

The area and volume of soil in the FMP and Eastern Off-Property Area that contain LNAPL are presented on Table 3. This area has been obtained from the lines of evidence presented in the LNAPL Report.

3.3.3. Sediment

The total estimated sediment areas and in-place volume of sediment found to exceed the PRGs were estimated to support the analysis of the potential remedial alternatives. Similar to soil, the areas and volumes of sediment addressed in the final remedial alternatives will vary depending on the nature and components of that alternative. The estimated area and volume of contaminated sediment based upon the PRGs for Upper Hilliards Creek are summarized in Table 3.

3.3.4. Surface Water

Upper Hilliards Creek is approximately 1,100 feet long and ranges in width from approximately 10 to 25 feet and water depth ranges from 2 to 18 inches.

3.4. Identification and Screening of Technology Types and Process Options

Tables 4 through 8 provide a screening of potential remedial technology types and process options based on the media and contaminants to be addressed. Technology types and process options are screened on the basis of Effectiveness, Implementability, and Cost in Tables 9 through 12. Selected process options retained from the screening are then developed into remedial alternatives in Section 4.

It is to be noted that two technologies that are sometimes evaluated and/or implemented at LNAPL sites, enhanced LNAPL recovery technologies, such as dual-phase extraction (DPE), and thermal-enhanced extraction, have not been carried through in the detailed evaluation of alternatives at the Site. A summary of the rationale for not including these categories of technologies in the detailed alternative review is presented below.

Enhanced LNAPL Recovery Technologies

Enhanced recovery technologies such as DPE are typically utilized for two primary purposes. First, they are used to strip the more volatile components of the LNAPL, such as BTEX, to remove a source of dissolved-phase constituents in groundwater. Second, they are used to lower the water table to reduce the hydraulic pressures on the LNAPL, so drainage of the LNAPL from the soil pores occurs and the LNAPL can be recovered.

Based on the current understanding of the LNAPL composition and distribution, application of an enhanced LNAPL recovery technology will not provide a meaningful benefit with regard to removal of the more volatile components, and it will not result in any significant increase in recovery volumes. Therefore, when evaluated with regard to effectiveness, it provides no additional benefit to other technologies.

As presented in the RIR and LNAPL Report, the weathered mineral spirits that comprise the LNAPL contain low levels of the more volatile components (see Table 6-3 from the LNAPL Report in Appendix B). Benzene was measured in LNAPL samples at concentrations ranging from 5 mg/kg to 100 mg/kg. Xylenes and ethylbenzene were measured at higher, but still low, concentrations, and they are not found in groundwater at concentrations greater than the GWQS. Therefore, it can be concluded that application of DPE would not provide any meaningful benefit with regard to controlling groundwater sources via stripping.

As also presented in the LNAPL Report, the residual saturation levels of the LNAPL in soil are much lower (maximum of approximately 8%; see Figure 6-6 from the LNAPL Report in Appendix B) than saturation values cited in the literature as allowing recovery. Additionally, imbibition testing found that even under high pressures, the residual LNAPL could not be displaced from the soil pores. Therefore, depressing the water table would have limited effectiveness in increasing the recoverability of the LNAPL.

Based on the above, enhanced LNAPL recovery technologies were not carried through into the detailed evaluation of alternatives.

Thermal Enhanced Recovery Technologies

A detailed evaluation of thermal recovery at the FMP was performed to assess whether it is a viable technology for the site. This evaluation was conducted as part of the technology screening to determine if development of a more detailed design and cost estimates for the comparative evaluation of alternatives was merited.

The evaluation identified the most likely locations for application of thermal enhanced technologies at the site, developed a conceptual design and approach, evaluated obstacles to application of the technology, and assessed its potential effectiveness. As part of the review, discussions were conducted with a recognized thermal technology vendor. A technical memorandum summarizing the technology screening evaluation is included as Appendix C.

The technology screening evaluation concluded:

- Thermal enhanced recovery was most applicable to a portion of the former Resin Plant/Tank Farm A Area. The technology is not likely to be applied in the Eastern Off-Property Area because of the presence of the residential buildings, and it would not be applied beneath Foster Avenue or U.S. Avenue because of the presence of buried utilities. Since excavation is a feasible technology for the Seep Area, thermal enhanced recovery is also unlikely to be applied there.

- If the technology were to be applied in the former Resin Plant/Tank Farm A Area, there would need to be a buffer area between the area of application and Foster Avenue and U.S. Avenue, to protect utilities that are present beneath the roadways.

- The likely technology for heating would be thermal conduction heating (TCH) because of the high boiling point of the LNAPL at the FMP.

- More than 1,000 borings would be needed within the treatment area for heating and steam and gas extraction.

- It is uncertain that the current electrical grid serving the FMP and surrounding area is capable of providing the needed energy for the technology.

- Because the treatment is feasible for only a portion of the FMP, the time needed to complete active remediation of the LNAPL is a function of the time another technology, such as bioremediation, would be required to degrade the LNAPL. Therefore, application of thermal treatment to one area of the FMP would not decrease the time of remediation.

- Estimated costs for application of the technology, based on unit costs at other sites, were substantial.

Since application of thermal enhanced removal would not provide a benefit in terms of the time needed to complete remediation, and it would create significant short-term effectiveness and implementability issues, at a significantly higher cost than other technologies, thermal enhanced recovery was not carried through in the detailed evaluation of alternatives.

4.0 DEVELOPMENT AND ANALYSIS OF ALTERNATIVES

The objectives of this section are to present the remedial alternatives developed for soils, LNAPL, soil gas, sediments, and surface water for the FMP Site, and to analyze each alternative against the specific evaluation criteria required by CERCLA (Section 121[d]) and the National Contingency Plan (NCP) (Section 300.430 (e)(9)(iii)).

The remedial alternatives for the FMP are evaluated separately from the remedial alternatives for the Eastern Off-Property Area. The FMP study areas require evaluation of alternatives for surface and subsurface soil, as well as sediment and surface water, and both the former Resin Plant/Tank Farm A and Seep Areas require evaluation of remedial alternatives for LNAPL. In comparison, the Eastern Off-Property Area requires an evaluation of remedial alternatives for LNAPL and, potentially, soil gas.

Descriptions of the remedial alternatives for the FMP are provided in Subsections 4.2.1 (Soil), 4.2.3 (Sediment) and 4.2.5 (Surface Water). A comparative evaluation of the soil, sediment and surface water alternatives is provided in Subsections 4.2.2, 4.2.4, and 4.2.6, respectively. Descriptions and comparative analysis of the remedial alternatives for the Eastern Off-Property Area are provided in Sections 4.2.8 and 4.2.9, respectively.

4.1. Evaluation Criteria for Remedial Alternatives

This section provides the detailed analysis of the Remedial Alternatives in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988a). This analysis will be applied to each of the Site-wide alternatives.

4.1.1. Evaluation Criteria

EPA guidance specifies nine criteria against which each alternative is to be evaluated. Two of these criteria will be evaluated by EPA following public comment. Therefore, this analysis evaluates each alternative retained for detailed analysis against seven evaluation criteria.

Assessment against two of the nine criteria relate directly to statutory findings that must ultimately be made by EPA in the ROD (EPA, 1988a). In order for an alternative to be selected as the preferred remedy, these two criteria must be achieved. Therefore, these are categorized as "Threshold Criteria". The two threshold criteria are:

1. Overall protection of human health and the environment: The assessment of this criterion describes how the remedial alternative, as a whole, achieves and maintains protection of human health and the environment.

2. Compliance with ARARs: The assessment of this criterion evaluates how each of the remedial alternatives comply with ARARs, or if an ARAR waiver is required and how it is justified.

The other five criteria are termed "Balancing Criteria," and are the criteria upon which the comparative analysis of alternatives is based (EPA, 1988a). These criteria are:

1. Long-term Effectiveness and Permanence: The assessment of this criterion evaluates the long-term effectiveness of a remedial alternative in maintaining protection of human health and the environment after the response objectives have been met.

2. Reduction of Toxicity, Mobility and Volume Through Treatment: The assessment of this criterion evaluates whether treatment is employed and, if so, the expected performance of the specific treatment technologies employed in the alternative in eliminating or reducing the residual toxicity, mobility and volume of wastes.

3. Short-term Effectiveness: The assessment of this criterion evaluates the effectiveness of each alternative in protecting human health and the environment during the construction and implementation of a remedy until the remedial objectives have been met. This criterion includes evaluation of the risks and impacts of remedy implementation.

4. Implementability: The assessment of this criterion evaluates the technical and administrative feasibility of each alternative and the availability of required goods and services.

5. Cost: The assessment of this criterion evaluates the capital, operation and maintenance (O&M), and total project present-worth costs of each alternative.

The final two of the nine criteria are "Modifying Criteria" and are evaluated by EPA following comments on the proposed plan and are addressed when the ROD is being prepared. The modifying criteria are:

1. State Acceptance: This assessment considers the State's (or support agency's) apparent preferences among, or concerns about, the alternatives.

2. Community Acceptance: This assessment considers the community's apparent preferences among, or concerns about, the alternatives.

4.2. Identification, Description and Evaluation of Remedial Alternatives for the FMP

4.2.1. FMP Soil Remedial Alternatives

As described in the RIR, constituents are present at concentrations greater than cleanup standards in both surface and subsurface soils. In this section, remedial alternatives for soil are identified and evaluated. The following conclusions from the RIR, HHRA, and BERA have been considered in developing and evaluating these alternatives:

Former Main Plant Area

- The vast majority of the former Main Plant Area is covered by an impermeable cap consisting of buildings and parking areas. This cap meets the general definition of a cap as presented in NJDEP guidance, and, since it is impermeable, provides capping for those metals and semivolatile compounds found at concentrations greater than the IGWSRS in the unsaturated zone that are not considered to be immobile.

- Arsenic, lead, PCBs and PAHs are found at concentrations greater than the RDCSRS throughout much of the FMP. These constituents are found at depths up to 15 feet bgs.

- PCBs are found at concentrations greater than 50 mg/kg in three locations in the Main Plant area.

- Arsenic is found in shallow groundwater at concentrations greater than the GWQS in monitoring wells adjacent to and down gradient of locations where elevated concentrations of arsenic have been found in saturated soil.

Former Resin Plant/Tank Farm A and Seep Area

- The majority of the former Resin Plant/Tank Farm A area is covered by an impermeable cap consisting of the 2 and 4 Foster and 3 U.S. Avenue buildings and the adjacent asphalt parking areas. A soil cover is present in the northeastern portion of the area.

- With the exceptions of the slopes leading to Foster Avenue and U.S. Avenue, the entire Seep Area is covered with an impermeable cap consisting of the 1 and 5 Foster Avenue buildings and the associated parking area.

- Arsenic and lead are found at a concentration greater than the RDCSRS in one location at a depth of 3.5'–4.0' bgs in the northeastern portion of the area. The soil cover

provides a barrier against direct contact, but arsenic is present at a concentration greater than the IGWSRS.

- LNAPL is present in the Former Resin Plant/Tank Farm A and Seep Areas, with the nature and extent characterized as follow:

    - The LNAPL is generally found at the top of the water table and, depending on location, extends from five to fifteen feet into the water table. In the Former Resin Plant/Tank Farm A area, the LNAPL is generally found from approximately 10 ft bgs to as deep as 25 feet bgs. In the Seep Area, the LNAPL is generally from just below the surface to depths of 5 to 7 feet bgs, although the depths are greater near Foster Avenue and U.S. Avenue.

    - Much of the LNAPL in the Former Resin Plant/Tank Farm A area is located beneath the 2 and 4 Foster Avenue buildings and is, therefore, inaccessible without removal of the buildings. In contrast, the LNAPL in the Seep Area is generally accessible.

    - As a result of historic LNAPL recovery activities and natural processes, the LNAPL exhibits low soil saturation levels, and is generally not recoverable. No recovery activities have been attempted beneath the 2 and 4 Foster Avenue buildings.

    - Where LNAPL is present, naphthalene and benzene are sometimes found in soil at concentrations greater than the RDCSRS. These constituents are found in the saturated zone.

    - The LNAPL is a source of VOC and SVOC TICs in groundwater, and, to a lesser extent, a source of naphthalene and benzene in groundwater.

- The LNAPL is undergoing physical and biological natural source zone depletion processes and, based on a review of the literature, these processes are likely responsible for significant mass losses of the LNAPL. However, the biological degradation component is limited by the depletion of key electron donors.

- As a result of the NSZD processes, methane and petroleum vapors are generated. Where impermeable surfaces, such as buildings and parking areas are present, the vapors have accumulated.

Former Lagoon Area

- Pentachlorophenol is found at concentrations greater than the RDCSRS in soil and at concentrations greater than the GWQS in groundwater in the former Lagoon Area.

- The highest concentrations of pentachlorophenol are found in saturated soil in the western portion of the area.

- The majority of the locations where pentachlorophenol is found at a concentration greater than the default IGWSRS are in the saturated zone. There are, however, some locations in the western portion of this area where pentachlorophenol exceeds the default IGWSRS in unsaturated soil.

- VOC and SVOC TICs are found in shallow and intermediate groundwater at concentrations greater than the GWQS. There is no apparent source of the VOC and SVOC TICs in soil; additional investigation is needed as part of a PDI to identify the source(s) of the VOC and SVOC TICs.

Upper Hilliards Creek

- Arsenic, lead, PAHs and PCBs are present in the Hilliards Creek floodplain at concentrations greater than PRGs (soil in the 0.0' – 1.0' interval) and RDCSRS (soil at depths greater than one foot).

- The vertical extent of the arsenic, lead and PAHs present at concentrations greater than the RDCSRS ranges from approximately two feet to six to eight feet bgs.

- A relatively small area of shallow soil containing arsenic, lead and PAHs at concentrations greater than the RDCSRS is present behind the eastern fence line of residential properties B-4 through B-7.

Based on these considerations, the following remedial alternatives were developed and evaluated for soil and LNAPL at the FMP:

Alternative 1 – No Action

Alternative 2 – Targeted Surface Soil Removal, Capping and Institutional Controls

Alternative 3 – Soil and LNAPL Removal/Treatment, Capping and Institutional Controls

Alternative 4 – Extensive Excavation to Depth and Institutional Controls

Additional detail regarding each alternative is provided below. The discussion includes the locations where specific remedial activities would be conducted under each alternative, volumes of soil that would be removed and volumes of soil that would be imported, as applicable, and other details such as the estimated schedule for each alternative. It is important to note that the details for each alternative are best engineering estimates based on the current understanding of Site conditions. The actual details may vary based on any additional pre-design data that are collected or changes in the understanding of Site conditions.

Table 13 provides the summary costs for each alternative. Detailed cost estimates for each of the five areas are presented in Appendix D.

Cost estimates in Table 13 and Appendix D are based on the understanding of the horizontal and vertical extent of constituents presented in the RIR and LNAPL Report. In some locations, these data are limited with regard to establishing the horizontal and/or vertical extent of a remedial action. Professional judgement has been used in these locations to develop the scope, and cost, of the soil alternatives. Prior to remedial design, a PDI will be conducted, and the areas and volumes will be refined.

4.2.1.1. Soil Alternative 1 – No Action

CERCLA requires that the No Action alternative be evaluated in the FS. Under the No Action alternative, no soil remediation would be implemented for soils at the FMP. Current site contaminant exposures and risks would remain.

Routine monitoring of contaminants or site conditions would not be conducted. Under current conditions, the majority of the site is covered by an impermeable cap, preventing direct contact with most constituents in soil and the LNAPL. However, human health and ecological exposures would remain along Upper Hilliards Creek, and no effort would be made to address the LNAPL or sources to groundwater. Statutory CERCLA Five Year Reviews would be conducted in accordance with CERCLA Section 121(c) because contamination would remain on site above levels that allow unlimited use and unrestricted exposure (EPA, 2001).

There is no construction field effort required for this alternative. Total costs for this alternative are approximately $142,000, resulting from the need to conduct the Five-Year Reviews (estimated six reviews).

4.2.1.2. Soil Alternative 2 – Targeted Surface Soil Removal, Capping and Institutional Controls

This alternative would use engineering controls consisting of impermeable caps and soil covers as the primary method to prevent exposure to the contaminants in site soils, and institutional controls in the form of a Deed Notice to ensure that future use of the Site recognizes and maintains these controls.

Up to two feet of soil would be removed from the Upper Hilliards Creek floodplain and the Former Lagoon Area.

Following the shallow soil removal, if the RDCSRS are achieved, the area would be backfilled and revegetated.

At those locations where constituents remain in the subsurface at concentrations greater than the RDCSRS, a cap would be installed. The cap would consist of a demarcation layer, one and a half feet of common fill and six inches of topsoil. The area would be revegetated according to regulatory requirements.

A Deed Notice would be established for those parcels where constituents remain at concentrations greater than the RDCSRS.

In other study areas, the existing impermeable cap, consisting of buildings, parking areas and roadways would serve as the engineering control.

The estimated limits of Soil Alternative 2 are shown on Figure 32.

Specific components would include:

- Upper Hilliards Creek and the Former Lagoon Area: Up to two feet of soil would be removed in those areas where constituents are present in the upper one foot of soil at concentrations greater than the PRGs or in soil in the upper two feet at

concentrations greater than the RDCSRS. An evaluation of either removing the unsaturated soil where pentachlorophenol is present at a concentration greater than the default IGWSRS or establishing a site-specific IGWSRS would be conducted.

Upper Hilliards Creek and the Former Lagoon Area include wetlands, wetlands transition areas and/or flood hazard areas where no net fill is allowed pursuant to NJDEP regulation. Since the soil excavation would be conducted immediately adjacent to Upper Hilliards Creek, temporary water diversion and management structures would be installed. In all locations, the soil removal would be terminated at the depth the PRGs are achieved, if at a depth of one foot or less, or the RDCSRS, if between one and two feet.

In those locations where the RDCSRS are not achieved at two feet below ground surface, a two-foot vegetated cap, consisting of a demarcation layer, one foot of common fill and one foot of top soil, would be installed. In those locations where the RDCSRS are achieved at the bottom of the excavation, the excavation would be backfilled with soil, consistent with the soil removed and revegetated.

- Former Main Plant, Seep Areas: The existing impermeable cap consisting of building slabs, parking areas and roadways would be inspected and supplemented, if necessary. Locations not covered by the impermeable cap would be evaluated to determine if unsaturated soil containing arsenic at concentrations greater than the default IGWSRS would be removed or if the impermeable cap would be expanded onto those areas.

- Former Resin Plant/Tank Farm A: The existing impermeable cap, consisting of building slabs, parking and roadways, and the soil cover in the northeast portion of the area would be maintained. An evaluation would be conducted to determine whether the arsenic present at a concentration greater than the IGWSRS needs to be removed.

- Seep Area: The existing impermeable cap consisting of building slabs, parking areas and roadways would be inspected and supplemented, if necessary.

- A Deed Notice would be established for all parcels where constituents remain at concentrations greater than the RDCSRS.

- The caps would be inspected at least biennially, and maintenance would be conducted as necessary to ensure their integrity.

- Statutory CERCLA Five Year Reviews would be conducted in accordance with CERCLA Section 121(c) because contamination would remain on site above levels that allow unlimited use and unrestricted exposure (EPA, 2001).

Implementation of this alternative would involve the following major steps:

- Survey property boundaries;

- Delineate wetlands and other sensitive areas as necessary;

- Implement a supplemental pre-design investigation;

- Obtain permit equivalencies for wetlands, transition areas, and flood hazard areas;

- Establish laydown areas and erosion and sedimentation (E&S) Controls;

- Establish exclusion areas for public safety;

- Mobilize construction equipment;

- Obtain utility clearances and, as needed, protection;

- Install temporary access roads, as needed;
- Establish perimeter air monitoring for dust;
- Clear areas of Upper Hilliards Creek and the Former Lagoon Area where soil removal prior to capping would be conducted and any necessary access routes would be constructed;
- Install temporary water diversion and management structures;
- Excavate contaminated soil from those areas where new soil covers would be installed;
- Transport and dispose (T&D) contaminated soil and waste at an approved disposal facility;
- Backfill the excavated areas where constituents are no longer present at concentrations greater than the RDCSRS with clean soil;
- Construct a two-foot vegetated cap in the Upper Hilliards Creek floodplain and Former Lagoon Area where constituents remain below two feet bgs at concentrations greater than the RDCSRS;
- Restore the site according to regulatory requirements;
- Monitor to confirm the success of the wetlands restoration;
- Long-term inspection and maintenance of all engineering controls; and
- Establish a Deed Notice for all parcels where constituents remain at concentrations greater than the RDCSRS.

It is anticipated that this alternative would require approximately 10 months to complete. As part of the implementation, approximately 6,000 CY of soil would be removed from the Upper Hilliards Creek floodplain, and approximately 2,000 CY of soil would be removed from the Former Lagoon Area. The same amount of soil would be brought onto the site as backfill, and the cap would be constructed on approximately 3 acres of the site. Total costs for this alternative are estimated at approximately $5.8 million.

4.2.1.3. Soil Alternative 3 – Soil and LNAPL Removal/Treatment, Capping and Institutional Controls

This alternative, similar to Soil Alternative 2, would rely on engineering and institutional controls, to control exposure to much of the FMP. Soil Alternative 3 would consist of the following actions:

<u>Former Main Plant Area</u>

- Remove the soil that is the source of arsenic found in groundwater north of Foster Avenue.

- Remove soil containing PCBs at concentrations greater than 50 mg/kg (the concentration at which the PCBs become defined as a PCB remediation waste under TSCA) at locations adjacent to the Silver Lake conveyance north of Foster Avenue.

- Install an impermeable cap in those areas where soil removal was conducted.

- Maintain the existing impermeable cap. Locations not covered by the impermeable cap would be evaluated to determine if unsaturated soil containing arsenic at concentrations greater than the default IGWSRS would be removed or if the impermeable cap would be expanded onto those areas.

- Address any underground structures that may be a source of contamination.

Former Resin Plant/Tank Farm A Area

- Maintain the existing impermeable cap and soil cover.
- Evaluate the need to remove the arsenic present beneath the soil cover at a concentration greater than the IGWSRS.
- Install a LNAPL recovery system in the 2 and 4 Foster Avenue buildings.
- Install a system to deliver sulfate and nitrate to the LNAPL across the Former Resin Plant/Tank Farm A area to stimulate the existing LNAPL biodegradation.
- Install a system to remove methane and other soil gas from the subsurface.
- Address any underground structures that may be a source of contamination.

Seep Area

- Remove soil containing LNAPL from the Seep Area to an approximate depth of five to seven feet.
- Restore the excavation area and reinstall the parking area.
- Install a collection trench south of Foster Avenue to prevent LNAPL transport under Foster Avenue from the Former Resin Plant/Tank Farm A area to the Seep Area and Upper Hilliards Creek.

Former Lagoon Area

- Remove soil from the western portion of the Former Lagoon Area to a depth of approximately 8 feet bgs to address the source of pentachlorophenol in groundwater.

- Develop a site-specific IGWSRS for pentachlorophenol to support an evaluation of the need to remove any additional unsaturated soil where pentachlorophenol is present at concentrations greater than the default IGWSRS. The information needed to develop the site-specific IGWSRS would be collected as part of a PDI.

- Restore the excavation areas and maintain the existing soil cap that is present across the remainder of the former Lagoon Area.

- Conduct additional characterization within the Former Lagoon Area to identify the source of VOC/SVOC TICs in groundwater. It is expected that the results of this evaluation would be used to develop and evaluate remedial alternatives for the VOC and SVOC TICs in the groundwater FS.

<u>Upper Hilliards Creek</u>

- Remove all soil containing constituents greater than the PRGs in the top one foot of the Upper Hilliards Creek flood plain.

- Remove all soil at depths greater than one foot where constituents are present at concentrations greater than the RDCSRS throughout the Upper Hilliards Creek floodplain.

The extent of the remedial actions that would be conducted under Soil Alternative 3 are shown on Figure 33. For arsenic and PCP specifically, based on the current understanding of the distribution, the following criteria defining source areas have been applied: arsenic: 50 mg/kg, pentachlorophenol: 15 mg/kg. Note that based on the conceptual model of partitioning in the saturated zone as the mechanism by which these constituents are transferred from the solid to dissolved phase, these values are applied in the saturated zone. Also, additional PDI sampling will be conducted prior to the remedial design and it is possible that, based on the PDI results, these values may be revised.

In all areas, a groundwater monitoring network would be installed following implementation of the remedial action. Detailed figures showing the conceptual design for the LNAPL remediation systems are provided in Appendix E. The bases for, and descriptions of, these additional actions are discussed below.

Former Main Plant Area

Arsenic was found in groundwater at concentrations greater than the GWQS in shallow monitoring wells MPMW0032 and MPMW00049 (Figure 2). In the area where arsenic was found in groundwater, arsenic was found at a concentration of approximately 80 mg/kg in soil at the 4.0'–6.0' interval at sampling location ERTSB-014 (Figures 8 and 9), located near MPMW0032, and there are several locations beneath the 6 East Clementon Road building slab where elevated arsenic concentrations were found in either XRF or analytical laboratory results at depths ranging from 10 to 15 feet bgs. Although the extent of any removal would need to be better defined by a PDI, the current data provide a basis to approximate area and depth of a soil removal for the purpose of addressing the sources of arsenic to groundwater.

PCBs are present at concentrations greater than 50 mg/kg in three locations, MPSB0143, MPSM0144, and ERTSB012, immediately west of the Silver lake conveyance system (Figure 8). PCBs at concentrations greater than 50 mg/kg are regulated as remediation wastes pursuant to the Toxic Substances Control Act (TSCA; 40 CFR 761), and, while regulations provide for risk-based cleanups, removal of PCBs at these concentrations is typically conducted. The PCBs are found at depths ranging from approximately 4 to 6 feet bgs.

Based on the existing data, excavations would be conducted in three areas of the Main Plant area north of Foster Avenue:

- An excavation ranging from 10 to 15 feet bgs would be conducted beneath and adjacent to the 6 East Clementon Road building slab to remove the arsenic that is a

source to groundwater. As part of the excavation, portions of the building slab would need to be removed.

- A six-foot excavation would be conducted at the southeastern corner of the 10 Foster Avenue building to address arsenic that is a source to groundwater.

- An excavation ranging from four to six feet would be conducted north of the 10 Foster Avenue building and west of the Silver Lake conveyance system to address the PCBs at concentrations greater than 50 mg/kg.

Following the excavations, the areas would be backfilled to grade and an impermeable cap would be installed.

South of Foster Avenue, the existing impermeable cap consisting of the 7 Foster Avenue building and the adjacent parking area would be maintained. An evaluation would be conducted to determine if unsaturated soil containing constituents at concentrations greater than the IGWSRS would need to be removed or if the impermeable cap would be expanded.

Implementation of the soil removal component in this alternative would involve the following major steps:

- Survey of property boundaries;

- A supplemental pre-design investigation;

- Establishment of laydown areas and erosion and sedimentation (E&S) Controls;

- Establishment of exclusion areas for public safety;

- Construction mobilization;

- Obtaining utility clearances and, as needed, implementing measures for utility protection;
- Closure of monitoring wells within the excavation areas;
- Installation of temporary access roads;
- Establishment of perimeter air monitoring for dust;
- Removal of asphalt parking area and a portion of the 6 East Clementon Road building slab;
- Excavation of contaminated soil;
- Management of groundwater;
- Dewatering and/or stabilization of wet soil;
- Soil waste classification;
- Transportation and disposal (T&D) at an approved disposal facility;
- Backfill of the excavation with clean soil;
- Site restoration;
- Long-term maintenance of the engineering controls; and
- Establishment of a Deed Notice.

Former Resin Plant/Tank Farm A Area

As discussed in Section 2:

- The vast majority of the former Resin Plant/Tank Farm A Area is covered with an impermeable cap. The northeastern portion of the area, which is not covered by an impermeable cap, has a soil cover on it.

- Constituents present at concentrations greater than the RDCSRS and/or default IGWSRS are almost exclusively associated with the LNAPL and are found in the saturated zone. Arsenic and lead are found in one location beneath the soil cover at concentrations greater than the RDCSRS and default IGWSRS.

- LNAPL, consisting of weathered mineral spirits with relatively low concentrations of BTEX and naphthalene, is present in the Former Resin Plant/Tank Farm A area at depths ranging from approximately 10 feet bgs to more than 20 feet bgs.

- The LNAPL extends west to east from the west side of the 2 and 4 Foster Avenue buildings to U.S. Avenue, and north to south from the northern end of the 3 U.S. Avenue building to Foster Avenue.

- As a result of historic recovery activities and natural mechanisms, LNAPL saturation levels in areas accessible for sampling are well below literature-based residual saturation values, supporting a conclusion that the majority of the LNAPL is not recoverable.

- Imbibition testing has found that even under high pore pressures, the LNAPL is not displaced from the soil pores, further supporting the conclusion that the majority of the LNAPL is immobile and unrecoverable.

- Recovery rates in areas accessible for manual recovery activities have declined, and measurable product is typically not present in monitoring wells.

- NSZD is occurring as a result of physical and biological processes. Based on literature, the magnitude of the NSZD processes may be substantial.

- The presence of methane and petroleum compound vapors in soil gas beneath the 2 and 4 Foster Avenue buildings, 3 U.S. Avenue building, and the adjacent parking areas is a line of evidence for NSZD.

- The biological components of the NSZD processes are limited by the absence of key electron donors, primarily sulfate and nitrate.

Based on these considerations, the remedial activities to be conducted in the Former Resin Plant/Tank Farm A area would be:

1. Maintenance of the current impermeable cap and soil cover.

2. Evaluation of the arsenic found at a concentration greater than the IGWSRS beneath the soil cover to determine whether it can be left in place or needs to be removed.

3. Installation of a LNAPL recovery system targeting locations where some recoverable LNAPL may still be present.

4. Installation of a series of injection wells to deliver nutrients to stimulate the biodegradation of the LNAPL in the subsurface.

5. Installation of a system to remove the methane and other vapors from the subsurface beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings.

The extent of the remedial actions to be conducted under Alternative 3 are shown on Figure 33.

The LNAPL recovery system would be installed beneath the 2 Foster Avenue building, the location where LNAPL is most likely to be recoverable. For purposes of this FS, the recovery system would consist of:

- Eight new 4-inch LNAPL extraction wells. Based on the understanding of the depth at which the LNAPL is encountered and the thickness of the LNAPL, the recovery wells would be installed to an approximate depth of 15 feet.

- Four in-well electrically-powered LNAPL skimmers (to alternate between wells), complete with:

    - Autoseeker spool (wellhead mount)

    - Control box

    - Down-well robe (with pump and level sensor)

    - Cables and product discharge tubing

    - Tank full shut-off control

- Product recovery tank with spill/leak containment

- Electrical connections

- Security fencing

Figures showing the details of the recovery system as well as detailed assumptions used to develop cost estimates are provided in Appendix E.

Operation and maintenance is assumed to include:

- Monitoring of skimmer pump operations, product levels in tanks, removal of accumulated product, and gauging of wells on a monthly basis;
- Quarterly rotation of skimmers between wells;
- Quarterly off-site transportation and disposal of the LNAPL; and
- Replacement of one LNAPL pump assembly every six months, and replacement of one LNAPL skimming assembly every year.

For cost purposes, it is assumed that the recovery system would operate for a period of three (3) years.

A system to enhance the existing biological processes that are degrading the LNAPL would be installed throughout the Former Resin Plant/Tank Farm A area. The system would inject fertilizer-like ingredients such as sulfate, nitrogen and phosphorous. These ingredients would be delivered by a system consisting of:

1) A network of shallow 15-foot deep PVC fertilization wells, designed to stimulate the biodegradation that is occurring, spaced across the treatment area.

2) A series of trenches in which irrigation piping and emitters are installed.

In addition, because methane is generated as part of the biodegradation of the LNAPL, and other petroleum vapors are generated by volatilization of the LNAPL components, a soil

ventilation system that would prevent indoor exposure to these constituents would be part of the system design.

The conceptual system design of the bioremediation system is based on the assumption of a treatment rate of one pore volume (approximately 5,000,000 gallons) per year over a treatment zone of 700' x 350' x 10' (2,450,000 ft^3), a porosity of 0.27, which would result in a continuous application rate of approximately 9.5 gpm.

The system would consist of:

- Preparation and submission of permit applications to NJDEP for chemical injection.

- A network of 2-inch diameter 15-foot deep PVC bioremediation wells at nominal 40-foot centers outside the buildings and high-pressure injection wells on 80-foot centers within the buildings.

- Installation of pipe trenches throughout the 2 and 4 Foster Avenue parking area to a depth of approximately four feet. The pipe trenches would carry conveyance pipes to deliver the nutrients to each injection well and drip irrigation piping that would deliver the nutrients from near surface to the top of the water table. The drip irrigation pipe would be equipped with 4-gallons per hour (gph) emitters at 1-foot centers in the buried pipe trenches.

- Installation of horizontal nutrient delivery wells beneath the 2 and 4 Foster Avenue buildings.

- Installation of vertical soil gas extraction/subsurface ventilation wells within the 2 and 4 Foster Avenue parking area, and horizontal soil gas extraction/ soil ventilation wells beneath the 2 and 4 Foster Avenue building. Note that the conceptual design is for FS costing purposes only. The actual number and layout of the soil gas extraction/ventilation wells would be determined based on pilot testing.

- A 1,000 ft^2 heated equipment building/enclosure and fenced compound for housing of nutrient storage, mixing, and delivery equipment, and soil gas extraction equipment.

- A soil gas extraction blower.

- A 115/230-volt electrical service (100-amp minimum) to the treatment building.

- Nutrient mixing and pumping assembly.

- A PLC and nutrient injection controller system for automated delivery of water and reagents to the bioremediation wells and drip irrigation systems.

- Soil gas monitoring probes installed along United States Avenue and north of the 4 Foster Avenue/3 U.S. Avenue building.

- Utilities, consisting of:

    - A municipal water service capable of providing 20 gpm supply.

    - Internet service to support the PLC and enable automated monitoring and control of equipment.

Operation and maintenance of this system would consist of:

- Weekly system inspections and automated monitoring of system functions, including water flow rates and injected pressures, volumes injected into individual wells and nutrient delivery lines, and amounts of nutrients used and available.

- Weekly maintenance on the extraction blower, and field measurement of vapor concentrations with organic vapor analyzer (for VOCs) and landfill gas monitor (for methane and CO_2).

- Soil gas monitoring in soil gas probes to assess concentrations of VOCs, methane and carbon dioxide to determine the presence of biological activity and effectiveness of soil gas extraction systems. Soil gas monitoring would be conducted monthly for the first year, quarterly for the next 2 years, semiannually for the next 2 years, and annually thereafter for 5 years.

- Quarterly monitoring of shallow groundwater for two years, and semi-annual monitoring after the first two years.

It has been estimated that the system would need to operate for a period of seven years, but for cost purposes an operating period of 10 years has been used.

Implementation of the LNAPL extraction and nutrient injection alternative would involve the following major steps:

- Pilot tests to evaluate the presence of recoverable LNAPL and radii of influence for nutrient injection and soil gas ventilation wells;

- Permitting for nutrient injection and building construction;

- Establishment of laydown areas and erosion and sedimentation (E&S) Controls;

- Establishment of exclusion areas for public safety;

- Construction mobilization;

- Obtaining utility clearances and, as needed, implementing measures for utility protection;
- Protection of monitoring wells within the nutrient injection areas;
- Establishment of perimeter air monitoring for dust;
- Excavation of soil for piping trenches;
- Installation of nutrient injection wells, LNAPL recovery wells, and soil gas extraction wells;
- Backfilling of piping trenches to restore the impermeable cap and soil cover;
- Off-site transportation and disposal of excess soil from piping trench excavation;
- Installation of LNAPL recovery system;
- Building construction;
- Installation of nutrient mixing and delivery system;
- Installation of soil gas extraction blower;
- Utility connections;
- Operation and maintenance of the LNAPL recovery, nutrient injection and soil gas ventilation systems;
- System decommissioning;

- Establishment of a Deed Notice.

Seep Area

LNAPL in the Seep Area extends from Foster Avenue in the north, through the parking area for the 1 and 5 Foster Avenue buildings, to U.S. Avenue to the east (Figure 10). The LNAPL is first encountered in the 1 and 5 Foster Avenue building parking area at depths as shallow as approximately one foot. The depth at which the LNAPL is encountered increases towards Foster Avenue and U.S. Avenue and the topography slopes up towards the roads.

Conditions in the Seep Area that are relevant to the evaluation of remedial alternatives are:

- With the exceptions of the slopes along Foster Avenue and U.S. Avenue, the entire Seep Area is covered by an impermeable cap.

- Based on the shallow depth to groundwater, the soil in the Seep Area can be considered saturated.

- With the exceptions of some PAHs in soil samples collected immediately beneath the asphalt parking area, the only constituents found in soil at concentrations greater than the RDCSRS or IGWSRS are associated with the LNAPL.

- Characteristics of the LNAPL include:

    - LNAPL saturation levels are well below literature values, supporting a conclusion that the majority of the LNAPL is not recoverable.

    - Imbibition testing has found that even under high pressures, the LNAPL is not displaced from the soil pores and exhibits limited to no mobility and recoverability.

- Recovery rates in areas accessible for manual recovery activities have declined, and measurable product is typically not present in monitoring wells.

- NSZD is occurring as a result of physical and biological processes. Based on literature, the magnitude of the NSZD processes may be substantial.

- Much of the area in which LNAPL is present in the Seep Area is accessible, as opposed to the Former Resin Plant/Tank Farm A area, where a large area of LNAPL is located under the 2 and 4 Foster and 3 U.S. Avenue buildings and, therefore, is inaccessible without removing the buildings.

- The LNAPL in the Seep Area is much shallower than the LNAPL in the Former Resin Plant/Tank Farm A area. The majority of the LNAPL in the Seep Area is encountered at depths of one to seven feet, rather than the ten to 25 feet in the Former Resin Plant/Tank Farm A area.

- The Seep Area is immediately adjacent to Upper Hilliards Creek and has been the source of historical discharges to the creek. Although no discharges to Upper Hilliards Creek have occurred in approximately fifteen years, there remains some potential that, without ongoing manual recovery activities, a discharge could occur.

Based on the above considerations, the component of Soil Alternative 3 applicable to the Seep Area is removal of the accessible LNAPL. This would include removal of approximately five to seven feet of soil from the 1 and 5 Foster Avenue parking area, and approximately seven to ten feet of soil from the slope areas between the parking area and Foster Avenue to the north and U.S. Avenue to the east. The 5 Foster Avenue building would not be removed, so LNAPL may remain under it, and LNAPL would remain beneath U.S. Avenue south of Foster Avenue. It is expected that, by removing the vast majority of the LNAPL from the Seep Area, the relatively small mass of LNAPL that may be present beneath the 5 Foster Avenue building would biodegrade. However, until such time as this occurs, a Deed Notice would be

required for the 5 Foster Avenue building. Nutrient injections to stimulate biodegradation of the LNAPL beneath U.S. Avenue are a component of a remedial alternative for the Eastern Off-Property Area.

Alternative 3 would also include a LNAPL recovery trench south of Foster Avenue. The purpose of the trench is to capture any LNAPL that may be mobilized during the LNAPL soil removal activities in the Seep Area as well as any LNAPL that may potentially be mobilized as a result of the fertigant injection in the Former Resin Plant/Tank Farm A area. Therefore, any potential for LNAPL transport towards the Seep Area and Hilliards Creek would be eliminated.

The trench would be approximately 400 feet long, seven feet deep and three feet wide. It would extend along U.S. Avenue for approximately 100 feet to the corner of U.S. Avenue and Foster Avenue and then approximately 300 feet to the interpreted western end of the LNAPL. Sumps would be installed at approximately 100-foot distances along the trench, and skimmer pumps would be installed. Any recovered LNAPL would be transferred to dedicated and secure totes before off-site transport for disposal. It is assumed that the skimmers would operate for three years. A detailed discussion of the assumptions used in developing costs for the recovery trench is presented in Appendix E.

Implementation of this alternative would involve the following major steps:

- Survey of property boundaries;
- Delineation of Upper Hilliards Creek wetlands transition zone and flood hazard area;
- Performing a supplemental pre-design investigation, including sampling beneath the 1 Foster Avenue building;
- Obtaining permit equivalencies for wetlands transition area and flood hazard area, if required;

- Establishment of laydown areas and erosion and sedimentation (E&S) Controls;
- Establishment of exclusion areas for public safety;
- Construction mobilization;
- Obtaining utility clearances and, as needed, implementing measures for utility protection;
- Closure of monitoring wells within the excavation areas;
- Installation of temporary access roads;
- Establishment of perimeter air monitoring for dust and vapors;
- Excavation of contaminated soil;
- Management of groundwater;
- Dewatering and/or stabilization of wet soil;
- Waste classification sampling;
- Transportation and disposal (T&D) of contaminated soil and waste at an approved disposal facility;
- Backfilling the excavation with clean soil;
- Installation of the LNAPL recovery trench;
- Site restoration, including reinstallation of the impermeable asphalt parking area;

- O&M of recovery trench;
- Long-term maintenance of the engineering controls; and
- Establishment of a Deed Notice.

It is anticipated that this alternative would require approximately 8 months to complete. As part of the implementation, approximately 15,000 CY of soil and as much as one million gallons of water/LNAPL mixture would be removed from the Site and disposed at a properly permitted facility.

Upper Hilliards Creek

Soil Alternative 3 for Upper Hilliards Creek would consist of removing all soil from the Upper Hilliards Creek floodplain that, in the 0'–1' interval, contains constituents at concentrations greater than the PRGs, and, in intervals deeper than 1', contains constituents at concentrations greater than the RDCSRS. Since groundwater within the majority of the Hilliards Creek flood plain is at or near the surface, the IGWSRS do not generally apply.

Although NJDEP guidance states that the residential and nonresidential soil standards are generally not applicable to ecological habitat areas because human exposure frequencies in the ecological habitat areas are different than residential and nonresidential settings, Upper Hilliards Creek is easily accessible by the public and portions of the flood plain border residential properties.

As shown on Figure 33, the depths of excavation would range from approximately one to six feet. As part of the remedial action, temporary water diversion structures, such as portadams or sheet piling, would need to be installed along Upper Hilliards Creek, to prevent surface water discharges into the removal areas and contaminated soil from entering Hilliards Creek. Since the excavations would extend beneath the water table, groundwater management would be required. For purposes of this FS, it has been assumed that

groundwater would be collected, filtered and disposed off-site. If a permit equivalency for treatment and discharge to Hilliards Creek can be obtained, costs for this alternative may be slightly less than estimated.

Under this alternative, approximately 10,000 CY of soil would be removed from the Upper Hilliards Creek floodplain, and an equal amount of soil would be imported as backfill. As much as 1,000,000 gallons of groundwater produced as part of the remedial action may require off-site disposal. Slightly over two acres of wetlands and wetlands transition areas would need to be restored.

Former Lagoon Area

Pentachlorophenol is present in soil at concentrations greater than the RDCSRS at depths up to 20 feet bgs in the northwest portion of the Former Lagoon Area (Figure 14). In general, the pentachlorophenol is found in the saturated zone, but there are some locations in the western part of the former Lagoon Area where pentachlorophenol concentrations exceed the default IGWSRS.

The highest pentachlorophenol concentrations in soil are found from approximately four to eight feet in the western portion of the former Lagoon Area, where concentrations of several hundred milligrams per kilogram have been reported. Additionally, pentachlorophenol is found at a concentration of 72 mg/kg in the 8– to 10-foot interval in one location in the eastern portion of the former lagoon Area. It is not known whether this is an isolated area or may represent a source to groundwater.

Pentachlorophenol is present at concentrations greater than the GWQS in shallow monitoring wells MPMW0027 and MPMW0101. Additionally, VOC and SVOC TICs are present in shallow and intermediate groundwater at concentrations greater than the interim specific GWQS. Based on a review of the VOC and SVOC TIC soil data in Table 3 of the RIR, no apparent source of the VOC and SVOC TICs in groundwater has been found in soil.

The component of Soil Alternative 3 applicable to the former Lagoon Area would consist of:

- Conducting a PDI to evaluate possible sources of VOC/SVOC TICs in groundwater and determine if a source area for pentachlorophenol is present in the eastern portion of the area.

- Conducting focused removal of surface soils to address pentachlorophenol and PAHs where present at concentrations greater than the RDCSRS.

- Developing a site-specific IGWSRS to support evaluation of the need to remove soil in the unsaturated zone where pentachlorophenol is present at concentrations greater than the IGWSRS (0.3 mg/kg).

- Removal of soil to a depth of approximately six to eight feet in the northwest corner of the Former Lagoon Area which may be a source of pentachlorophenol to groundwater.

- Conducting any additional removal that may be required to address sources of pentachlorophenol to groundwater based on the results of the PDI.

Based on the current understanding of the distribution of constituents in soil, approximately 4,000 CY of soil would be removed as part of this alternative, and an equal amount of soil would be imported for use as backfill. Since the excavation would extend only approximately six to eight feet, groundwater management is not anticipated to be a significant concern.

Alternative 3 Summary

Based on the current understanding of the distribution of constituents in soil and the extent of the LNAPL, Soil Alternative 3 would consist of:

- Removal and off-site disposal of approximately 8,500 CY of soil from the Main Plant Area to address sources of arsenic in groundwater and PCBs at concentrations greater than 50 mg/kg;

- Removal of any underground structures that may be sources of contamination;

- LNAPL recovery, biostimulation and soil gas ventilation in the Former Resin plant/Tank Farm A area;

- Installation of a LNAPL recovery trench south of Foster Avenue to prevent transport of LNAPL from the Former Resin Plant/Tank Farm A area towards the Seep Area and Hilliards Creek;

- Removal of approximately 15,000 CY of soil from the Seep Area to address LNAPL;

- Removal of approximately 10,000 CY of soil from the Upper Hilliards Creek floodplain to address constituents present in surface soil at concentrations greater than the PRGs and constituents in subsurface soil at concentrations greater than the RDCSRS;

- Restoration of the Upper Hilliards Creek floodplain;

- Removal of approximately 4,000 CY of soil from the Former Lagoon Area to address constituents present in the upper two feet at concentrations greater than the RDCSRS and sources of pentachlorophenol in groundwater;

- Installation of a groundwater monitoring network in those areas where groundwater monitoring wells were removed during the remedial action. The monitoring well network will be used to monitor the effectiveness of the remedial action such that modifications can be made, as necessary, to ensure the remedial action does not cause an increase in the extent of dissolved-phase constituents at concentrations greater than the GWQS ; and

- Deed Notices for those parcels where constituents remain at concentrations greater than the RDCSRS.

Total costs for Soil Alternative 3 are estimated to be $24 million. It is estimated approximately one year would be required to complete the remedial construction.

4.2.1.4. Soil Alternative 4 – Extensive Excavation to Depth and Institutional Controls

Under Alternative 4, all soil exceeding the applicable cleanup criteria (PRGs and RDCSRS) and all soil containing LNAPL would be removed, regardless of depth. The removal would also include the demolition and removal of the 2 and 4 Foster Avenue buildings, as they prevent access to a large area where the LNAPL is present. Removal of Foster Avenue and U.S. Avenue is not included, as these roadways are necessary for the community. Also, the 5 Foster Avenue, 7 Foster Avenue and 10 Foster Avenue buildings would also not be removed, as these buildings are relatively small in comparison to the overall site and do not prevent access to large volumes of contaminated soil. However, since some structures would remain in place above soil that likely contains one or more constituents at concentrations greater than the RDCSRS, Deed Notices would be required.

The approximate extent of Soil Alternative 4 is shown on Figure 34.

Based on the current understanding of the distribution of constituents and LNAPL in soil at the FMP, the scope of Alternative 4 would be:

Former Main Plant Area

- Removal of the parking areas on the property adjacent to the 7 Foster Avenue building, and the parking areas and the majority of the 6 East Clementon Road building slab on the property adjacent to the 10 Foster Avenue building;

- Removal of soil to a depth of one to ten feet on the property adjacent to the 7 Foster Avenue building;

- Removal of soil to depths of five to fifteen feet on the property currently occupied by the 6 East Clementon Road building slab and adjacent to the 10 Foster Avenue building;

- Removal of any underground structures that may represent a source of contamination; and

- Backfilling all areas to existing grade.

Former Resin Plant/Tank Farm A Area

- Removal of the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings and building slabs;

- Removal of the parking area and former red barn building slab;

- Removal of soil containing LNAPL to a depth of 25 feet bgs;

- Removal of any below ground structures that may represent sources of contamination; and

- Backfilling all areas to existing grade, and removal of soil to seven to ten feet on the slopes towards Foster Avenue and U.S. Avenue.

Seep Area

The scope of Alternative 4 is the same as that of Alternative 3:

- Removal of soil to a depth of five to seven feet in the parking area;

- Removal of soil to a depth of seven to ten feet on the slopes towards Foster Avenue and U.S. Avenue;

- Backfill to grade and reinstall asphalt parking; and

- Installation of a LNAPL recovery trench south of Foster Avenue.

Former Lagoon Area

- Remove approximately 20 feet of soil throughout the northwest portion of the Former Lagoon Area; and

- Backfill to grade and restore.

Upper Hilliards Creek

The scope of the remedial action under Alternative 4 is the same as that for Alternative 3:

- Remove all soil in the top one foot containing arsenic, lead and cyanide at concentrations greater than the PRGs;

- Remove all soil below one foot that contains constituents at concentrations greater than the RDCSRS; and

- Backfill to grade and restore.

Implementation of this alternative would involve the following major steps:

- Survey of property boundaries;

- Delineation of wetlands and other sensitive areas as necessary;

- Performing a supplemental pre-design investigation;

- Obtaining permit equivalencies for wetlands and flood hazard areas;

- Establishment of laydown areas and erosion and sedimentation (E&S) Controls;

- Establishment of exclusion areas for public safety;
- Construction mobilization;
- Obtaining utility clearances and, as needed, implementing measures for utility protection;
- Closure of monitoring wells within the excavation areas;
- Installation of temporary access roads;
- Establishment of perimeter air monitoring for dust;
- Clearing of the contaminated area (and necessary access ways);
- Installation of temporary water diversion and management structures adjacent to waterways;
- Excavation of contaminated soil;
- Management of groundwater;
- Dewatering and/or stabilization of wet soil;
- Waste classification sampling;
- Transportation and disposal (T&D) of contaminated soil and waste at an approved disposal facility;
- Backfill of the excavation with clean soil;

- Site restoration;

- Long-term maintenance of the engineering controls; and

- Establishment of Deed Notices for the soil beneath the 5, 7 and 10 Foster Avenue buildings where constituents may remain at concentrations greater than the RDCSRS.

It is anticipated that this alternative would require up to five years to complete, primarily due to the size and complexity of the soil removal action at the Former Resin Plant/Tank Farm A area. As part of the implementation, approximately 315,000 CY of soil, more than half of which would be generated at the Former Resin Plant/Tank Farm A area, would be removed from the Site and disposed at a properly permitted facility. Total costs for this alternative are estimated at approximately $87 million.

4.2.2. Comparative Analysis of Alternatives for FMP Soil

Pursuant to EPA guidance for preparation of FSs, and as discussed in Section 4.1, the identified remedial alternatives were evaluated based on seven criteria.

The first two criteria are termed "threshold criteria" and must be achieved in order for an alternative to be selected. These are:

1. Overall protection or public health and the environment; and

2. Compliance with ARARs.

The remaining five criteria are termed "balancing criteria", and are used to distinguish between the alternatives where the threshold criteria are achieved. These are:

3. Long-term Effectiveness and Permanence;

4. Reduction of Toxicity, Mobility and Volume Through Treatment;

5. Short-term Effectiveness;

6. Implementability; and

7. Cost.

There are two additional criteria, termed "Modifying Criteria": "State or Support Agency Acceptance" and "Community Acceptance". These criteria are evaluated by EPA following comments on the proposed plan and are addressed by EPA when the ROD is prepared.

The following provides the comparative analysis of the five soil alternatives against the two Threshold Criteria and the five Balancing Criteria.

4.2.2.1. Overall Protection of Human Health and the Environment

Soil Alternative 1 - No Action would not provide protection of human health and the environment. Although a cap is present over the majority of the site, preventing direct contact with the constituents in soil, the human health and ecological exposures along Hilliards Creek and the former Lagoon Area would remain, and no action would be conducted to address sources of groundwater contamination or the LNAPL. This alternative would not achieve the RAOs for the Site. Institutional controls would not be established to prevent exposure to contaminated soil or provide guidance in the event that exposure occurs. Routine monitoring of site conditions would not be conducted and future changes in contaminant conditions would not be identified.

Soil Alternative 2 – Targeted Surface Soil Removal, Capping and Institutional Controls would be protective of human health and ecological receptors. All exposure pathways would be eliminated by soil removal (in the ecological habitat areas), existing and new capping (in other areas of the Site), and institutional controls (a Deed Notice). The soil removal and capping in the ecological habitat areas would prevent transport of soil containing contaminants into surface water bodies. However, under this alternative, sources of groundwater contamination would remain, no actions to remove or contain the LNAPL

would be performed, and no actions would be conducted to mitigate the soil gas vapors beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings. Therefore, there would remain the possibility that, without ongoing manual recovery activities, discharges of LNAPL to Hilliards Creek and indoor exposure to vapors originating in the subsurface could occur.

Soil Alternative 3 - Soil and LNAPL Treatment/Removal, Capping and Institutional Controls would be protective of human health and ecological receptors. The combination of soil and LNAPL removal, and use of existing structures for capping, would eliminate all exposure pathways. Within ecological habitat areas, all surface soil within the ecological habitat areas would meet PRGs. Where subsurface soil does not meet the RDCSRS within the former Lagoon Area, a cap would be installed. The soil removal and capping in the ecological habitat areas would prevent transport of soil containing contaminants into surface water bodies.

Alternative 3 would remove sources of arsenic in groundwater at the Main Plant Area and sources of pentachlorophenol and, based on the results of the PDI, potentially the VOC and SVOC TICs in the Former Lagoon Area. Alternative 3 would also remove the accessible LNAPL from the Seep Area, enhance LNAPL degradation in the Former Resin Plant/Tank Farm A area and implement LNAPL recovery actions beneath the 2 Foster Avenue building and south of Foster Avenue. The biostimulation in the former Resin Plant/Tank Farm A Area would enhance biodegradation beneath Foster Avenue and the upper portion of U.S. Avenue. The LNAPL removal in the Seep Area would remove the vast majority of LNAPL, such that any remaining LNAPL beneath the 5 Foster Avenue building would biodegrade. Treatment of the LNAPL beneath the southern portion of U.S. Avenue is contemplated in a remedial alternative for the Eastern Off-Property Area.

The subsurface soil ventilation system would remove/biodegrade the methane and petroleum vapors from beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings, and the associated parking areas. A Deed Notice would be established to prevent unauthorized activities in areas where constituents remain in soil at concentrations greater than the RDCSRS.

Soil Alternative 4 – Extensive Excavation to Depth, Capping and Institutional Controls would be protective of human health and ecological receptors. All surface soil containing constituents at concentrations greater than the PRGs in ecological habitat areas would be removed. All accessible subsurface soil containing constituents at concentrations greater than the RDCSRS would be removed, and, where the soil is not accessible (such as beneath Foster Avenue, U.S. Avenue and the remaining buildings), the direct contact pathway would be eliminated. Achieving the PRGs in the ecological habitat areas would also prevent transport of constituents into the water bodies. By removing all accessible subsurface soil containing constituents at concentrations greater than the RDCSRS, the sources of groundwater contamination would be addressed. A Deed Notice would be established for the areas of the property where soil remains at concentrations greater than the RDCSRS to prevent unauthorized contact.

4.2.2.2. Compliance with ARARs

Soil Alternative 1 - No Action would not meet chemical-specific ARARs for those areas where soil containing constituents at concentrations greater than the NRDCSRS is present and not capped, where soil at concentrations greater than the RDCSRS and no Deed Notice is established, and those ecological habitats where constituents remain in surface soil at concentrations greater than the PRGs. Control of groundwater contamination sources would not be achieved. No efforts to recover or contain LNAPL would be performed and soil gas vapors would remain beneath the 2 and 4 Foster Avenue buildings. Since no site activity (i.e., construction) would be required, location-specific and action-specific ARARs do not apply to this alternative.

Soil Alternative 2 – Targeted Surface Soil Removal, Capping and Institutional Controls would not achieve ARARs for control of groundwater sources, removal or containment of LNAPL, or management of PCBs. However, surface soil containing constituents at concentrations greater than the PRGs would be removed from the Upper Hilliards Creek floodplain, and a cap would be placed over areas where constituents remain in subsurface soil at concentrations greater than the RDCSRS. In other areas of the Site, the existing buildings and

other impermeable surfaces would provide a cap, and a Deed Notice would be established for all parcels where constituents remain at concentrations greater than the RDCSRS. Because all surface soil containing constituents at concentrations greater than PRGs would be capped, the potential for surface water standard exceedances due to contaminated storm water runoff would be eliminated.

Soil Alternatives 3 and 4 would achieve all ARARs. All surface soil containing constituents at concentrations greater than the PRGs would be removed from ecological habitat areas in the Upper Hilliards Creek floodplain and the Former Lagoon Area. Both alternatives would address any locations where either default or site-specific exceedances of the IGWSRS are found. Both alternatives would remove sources of groundwater contamination and PCBs above 50 mg/kg, and would remove or contain LNAPL to the extent practicable. Both alternatives would remove the soil vapors from beneath the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings. Under both alternatives, all soil left in place at concentrations greater than the RDCSRS would be covered with a cap, and a Deed Notice would be established for all areas where constituents remain in soil at concentrations greater than the RDCSRS.

4.2.2.3. Long-Term Effectiveness and Permanence

Soil Alternative 1 - No Action does not provide long-term effectiveness and permanence for those areas where soil containing contaminants at concentrations greater than ARARs is present. Existing contamination, exposures and risks would remain.

Soil Alternative 2 – Targeted Surface Soil Removal, Capping and Institutional Controls would provide long-term effectiveness and permanence for control of direct contact exposure by human health and ecological receptors to constituents in soil. It can be expected that the cap placed on the Site would be maintained as required by regulation, eliminating direct contact with Site-related constituents to human and ecological receptors. Similarly, because the cap would be maintained, the potential for surface water exceedances as a result of contaminated storm water runoff would be eliminated. The institutional controls would notify future owners, occupants and workers of the presence of constituents in soil (Deed Notice) to

prevent unauthorized intrusive work on the Site. However, the sources of groundwater contamination would remain, such that the long-term effectiveness and permanence of the remedy for groundwater would be dependent upon the chosen groundwater remedy.

Soil Alternative 3 – Soil and LNAPL Removal/Treatment, Capping and Institutional Controls would provide a high degree of long term effectiveness and permanence because all surface soil containing constituents greater than the PRGs and subsurface soil containing constituents at concentrations greater than the RDCSRS would be removed from the Upper Hilliards Creek floodplain, the sources of groundwater contamination would be removed from the Former Main Plant and Lagoon areas, the LNAPL would be removed to the extent practicable and the degradation processes would be enhanced, and the methane and petroleum vapors produced by the degradation of the LNAPL would be removed.

Removing surface soil containing constituents at concentrations greater than the PRGs would eliminate the potential for exceedances of surface standards due to contaminated storm water runoff. The removal of the sources of groundwater contamination provides permanence for the groundwater remedy because there would not be a need to rely on active groundwater treatment to achieve the GWQS. Removing the LNAPL south of Foster Avenue and installing a recovery trench would eliminate the potential for discharges to Hilliards Creek. Removing and enhancing degradation of LNAPL north of Foster Avenue would reduce the time frame that the LNAPL acts as a source to groundwater and soil gas vapors. As noted in Section 4.2.1.3, it is expected that the treatment system would operate for seven years, but for costing purposes a ten year operating period has been assumed.

Soil Alternative 4 – Extensive Excavation to Depth and Institutional Controls provides an equivalent degree of long-term effectiveness and permanence as Soil Alternative 3. As with Soil Alternative 3, all surface soil containing constituents greater than the PRGs and subsurface soil containing constituents greater than the RDCSRS would be removed from the Hilliards Creek floodplain. Under Alternative 4, all subsurface soil containing constituents at concentrations greater than the RDCSRS would be removed from the remainder of the Site

except for inaccessible areas beneath roadways and some buildings. Sources of groundwater contamination and LNAPL would also be removed. Removing surface soil containing constituents at concentrations greater than the PRGs from the ecological habitat areas would eliminate the potential for exceedances of surface standards due to contaminated storm water runoff. The removal of the sources of groundwater contamination and LNAPL provide would permanence for the groundwater remedy because there would not be a need to rely on active groundwater treatment to achieve the GWQS.

4.2.2.4. Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility or volume through treatment would occur for the LNAPL under Alternatives 1, 2 and 3 since, as documented in the LNAPL Report, there would be ongoing biodegradation of the LNAPL. Soil Alternative 3, which would stimulate the LNAPL degradation through enhancing the ongoing bioremediation, would provide the highest degree of reduction of toxicity, mobility or volume through treatment. Soil Alternative 4 does not provide for reduction of toxicity, mobility or volume through treatment because soil removal, not treatment, would be the approach used for remediation.

4.2.2.5. Short-Term Effectiveness

All of the soil alternatives where excavation is involved would have some degree of short-term impacts upon the community and the environment. Based on the projected schedules for each alternative, short term impacts would range from several months to almost five years. The impacts include vehicular (truck and heavy construction equipment) traffic, noise, emissions, possible road closures, potential damage to roadways, and short-term ecological habitat destruction. These short-term impacts are unavoidable, and the extent of the impacts is a function of the extent of the remedial action. That is, the more extensive the remedial action is, the more soil is removed and larger areas are impacted. Accordingly, the remedial action requires a longer period of time to complete, and results in a greater number of truckloads of soil and backfill, having a higher degree of short-term impact.

The short-term impacts of Soil Alternatives 3 and 4 - those alternatives in which large volumes of soil would be removed – would be significant because of the volume of soil that would be removed, the volume of soil to be brought onto the Site as backfill or cap material, and the area of the Site that would be affected during the remedial action.

For example, under Alternative 3, the alternative in which all soil containing constituents above the PRGs and RDCSRS in the Upper Hilliards creek floodplain, sources of groundwater contamination in the Former Main Plant and Lagoon areas, and the LNAPL in the Seep Area would be excavated, would result in almost 40,000 CY (nearly 70,000 tons) of soil being removed from the Site. A similar volume of soil would be brought onto the site for backfilling and capping. Using a typical truck load of 20 tons, these numbers translate to approximately 7,000 truck trips to move soil into and out of the Site. These trucks would use U.S. Avenue, Clementon Road, Foster Avenue and other two-lane surface streets to get to and from the Site.

Under Soil Alternative 4, more than 300,000 CY (more than 450,000 tons) of soil would be removed from, and brought onto, the Site. This translates to more than 45,000 truck trips solely to move soil to and from the Site under this alternative. This does not account for transport of concrete, asphalt and other debris generated during the soil removal or the construction debris generated by the building demolition.

Currently, access to the Site is from U.S. Avenue and West Clementon Road. Depending upon the volume of truck traffic entering and leaving the Site during construction, there may be a need for intermittent closures of one or both of these streets. It can be expected that there would be closures of Foster Avenue. Traffic control would be required for U.S. Avenue and West Clementon Road while trucks enter and leave the Site.

Remediation would be conducted on approximately three acres of regulated wetlands and transition areas in the Upper Hilliards Creek floodplain and the Former Lagoon Area. The majority of the Site is currently wooded, containing large overstory trees. Under any of the

remedial alternatives, the entire three acres would be cleared, including the land immediately behind residential properties B-4 through B-7. Although the Site would be restored, it would be years or decades before the Site would return to its current status.

Based on the understanding of the activities that would be conducted under each alternative, the comparison of short term effectiveness follows.

- Soil Alternative 1 would have no short-term impacts because there is no construction activity associated with either alternative.

- Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls would have the least short-term impacts than any of the alternatives in which soil removal would be conducted. The volume of soil that would be removed is significant (approximately 8,000 CY), and approximately 3 acres of forested floodplain would be cleared as part of the remedial action. The construction time frame would be the least of all of the soil removal alternatives but would still extend for approximately 9 months.

- The short-term impacts associated with Soil Alternative 3 would be greater than those for Soil Alternative 2. Approximately 40,000 CY of soil would be excavated, and an equivalent volume of soil would be imported onto the Site. This translates to approximately 7,000 truck trips to move soil to and from the Site. As discussed previously, there are no alternatives to U.S. Avenue and West Clementon Road by which to access the Site. As with Soil Alternative 2, the entire Hilliards Creek floodplain would be cleared as part of the remedial action. Soil Alternative 3 is expected to require approximately 16 months to complete.

  It is noted that the 5 Foster Avenue building is the current headquarters for the Gibbsboro Police Department. Under Soil Alternative 3 and Soil Alternative 4,

extensive excavation would be conducted in the parking area, potentially restricting access to the 5 Foster Avenue building.

- Soil Alternative 4 would pose very substantial short-term risks and impacts. Not only does it involve the removal of almost eight times as much soil as Alternative 3 (more than 300,000 CY), the depths are much greater, and it would require the removal of two very large structures and the management of large volumes of produced groundwater and LNAPL mixture.

  Since the majority of soil excavated under Soil Alternative 4 would be from under the water table, a very large amount of soil would require stabilization to eliminate free liquids prior to offsite transport. For purposes of the FS, it is assumed that the stabilization would occur on the Site. If, however, construction of a separate facility to manage the soil is needed, additional time and truck trips would be required, which would increase the short-term impacts on the community. The likelihood of needing a separate facility is higher for this alternative due to the large volumes of soil that would need to be managed.

  It is projected that it would require as long as five years to complete this alternative, and more than 45,000 truck trips in and out of the site would occur over this time.

  Short-term risks to construction workers would also be the greatest under Soil Alternative 4. The most soil would be removed, the most truck trips would occur, and building demolition would be conducted.

4.2.2.6. Implementability

Similar to the "Short-Term Effectiveness" discussion, Soil Remedial Alternatives 2, 3 and 4 would all have implementability difficulties:

- Conducting large-scale construction activities along U.S. Avenue, West Clementon Road and Foster Avenue would require careful planning, coordination with local authorities, and constant attention to ensure worker and public safety.

- Excavation next to U.S. Avenue and Foster Avenue may require the use of structural supports to prevent damage and allow for safe excavation of soil. This is particularly true for Soil Alternative 4, where deep excavations adjacent to Foster Avenue and U.S. Avenue would require special measures to ensure worker safety and road stability.

- Produced groundwater from the Former Resin Plant/Tank Farm A and Seep Area would likely contain measurable concentrations of petroleum compounds, requiring treatment or containerization and offsite disposal.

- Odor control would be needed for soil excavated from the Seep Area, as it can be expected that the LNAPL in soil would have a strong petroleum odor, and residential properties are immediately across U.S. Avenue from the Seep Area.

- Management of LNAPL in water would be necessary, particularly during excavation of the Seep Area, where LNAPL-containing soil would be removed.

- Ingress and egress for trucks and equipment would need to be planned and coordinated.

- Excavation of saturated soil would require management of groundwater as well as processing of saturated soil to meet disposal site requirements.

- Excavation in and along Upper Hilliards Creek would require the use of stream diversion measures and sediment and soil erosion measures to prevent downstream transport of contaminated soil during construction.

- Ecological restoration would need to be carefully designed and monitored, to ensure the functionality of the habitat would be restored and invasive species would be managed.

Again, these implementability difficulties are unavoidable for any of the active soil remediation alternatives. The difference in the implementability difficulties between Soil Alternatives 2, 3, and 4 is the extent of the soil removal. The greater the volume of soil removed, the greater the implementability difficulties would be.

Soil Alternative 1, No Action would have the lowest degree of implementability difficulties, because no construction activities would be conducted under this alternative.

Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls would have the least amount of implementability difficulties than any of the alternatives in which soil removal would be conducted, but the implementability issues would be significant. Acceptance of a Deed Notice by the current property owners would be needed. Approximately 8,000 CY of soil would be removed, with most from the Hilliards Creek floodplain, where excavation is predicted to be most difficult as a result of access and shallow water table conditions. One component of the excavation would be the soil between the two channels at the southern end of Upper Hilliards Creek, where both groundwater and surface water management would be required.

Site restoration along Upper Hilliards Creek is a significant implementability issue. Currently, the floodplain is a forested wetland and transition area with few invasive species noted. However, any disturbed area would potentially be subject to the propagation of invasive species.

Soil Alternative 3 – Soil and LNAPL Removal/Treatment, Capping and Institutional Controls would have greater implementability difficulties than would Soil Alternative 2. Much more soil would be removed (approximately 40,000 CY), and the majority of the additional soil would be from saturated conditions (Upper Hilliards Creek floodplain, the Seep Area and

deep excavations on the Former Main Plant Area), so more groundwater would need to be managed, and more saturated soil would need to be stabilized. The produced groundwater in the Seep Area is likely to contain measurable amounts of petroleum hydrocarbons, which would likely require treatment prior to discharge or containerization and offsite disposal, and LNAPL may be present at the water table.

The excavation in the Seep Area next to U.S. Avenue and Foster Avenue is likely to require some level of structural support to prevent damage to the roadways. Acceptance of a Deed Notice by the current property owners would be needed.

The excavations along the Hilliards Creek floodplain would be deeper than under Alternative 2, producing more groundwater and requiring additional measures to limit surface water intrusion into the excavations. In the northern portion of Upper Hilliards Creek, the excavation on the west side may require structural stability measures to prevent damage to the 7 Foster Avenue building. Like Alternative 2, restoration of Upper Hilliards Creek would be difficult as a result of the potential for invasive species.

Soil Alternative 4, Extensive Removal to Depth and Institutional Controls would have by far the greatest degree of implementability difficulties of any alternative. The most soil would be removed (more than 300,000 CY), and the excavation depths would be extensive (20 feet in the Former Lagoon Area and 25 feet in the Former Resin Plant/Tank Farm A area). Because of the depth to which the soil removal would be performed, groundwater management would be a major implementability issue. As with Soil Alternative 3, any groundwater produced from the Former Resin Plant/Tank Farm A and Seep Areas can be predicted to contain measurable amounts of petroleum hydrocarbons, such that treatment or offsite disposal would be required. If excavations could not be conducted in saturated conditions, or if pumping and on-site discharge pursuant to a NJDEP permit by rule could not be used, even more groundwater would need to be containerized and disposed off-site. Also because of the depth of the excavation, structural supports would be required along the

entire perimeter of the excavations in the Former Lagoon Area and the Former Resin Plant/Tank Farm A area.

4.2.2.7. Cost

Soil Alternative 1, No Action is the least costly alternative, followed by Soil Alternative 2, Targeted Surface Soil Removal, Capping and Institutional Controls, which is the least costly of the alternatives involving soil removal ($6 million), Soil Alternative 3, Soil and LNAPL Removal/Treatment, Capping and Institutional Controls ($24 million) and Soil Alternative 4, Extensive Removal to Depth and Institutional Controls ($87 million). The cost estimates for each alternative are presented in Table 13 and Appendix D.

4.2.3. Identification and Description of Alternatives for Sediment

In this section, remedial alternatives for sediment in Upper Hilliards Creek are identified and evaluated. The following factors have been considered in developing and evaluating these alternatives:

- Arsenic, cyanide and lead are the primary constituents identified in the BERA as being responsible for potential unacceptable risks to ecological receptors, and, as presented in Appendix A, it is expected that addressing sediment containing these COPCs at concentrations greater than the PRGs would reduce sediment COPC concentrations to levels that are protective of benthic invertebrates and wildlife that feed on benthic invertebrates.

- No sediment toxicity to benthic organisms was observed in testing conducted to support the BERA, and the PRGs are based on protection of wildlife receptors.

- The three constituents are present at concentrations greater than the PRGs at depths ranging from two to six feet in Upper Hilliards Creek.

- There is no ongoing discharge of constituents from sediment to surface water such that surface water standards are exceeded.

- The remedial action for sediment would be accompanied by a remedial action within the Upper Hilliards Creek floodplain that would remove surface soil containing the COPCs present at concentrations greater than wildlife PRGs for soil. Therefore, there would be no potential for recontamination of the stream from the floodplain.

The following alternatives were developed to address the contaminated sediment in Upper Hilliards Creek:

Sediment Alternative 1 - No Action;

Sediment Alternative 2 - Targeted Removal of Surface Sediment with Contaminants Greater than PRGs, Capping and Natural Recovery; and

Sediment Alternative 3 - Removal of all Sediment with Contaminants Greater than PRGs.

4.2.3.1. Sediment Alternative 1 – No Action

CERCLA requires that the No Action alternative be evaluated in the FS. Under Sediment Alternative 1 - No Action, no remediation would be implemented for sediments in Upper Hilliards Creek. Current site contaminant exposures and risks would remain. No routine monitoring of contaminants or site conditions would be conducted to determine if natural processes such as burial are reducing the surface concentrations of constituents in sediment. Statutory CERCLA Five Year Reviews would be conducted in accordance with CERCLA Section 121(c) because contamination would remain on site above risk-based goals (EPA, 2001).

4.2.3.2. Sediment Alternative 2 –Removal of Surface Sediment with Contaminants Greater than PRGs, Capping and Natural Recovery

One foot of sediment containing constituents at concentrations greater than the PRGs would be removed from Upper Hilliards Creek. A cap would then be installed, consisting of 6 inches of sand, covered by 3 inches of stone, that would act as an armoring layer. Natural sedimentation would then be allowed to fill in above the armoring layer and reestablish the current elevation of the stream. Under this Alternative, the design of the remedy would include a study of sedimentation and scouring within Upper Hilliards Creek to refine sediment capping requirements. As part of this alternative, the sediment that has accumulated in the Silver Lake conveyance system, located in the parking area between the 2 and 4 Foster Avenue buildings and the 7 Foster Avenue building, and the sediment that is in the concrete culvert south of Foster Avenue, would be removed.

The estimated limits of Sediment Alternative 2 are shown on Figure 35.

Approximately 310 CY of sediment would be removed under this alternative.

Implementation of this alternative would involve the following major components:

- Mobilization;
- Obtaining permit equivalencies for wetlands and flood hazard areas;
- Cleaning the Silver Lake conveyance system and the concrete culvert south of Foster Avenue;
- Clearing of the contaminated area and necessary access roads;
- Establishment of laydown areas and soil erosion and sediment controls;
- Construction of the stream diversion system to allow access to the sediment;

- Excavation of contaminated sediment;
- Dewatering and processing of the sediment, as needed;
- Transportation to and disposal at an approved disposal facility;
- Installation of the cap at identified locations;
- Stream bank and access road restoration;
- Monitoring to confirm the success of the restoration; and
- Demobilization.

Stream diversion structures would be installed as part of the remedial action. The structures would be installed at the upstream and downstream extents of the sediment removal and cap installation. Surface water would be diverted from the upstream location, around the area of remedial action and discharged beyond the downstream structure. Any groundwater that may discharge to the area where the remedial action is ongoing would be collected and also discharged, following filtering to remove any contaminated sediment, beyond the downstream diversion structure.

The sediment would require dewatering and/or treatment prior to transportation for disposal. It is assumed for cost estimating purposes that the sediment processing and handling would be conducted on the Site. The sediment would be removed, stockpiled in appropriate structures, and allowed to dewater. If needed, the sediment would be treated to remove free liquid prior to being transported to an appropriate disposal facility. For the purposes of this FS, it was assumed that a soil amendment would be necessary for all of the sediment.

For purposes of estimating costs for this alternative, it has been assumed that 25% of the sediment would be managed as RCRA hazardous (characteristic) waste. The actual classification would be determined prior to disposal.

Annual or at least biennial monitoring would be conducted to confirm that the cap remained in place and that natural sedimentation was successful in restoring the stream bottom to its previous elevation. Five years of monitoring would also be conducted to confirm that restoration of the stream bank, riparian zone and wetlands areas was successful.

In accordance with CERCLA Section 121(c), a statutory CERCLA Five Year Review performance evaluation would be conducted every 5 years, because contaminants would be left on site above risk-based goals (EPA, 2001).

The estimated construction time frame for this alternative, exclusive of any predesign activity, remedial design, and permitting/approvals, and assuming all areas are addressed concurrently, is approximately 2 months.

4.2.3.3. Sediment Alternative 3 – Removal of all Sediment with Contaminants Greater than PRGs

This alternative would consist of excavation of all sediment in Upper Hilliards Creek containing contaminants at concentrations greater than the PRGs. The areas where sediment was removed would be backfilled with clean material that would both remain stable and provide habitat for the benthic community. Because all contaminants present at concentrations greater that the PRGs would be removed, there would be no need for a cap and, therefore, no ongoing in-stream monitoring. It is assumed that one CERCLA Five-Year Review would be conducted.

The estimated limits of Sediment Alternative 3 are shown on Figure 36. Based on the current understanding of the distribution of COCs in sediment, it is expected that this alternative would consist of the following:

- Cleaning out the accumulated sediment from the Silver Lake conveyance system, located beneath the parking area between the 2 and 4 Foster Avenue buildings and the 7 Foster Avenue building.

- Cleaning out the sediment accumulated in the concrete culvert south of Foster Avenue.

- Removal of approximately two feet of sediment from the northern portion of Upper Hilliards Creek, just south of Foster Avenue, and in the center portion of Upper Hilliards Creek.

- Removal of five feet of sediment from the southern part of Upper Hilliards Creek, from just north of where Upper Hilliards Creek splits into two channels, to West Clementon Road.

- Removal of seven feet of sediment from the portion of Upper Hilliards Creek adjacent to the 1 Foster Avenue building.

For purposes of estimating costs, it is assumed that the two-foot removal areas would be allowed to naturally accumulate sediment until current stream depths were reached. The deeper five-foot and seven-foot removals would potentially create public safety issues by deepening a formerly shallow stream. Therefore, it is assumed that these areas would be backfilled to a depth of one foot below the current elevation, and natural sedimentation would bring the stream bottom to the current elevation.

Implementation of this alternative would involve the following major components:

- Mobilization;

- Obtaining permit equivalencies for wetlands and flood hazard areas;

- Cleaning the Silver Lake conveyance system and concrete culvert south of Foster Avenue;
- Clearing of the contaminated area and necessary access roads;
- Establishment of laydown areas and soil erosion and sediment controls;
- Construction of the stream diversion system to allow access to the sediment;
- Excavation of contaminated sediment;
- Dewatering and processing of the sediment, as needed;
- Transportation to and disposal at an approved disposal facility;
- Stream bed backfill and restoration;
- Stream bank and access road restoration;
- Monitoring to confirm the success of the restoration; and
- Demobilization.

Stream diversion structures would be installed as part of the remedial action. The structures would be installed at the upstream and downstream extents of the sediment removal or cap installation. Surface water would be diverted from the upstream location, around the area of remedial action and discharged beyond the downstream structure. Any groundwater that may discharge to the area where the remedial action is ongoing would be collected and also discharged, following filtering to remove any contaminated sediment, beyond the downstream diversion structure.

The sediment would require dewatering and/or treatment prior to transportation for disposal. It is assumed for cost estimating purposes that the sediment processing and handling would be conducted on the Site. The sediment would be removed, stockpiled in appropriate structures, and allowed to dewater. If needed, the sediment would be treated to remove free liquid prior to being transported to an appropriate disposal facility. For the purposes of this FS, it was assumed that a soil amendment would be necessary for all of the sediment.

For purposes of estimating costs for this alternative, it has been assumed that 25% of the sediment would be managed as RCRA hazardous (characteristic) waste. The actual classification would be determined prior to disposal.

Five years of monitoring would also be conducted to confirm that restoration of the stream bank, riparian zone and wetlands areas was successful.

Under this alternative, approximately 1,400 CY of sediment would be removed. Completion of this alternative is expected to require approximately 3 months.

4.2.4. Comparative Analysis of Alternatives for Sediment

As discussed previously, all remedial alternatives are evaluated against the two threshold criteria, Overall Protection of Human Health and the Environment, and Compliance with ARARs, as well as the five balancing criteria. The following presents this evaluation for the sediment alternatives.

4.2.4.1. Overall Protection of Human Health and the Environment

Sediment Alternative 1 - No Action would not provide protection of human health and the environment. Current site contamination, exposures and risks would remain. Human Health and Environmental Protection RAOs would not be achieved. Routine monitoring of site conditions would not be conducted and future changes in contaminant conditions would not be identified.

Sediment Alternative 2 - Targeted Removal of Surface Sediment with Contaminants Greater than PRGs, Capping and Natural Recovery would provide protection of human health and the environment by removing the sediment containing the highest concentrations of constituents and providing a cap to prevent human and ecological exposure to the remaining sediment that contains constituents at concentrations greater than the PRGs. Preventing exposure to sediment at concentrations greater than PRGs would protect ecological receptors. Since the PRGs are less than the RDCSRS, and human exposure to sediment is less than human exposure to residential soil, achieving the sediment PRGs would also be protective of human health exposures. Sedimentation above the cap would provide additional protection for human health and ecological receptors.

Sediment Alternative 3 - Removal of all Sediment with Contaminants Greater than PRGs would provide human health and ecological receptor protection by removing the sediment containing contaminants at concentrations greater than the PRGs and placing clean material in the stream bed as part of the restoration. Preventing exposure to sediment at concentrations greater than PRGs would protect ecological receptors. Since the PRGs are less than the RDCSRS, and human exposure to sediment is less than human exposure to residential soil, achieving the sediment PRGs would also be protective of human health exposures.

4.2.4.2. Compliance with ARARs

The ESCs used in the RIR, the PECs referred to in the BERA, and the PRGs that have been calculated in Appendix A are not enforceable standards and therefore are not ARARs, but are considered TBCs. However, pursuant to EPA and NJDEP guidance, development of site-specific cleanup objectives is acceptable. Therefore, for purposes of assessing whether the sediment remedial alternatives meet ARARs, this analysis considers whether surface sediment would meet the PRGs developed for the Site.

Sediment Alternative 1 - No Action would not meet the PRGs for surface sediment and, therefore, would not be considered to meet ARARs.

Sediment Alternatives 2 and 3 would meet the risk-based goals in surface sediment and, therefore, are considered to achieve ARARs for sediment.

4.2.4.3. Long-Term Effectiveness and Permanence

Sediment Alternative 1 - No Action does not provide long-term effectiveness and permanence for the sediment areas where constituents are present at concentrations greater than the PRGs. Existing contamination, exposures and risks would remain, and, therefore, this alternative would not address those areas where contaminant concentrations are above risk-based goals.

Sediment Alternative 2 - Targeted Removal of Surface Sediment with Contaminants Greater than PRGs, Capping and Natural Recovery would provide long-term effectiveness and permanence if the cap preventing exposure to the underlying residual constituents is properly maintained. Based on the shallow water depths and low topographic relief throughout Upper Hilliards Creek, it is unlikely that under foreseeable conditions there would be adequate energy in the stream flow to damage an engineered cap. Therefore, it should be possible to design and maintain a cap that provides long-term effectiveness and permanence.

Sediment Alternative 3 - Removal of all Sediment with Contaminants Greater than PRGs would provide a high degree of long-term permanence and effectiveness because all constituents that may pose human health and/or ecological risks would be removed.

4.2.4.4. Reduction of Toxicity, Mobility, or Volume through Treatment

Since removal and containment are the technologies that would be used for the remediation of sediment, none of the alternatives provide reduction of toxicity, mobility, or volume through treatment.

4.2.4.5. Short-Term Effectiveness

Since Sediment Alternative 1 - No Action does not require site work, there would be no short-term impact to the environment or community.

The short-term impacts associated with Sediment Alternatives 2 – Targeted Removal of Surface Sediment with Contaminants Greater than PRGs, Capping and Natural Recovery and 3 - Removal of all Sediment with Contaminants Greater than PRGs would include damages to uplands and benthic ecological habitat, the removal of mature vegetation, and short-term loss of aquatic habitat. Damages to adjacent wetlands could also occur and would require mitigation. Short-term community impacts include increased truck traffic, particularly along U.S. Avenue, West Clementon Road and Foster Avenue, noise, and other construction-related impacts. The impacts relate not only to the actual sediment removal, but also the preliminary activities such as clearing and installation of temporary roadways to gain access to the sediment and transport of the sediment off-site for disposal.

The extent of the impacts associated with Alternatives 2 and 3 would be similar. The remediation footprint for both alternatives would be the same. Under both alternatives, remedial action in Upper Hilliards Creek would extend from Foster Avenue to West Clementon Road. Therefore, the footprint of impacts on the Site associated with clearing and temporary road construction would encompass the same areas.

The primary difference in short-term impacts between Alternatives 2 and 3 is the length of time needed to complete the remedial action, which is a function of the volume of sediment removed. Under Sediment Alternative 2, approximately 315 CY of sediment would be removed, and the remedial action would require approximately 2 months to complete. Under Sediment Alternative 3, approximately 1,400 CY of sediment would be removed, and the remedial action would require approximately 3 months to complete.

4.2.4.6. Implementability

Sediment Alternative 1 - No Action has the lowest degree of implementability difficulties since no construction or administrative effort would be required.

The types of implementability difficulties that would be encountered with Sediment Alternatives 2 - Targeted Removal of Surface Sediment, Capping and Natural Recovery, and 3 – Removal of All Sediment with Contaminants Greater than PRGs, are similar. These include:

- Gaining access for construction equipment and trucks into the locations where the sediment is to be removed;
- Controlling the flow of surface water and the influx of groundwater;
- Dewatering and processing the sediment;
- Restoring the stream bottom in a manner that is both stable and provides habitat; and
- Restoring the floodplain adjacent to the areas where the sediment removal was conducted.

It is expected that the degree of implementability difficulties for Alternatives 2 and 3 would be similar. The only differences between the two alternatives are the volumes of sediment that would be removed (more for Alternative 3 than Alternative 2), and the placement of more backfill (more in Alternative 3 than would be required for the cap in Alternative 2). Because more sediment would be removed under Alternative 3, more sediment would need to be processed, more water would need to be managed, and the water diversion structures would need to be maintained for a longer period of time during sediment removal.

4.2.4.7. Cost

Costs for the sediment alternatives range from approximately $29,000 (Sediment Alternative 1, No Action) to approximately $1.8 million (Sediment Alternative 3, Removal of all Sediment with Contaminants Greater than PRGs). The costs for Sediment Alternative 2, Targeted Removal of Surface Sediment, Capping and Natural Recovery, is estimated to be approximately $1.6 million. Although approximately 1,000 CY more sediment would be removed in Sediment Alternative 3 than Sediment Alternative 2, Alternative 2 requires construction of a cap and ongoing monitoring and O&M of the cap, which increase the cost.

4.2.5. Identification and Description of Alternatives for Surface Water

In this section, Remedial Alternatives for surface water are identified. The key factor in evaluating the surface water alternatives is that surface water is not a source of contamination, but rather is a receptor of contaminants from soil and sediment. Therefore, as discussed in Section 4.1, preventing exceedances of surface water standards is a remedial action objective for both soil and sediment.

As noted in the RIR, lead was found in surface water in the most downstream sampling location in Upper Hilliards Creek at a concentration greater than the surface water standard. This was also observed in the BERA sampling.

The following alternatives were developed to address the contaminated surface water in Upper Hilliards Creek:

Surface Water Alternative 1 - No Action; and

Surface Water Alternative 2 - Institutional Controls with Monitoring.

4.2.5.1. Surface Water Alternative 1 – No Action

CERCLA requires that the No Action alternative be evaluated in the FS. Under the Surface Water Alternative 1 - No Action, no remediation would be implemented for surface water in

Upper Hilliards Creek. Exposures and risks would be those that remain following implementation of the selected remedies for soil and sediment. Statutory CERCLA Five Year Reviews would be conducted.

There is no construction field effort required for this alternative.

4.2.5.2. Surface Water Alternative 2 – Institutional Controls with Monitoring

This alternative would use Institutional Controls to prevent exposure to contaminated surface water at the FMP. Institutional Controls would include prohibitions on the contact with or use of surface water. Monitoring would be conducted on a quarterly basis to assess any changes in contaminant conditions over time.

There is no construction field effort required for this alternative.

4.2.6. Comparative Analysis of Alternatives for Surface Water

4.2.6.1. Overall Protection of Human Health and the Environment

Surface Water Alternative 1 - No Action would provide protection of human health and the environment if soil and sediment remedies were conducted to prevent exceedances of the surface water standards. Currently, lead is the only site-related constituent found in Upper Hilliards Creek at a concentration greater than the surface water standard. It can be expected, with the implementation of a sediment remedy that would be protective of human health and the environment, that the potential for exceedance of the lead standard would be eliminated.

Surface Water Alternative 2 - Institutional Controls and Monitoring would provide protection of human health by interrupting the human health exposure pathway and preventing access to, and contact with, the contaminated surface water. The institutional controls would not address any ecological exposure. However, in the event that source control measures were implemented to prevent exceedances of the surface water standards,

protection of public health and the environment would be achieved without the institutional controls.

4.2.6.2. Compliance with ARARs

Surface Water Alternative 1 - No Action would meet chemical-specific ARARs since source control measures for soils and/or sediments would likely address the surface water contamination. Location-specific and action-specific ARARs do not apply to this alternative, since no site activity (i.e., construction) would be required.

Surface Water Alternative 2 - Institutional Controls and Monitoring would provide compliance with ARARs if source control measures are implemented that prevent exceedances of the surface water standards.

As discussed above, lead is the only site-related constituent found in Upper Hilliards Creek at a concentration greater than the surface water standard. If a sediment remedy that is protective of public health and the environment is implemented, the surface water standard for lead would be achieved under both alternatives.

4.2.6.3. Long-Term Effectiveness and Permanence

Surface Water Alternative 1 - No Action, and Surface Water Alternative 2 - Institutional Controls and Monitoring would provide long-term effectiveness and permanence if source control measures for sediment are implemented that prevent exceedances of the surface water standards.

4.2.6.4. Reduction of Toxicity, Mobility, or Volume through Treatment

Neither Surface Water Alternative 1, No Action, nor Surface water Alternative 2, Institutional Controls with Monitoring, would provide reduction of toxicity, mobility or volume of site contamination through treatment.

4.2.6.5. Short-Term Effectiveness

Surface Water Alternative 1 - No Action does not require site work, so there would be no short-term impact to the community.

Surface Water Alternative 2 - Institutional Controls and Monitoring would potentially reduce public use of surface water in Upper Hilliards Creek. If institutional controls are imposed, public use would be restricted, even if source control measures are implemented.

4.2.6.6. Implementability

Surface Water Alternative 1 - No Action is technically implementable, since no construction, remediation or administrative effort would be required.

There would be difficulties in both implementing and maintaining Surface Water Alternative 2 - Institutional Controls and Monitoring. These are primarily associated with the need to impose restrictions on public access to Upper Hilliards Creek.

4.2.6.7. Cost

Total estimated costs for Surface Water Alternative 1, No Action, are approximately $29,000. These costs are associated with performing a series of CERCLA Five-Year Reviews.

Total estimated costs for Surface Water Alternative 2, Institutional Controls with Monitoring, are approximately $124,000. These are associated with the monitoring that would be conducted and the Five-Year Reviews that would be performed.

4.2.7. Summary of Remedial Alternative Comparative Analysis

A comparative analysis of each of the alternatives for all contaminated media is presented in Figures 37, 38 and 39. The results of the comparative analysis are summarized below.

4.2.7.1. Soil

As shown on Figure 37, both Soil Alternative 3, Soil and LNAPL Removal/Treatment Capping and Institutional Controls, and Soil Alternative 4, Extensive Excavation to Depth, fully meet the two threshold criteria of "Protection of Public Health and Environment" and "Compliance with ARARs". Although other soil alternatives partially achieve the two threshold criteria, primarily because of the extensive cap that is already on the site, the criteria are not fully achieved. Soil Alternatives 3 and 4 score the same for the two threshold criteria.

Soil Alternative 4 ranks lower than Soil Alternative 3 in three of the five balancing criteria: "Short-Term Effectiveness", "Implementability", and "Cost":

- Short-Term Effectiveness: implementation of Soil Alternative 4 would require that nearly eight times as much soil (315,000 vs. 40,000 tons) be excavated from the Site than would be required under Soil Alternative 3. This translates to approximately 2,500 more truck trips through the community. Soil Alternative 4 would require four years longer to complete than Soil Alternative 3, resulting in a longer term by which impacts to the community would occur. Excavation depths for Soil Alternative 4 are much greater than those for Soil Alternative 3, particularly in the Former Resin Plant/Tank Farm A area, potentially creating greater risks to U.S. Avenue and Foster Avenue during construction.

- Implementability: Because the volume of soil to be removed under Soil Alternative 4 is much greater than under Soil Alternative 3, the implementability difficulties are much greater. In particular, the depth of the excavations that would be conducted under Soil Alternative 4 would result in the need to manage substantially more contaminated groundwater and stabilize substantially more saturated soil.

- Cost: Soil Alternative 4 is estimated to cost more than three times as much $87 million more than Soil Alternative 3 ($24 million).

4.2.7.2. Sediment

Sediment Alternative 2, Targeted Surface Sediment Removal and Capping, and Sediment Alternative 3, Removal of All Sediment with Contaminants Greater than PRGs, meet the threshold criteria. Sediment Alternatives 2 and 3 score similarly in all balancing criteria (Figure 38). Although the cost for Sediment Alternative 3 ($1.8 million) is slightly higher than Alternative 2 ($1.6 million), the difference is not substantial.

4.2.7.3. Surface Water

Both alternatives would meet the two threshold criteria if soil and sediment source control actions are implemented (Figure 38). Surface Water Alternative 1, No Action, would not have short-term impacts on the community, and it would be somewhat less expensive to implement.

4.2.8. Identification and Description of Remedial Alternatives for the Eastern Off-Property Area

The only medium for which evaluation of remedial alternatives is required in the Eastern Off-Property Area is the LNAPL present in the saturated zone at depths of approximately 10 to 20 feet below ground surface depending on the ground elevation. Site-related constituents are not present in unsaturated soils, and sampling conducted by EPA and Sherwin-Williams has found no evidence of vapor intrusion. As noted in the HHRA, there are no unacceptable cancer or non-cancer risks in this area.

Key considerations in developing the remedial alternatives for the Eastern Off-Property Area are summarized as follows:

- The LNAPL is present at low saturation levels. As such, it is neither mobile nor recoverable.

- Constituents associated with the LNAPL are present at depths greater than ten feet below ground surface, well below the depths at which a resident or worker would be

expected to come into contact with these constituents. As such, the area over which the LNAPL is present is essentially capped.

- In general, the LNAPL thickness throughout the Eastern Off-Property Area is approximately two to four feet. The exception to this is the former tavern/service station where the LNAPL thickness is approximately five to seven feet.

- The LNAPL is undergoing NSZD via biodegradation. The biodegradation rates of the LNAPL are likely limited by the absence of key nutrients.

Based on this understanding of the LNAPL, three remedial alternatives were evaluated:

1. Alternative EOP1 – No Action

2. Alternative EOP2 – Enhanced LNAPL Biodegradation and Soil Gas Recovery

3. Alternative EOP3 – Extensive Removal to Depth

Each is discussed below.

4.2.8.1. Alternative EOP1 – No Action

CERCLA requires that the No Action alternative be evaluated. Under the No Action alternative, no soil remediation would be implemented for LNAPL on the Eastern Off-Property Area. Current site conditions would remain. Under the No Action Alternative, there is no current risk to human health, as documented by the HHRA. The LNAPL and all constituents associated with the LNAPL are present at depths greater than would be encountered by residents or workers, and sampling has found no constituents in soil gas at concentrations greater than screening levels under any structure. However, no effort would be made to remove or treat the LNAPL, and it would remain a source of groundwater contamination.

Routine monitoring of contaminants or site conditions would not be conducted. Statutory CERCLA Five Year Reviews would be conducted in accordance with CERCLA Section 121(c) because contamination would remain on site above levels that allow unlimited use and unrestricted exposure (EPA, 2001).

There is no construction field effort required for this alternative. Total costs for this alternative are approximately $142,000, resulting from the need to conduct the Five-Year Reviews (estimated six reviews).

4.2.8.2. Alternative EOP2 – Enhanced LNAPL Biodegradation and Soil Gas Removal

Under this alternative, the ongoing LNAPL and dissolved-phase biodegradation on the Eastern Off-Property Area would be stimulated and enhanced. As necessary, any soil gas that is created as a result of the enhanced bioremediation would be extracted. This alternative would consist of:

- Installing injection wells and soil gas extraction wells on the former tavern/service station property and on the west side of U.S. Avenue,
- Installing pressurized nutrient injection wells along the U.S. Avenue right of way east of U.S. Avenue and south of the former tavern/service station,
- Installing soil gas extraction and treatment, and nutrient mixing and injection systems in the eastern parking area of the 2 and 4 Foster Avenue buildings,
- Installing piping beneath U.S. Avenue from the former tavern/service station to the 2 and 4 Foster Avenue parking area,
- Conducting direct push nutrient injections in those areas beneath properties E-1, E-7, E-8, E-9, E-10 and E-11 where LNAPL is present,

- Operating the nutrient injection and soil gas recovery systems.

As a contingency in the event that bioremediation of the LNAPL present beneath U.S. Avenue is not adequately enhanced, a series of direct push injections would be conducted within the roadway. It is also to be noted that there is some overlap between Soil Alternative 3 for the FMP and Soil Alternative EOP2 for the Eastern Off-Property Area. If these alternatives are selected by EPA as the remedies for each respective area, the remedial design would include a treatment system for both areas, incorporating components from each.

The primary components of EOP Alternative 2 are:

- Obtaining access from property owners to conduct investigation and remediation activities;

- A Pre-Design Investigation to better refine the extent of residual LNAPL, the residual LNAPL thickness, the presence and concentration of any soil gas, and the geochemistry and biological activity throughout the Eastern Off-Property Area;

- Bench and pilot tests to evaluate different nutrients and delivery mechanics (pressure, depth, radii of influence) for nutrient injection and soil gas removal wells;

- Design of the bioremediation system;

- Permitting for well installation, nutrient injection and building construction;

- Establishment of laydown areas and erosion and sedimentation (E&S) Controls;

- Establishment of exclusion areas for public safety;

- Construction mobilization;

- Obtaining utility clearances and, as needed, implementing measures for utility protection;

- Establishment of perimeter air monitoring for dust;

- Installation of nutrient injection and soil gas extraction wells on the former tavern/service station property, and along the west side of U.S. Avenue east of the 2 and 4 Foster Avenue buildings;

- Installation of nutrient injection wells in the right of way east of U.S. Avenue west of properties E-7, E-8, E-9, E-10 and E-11;

- Installation of piping trenches and piping connecting the nutrient injection and soil gas recovery wells;

- Construction of a nutrient mixing system and soil gas treatment system on the west side of U.S. Avenue in the parking area of the 2 and 4 Foster Avenue buildings;

- Installation of a tunnel beneath U.S. Avenue and installation of piping to connect the nutrient mixing and soil gas treatment systems with the nutrient injection and soil gas recovery wells;

- Backfill of piping trenches;

- Off-site transportation and disposal of excess soil from piping trench excavation;

- Utility connections;

- Operation and maintenance of the nutrient injection and soil gas removal systems;

- Two rounds of nutrient injections on properties E-1, E-7, E-8, E-9, E-10 and E-11;

- System decommissioning;

- Post-treatment groundwater monitoring (the monitoring well network will be used to monitor the effectiveness of the remedial action such that modifications can be made, as necessary, to ensure the remedial action does not cause an increase in the extent of dissolved-phase constituents at concentrations greater than the GWQS).

Figure 40 shows the extent of the remedial action that would be conducted under Alternative EOP2.

Presented in Appendix E are a more detailed discussion of the conceptual design of this alternative, a conceptual system layout and a preliminary process flow diagram. The assumptions used to develop estimated costs are also presented. As noted above, the first steps in this alternative would be conducting a PDI and bench- and pilot-tests. Based on these results, a final design would be developed. Therefore, if this alternative is chosen, the final design and costs may be different than those presented in this FS.

4.2.8.3. Alternative EOP3 – Extensive Excavation to Depth

Under this alternative, all soil on properties E-1, E-7, E-8, E-9, E-10, E-11 and the former tavern/service station in which LNAPL is present would be removed and disposed, regardless of depth. The extent of the remedial action that would be conducted under Alternative EOP3 is shown on Figure 41.

Since structures are present on six of the seven properties, these structures would need to be relocated, all landscaping would be removed, the utilities would be disconnected and the foundations/basements would be removed prior to excavation. Residents and workers would need to be relocated for the duration of the remedial action on each property. Upon completion of the remediation on a property, new foundations would need to be installed, utilities would need to be reconnected and the structures would need to be placed onto the new foundations.

The LNAPL is present at depths of approximately 10 to 20 feet below ground surface, and extends from two to seven feet into the water table, depending on property and location. All properties abut U.S. Avenue, and Property E-1 and the former tavern/service station are also adjacent to Berlin-Haddonfield Road. Therefore, extensive sheeting and shoring would be needed to protect the roadways and prevent excavations from collapsing, and it can be expected that there would be a need for substantial water management.

The land between Properties E-10 and E-11 and the Burn Site is wetlands or wetlands transition areas and would require restoration following remediation.

Based on the current understanding of the distribution of the LNAPL, EOP Alternative 3 would consist of:

- Temporary relocation and reconstruction of five residences and one office;
- Demolition and replacement of several smaller structures such as garages and storage sheds;
- Temporary relocation of five sets of residents for and a group of office workers for as long as one year each;
- Management of several million gallons of groundwater that is potentially contaminated with LNAPL constituents;
- Installation of approximately 3,200 linear feet (100,000 ft^2) of shoring;
- Excavation of approximately 80,000 CY of soil;
- Disposal of approximately 20,000 CY of the excavated soil, importing 20,000 CY of replacement soil, and reuse of 60,000 CY of soil; and

- Restoration of the properties, including landscaping, driveways, garages and storage sheds, to current conditions.

The soil excavation would be phased. The tavern/service station would be performed first, as this property does not require building removal or occupant relocation. This would be followed by Properties E-1 and E-7, together, then E-8, E-9, E-10 and E-11 individually. After completion of the tavern/service station remedial action, the structures from Properties E-1 and E-7 would be temporarily relocated onto the tavern/service station until the remedial action on those properties has been completed. Then, following the remedial action but prior to full restoration of Property E-7, it would be used for the temporary relocation of the structure on Property E-8. Then, Property E-8 would be used for the temporary relocation of the structure from Property E-9, Property E-9 would be used for the temporary relocation of the structure on Property E-10, and, finally, Property E-10 would be used for the temporary relocation of the residence on Property E-11.

Adjacent properties would also be used for the temporary stockpiling of clean overburden soil. The unsaturated soil above the water table does not contain any constituents at concentrations greater than the RDCSRS, so this soil can be reused rather than disposed. The FMP would be used for the temporary stockpiling of soil from the former tavern/service station.

Water management would be performed by extracting groundwater from each individual property, treating it with activated carbon and discharging the treated groundwater to Upper Hilliards Creek, pursuant to a permit equivalency.

Implementation of this alternative would involve the following major steps:

- Relocate residents/workers to temporary housing/offices;

- Survey property boundaries;

- Delineate wetlands and other sensitive areas in the rear of Properties E-10 and E-11;
- Perform a supplemental pre-design investigation;
- Obtain permit equivalencies for wetlands, flood hazard areas and water discharges;
- Establishment of laydown areas and erosion and sedimentation (E&S) Controls;
- Establishment of exclusion areas for public safety;
- Construction mobilization;
- Closure of monitoring wells within the excavation areas;
- Establishment of perimeter air monitoring for dust;
- Temporary relocation of structures;
- Temporary disconnection of utilities;
- Removal of building foundations, basements and other buildings;
- Clearing of the properties;
- Installation of temporary water extraction and treatment equipment, and piping to connect to Hilliards Creek;
- Excavation of clean and contaminated soil;
- Stockpiling of clean soil;
- Management of groundwater;

- Dewatering and/or stabilization of wet soil;
- Waste classification sampling;
- Transportation and disposal (T&D) of contaminated soil and waste at an approved disposal facility;
- Backfill of the excavation with clean stockpiled soil and clean imported soil;
- Installation of new foundations and basements;
- Placement of relocated structures onto new foundations;
- Reconnection of utilities;
- Site restoration, including garages, storage sheds, driveways and landscaping; and
- Relocation of residents/workers back into homes and offices.

Given the complexity of the logistics for relocating residents and workers, the very difficult construction issues, and the large volume of soil that would be removed, no more than two sets of properties would be completed annually. Therefore, it is expected that completion of this alternative would require at least three years. Estimated costs are approximately $18.5 million.

4.2.9. Comparative Analysis of Alternatives for the Eastern Off-Property Area

Pursuant to EPA guidance for preparation of FSs, and as discussed in Section 4.1, the identified remedial alternatives were evaluated based on the seven criteria referenced in Section 4.1.

The following provides the comparative analysis of the three Eastern Off-Property Area alternatives against the two Threshold Criteria and the five Balancing Criteria.

4.2.9.1. Overall Protection of Human Health and the Environment

Alternative EOP1 - No Action would be protective of human health and ecological receptors because there are no current unacceptable risks to human or ecological receptors. The constituents in the LNAPL are present at depths below those that residents, workers or ecological receptors would be expected to encounter, there is no evidence of vapor intrusion, and shallow/intermediate groundwater is prohibited by NJDEP regulation from being used as a drinking water source.

However, no action would be conducted to address the LNAPL as a source of groundwater contamination and no institutional controls (Classification Exception Area/Well Restriction Area) would be established to prevent potable well installation within the area where dissolved-phase constituents associated with the LNAPL are present. Routine monitoring of site conditions would not be conducted and future changes in contaminant conditions would not be identified.

Alternative EOP2 – Enhanced LNAPL Biodegradation and Soil Gas Recovery would be protective of human health and ecological receptors. There are no current exposure pathways, and institutional controls (CEA) would be established to prevent any future use of groundwater until such time as the LNAPL is no longer a source of groundwater contamination.

Alternative EOP3 – Extensive Excavation to Depth would also be protective of human health and the environment since all constituents would be removed and disposed.

4.2.9.2. Compliance with ARARs

Alternative EOP1 - No Action would not meet ARARs because LNAPL would not be removed to the extent practicable.

Alternative EOP2 – Enhanced LNAPL Biodegradation and Soil Gas Recovery would achieve ARARs because the LNAPL would be treated and any soil gas generated as a result of the LNAPL treatment would be removed.

Alternatives EOP3 - Extensive Excavation to Depth would also achieve ARARs by removing the soil containing the residual LNAPL.

4.2.9.3. Long-Term Effectiveness and Permanence

Alternative EOP1 - No Action provides for long-term effectiveness and permanence for risks to human and ecological receptors since there is no current human health or ecological risk. It also provides for long-term effectiveness for removal of the LNAPL since the LNAPL is currently undergoing bioremediation. However, without enhancing the current mechanisms, an extended time period to complete biodegradation of the LNAPL would be needed.

Alternative EOP2 – Enhanced LNAPL Biodegradation and Soil Gas Recovery, would also provide long-term effectiveness and permanence by enhancing the ongoing bioremediation of the LNAPL.

Alternative EOP3 – Extensive Excavation to Depth, would provide for long-term effectiveness and permanence by removing the vast majority of the residual LNAPL.

4.2.9.4. Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility or volume through treatment would occur for the LNAPL under Alternatives EOP1 (No Action) and EOP2 (Enhanced LNAPL Biodegradation and Soil Gas Recovery) since, as documented in the LNAPL Report, there is ongoing biodegradation of the LNAPL.

Alternative EOP3 does not provide for reduction of toxicity, mobility or volume through treatment because soil removal, not treatment, would be the approach used for remediation.

4.2.9.5. Short-Term Effectiveness

Alternative EOP1, No Action, would have no short-term impacts because there is no construction activity associated with either alternative.

Alternative EOP2 - Enhanced LNAPL Biodegradation and Soil Gas Recovery would have a moderate degree of short-term impacts as a result of the need to perform at least two rounds of nutrient injections on residential properties and conduct remediation activities in, adjacent to and beneath U.S. Avenue. As such, there would be a need for temporary closures of U.S. Avenue while conducting the remedial action. However, there would be no significant soil removal actions associated with this alternative.

The greatest degree of short-term impacts would be associated with Alternative EOP3, Extensive Excavation to Depth. Residents and workers would be relocated from their homes and workplaces, structures would be temporarily relocated and reconstructed, and there would be construction activity performed along U.S. Avenue for at least three years; 20,000 CY (approximately 30,000 tons) of soil would be removed and the same volume would be imported, translating into approximately 3,000 truck trips (1,500 to remove soil and 1,500 to import soil) during the construction time period. Closures of U.S. Avenue can be anticipated when buildings are being moved and soil is being stockpiled.

4.2.9.6. Implementability

Alternative EOP1, No Action, would not have implementability difficulties as there are no field activities associated with this alternative.

Alternative EOP2, Enhanced LNAPL Biodegradation and Soil Gas Recovery, would have moderate implementability difficulties. These include installing injection and recovery wells along U.S. Avenue, boring beneath U.S. Avenue to connect the recovery and injection wells to the treatment system on the FMP, and conducting nutrient injections on the residential properties.

Alternative EOP3 has by far the greatest degree of implementability difficulties:

- Finding and relocating residents and workers from their homes and offices and into acceptable alternative locations would be extremely difficult. Some of the homeowners have been in the same home for decades, and there may be great resistance to moving them and their possessions.

- Moving and temporarily storing the structures without damage would be very difficult. Based on available information, some of the structures were built in the late 1800's, so there is a high potential for damage if they were to be moved and stored.

- Conducting large-scale construction activities along U.S. Avenue would require careful planning, coordination with local authorities, and constant attention to ensure worker and public safety.

- Excavation next to U.S. Avenue would require the use of structural supports to prevent damage and allow for safe excavation of soil. As stated previously, it is expected that approximately 3,200 linear feet of sheeting and shoring would be required.

- Produced groundwater from the excavation areas would likely contain measurable concentrations of petroleum compounds, requiring treatment prior to discharge to Hilliards Creek.

- Odor control may be needed as the LNAPL may exhibit petroleum odors, and adjacent residences would be occupied during remediation.

- Ingress and egress for trucks and equipment would need to be planned and coordinated.

- Excavation of saturated soil would require management of groundwater as well as processing of saturated soil to meet disposal site requirements.

- Site security during remediation would be needed to prevent unauthorized access into the work areas and locations where the structures would be temporarily stored.

- Site restoration, including placement of the relocated primary structures, reconstruction of garages and sheds, landscaping and replacement of septic systems, would be extremely difficult.

4.2.9.7. Cost

Alternative EOP1, No Action is the least costly alternative,

Alternative EOP2, Enhanced LNAPL Biodegradation and Soil Gas Recovery is relatively expensive at approximately $5 million.

Alternative EOP3, Extensive Excavation to Depth is the most expensive at approximately $18.5 million.

The cost estimates for each alternative are presented in Table 13 and Appendix D.

4.2.10. Summary of Remedial Alternatives for the Eastern Off-Property Area

Figure 42 provides a summary of the comparative analysis of the remedial alternatives for the Eastern Off-Property Area. As shown, both Alternatives EOP2 and EOP3 meet the threshold criteria. Both rank comparably with regard to long term effectiveness and permanence. However, Alternative EOP3 ranks much lower than Alternative EOP2 for the balancing criteria of short-term effectiveness, implementability and cost.

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Ecological Preliminary Remediation Goals

APPENDIX B

LNAPL Report Exhibits

APPENDIX C

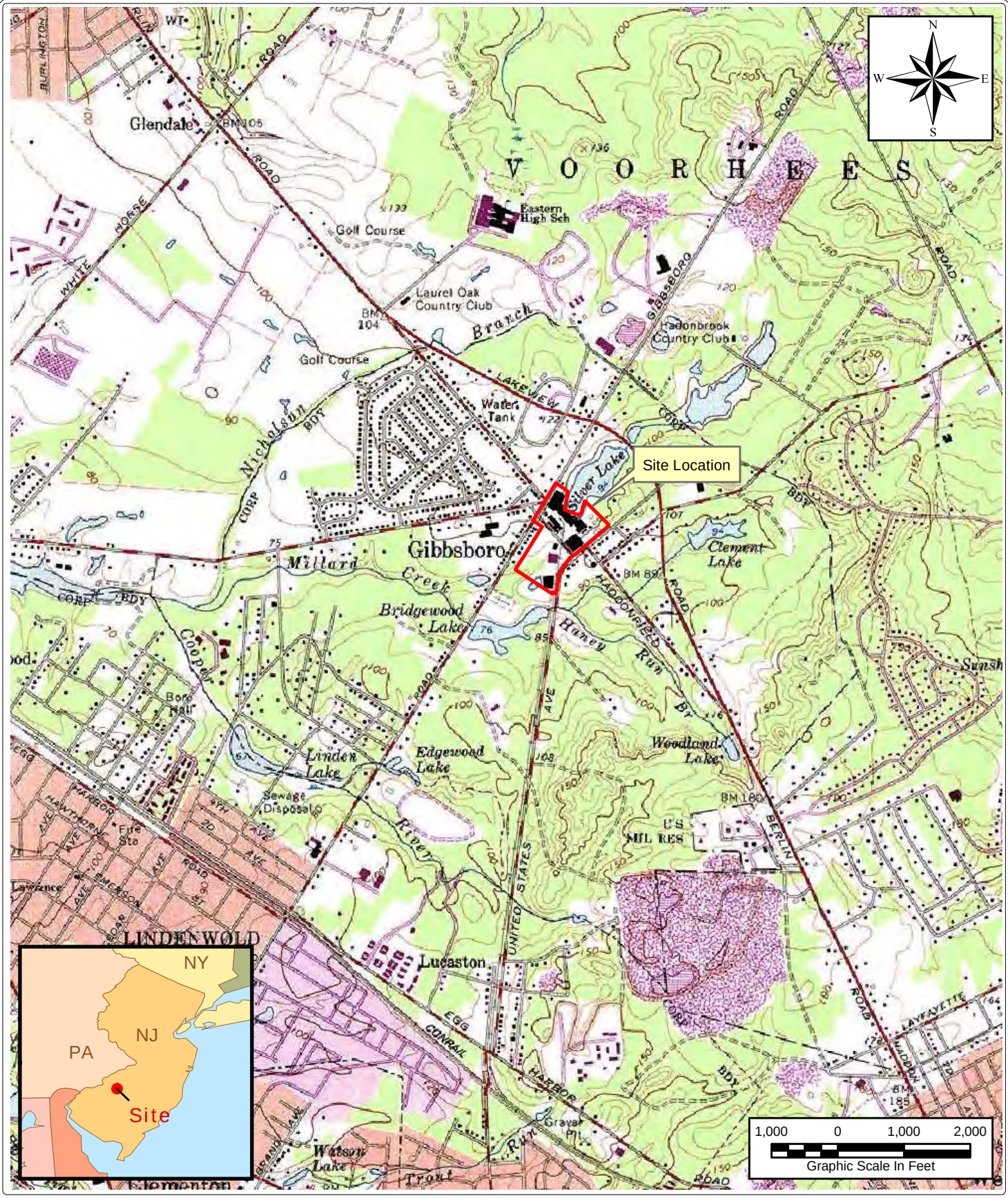
Evaluation of the Applicability of Thermal-Enhanced Recovery at the Former Manufacturing Plant

APPENDIX D

Cost Estimates

APPENDIX E

Detailed LNAPL Treatment Conceptual Design Documents



LEGEND:

Former Manufacturing Plant Extent

SOURCE:

National Geographic TOPO! U.S. Geologic Survey (USGS). 7.5 Minute Series (Topographic) Quadrangles: Clementon, NJ, 1981.

PROJECT:

Former Manufacturing Plant
Feasibility Study

TITLE:

FORMER MANUFACTURING PLANT SITE LOCATION MAP

CLIENT NAME: The Sherwin-Williams Company

WESTON SOLUTIONS

DATE: January 2019

FIGURE #: 1

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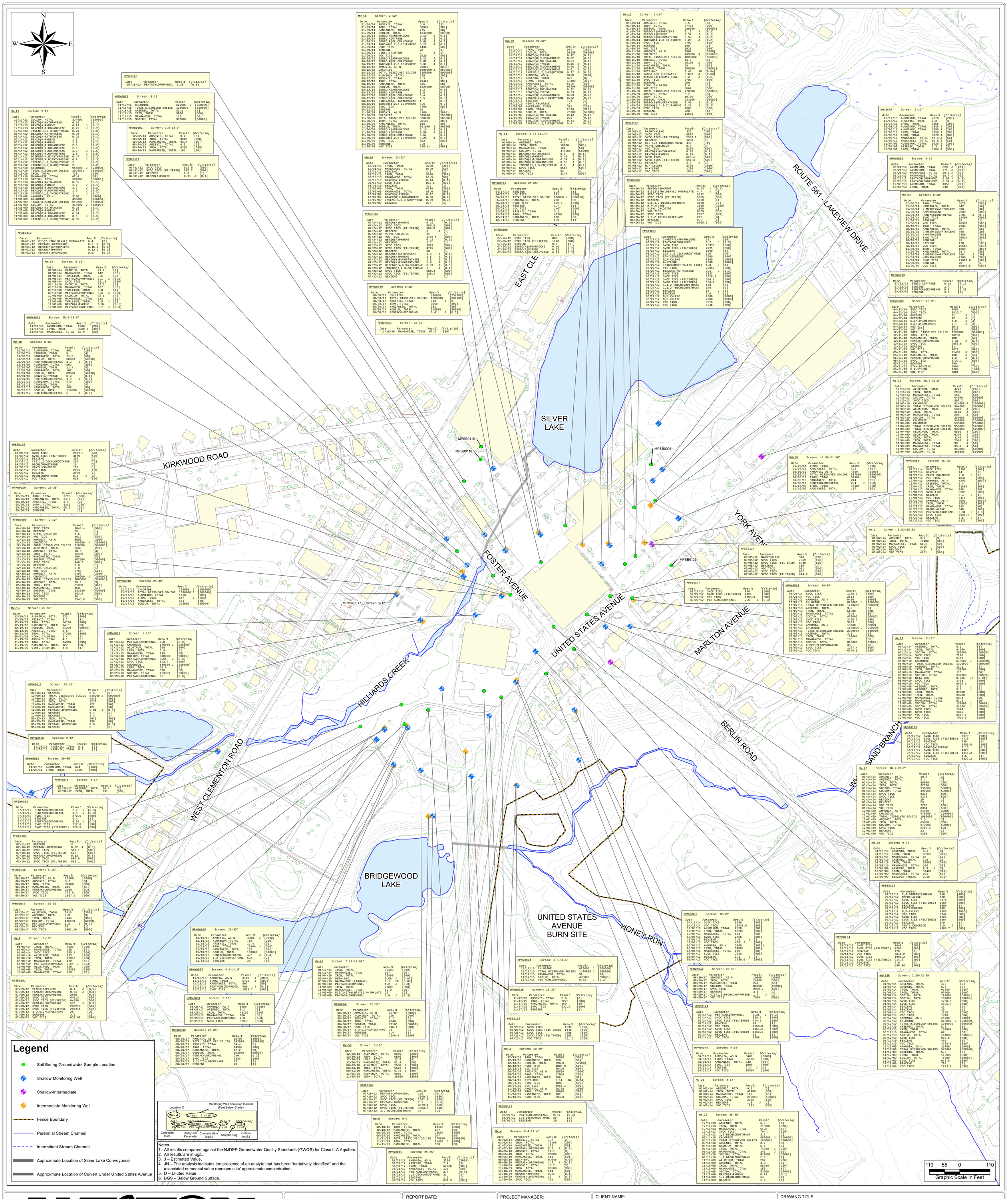


MW-15 Screen: 2-12'

Date	Parameter	Result	[Criteria]
01/09/14	ARSENIC, TOTAL	5.8	[3]
01/09/14	IRON, TOTAL	68800	[300]
01/09/14	MANGANESE, TOTAL	775	[50]
01/09/14	SODIUM, TOTAL	1340000	[50000]
01/09/14	BENZO(A)ANTHRACENE	0.19 J	[0.1]
01/09/14	BENZO(A)PYRENE	0.36 J	[0.1]
01/09/14	BENZO(B)FLUORANTHENE	0.68 J	[0.2]
01/09/14	INDENO(1,2,3-CD)PYRENE	0.22 J	[0.2]
01/09/14	SVOC TICS	4439	[500]
01/09/14	BENZENE	28	[1]
01/09/14	VINYL CHLORIDE	2 J	[1]
01/09/14	VOC TICS	1528	[500]
06/19/12	BENZO(A)ANTHRACENE	0.21 J	[0.1]
06/19/12	BENZO(B)FLUORANTHENE	0.62 J	[0.2]
06/19/12	INDENO(1,2,3-CD)PYRENE	0.33 J	[0.2]
08/12/10	AMMONIA, AS N	23000	[3000]
08/12/10	CHLORIDE	1600000 J	[250000]
08/12/10	TOTAL DISSOLVED SOLIDS	3150000	[500000]
08/12/10	ALUMINUM, TOTAL	329	[200]
08/12/10	ARSENIC, TOTAL	4.3	[3]
08/12/10	IRON, TOTAL	29400	[300]
08/12/10	MANGANESE, TOTAL	495	[50]
08/12/10	SODIUM, TOTAL	1020000	[50000]
08/12/10	BENZO(A)ANTHRACENE	1.2	[0.1]
08/12/10	BENZO(A)PYRENE	3.5	[0.1]
08/12/10	BENZO(B)FLUORANTHENE	6.4	[0.2]
08/12/10	BENZO(K)FLUORANTHENE	3.5	[0.5]
08/12/10	DIBENZO(A,H)ANTHRACENE	1	[0.3]
08/12/10	INDENO(1,2,3-CD)PYRENE	3.6	[0.2]
08/12/10	SVOC TICS	7700	[500]
08/12/10	BENZENE	16	[1]
11/30/09	AMMONIA, AS N	4100	[3000]
11/30/09	CHLORIDE	395000	[250000]
11/30/09	TOTAL DISSOLVED SOLIDS	820000	[500000]
11/30/09	IRON, TOTAL	20100	[300]
11/30/09	MANGANESE, TOTAL	168	[50]
11/30/09	SODIUM, TOTAL	301000 J	[50000]
11/30/09	BENZO(A)ANTHRACENE	0.10 J	[0.1]
11/30/09	BENZO(A)PYRENE	0.59 J	[0.1]
11/30/09	BENZO(B)FLUORANTHENE	0.94 J	[0.2]
11/30/09	INDENO(1,2,3-CD)PYRENE	0.28 J	[0.2]
11/30/09	SVOC TICS	802	[500]
11/30/09	BENZENE	2.8	[1]
11/30/09	VOC TICS	610.11	[500]

MW-19 Screen: 22-32'

Date	Parameter	Result	[Criteria]
01/14/14	IRON, TOTAL	974	[300]
01/14/14	SODIUM, TOTAL	53500	[50000]
01/14/14	BENZO(A)PYRENE	0.17	[0.1]
01/14/14	BENZO(B)FLUORANTHENE	0.22	[0.2]
06/15/12	BENZO(A)ANTHRACENE	0.34	[0.1]
06/15/12	BENZO(A)PYRENE	0.65 J	[0.1]
06/15/12	BENZO(B)FLUORANTHENE	0.78 J	[0.2]
06/15/12	BENZO(K)FLUORANTHENE	0.61 J	[0.5]
06/15/12	INDENO(1,2,3-CD)PYRENE	0.72 J	[0.2]
08/16/10	AMMONIA, AS N	3700	[3000]
08/16/10	ARSENIC, TOTAL	3.5	[3]
08/16/10	IRON, TOTAL	10100	[300]
08/16/10	MANGANESE, TOTAL	65.5	[50]
08/16/10	SODIUM, TOTAL	95900	[50000]
08/16/10	BENZO(A)ANTHRACENE	0.12	[0.1]
08/16/10	BENZO(A)PYRENE	0.33	[0.1]
08/16/10	BENZO(B)FLUORANTHENE	0.33	[0.2]
08/16/10	INDENO(1,2,3-CD)PYRENE	0.22	[0.2]
08/16/10	BENZENE	7.5	[1]
08/16/10	VINYL CHLORIDE	14	[1]
11/09/09	ALUMINUM, TOTAL	325	[200]
11/09/09	IRON, TOTAL	2530	[300]
11/09/09	MANGANESE, TOTAL	7670	[50000]
11/09/09	BENZO(A)ANTHRACENE	0.12	[0.1]
11/09/09	BENZO(A)PYRENE	0.5	[0.1]
11/09/09	BENZO(B)FLUORANTHENE	0.43	[0.2]
11/09/09	INDENO(1,2,3-CD)PYRENE	0.4	[0.2]

MW-12 Screen: 6-16'

Date	Parameter	Result	[Criteria]
01/09/14	ARSENIC, TOTAL	8.5	[3]
01/09/14	IRON, TOTAL	37400	[300]
01/09/14	SODIUM, TOTAL	228000	[50000]
01/09/14	BENZO(A)ANTHRACENE	0.12 J	[0.1]
01/09/14	BENZO(A)PYRENE	0.37 J	[0.1]
01/09/14	BENZO(B)FLUORANTHENE	0.58 J	[0.2]
01/09/14	INDENO(1,2,3-CD)PYRENE	0.29 J	[0.2]
01/09/14	SVOC TICS	7792	[500]
01/09/14	BENZENE	160	[1]
01/09/14	VOC TICS	3931	[500]
08/11/10	AMMONIA, AS N	3500	[3000]
08/11/10	CHLORIDE	433000 J	[250000]
08/11/10	TOTAL DISSOLVED SOLIDS	1020000	[500000]
08/11/10	ARSENIC, TOTAL	11.3	[3]
08/11/10	IRON, TOTAL	45100 J	[300]
08/11/10	MANGANESE, TOTAL	69 J	[50]
08/11/10	SODIUM, TOTAL	308000 J	[50000]
08/11/10	BETA-BHC	0.43 JN	[0.04]
08/11/10	GAMMA-BHC (LINDANE)	0.083 J	[0.05]
08/11/10	BENZO(B)FLUORANTHENE	0.2 J	[0.2]
08/11/10	SVOC TICS	3782 J	[500]
08/11/10	BENZENE	250 J	[1]
08/11/10	VINYL CHLORIDE	2.4 J	[1]
08/11/10	VOC TICS	8667	[500]
11/09/09	TOTAL DISSOLVED SOLIDS	770000	[500000]
11/09/09	ARSENIC, TOTAL	8.7	[3]
11/09/09	IRON, TOTAL	19700	[300]
11/09/09	SODIUM, TOTAL	223000	[50000]
11/09/09	BENZO(B)FLUORANTHENE	0.41 J	[0.2]
11/09/09	INDENO(1,2,3-CD)PYRENE	0.28 J	[0.2]
11/09/09	SVOC TICS	7360	[500]
11/09/09	BENZENE	220	[1]
11/09/09	VOC TICS	11626	[500]

MW-SCAR Screen: 3-13'

Date	Parameter	Result	[Criteria]
12/17/13	ALUMINUM, TOTAL	2270	[200]
12/17/13	ARSENIC, TOTAL	8.3	[3]
12/17/13	IRON, TOTAL	9350	[300]
08/03/10	ALUMINUM, TOTAL	1340 J	[200]
08/03/10	ALUMINUM, TOTAL	1350 J	[200]
08/03/10	IRON, TOTAL	8150 J	[300]
08/03/10	IRON, TOTAL	8170 J	[300]
08/03/10	MANGANESE, TOTAL	60.3 J	[50]
08/03/10	MANGANESE, TOTAL	60.2 J	[50]
11/04/09	ALUMINUM, TOTAL	3020 J	[200]
11/04/09	ARSENIC, TOTAL	5.3 J	[3]
11/04/09	IRON, TOTAL	6780 J	[300]

MW-16 Screen: 2-12'

Date	Parameter	Result	[Criteria]
12/17/13	SODIUM, TOTAL	324000	[50000]
12/17/13	BENZO(A)ANTHRACENE	0.14 J	[0.1]
12/17/13	BENZO(A)PYRENE	0.29 J	[0.1]
12/17/13	BENZO(B)FLUORANTHENE	0.25 J	[0.2]
12/17/13	INDENO(1,2,3-CD)PYRENE	0.29 J	[0.2]
06/14/12	BENZO(A)ANTHRACENE	0.93 J	[0.1]
06/14/12	BENZO(A)ANTHRACENE	0.92 J	[0.1]
06/14/12	BENZO(A)PYRENE	1.9 J	[0.1]
06/14/12	BENZO(A)PYRENE	1.9 J	[0.1]
06/14/12	BENZO(B)FLUORANTHENE	2.5 J	[0.2]
06/14/12	BENZO(B)FLUORANTHENE	2.5 J	[0.2]
06/14/12	BENZO(K)FLUORANTHENE	1.9 J	[0.5]
06/14/12	BENZO(K)FLUORANTHENE	1.8 J	[0.5]
06/14/12	DIBENZO(A,H)ANTHRACENE	0.47 J	[0.3]
06/14/12	DIBENZO(A,H)ANTHRACENE	0.7 J	[0.3]
06/14/12	INDENO(1,2,3-CD)PYRENE	2 J	[0.2]
06/14/12	INDENO(1,2,3-CD)PYRENE	2 J	[0.2]
08/10/10	CHLORIDE	955000 J	[250000]
08/10/10	TOTAL DISSOLVED SOLIDS	1820000	[500000]
08/10/10	IRON, TOTAL	730	[300]
08/10/10	MANGANESE, TOTAL	67.4	[50]
08/10/10	SODIUM, TOTAL	582000	[50000]
08/10/10	BENZO(A)ANTHRACENE	0.55	[0.1]
08/10/10	BENZO(A)PYRENE	1.2 J	[0.1]
08/10/10	BENZO(B)FLUORANTHENE	1.9 J	[0.2]
08/10/10	BENZO(K)FLUORANTHENE	1.3 J	[0.5]
08/10/10	INDENO(1,2,3-CD)PYRENE	1 J	[0.2]
11/30/09	AMMONIA, AS N	3100	[3000]
11/30/09	CHLORIDE	435000	[250000]
11/30/09	TOTAL DISSOLVED SOLIDS	940000	[500000]
11/30/09	SODIUM, TOTAL	314000 J	[50000]
11/30/09	BENZO(A)ANTHRACENE	0.28 J	[0.1]
11/30/09	BENZO(A)PYRENE	0.87 J	[0.1]
11/30/09	BENZO(B)FLUORANTHENE	0.84 J	[0.2]
11/30/09	BENZO(K)FLUORANTHENE	0.6 J	[0.5]
11/30/09	INDENO(1,2,3-CD)PYRENE	0.65 J	[0.2]

MW-11 Screen: 5.73-15.73'

Date	Parameter	Result	[Criteria]
01/09/14	ARSENIC, TOTAL	4.1	[3]
01/09/14	IRON, TOTAL	10800	[300]
01/09/14	MANGANESE, TOTAL	102	[50]
01/09/14	SODIUM, TOTAL	444000	[50000]
01/09/14	BENZO(A)ANTHRACENE	0.3 J	[0.1]
01/09/14	BENZO(A)PYRENE	0.46 J	[0.1]
01/09/14	BENZO(B)FLUORANTHENE	0.54 J	[0.2]
01/09/14	BENZO(K)FLUORANTHENE	0.56 J	[0.5]
01/09/14	INDENO(1,2,3-CD)PYRENE	0.3 J	[0.2]
01/09/14	SVOC TICS	5510	[500]
01/09/14	BENZENE	83	[1]
01/09/14	VOC TICS	3172	[500]

MPSB0100

Date	Parameter	Result	[Criteria]
07/05/12	NAPHTHALENE	320	[300]
07/05/12	SVOC TICS	5007	[500]
07/05/12	SVOC TICS (FILTERED)	2333.9	[500]
07/05/12	BENZENE	1200	[1]
07/05/12	CIS-1,2-DICHLOROETHENE	440	[70]
07/05/12	VINYL CHLORIDE	8.3	[1]
07/05/12	VOC TICS	8386	[500]
07/05/12	BENZO(A)ANTHRACENE	0.16	[0.1]
07/05/12	BENZO(A)PYRENE	0.25	[0.1]
07/05/12	SVOC TICS	678.4	[500]
07/05/12	SVOC TICS (FILTERED)	654.3	[500]
07/05/12	BENZENE	2.9	[1]
07/05/12	M,P-XYLENE	3400	[1000]
07/05/12	O-XYLENE	1200	[1000]
07/05/12	VOC TICS	1661	[500]

MW-SCAR Screen: 9-19'

Date	Parameter	Result	[Criteria]
05/21/13	ALUMINUM, TOTAL	823 J	[200]
05/21/13	ALUMINUM, TOTAL	771 J	[200]
05/21/13	MANGANESE, TOTAL	59.3 J	[50]
05/21/13	MANGANESE, TOTAL	55.7 J	[50]
05/21/13	PENTACHLOROPHENOL	0.97 J	[0.3]
05/21/13	PENTACHLOROPHENOL	0.32 J	[0.3]
12/03/13	ALUMINUM, TOTAL	1350	[200]
12/03/13	IRON, TOTAL	548	[300]

MPSB0097

Date	Parameter	Result	[Criteria]
06/26/12	BENZO(A)PYRENE	0.13 J	[0.1]
06/26/12	BIS(2-ETHYLHEXYL) PHTHALATE	1.4 J	[3]
06/26/12	SVOC TICS	5182	[500]
06/26/12	SVOC TICS (FILTERED)	3385	[500]
06/26/12	BENZENE	1100	[1]
06/26/12	CIS-1,2-DICHLOROETHENE	3900	[70]
06/26/12	M,P-XYLENE	3000	[1000]
06/26/12	VINYL CHLORIDE	600	[1]
06/26/12	VOC TICS	8139	[500]
06/26/12	SVOC TICS	2387	[500]
06/26/12	1,1,2-TRICHLOROETHANE	210	[3]
06/26/12	BENZENE	9.5	[1]
06/26/12	VOC TICS	9905.1	[500]

MW-24 Screen: 8-18'

Date	Parameter	Result	[Criteria]
01/06/14	IRON, TOTAL	6520	[300]
01/06/14	MANGANESE, TOTAL	342	[50]
01/06/14	2-METHYLNAPHTHALENE	330	[30]
01/06/14	NAPHTHALENE	2220	[300]
01/06/14	PENTACHLOROPHENOL	0.93 J	[0.3]
01/06/14	SVOC TICS	11490	[500]
01/06/14	BENZENE	53	[1]
01/06/14	VOC TICS	10983	[500]
08/10/10	IRON, TOTAL	7260	[300]
08/10/10	MANGANESE, TOTAL	307	[50]
08/10/10	2-METHYLNAPHTHALENE	400	[30]
08/10/10	NAPHTHALENE	2300	[300]
08/10/10	SVOC TICS	26014	[500]
08/10/10	BENZENE	45	[1]
08/10/10	STYRENE	170	[100]
08/10/10	VOC TICS	15516	[500]
11/09/09	IRON, TOTAL	1660	[300]
11/09/09	MANGANESE, TOTAL	78.1	[50]
11/09/09	2-METHYLNAPHTHALENE	380 J	[30]
11/09/09	NAPHTHALENE	2200 J	[300]
11/09/09	SVOC TICS	21057.8	[500]
11/09/09	BENZENE	20 J	[1]
11/09/09	VOC TICS	10845.5	[500]

MPMW0004 Screen: 25-35'

Date	Parameter	Result	[Criteria]
04/17/14	BENZENE	2.3	[1]
04/17/14	VOC TICS	691	[500]
05/28/13	TOTAL DISSOLVED SOLIDS	638000 J	[500000]
05/28/13	MANGANESE, TOTAL	288	[50]
05/28/13	SVOC TICS	522.2	[500]
05/28/13	BENZENE	1.7	[1]
05/28/13	VOC TICS	1467	[500]
12/04/13	ARSENIC, TOTAL	5.1	[3]
12/04/13	IRON, TOTAL	40200	[300]
12/04/13	MANGANESE, TOTAL	170	[50]
12/04/13	BENZENE	3.9	[1]

MPSB0098

Date	Parameter	Result	[Criteria]
06/27/12	2-METHYLNAPHTHALENE	38	[30]
06/27/12	PENTACHLOROPHENOL	0.7 J	[0.3]
06/27/12	SVOC TICS	15936	[500]
06/27/12	SVOC TICS (FILTERED)	2221	[500]
06/27/12	BENZENE	1600	[1]
06/27/12	CIS-1,2-DICHLOROETHENE	190	[70]
06/27/12	ETHYLBENZENE	2000	[700]
06/27/12	M,P-XYLENE	8800	[1000]
06/27/12	O-XYLENE	2600	[1000]
06/27/12	TRICHLOROETHYLENE (TCE)	1.8 J	[1]
06/27/12	VOC TICS	20050	[500]
06/27/12	BENZO(A)ANTHRACENE	0.1 J	[0.1]
06/27/12	SVOC TICS	3837	[500]
06/27/12	SVOC TICS	1026.3	[500]
06/27/12	SVOC TICS (FILTERED)	586.4	[500]
06/27/12	SVOC TICS (FILTERED)	654.4	[500]
06/27/12	1,1,2-TRICHLOROETHANE	130	[3]
06/27/12	1,1,2-TRICHLOROETHANE	130	[3]
06/27/12	BENZENE	10 J	[1]
06/27/12	BENZENE	9.6 J	[1]
06/27/12	M,P-XYLENE	2800	[1000]
06/27/12	M,P-XYLENE	2900	[1000]
06/27/12	VOC TICS	5515	[500]
06/27/12	VOC TICS	4246	[500]

MPSB0099

Date	Parameter	Result	[Criteria]
07/02/12	BENZO(A)PYRENE	0.12	[0.1]
07/02/12	BENZENE	2.7	[1]
07/02/12	PENTACHLOROPHENOL	5.7	[0.3]
07/02/12	BENZENE	3.1	[1]

MPMW0003 Screen: 25-35'

Date	Parameter	Result	[Criteria]
04/22/14	SVOC TICS	2486	[500]
04/22/14	SVOC TICS	3836.7	[500]
04/22/14	BENZENE	11 J	[1]
04/22/14	BENZENE	12 J	[1]
04/22/14	DICHLOROMETHANE	3.8 J	[3]
04/22/14	DICHLOROMETHANE	3.7 J	[3]
04/22/14	VOC TICS	3076	[500]
04/22/14	VOC TICS	3243	[500]
12/11/13	TOTAL DISSOLVED SOLIDS	1730000	[500000]
12/11/13	IRON, TOTAL	20200	[300]
12/11/13	MANGANESE, TOTAL	108	[50]
12/11/13	PENTACHLOROPHENOL	0.31 J	[0.3]
12/11/13	SVOC TICS	2858.5	[500]
12/11/13	BENZENE	31	[1]
12/11/13	VOC TICS	4477	[500]
05/21/13	IRON, TOTAL	11400 J	[300]
05/21/13	MANGANESE, TOTAL	130 J	[50]
05/21/13	PENTACHLOROPHENOL	1.2 J	[0.3]
05/21/13	SVOC TICS	6729.1	[500]
05/21/13	BENZENE	250	[1]
05/21/13	ETHYLBENZENE	1400	[700]
05/21/13	M,P-XYLENE	2200	[1000]
05/21/13	VOC TICS	6801	[500]

MPSB0102

Date	Parameter	Result	[Criteria]
07/11/12	BENZENE	3	[1]
07/10/12	PENTACHLOROPHENOL	0.62 J	[0.3]
07/10/12	SVOC TICS	517.1	[500]
07/10/12	SVOC TICS (FILTERED)	627	[500]
07/10/12	PENTACHLOROPHENOL	0.32	[0.3]
07/10/12	SVOC TICS	666.8	[500]
07/10/12	SVOC TICS (FILTERED)	665.1	[500]

MPMW0046 Screen: 5-15'

Date	Parameter	Result	[Criteria]
08/29/17	AMMONIA, AS N	23600	[3000]
08/29/17	ARSENIC, TOTAL	3.2	[3]
08/29/17	IRON, TOTAL	30000	[300]
08/29/17	MANGANESE, TOTAL	213	[50]
08/29/17	PENTACHLOROPHENOL	2100	[0.3]
08/29/17	SVOC TICS	702.8	[500]
08/29/17	VOC TICS	1967.9	[500]

MPMW0047 Screen: 25-35'

Date	Parameter	Result	[Criteria]
08/29/17	ALUMINUM, TOTAL	2410	[200]
08/29/17	ARSENIC, TOTAL	6.3	[3]
08/29/17	IRON, TOTAL	3140	[300]
08/29/17	SODIUM, TOTAL	126000	[50000]
08/29/17	PENTACHLOROPHENOL	1.3 J	[0.3]
08/29/17	BENZENE	20	[1]
08/29/17	VOC TICS	1061.19	[500]

MW-2 Screen: 5-15'

Date	Parameter	Result	[Criteria]
01/09/14	IRON, TOTAL	4930	[300]
01/09/14	MANGANESE, TOTAL	128	[50]
01/09/14	SVOC TICS	595.1	[500]
08/04/10	ALUMINUM, TOTAL	223	[200]
08/04/10	IRON, TOTAL	76900	[300]
08/04/10	MANGANESE, TOTAL	172	[50]
08/04/10	PENTACHLOROPHENOL	0.64 J	[0.3]
11/05/09	ALUMINUM, TOTAL	220	[200]
11/05/09	IRON, TOTAL	12300	[300]
11/05/09	MANGANESE, TOTAL	115	[50]

MPSB0101

Date	Parameter	Result	[Criteria]
07/09/12	BENZO(A)PYRENE	0.1 J	[0.1]
07/09/12	PENTACHLOROPHENOL	0.61 J	[0.3]
07/09/12	PENTACHLOROPHENOL	2900	[0.3]
07/09/12	SVOC TICS	64113	[500]
07/09/12	SVOC TICS (FILTERED)	64858	[500]
07/09/12	PENTACHLOROPHENOL	570 J	[0.3]
07/09/12	SVOC TICS	230213	[500]
07/09/12	SVOC TICS (FILTERED)	205216	[500]
07/09/12	1,2-DICHLOROETHANE	26	[2]
07/09/12	BENZENE	3.6	[1]
07/09/12	VOC TICS	623.53	[500]

MPMW0028 Screen: 25-35'

Date	Parameter	Result	[Criteria]
11/18/15	AMMONIA, AS N	4900 J	[3000]
11/18/15	ALUMINUM, TOTAL	752	[200]
11/18/15	ARSENIC, TOTAL	12.4	[3]
11/18/15	IRON, TOTAL	12400 J	[300]
11/18/15	MANGANESE, TOTAL	102	[50]
11/18/15	SODIUM, TOTAL	153000	[50000]
11/18/15	PENTACHLOROPHENOL	4.7 J	[0.3]
11/18/15	1,2-DICHLOROETHANE	5.2	[2]
11/18/15	BENZENE	30	[1]

MW-23 Screen: 7.07-17.07'

Date	Parameter	Result	[Criteria]
01/13/14	IRON, TOTAL	30100	[300]
01/13/14	MANGANESE, TOTAL	107	[50]
08/04/10	IRON, TOTAL	20400	[300]
08/04/10	BETA-BHC	0.68 J	[0.04]
08/04/10	GAMMA-BHC (LINDANE)	0.1 JN	[0.05]
08/04/10	PENTACHLOROPHENOL	1.2 J	[0.3]
11/05/09	IRON, TOTAL	26800	[300]
11/05/09	MANGANESE, TOTAL	52.9	[50]
11/05/09	BIS(2-ETHYLHEXYL) PHTHALATE	30	[3]
11/05/09	PENTACHLOROPHENOL	1.6 J	[0.3]

MPMW0024 Screen: 6.5-16.5'

Date	Parameter	Result	[Criteria]
11/17/15	CHLORIDE	673000 J	[250000]
11/17/15	TOTAL DISSOLVED SOLIDS	1470000 J	[500000]
11/17/15	MANGANESE, TOTAL	59	[50]
11/17/15	SODIUM, TOTAL	438000	[50000]
11/17/15	PENTACHLOROPHENOL	0.32 J	[0.3]

MPMW0042 Screen: 25-35'

Date	Parameter	Result	[Criteria]
08/29/17	AMMONIA, AS N	19300	[3000]
08/29/17	IRON, TOTAL	24900	[300]
08/29/17	MANGANESE, TOTAL	247	[50]
08/29/17	SODIUM, TOTAL	83000	[50000]
08/29/17	SVOC TICS	2020.7	[500]
08/29/17	BENZENE	3.6	[1]
08/29/17	CIS-1,3-DICHLOROPROPENE	1.2 J	[1]
08/29/17	VOC TICS	7666	[500]

MPMW0025 Screen: 25-35'

Date	Parameter	Result	[Criteria]
11/17/15	ARSENIC, TOTAL	5.6	[3]
11/17/15	IRON, TOTAL	7270	[300]
11/17/15	MANGANESE, TOTAL	169	[50]
11/17/15	SVOC TICS	531.3	[500]
11/17/15	BENZENE	1.3	[1]

MPSB0127

Date	Parameter	Result	[Criteria]
09/14/12	PENTACHLOROPHENOL	0.35 J	[0.3]
09/14/12	SVOC TICS	898.7	[500]
09/14/12	SVOC TICS (FILTERED)	774.5	[500]
09/14/12	BENZENE	24	[1]
09/14/12	VOC TICS	2958.8	[500]
09/14/12	SVOC TICS	1157.5	[500]
09/14/12	SVOC TICS (FILTERED)	1063.1	[500]
09/14/12	BENZENE	16	[1]
09/14/12	VOC TICS	1099	[500]

MPSB0109

Date	Parameter	Result	[Criteria]
07/26/12	SVOC TICS	1090	[500]
07/26/12	SVOC TICS (FILTERED)	1448	[500]
07/26/12	SVOC TICS	2088	[500]
07/26/12	SVOC TICS (FILTERED)	1569	[500]
07/26/12	VOC TICS	681.5	[500]

MW-3 Screen: 10-20'

Date	Parameter	Result	[Criteria]
12/18/13	IRON, TOTAL	60500	[300]
12/18/13	MANGANESE, TOTAL	220	[50]
12/18/13	SODIUM, TOTAL	79600	[50000]
12/18/13	SVOC TICS	1000.9	[500]
12/18/13	VOC TICS	764.9	[500]
08/04/10	AMMONIA, AS N	25800	[3000]
08/04/10	IRON, TOTAL	67000	[300]
08/04/10	MANGANESE, TOTAL	198	[50]
08/04/10	BETA-BHC	0.11 JN	[0.04]
08/04/10	SVOC TICS	1882	[500]
08/04/10	VOC TICS	1663.1	[500]
11/10/09	AMMONIA, AS N	20700	[3000]
11/10/09	IRON, TOTAL	60900	[300]
11/10/09	MANGANESE, TOTAL	182	[50]
11/10/09	SVOC TICS	894.8	[500]

MPSB0113

Date	Parameter	Result	[Criteria]
08/06/12	PENTACHLOROPHENOL	0.31	[0.3]
08/06/12	1,2-DICHLOROETHANE	29	[2]
08/06/12	BENZENE	19	[1]

MW-4 Screen: 9.4-19.4'

Date	Parameter	Result	[Criteria]
01/02/14	ARSENIC, TOTAL	7.7	[3]
01/02/14	IRON, TOTAL	79400	[300]
01/02/14	MANGANESE, TOTAL	123	[50]
01/02/14	PENTACHLOROPHENOL	9.3 J	[0.3]
01/02/14	SODIUM, TOTAL	19.1	[3]
08/05/10	IRON, TOTAL	95800	[300]
08/05/10	MANGANESE, TOTAL	161	[50]
08/05/10	BETA-BHC	0.048	[0.04]
08/05/10	PENTACHLOROPHENOL	4.2 J	[0.3]
11/10/09	ARSENIC, TOTAL	11.7	[3]
11/10/09	IRON, TOTAL	98500	[300]
11/10/09	MANGANESE, TOTAL	114	[50]
11/10/09	BENZO(A)PYRENE	0.21	[0.1]
11/10/09	PENTACHLOROPHENOL	17 J	[0.3]
11/10/09	SVOC TICS	751	[500]

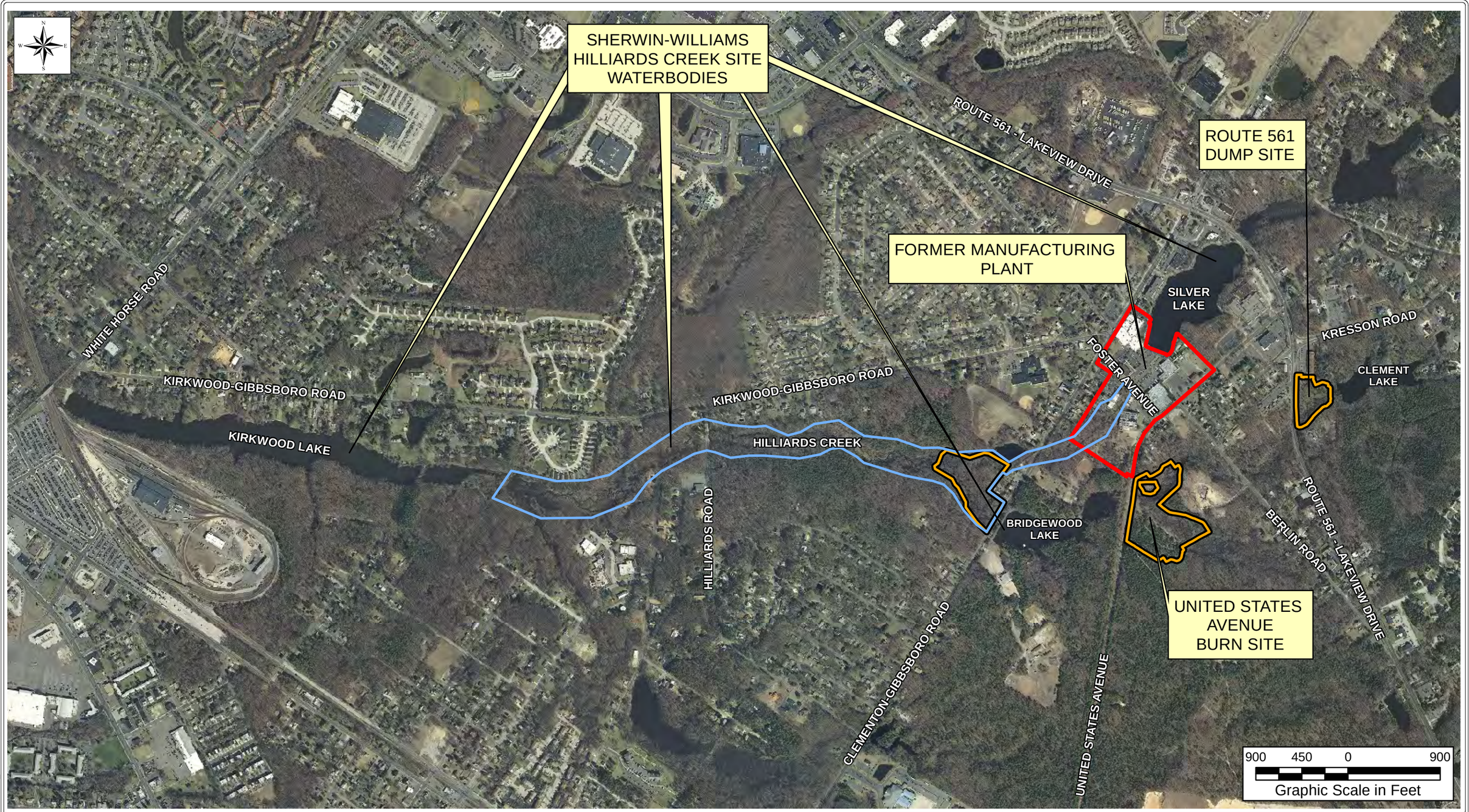
MPMW0008 Screen: 12-22'

Date	Parameter	Result	[Criteria]
04/17/14	SVOC TICS	8596	[500]
12/05/13	ALUMINUM, TOTAL	12438.5	[200]
12/05/13	IRON, TOTAL	2620	[300]
12/05/13	MANGANESE, TOTAL	66700	[50]
12/05/13	SVOC TICS	124	[500]
12/05/13	BENZENE	2758	[1]
12/05/13	VOC TICS	2.5 J	[500]
06/04/13	AMMONIA, AS N	4251.9	[3000]
06/04/13	IRON, TOTAL	3100	[300]
06/04/13	MANGANESE, TOTAL	54800	[50]
06/04/13	SODIUM, TOTAL	179	[50]
06/04/13	SVOC TICS	2510	[500]
06/04/13	BENZENE	1.1 J	[1]
06/04/13	VOC TICS	1935.6 J	[500]

MPSB0124

Date	Parameter	Result	[Criteria]
09/11/12	SVOC TICS	4649	[500]
09/11/12	SVOC TICS (FILTERED)	4700	[500]
09/11/12	BENZENE	170	[1]
09/11/12	VOC TICS	2844.2	[500]
09/11/12	SVOC TICS	1806.2	[500]
09/11/12	SVOC TICS (FILTERED)	914.5	[500]
09/11/12	BENZENE	4.9	[1]
09/11/12	VOC TICS	690.94	[500]

MW-13B Screen: 2.25-12



PROJECT NAME:	Former Manufacturing Plant Feasibility Study
CLIENT NAME:	The Sherwin-Williams Company
REPORT DATE:	January 2019
TITLE:	COMPREHENSIVE SITE MAP
DATE:	1/10/2019
FIGURE #:	3

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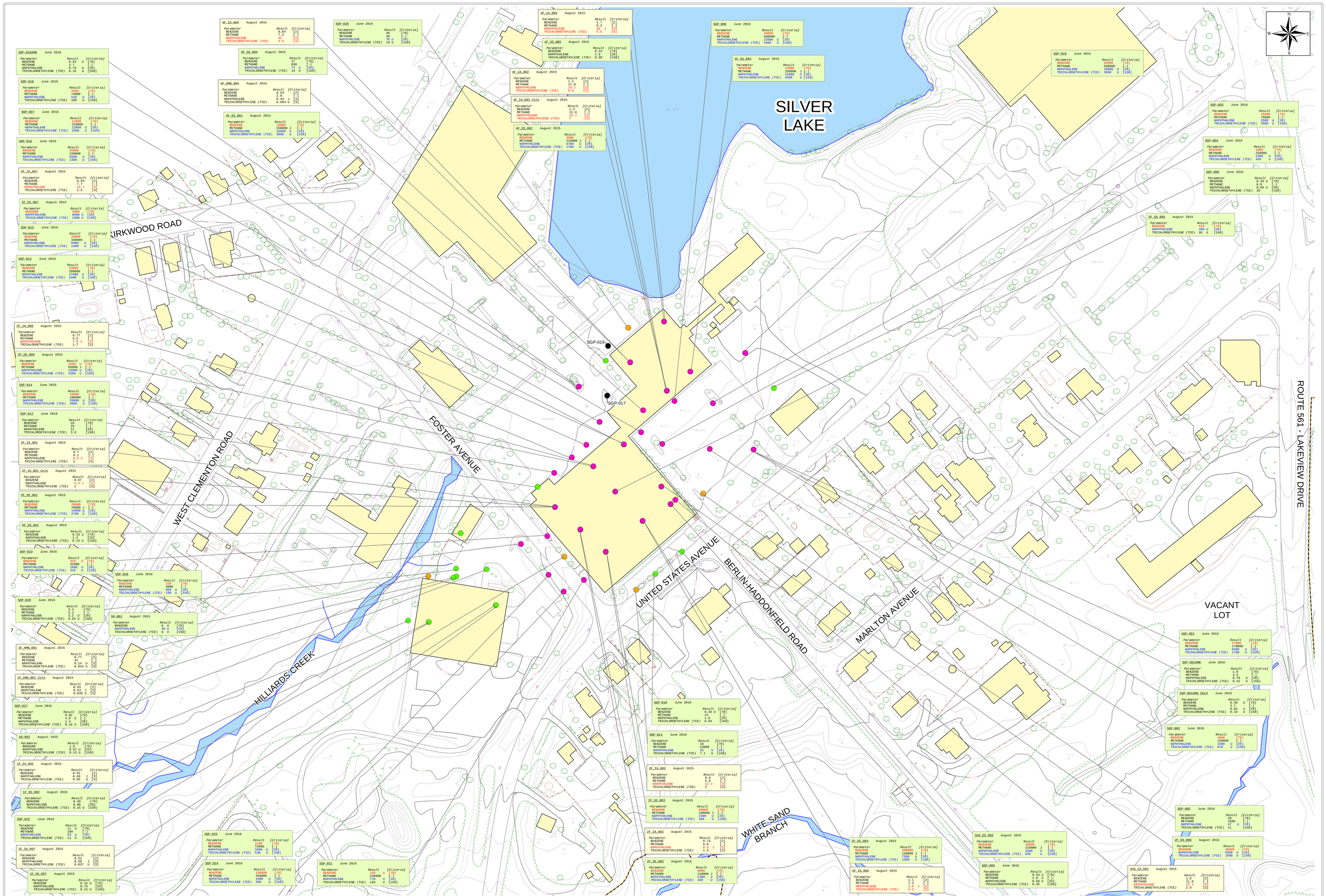
SILVER LAKE
EAST CLEMENTON ROAD
KIRKWOOD ROAD
6 East Clementon Rd. (Building Demolished Slab Only)
Former Main Plant Area
10 Foster Ave (Building)
FORMER MANUFACTURING PLANT
4 Foster Ave. (Building)
Lakeside Manor
Former Resin Plant and Material Storage Area
Barn (Building Demolished Slab Only)
Former Tank Farm A
Former Tank Farm B
FOSTER AVENUE
2 Foster Ave. (Building)
7 Foster Ave. (Building)
5 Foster Ave. (Building)
Seep Area
1 Foster Ave. (Building)
HILLIARDS CREEK
Former Lagoon Area
Former Service Station/Tavern (Demolished)
Eastern Off-Property Area
E-1
E-2
E-3
E-4
E-5
E-6
E-7
E-8
E-9
E-10
E-11
UNITED STATES AVENUE
MARLTON AVENUE
ROUTE 561 - LAKEVIEW DRIVE
ROUTE 561 DUMP SITE
VACANT LOT
BERLIN-HADDONFIELD ROAD
WHITE SAND BRANCH
WEST CLEMENTON ROAD
HILLIARDS CREEK
GIBBSBORO WILDLIFE REFUGE AREA
BRIDGEWOOD LAKE
UNITED STATES AVENUE BURN SITE
250 125 0 250
Graphic Scale in Feet

Legend

- Former Manufacturing Plant Remedial Units
- Former Manufacturing Plant Extent
- Unpaved Areas
- Surveyed Property Boundary (2015)
- Approximate Location of Silver Lake Conveyance

PROJECT NAME: Former Manufacturing Plant Feasibility Study	TITLE: FORMER MANUFACTURING PLANT REMEDIAL UNITS
CLIENT NAME: The Sherwin-Williams Company	
REPORT DATE: January 2019	WESTON SOLUTIONS SM — DATE: 1/10/2019 — FIGURE #: 4

L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\23264_FMP_Remedial_Units_Proposed_Changes.mxd



Legend

- Locations not Analyzed
- Soil Gas/Indoor Air/Ambient Air Sample Location with Exceedance(s)
- Soil Gas/Indoor Air/Ambient Air Sample Location with Non-Detect Result Greater than Applicable Criteria
- Soil Gas/Indoor Air/Ambient Air Sample Location with No Exceedance(s)

Notes:
1. All samples were collected by EPA.
2. Green boxes contain soil gas and sub-slab vapor sample results.
3. Yellow boxes contain indoor air and ambient air sample results.
4. Benzene, Naphthalene, and Trichloroethylene results are in ug/m^3. Methane results are in parts per million by volume (ppmv).
5. Soil gas and sub-slab vapor results are compared against the 2013 NJDEP Non-Residential Soil Gas Screening Levels (NRSGSL).
6. Indoor air and ambient air results are compared against the 2013 NJDEP Non-Residential Indoor Air Screening Levels (NRIASL).
7. U - Undetected Value
8. J - Estimated Value
9. Red text indicates results that exceed applicable criteria.
10. Blue text indicates reporting limit that exceed applicable criteria.

60 30 0 60
Graphic Scale in Feet

WESTON SOLUTIONS SM

Weston Solutions, Inc.
205 Campus Drive Edison, New Jersey 08837-3939
TEL: (732) 417-5800 Fax: (732) 417-5801
http://www.westonsolutions.com

SHERWIN Williams

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: FORMER MANUFACTURING PLANT EPA ERT VI INVESTIGATION AUGUST 2015 AND JUNE 2016 EVENT SUB-SLAB SOIL GAS, SOIL GAS, AND INDOOR AIR RESULTS BENZENE, METHANE, NAPTHALENE, AND TRICHLOROETHYLENE RESULTS ONLY
DRAWING: 23366_FMP_EPA_2015_2016_VI_Results.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: J. Gardner DATE CREATED: 1/3/2019		FIGURE: 5 SCALE: 1" = 60' DATE: 1/10/2019

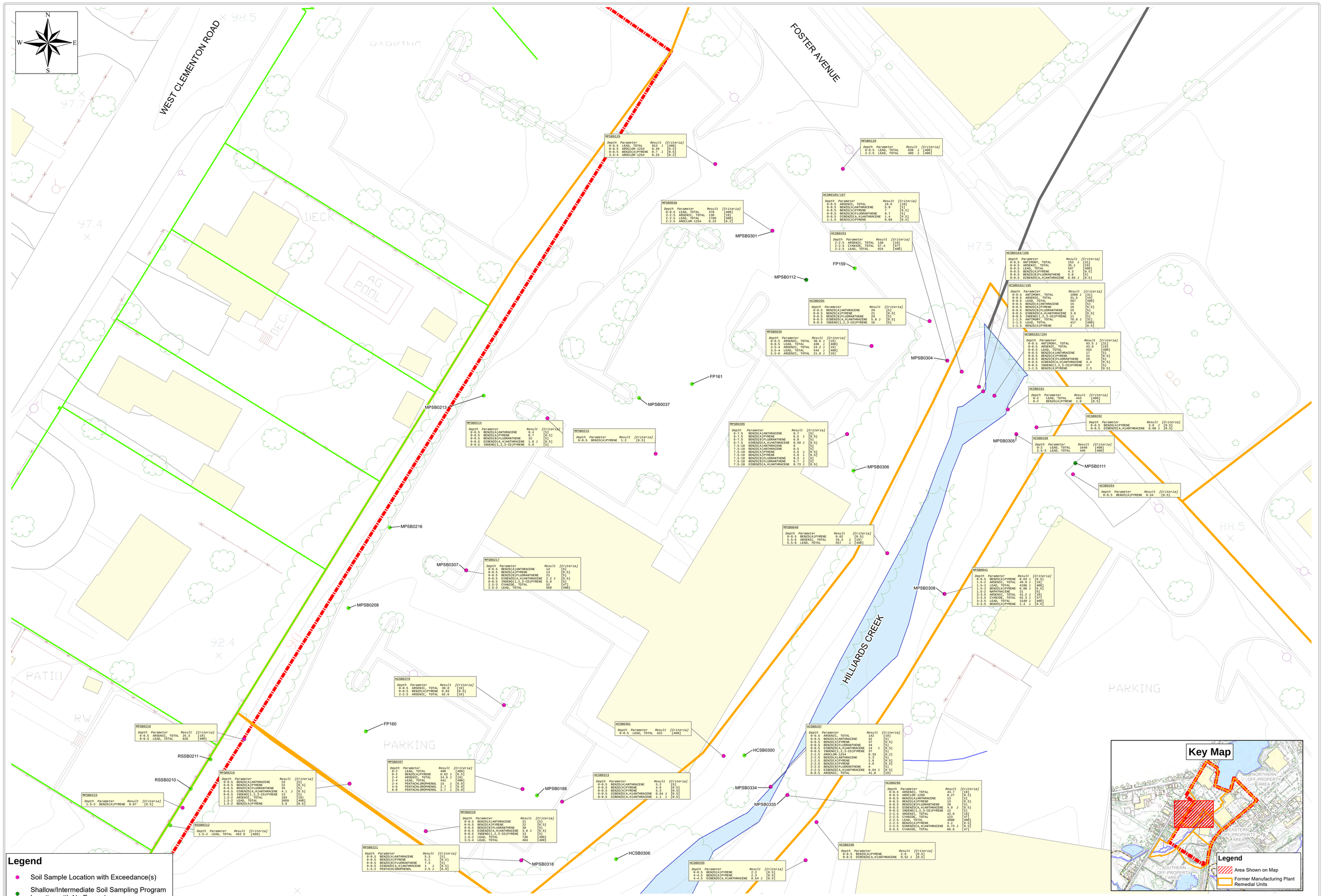
Legend

- 2017 Soil Sample Location
- 2017 Soil Sample Location Colocated with Monitoring Well
- 2015 FMP/Residential Soil Boring Location
- ERT Soil Boring Location
- Soil Boring Location Field Screened Only
- Soil Boring Location
- Brandywine Screening Boring Location
- Pre-2005 Soil Boring Location
- Shallow and Intermediate Soil Sampling Program Location
- Hilliards Creek BERA Soil Boring Locations
- EHS Soil Boring Location
- Former Manufacturing Plant Remedial Units
- Former Manufacturing Plant Extent
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Perennial Stream Channel
- Intermittent Stream Channel
- Fence Boundary

100 50 0 100
Scale in Feet

Weston Solutions, Inc.
205 Campus Drive Edison, New Jersey 08837-3939
TEL: (732) 417-5800 Fax: (732) 417-5801
http://www.westonsolutions.com

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: FORMER MANUFACTURING PLANT SAMPLE LOCATION MAP SOIL BORING LOCATION MAP
DRAWING: 23286_FMP_FS_SB_Loc_All_R1.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 6 SCALE: 1 " = 100 ' DATE: 1/10/2019



Legend

- Soil Sample Location with Exceedance(s)
- Shallow/Intermediate Soil Sampling Program Location with No Exceedance
- Soil Sample Location with No Exceedance(s)
- Match Line
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Former Manufacturing Plant Remedial Units
- Former Manufacturing Plant Extent
- Perennial Stream Channel
- Fence Boundary

Location ID — Analytical Parameter — Analytical Flag

MPSB0224

Depth (ft)	Parameter	Result (mg/kg)	Criteria (mg/kg)
0-0.5	BENZO(A)PYRENE	0.24 J	[0.5]

Sample Depth (ft) — Concentration (mg/kg) — Criteria (mg/kg)

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.

15 7.5 0 15
Scale in Feet

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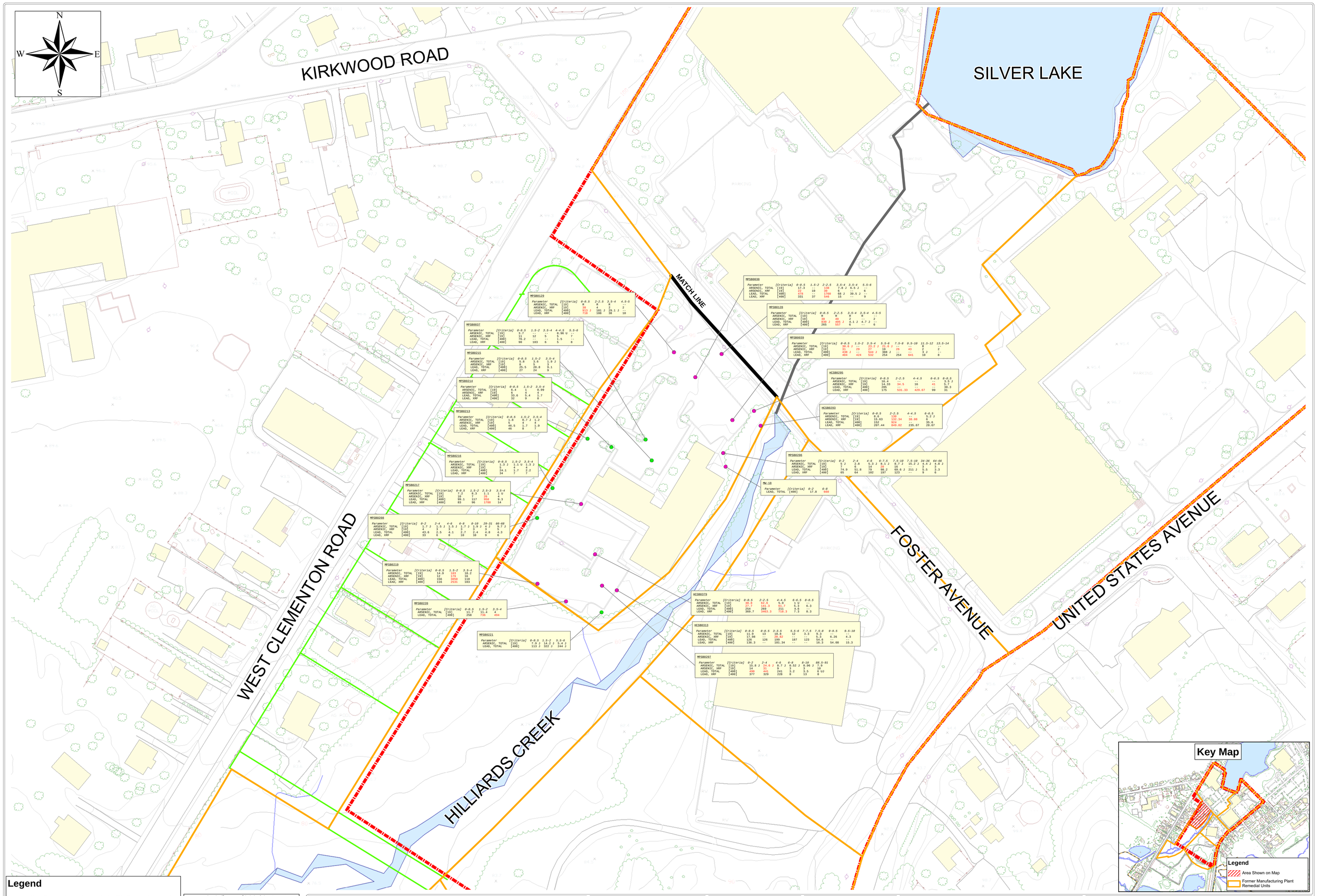
205 Campus Drive Edison, New Jersey 08837-3939
TEL: (732) 417-5800 Fax: (732) 417-5801
http://www.westonsolutions.com

SHERWIN WILLIAMS — COVER THE EARTH

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: MAIN PLANT REMEDIAL UNIT (TANK FARM B) AND HILLIARDS CREEK REMEDIAL UNIT SOIL SAMPLES - EXCEEDANCES [NJDEP RDCSRS]
DRAWING: 23267_FMP_FS_HC_All_Exceed_1.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 7 / SCALE: 1 " = 15 ' / DATE: 1/10/2019



Legend

- Soil Boring Location with As/Pb Exceedance(s)
- Soil Boring Location with No As/Pb Exceedance
- Former Manufacturing Plant Remedial Units
- Match Line
- Former Manufacturing Plant Extent
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Perennial Stream Channel
- Fence Boundary

Location ID | Criteria (mg/kg) | Sample Depth (ft)

MPSB0196

Parameter	[Criteria]	0-0.5	1.5-2	11.5-12
ARSENIC, TOTAL	[19]	11.1	15.8	2.2 J
LEAD, TOTAL	[400]	154	271	6.4 J

Analytical Parameter | Concentration (mg/kg) | Analytical Flag

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.
10. Red text indicates results that exceed NJDEP RDCSRS.

40 20 0 40
Scale in Feet

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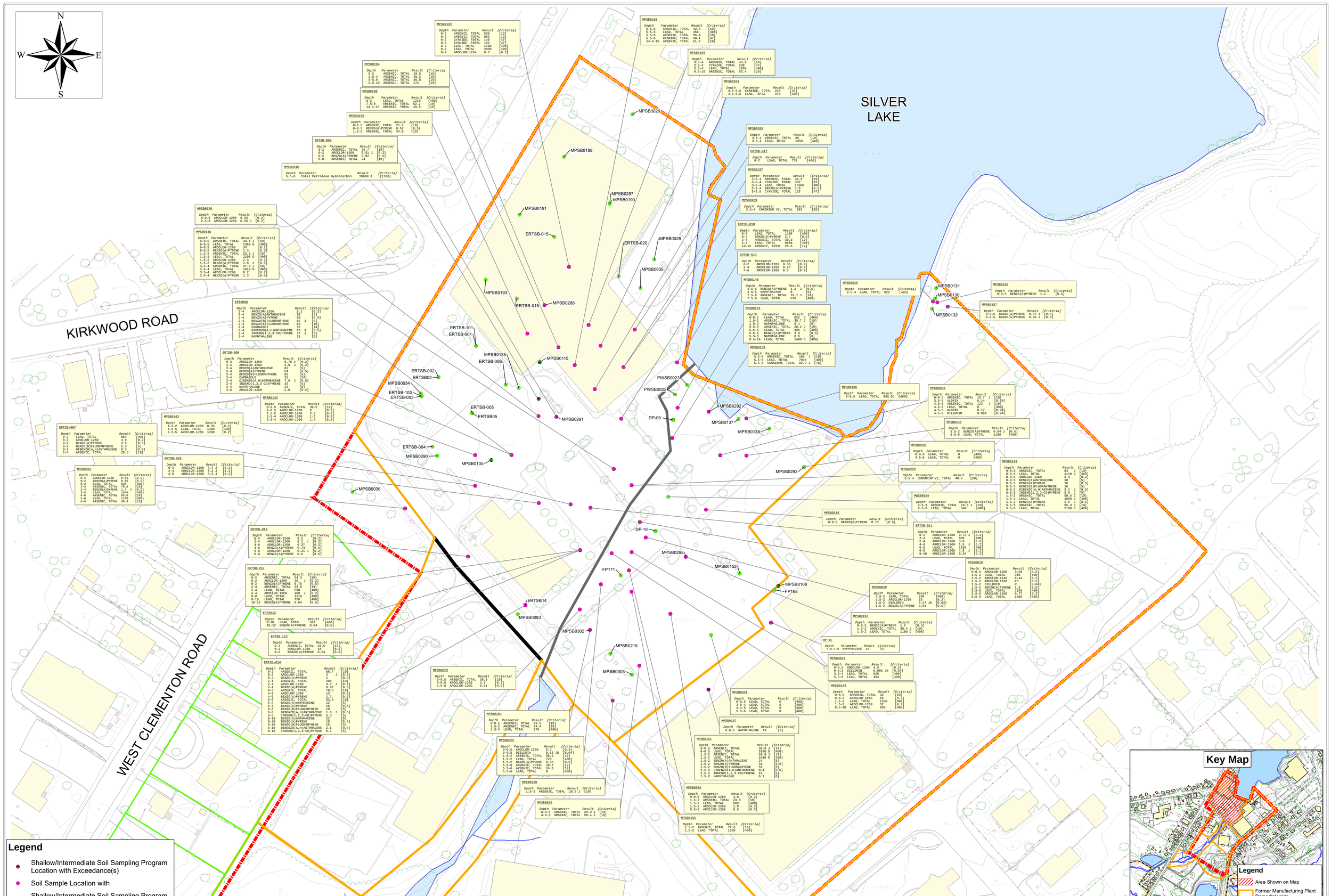
COVER THE EARTH
SHERWIN Williams

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: MAIN PLANT REMEDIAL UNIT TANK FARM B SOIL SAMPLES ARSENIC AND LEAD RESULTS ONLY LABORATORY AND XRF [NJDEP RDCSRS]
DRAWING: 23268_FMP_FS_Tank_Farm_B_As_Pb_Lab_XRF.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2018		FIGURE: 8 SCALE: 1 " = 40 ' DATE: 1/10/2019



Legend

- Shallow/Intermediate Soil Sampling Program Location with Exceedance(s)
- Soil Sample Location with
- Shallow/Intermediate Soil Sampling Program Location with No Exceedance
- Soil Sample Location with No
- Former Manufacturing Plant Remedial
- Match Line
- Former Manufacturing Plant Extent
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary
- Perennial Stream
- Fence Boundary

Location ID — Analytical Parameter
MPSB0076
Depth Parameter Result [Criteria]
0-0.5 AROCLOR-1260 0.33 [0.2]
2.5-3 AROCLOR-1254 0.26 J [0.2]
Sample Depth (ft) — Concentration (mg/kg) — Analytical Flag — Criteria (mg/kg)

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. Total Petroleum Hydrocarbon (TPH) and Extractable Petroleum Hydrocarbons (EPH) results compared against the NJDEP EPH Ecological Screening Value of 1,700 mg/kg.
3. All results are in mg/kg.
4. U – Undetected Value
5. J – Estimated Value
6. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
7. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
8. D – Diluted
9. R – Rejected Value
10. B – Analyte also detected in blank.

30 15 0 30
Scale in Feet

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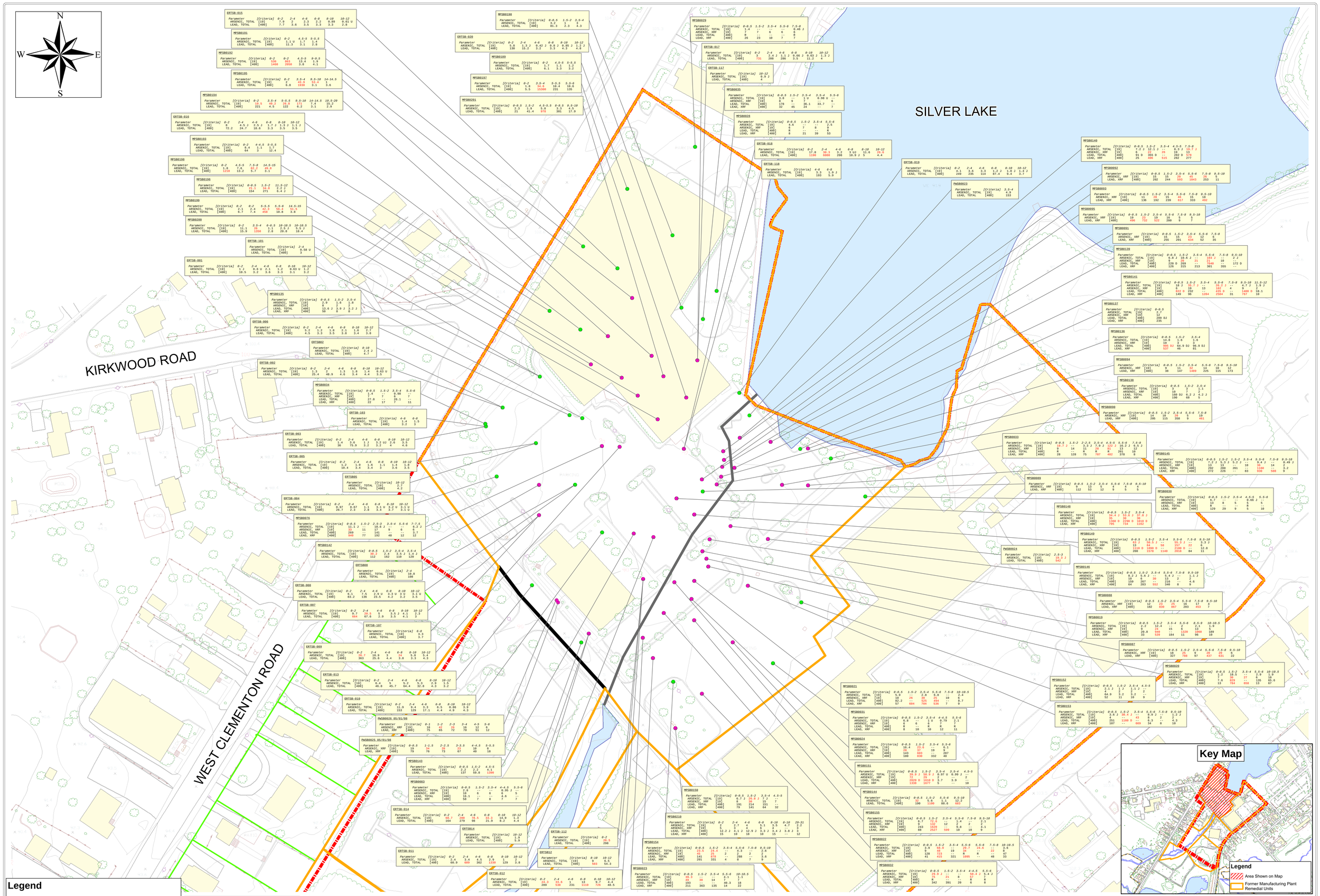
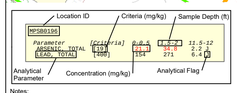
SHERWIN WILLIAMS

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: MAIN PLANT REMEDIAL UNIT 6 EAST CLEMENTON ROAD AND FORMER MAIN PLANT SOIL SAMPLES - EXCEEDANCES [NJDEP RDCSRS]
DRAWING: 23269_FMP_FS_Main_Plant_Exceedances.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 9 SCALE: 1 " = 40 ' DATE: 1/10/2019



Legend

- Soil Boring Location with As/Pb Exceedance(s)
- Soil Boring Location with No As/Pb Exceedance
- Former Manufacturing Plant Remedial Units
- Match Line
- Former Manufacturing Plant Extent
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Perennial Stream Channel
- Fence Boundary



Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.
10. Red text indicates results that exceed NJDEP RDCSRS.

40 20 0 40
Scale in Feet

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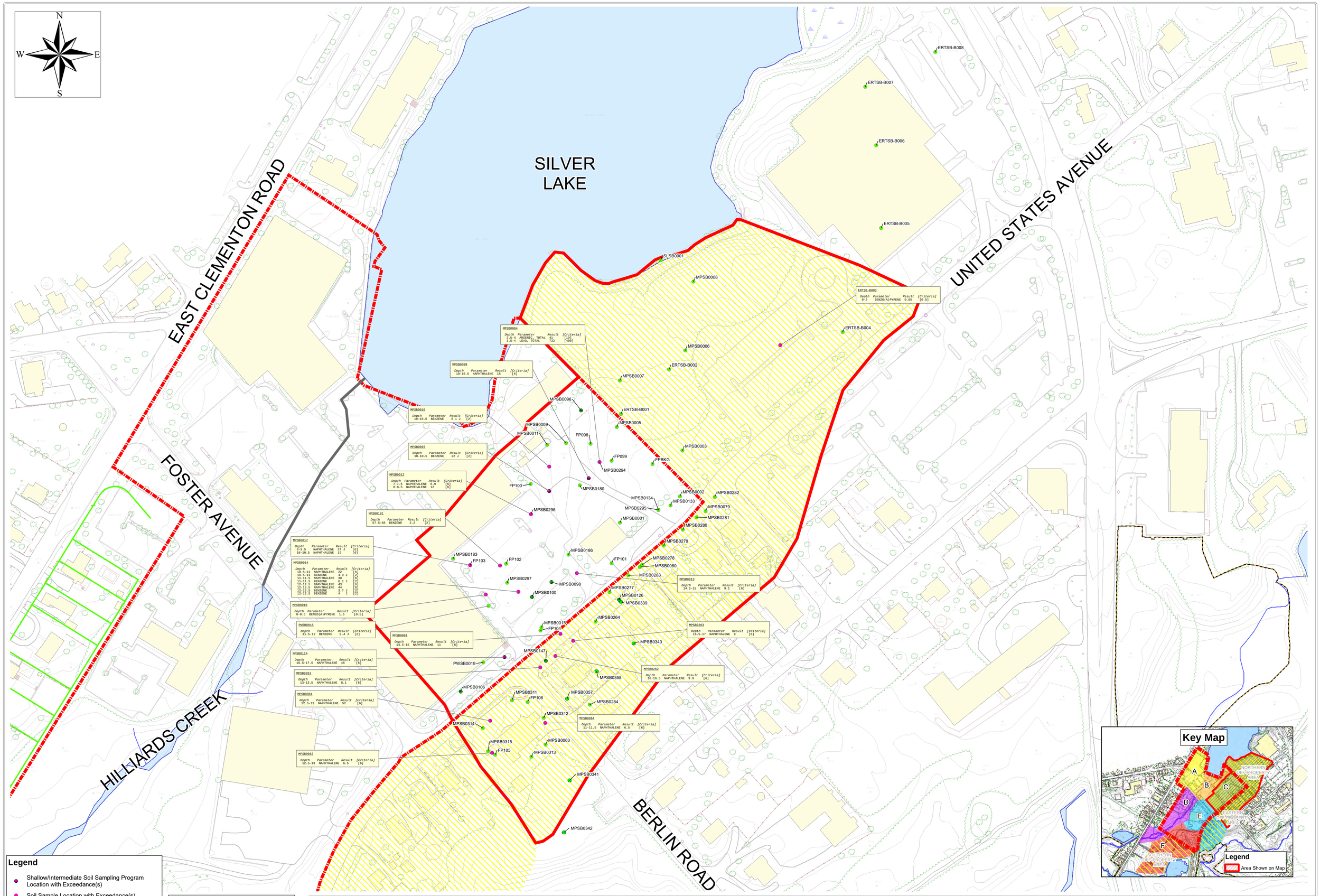
COVER THE EARTH
SHERWIN WILLIAMS

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: MAIN PLANT REMEDIAL UNIT 6 EAST CLEMENTON ROAD AND FORMER MAIN PLANT SOIL SAMPLES ARSENIC AND LEAD RESULTS ONLY LABORATORY AND XRF [NJDEP RDCSRS]
DRAWING: 23270_FMP_FS_Main_Plant_6_E_Clem_As_Pb_Lab_XRF.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 10 SCALE: 1 " = 40 ' DATE: 1/10/2019



Legend

- Shallow/Intermediate Soil Sampling Program Location with Exceedance(s)
- Soil Sample Location with Exceedance(s)
- Shallow/Intermediate Soil Sampling Program Location with No Exceedance
- Soil Sample Location with No Exceedance(s)
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Former Resin Plant and Tank Farm A
- Former Manufacturing Plant Extent
- Off Property Areas
- Perennial Stream Channel
- Fence Boundary

Location ID — Analytical Parameter — Analytical Flag

MPSB0017

Sample Depth (ft)	Concentration (mg/kg)			Criteria (mg/kg)
Depth	Parameter	Result	Flag	[Criteria]
9-9.5	NAPHTHALENE	27	J	[6]
10-10.5	NAPHTHALENE	19		[6]

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.

60 30 0 60
Scale in Feet

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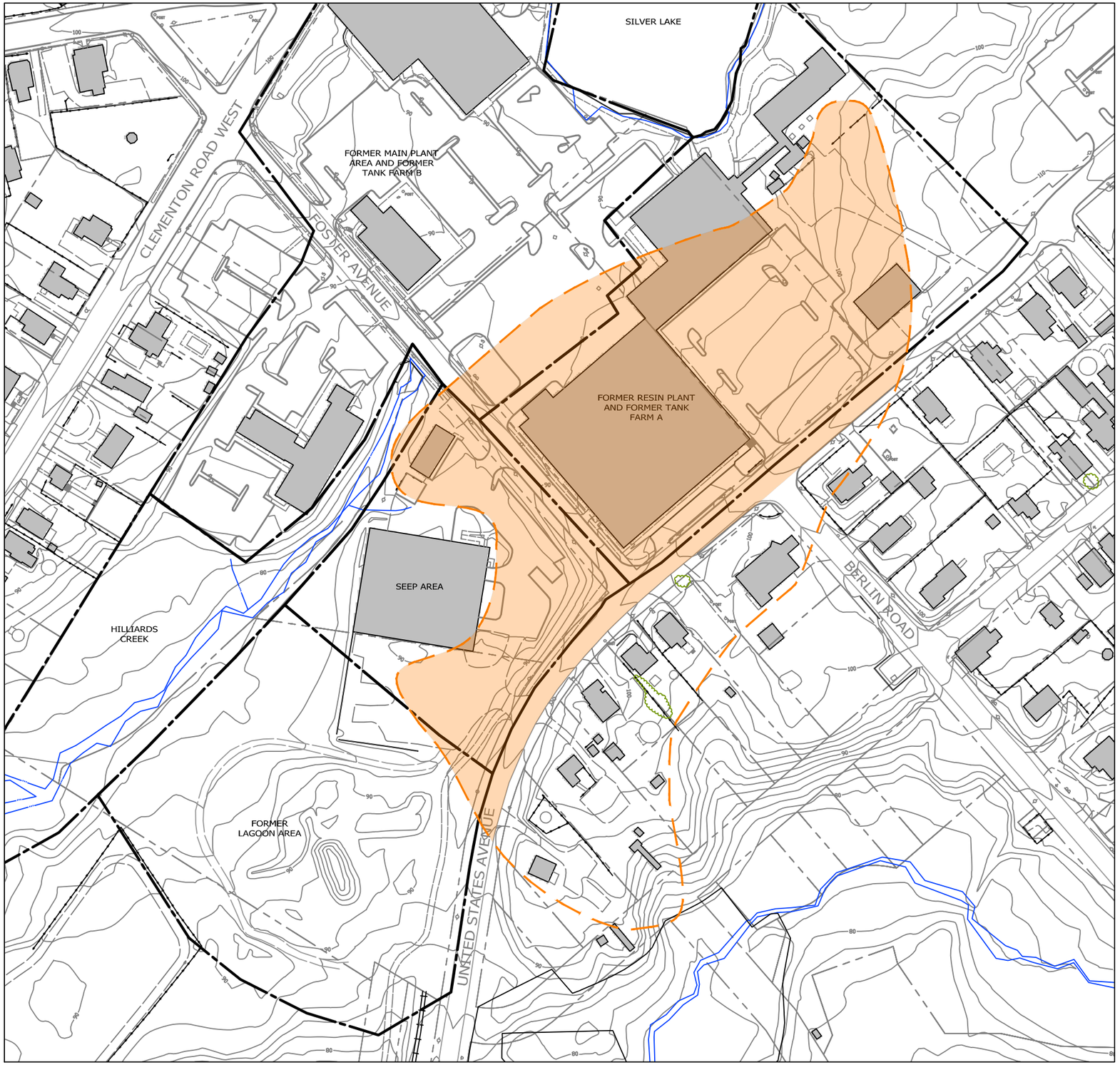
COVER THE EARTH
SHERWIN Williams

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: FORMER MANUFACTURING PLANT FORMER RESIN PLANT AND TANK FARM A SUBAREA SOIL SAMPLES - EXCEEDANCES [NJDEP RDCSRS]
DRAWING: 23271_FMP_RIR_RP_TFA_NOP_All_Exceed.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasbility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 11 SCALE: 1 " = 60 ' DATE: 1/10/2019



LEGEND

- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- INTERPRETED EXTENT OF LNAPL WITHIN THE FORMER MANUFACTURING PLANT REMEDIAL UNITS TO BE ADDRESS BY FEASIBILITY STUDY
- INTERPRETED EXTENT OF LNAPL
- SILVER LAKE CONVEYANCE

NOTES:

1. INTERPRETED EXTENT OF LNAPL BASED ON THE LNAPL INVESTIGATION COMPLETED IN ACCORDANCE WITH 2017 LNAPL INVESTIGATION WORK PLAN PREPARED BY EHS SUPPORT LLC THAT WAS ACCEPTED BY THE USEPA ON JULY 25, 2017.

SOURCE:

1. BASEMAP, WESTON SOLUTIONS, 2016.

0 150 300

SCALE: 1" = 150'

TITLE: FIGURE 12

LNAPL EXTENT FOR FORMER RESIN PLANT/TANK FARM A AND SEEP AREAS

LOCATION:

THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

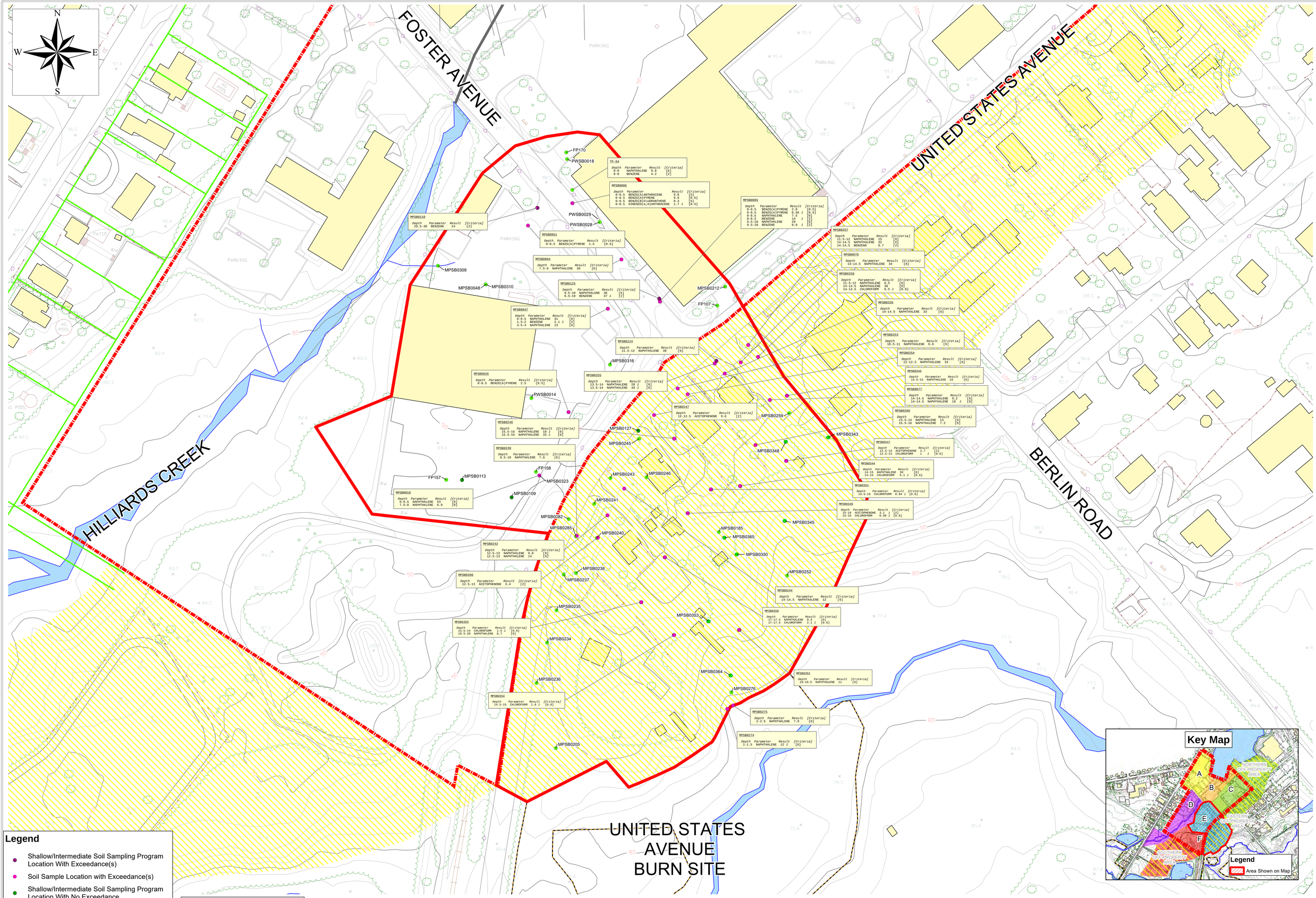
DATE: 01/10/2019

FILENAME: 204027_FMP_FS_REV1

LAYOUT: FMP_LNAPL_REV1

THE ELM GROUP
345 WALL STREET, PRINCETON, NEW JERSEY 08540
4936 YORK ROAD, SUITE 1000, HOLICONG, PENNSYLVANIA 18928
612 MAIN STREET, BOONTON, NEW JERSEY 07005
2436 EMRICK BOULEVARD, BETHLEHEM, PENNSYLVANIA 18020
www.ExploreELM.com

G:\204027_Sherwin-Williams_Gibbsboro\CADD\FMP\FS\204027_FMP_FS_REV1.dwg, FMP_LNAPL_rev1, 1/2/2019 11:52:29 AM, Lauren



Legend

- Shallow/Intermediate Soil Sampling Program Location With Exceedance(s)
- Soil Sample Location with Exceedance(s)
- Shallow/Intermediate Soil Sampling Program Location With No Exceedance
- Soil Sample Location with No Exceedance(s)
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Seep Area Subarea
- Former Manufacturing Plant Extent
- Off Property Areas
- Water Body/Stream Channel
- Fence Boundary

Location ID — Analytical Parameter — Analytical Flag

MPSB0133

Depth (ft)	Parameter	Result (mg/kg)	[Criteria] (mg/kg)
1.5-2	BENZO(A)PYRENE	0.23 U	[0.2]
5.5-6	ARSENIC, TOTAL	5.9	[19]
5.5-6	LEAD, TOTAL	7040	[400]
5.5-6	VANADIUM, TOTAL	82.2 J	[281]
5.5-6	BENZO(A)PYRENE	5.43	[0.2]

Sample Depth (ft) — Concentration (mg/kg) — Criteria (mg/kg)

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.

40 20 0 40
Scale in Feet

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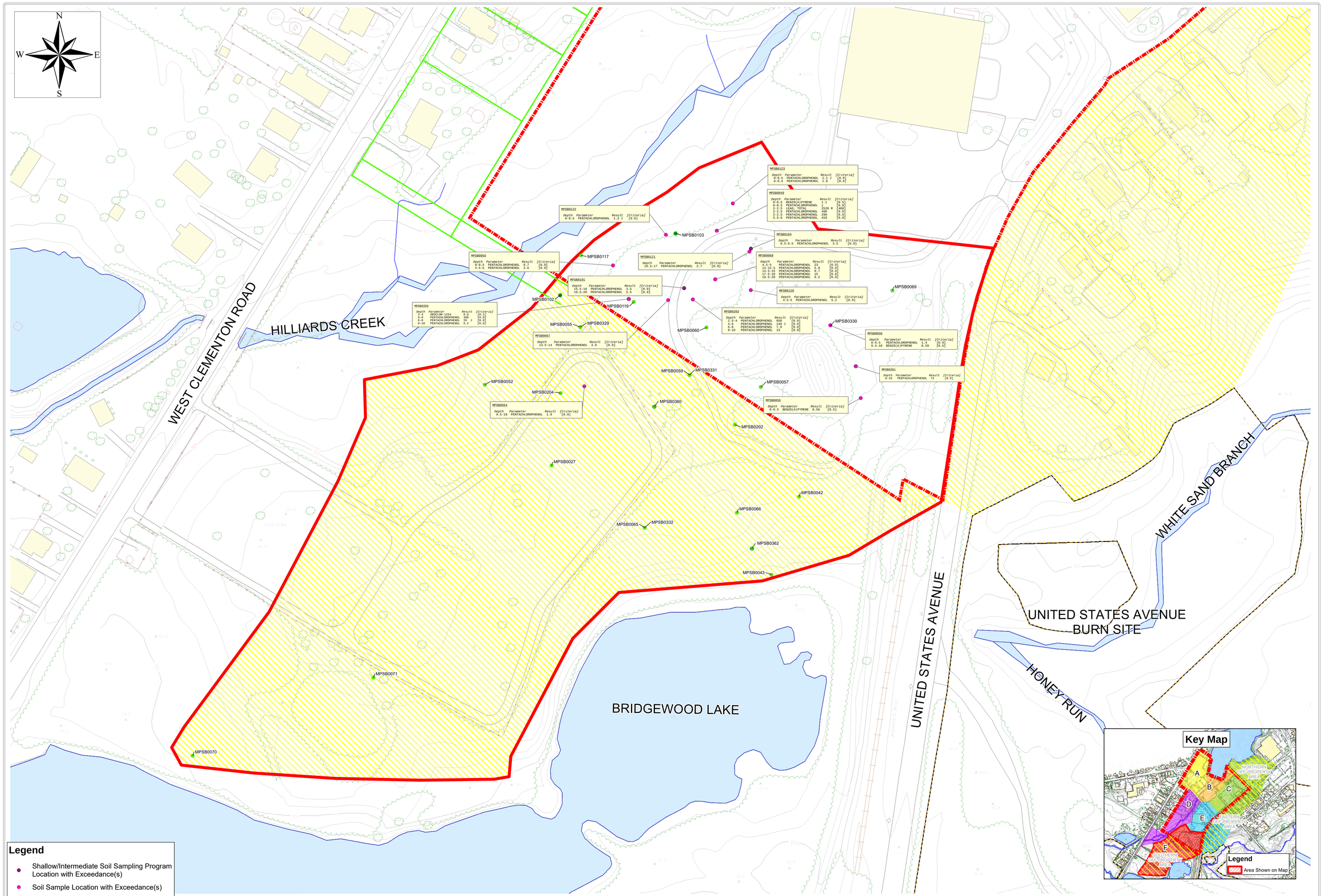
SHERWIN Williams

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: FORMER MANUFACTURING PLANT SEEP AREA SOIL SAMPLES - EXCEEDANCES [NJDEP RDCSRS]
DRAWING: 23272_FMP_RIR_Seep_Area_All_Exceed.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 13 / SCALE: 1 " = 40 ' / DATE: 1/10/2019



Legend

- Shallow/Intermediate Soil Sampling Program Location with Exceedance(s)
- Soil Sample Location with Exceedance(s)
- Shallow/Intermediate Soil Sampling Program Location with No Exceedance
- Soil Sample Location with No Exceedance(s)
- Surveyed Property Boundary (2015)
- Former Lagoon
- Former Manufacturing Plant Extent
- Off Property Areas
- Perennial Stream Channel
- Fence Boundary

Location ID — Analytical Parameter — Analytical Flag

MPSB0203

Depth	Parameter	Result	[Criteria]
2.5-4	PENTACHLOROPHENOL	650	[9]
4-6	PENTACHLOROPHENOL	140 J	[9]
6-8	PENTACHLOROPHENOL	7.9	[9]
8-10	PENTACHLOROPHENOL	13	[9]

Sample Depth (ft) — Concentration (mg/kg) — Criteria (mg/kg)

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.

40 20 0 40
Scale in Feet

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SHERWIN WILLIAMS — COVER THE EARTH

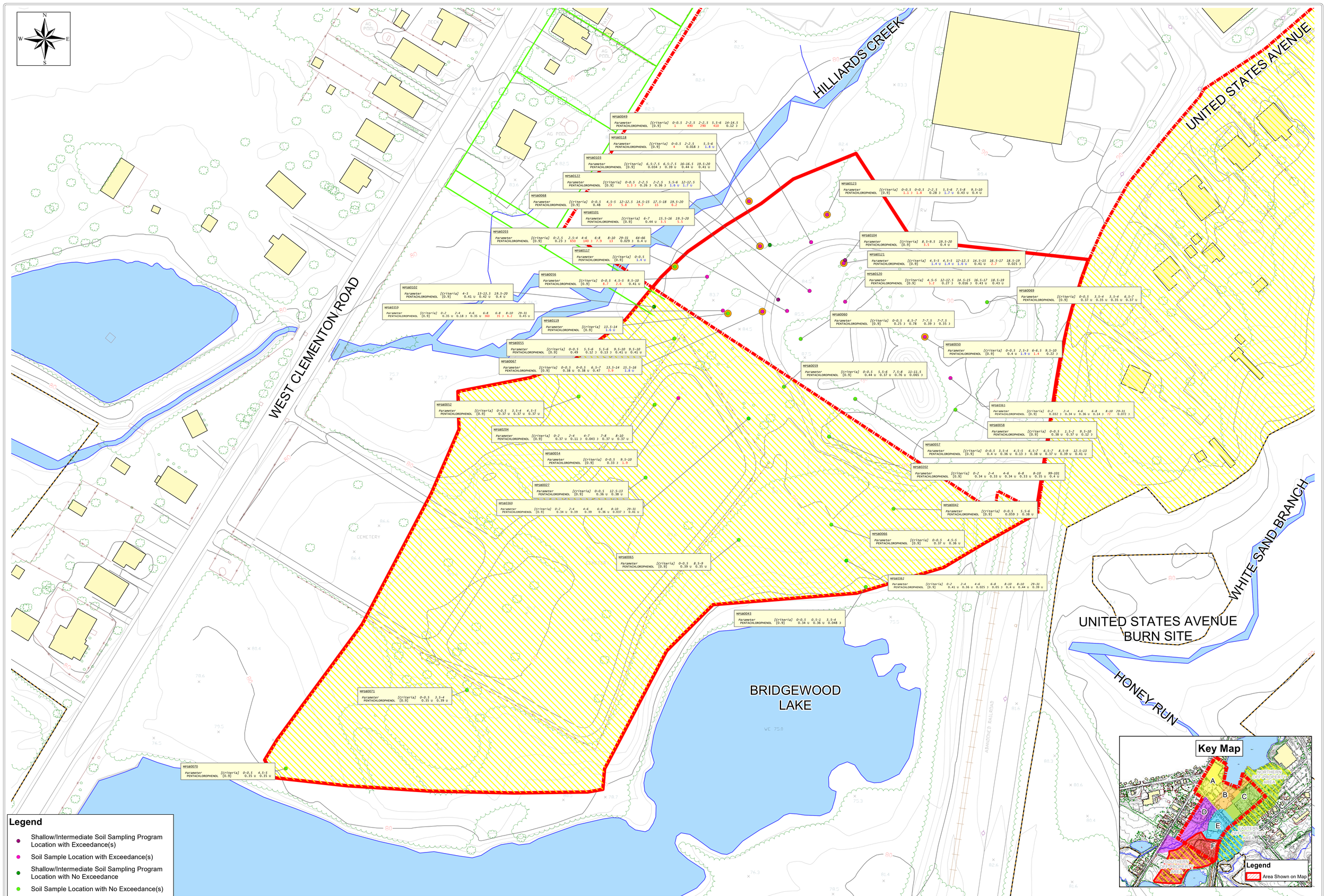
REPORT DATE: January 2019	PROJECT MANAGER: D. Kane
DRAWING: 23273_FMP_RIR_Lagoon_Area_All_Exceed.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019

CLIENT NAME: The Sherwin-Williams Company

PROJECT NAME: Former Manufacturing Plant Feasibility Study

DRAWING TITLE: FORMER MANUFACTURING PLANT FORMER LAGOON AREA SOIL SAMPLES - EXCEEDANCES [NJDEP RDCSRS]

FIGURE:	SCALE:	DATE:
14	1 " = 40 '	1/10/2019



Legend

- Shallow/Intermediate Soil Sampling Program Location with Exceedance(s)
- Soil Sample Location with Exceedance(s)
- Shallow/Intermediate Soil Sampling Program Location with No Exceedance
- Soil Sample Location with No Exceedance(s)
- Soil Boring Location with Non-Detect Result Greater than Respective NJDEP RDCSRS Criterion
- Former Manufacturing Plant Extent
- Off Property Areas
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Former Lagoon Area
- Water Body/Stream Channel
- Fence Boundary

Location ID — Criteria (mg/kg) — Sample Depth (ft)

WPS80070

Parameter [Criteria] 0-0.5 4.5-5

PENTACHLOROPHENOL [0.9] 0.35 U 0.35 U

Analytical Parameter — Concentration (mg/kg) — Analytical Flag

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.
10. Red text indicates results that exceed NJDEP RDCSRS.
11. Blue text indicates reporting limit that exceeds NJDEP RDCSRS.

40 20 0 40

Scale in Feet

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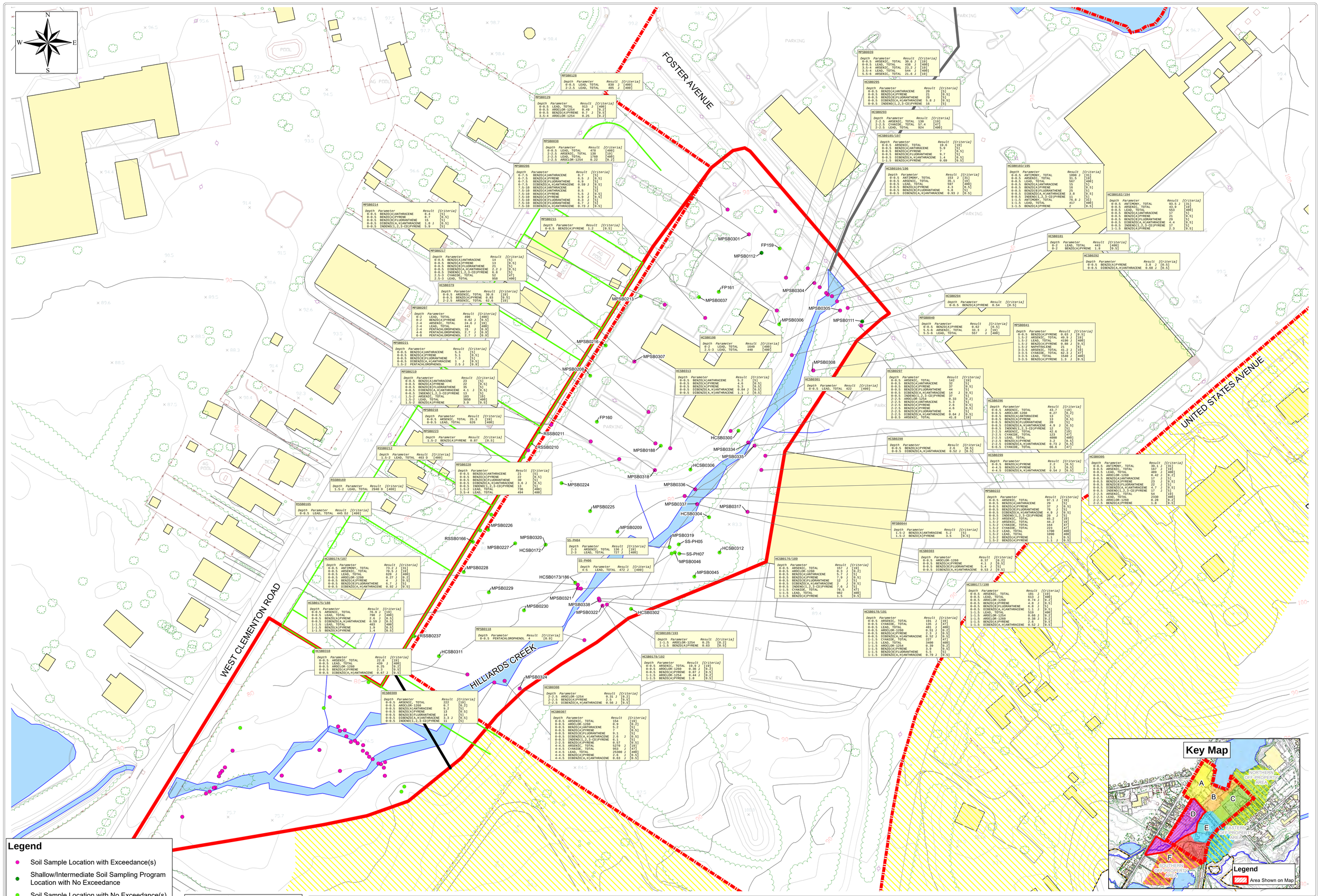
http://www.westonsolutions.com

COVER THE EARTH
SHERWIN Williams

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: FORMER MANUFACTURING PLANT FORMER LAGOON AREA SOIL SAMPLES PENTACHLOROPHENOL RESULTS ONLY [NJDEP RDCSRS]
DRAWING: 23287_FMP_RIR_FL_Soil_PCP_Results.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: J. Heaton DATE CREATED: 1/3/2019		FIGURE: 15 SCALE: 1 " = 40 ' DATE: 1/10/2019



Legend

- Soil Sample Location with Exceedance(s)
- Shallow/Intermediate Soil Sampling Program Location with No Exceedance
- Soil Sample Location with No Exceedance(s)
- Match Line
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Hilliards Creek Subarea
- Former Manufacturing Plant Extent
- Off Property Areas
- Water Body/Stream Channel
- Fence Boundary

Location ID | Analytical Parameter | Analytical Flag

MPSB0224

Depth Parameter	Result [Criteria]
0-0.5 BENZO(A)PYRENE	0.23 J [0.2]

Sample Depth (ft) | Concentration (mg/kg) | Criteria (mg/kg)

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.

40 20 0 40
Scale in Feet

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COVER THE EARTH
SHERWIN Williams

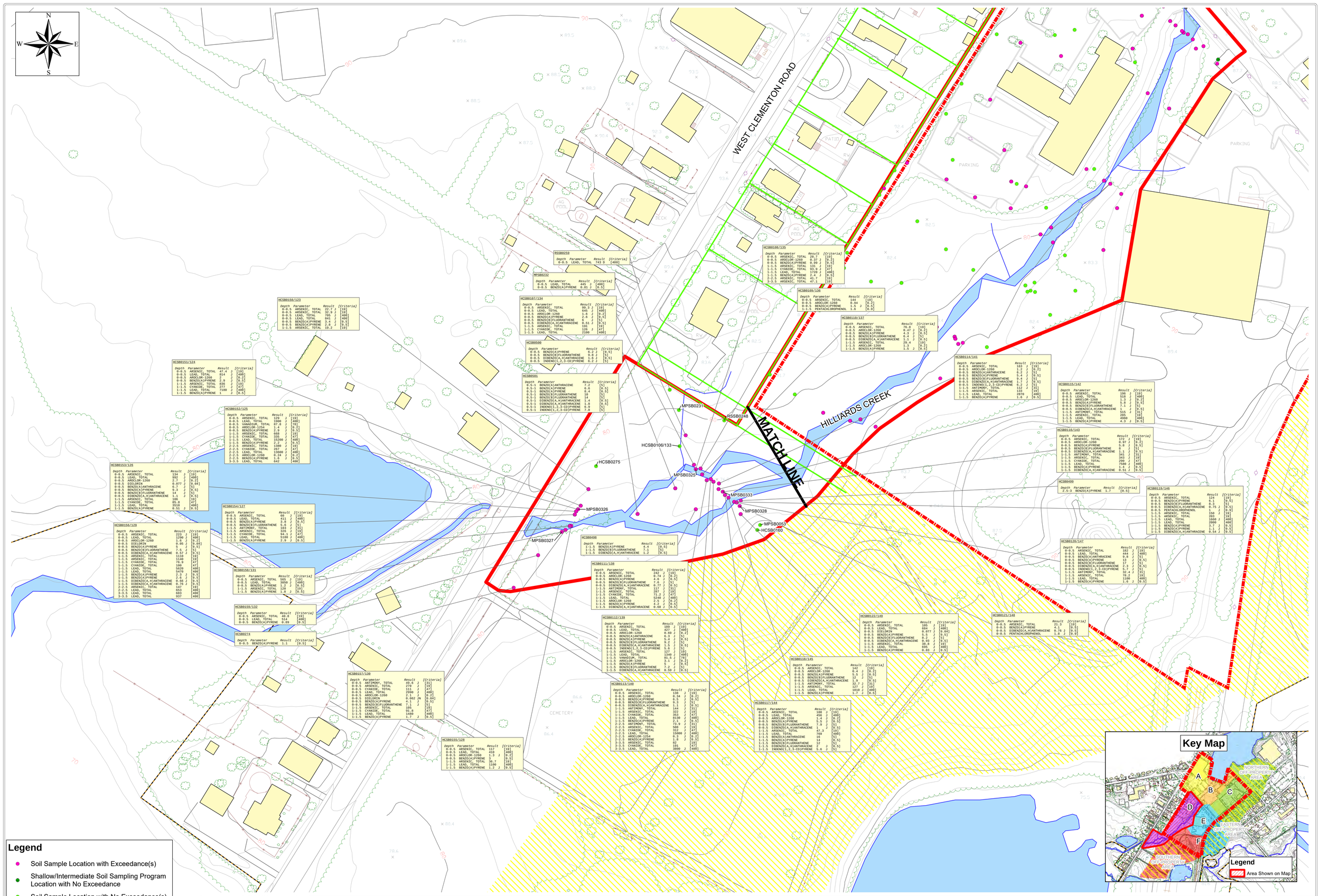
REPORT DATE: January 2019	PROJECT MANAGER: D. Kane
DRAWING: 23274_FMP_RIR_HC_All_Exceed_1.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019

CLIENT NAME: The Sherwin-Williams Company

PROJECT NAME: Former Manufacturing Plant Feasibility Study

DRAWING TITLE: FORMER MANUFACTURING PLANT HILLIARDS CREEK SUBAREA (NORTH) SOIL SAMPLES - EXCEEDANCES [NJDEP RDCSRS]

FIGURE:	SCALE:	DATE:
16	1 " = 40 '	1/10/2019



Legend

- Soil Sample Location with Exceedance(s)
- Shallow/Intermediate Soil Sampling Program Location with No Exceedance
- Soil Sample Location with No Exceedance(s)
- Match Line
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Hilliards Creek Subarea
- Former Manufacturing Plant Extent
- Off Property Areas
- Water Body/Stream Channel
- Fence Boundary

Location ID | Analytical Parameter | Analytical Flag

HCSB0121/148

Depth	Parameter	Result	Criteria
0-0.5	ARSENIC, TOTAL	21.3 J	[19]
0-0.5	BENZO(A)PYRENE	4.1 J	[0.5]
0-0.5	DIBENZO(A,H)ANTHRACENE	0.76 J	[0.5]
0-0.5	PENTACHLOROPHENOL	1.8 J	[0.9]

Sample Depth (ft) | Concentration (mg/kg) | Criteria (mg/kg)

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.

40 20 0 40
Scale in Feet

WESTON SOLUTIONS SM

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205 Campus Drive Edison, New Jersey 08837-3939
TEL: (732) 417-5800 Fax: (732) 417-5801
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COVER THE EARTH
SHERWIN Williams

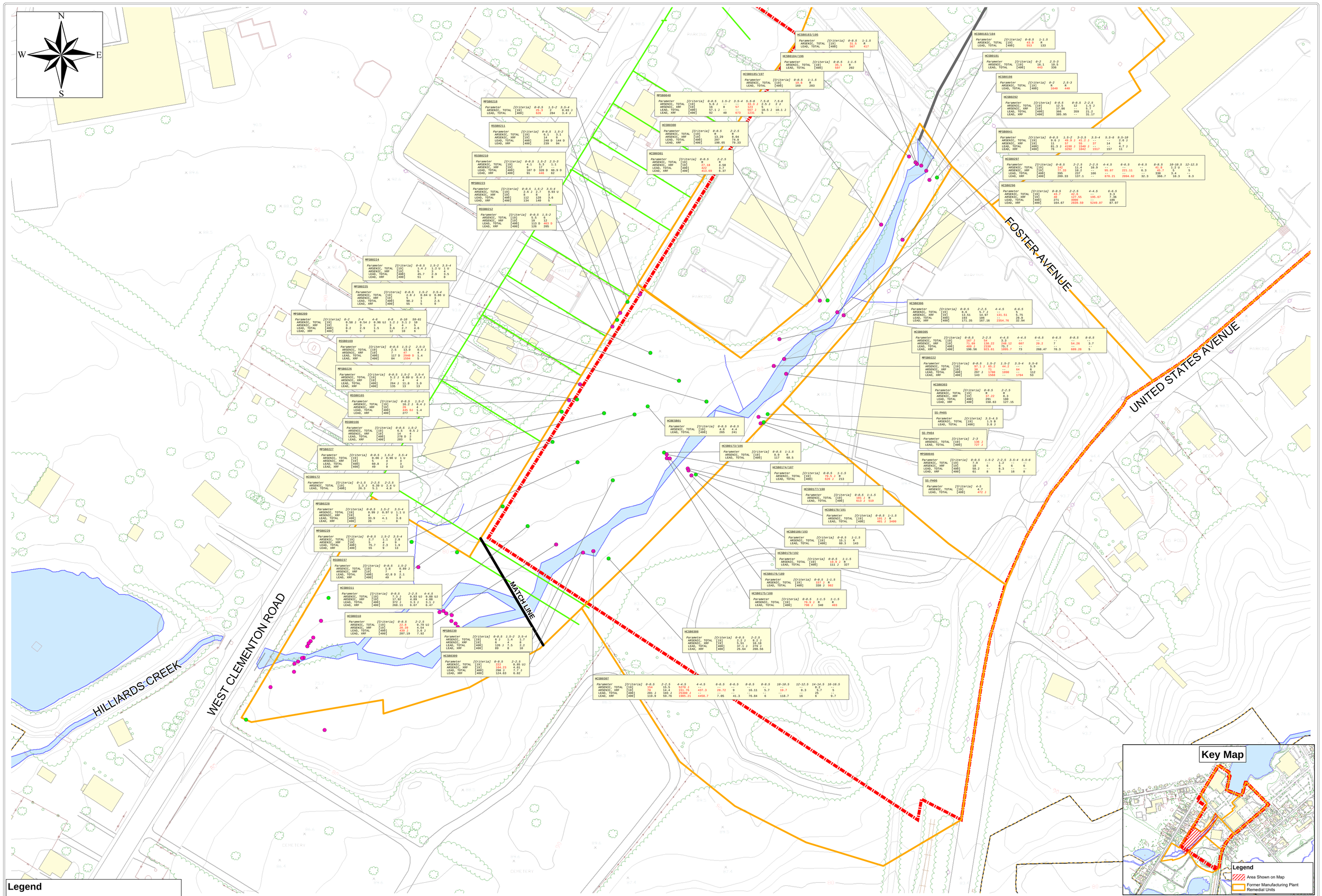
REPORT DATE: January 2019	PROJECT MANAGER: D. Kane
DRAWING: 23275_FMP_RIR_HC_All_Exceed_2.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019

CLIENT NAME: The Sherwin-Williams Company

PROJECT NAME: Former Manufacturing Plant Feasibility Study

DRAWING TITLE: FORMER MANUFACTURING PLANT HILLIARDS CREEK SUBAREA (SOUTH) SOIL SAMPLES - EXCEEDANCES [NJDEP RDCSRS]

FIGURE: 17 | SCALE: 1 " = 40 ' | DATE: 1/10/2019



Legend

- Soil Boring Location with As/Pb Exceedance(s)
- Soil Boring Location with No As/Pb Exceedance
- Match Line
- Former Manufacturing Plant Remedial Units
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Former Manufacturing Plant Extent
- Water Body/Stream Channel
- Fence Boundary

Location ID — Criteria (mg/kg) — Sample Depth (ft)

MPSB0195

Parameter	[Criteria]	0-0.5	11.5-12
ARSENIC, TOTAL	[19]	154	2.2 J
LEAD, TOTAL	[400]	154	271

Analytical Parameter — Concentration (mg/kg) — Analytical Flag

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.
10. Red text indicates results that exceed NJDEP RDCSRS.

40 20 0 40
Scale in Feet

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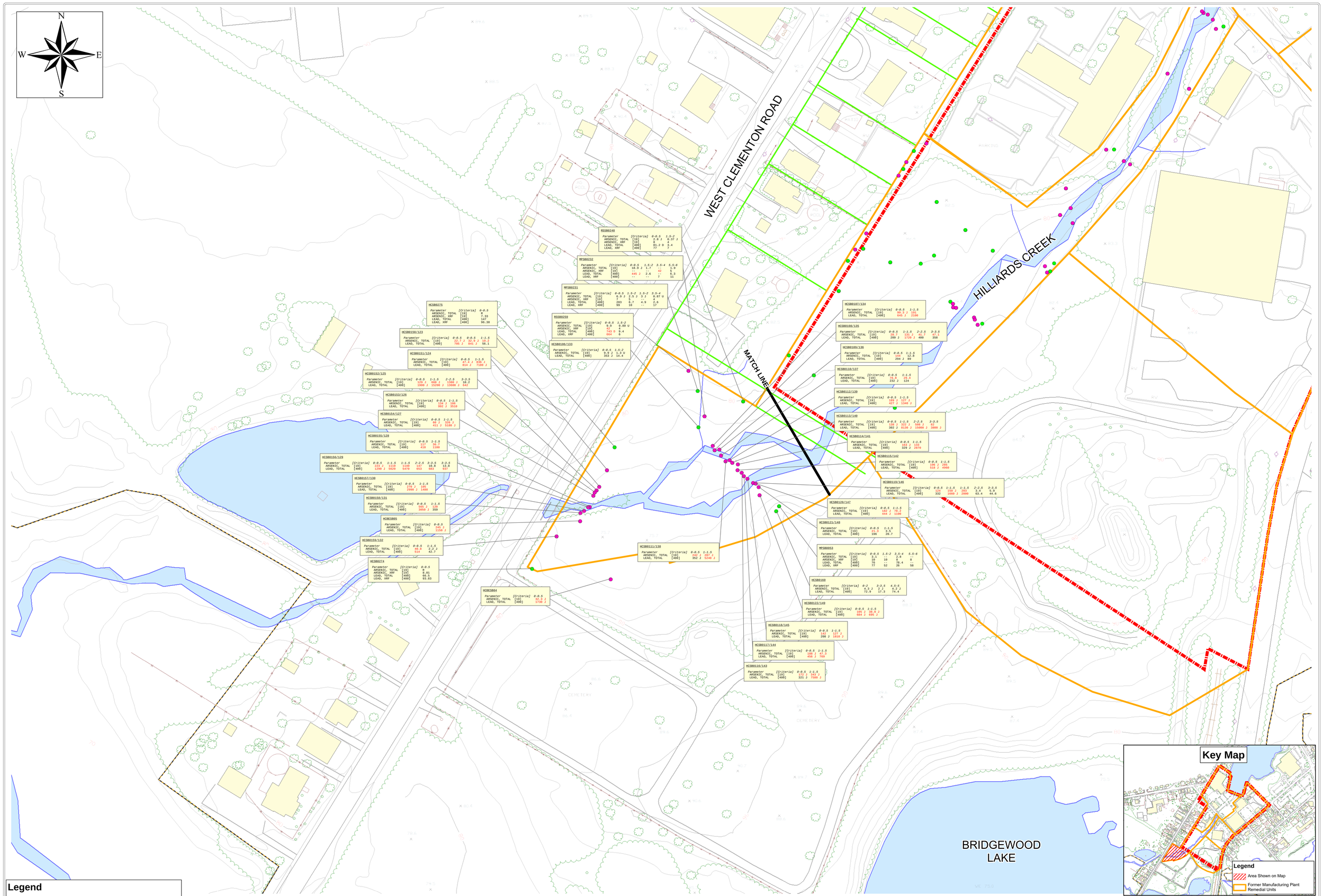
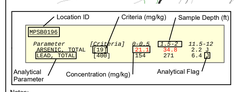
SHERWIN WILLIAMS — COVER THE EARTH

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: HILLIARDS CREEK REMEDIAL UNIT SOIL SAMPLES ARSENIC AND LEAD RESULTS ONLY LABORATORY AND XRF [NJDEP RDCSRS] MAP 1 OF 2
DRAWING: 23276_FMP_FS_Upper_Hilliards_As_Pb_Lab_XRF_1.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 18 SCALE: 1 " = 40 ' DATE: 1/10/2019



Legend

- Soil Boring Location with As/Pb Exceedance(s)
- Soil Boring Location with No As/Pb Exceedance
- Match Line
- Former Manufacturing Plant Remedial Units
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Former Manufacturing Plant Extent
- Water Body/Stream Channel
- Fence Boundary



Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.
10. Red text indicates results that exceed NJDEP RDCSRS.

40 20 0 40
Scale in Feet

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SHERWIN WILLIAMS
COVER THE EARTH

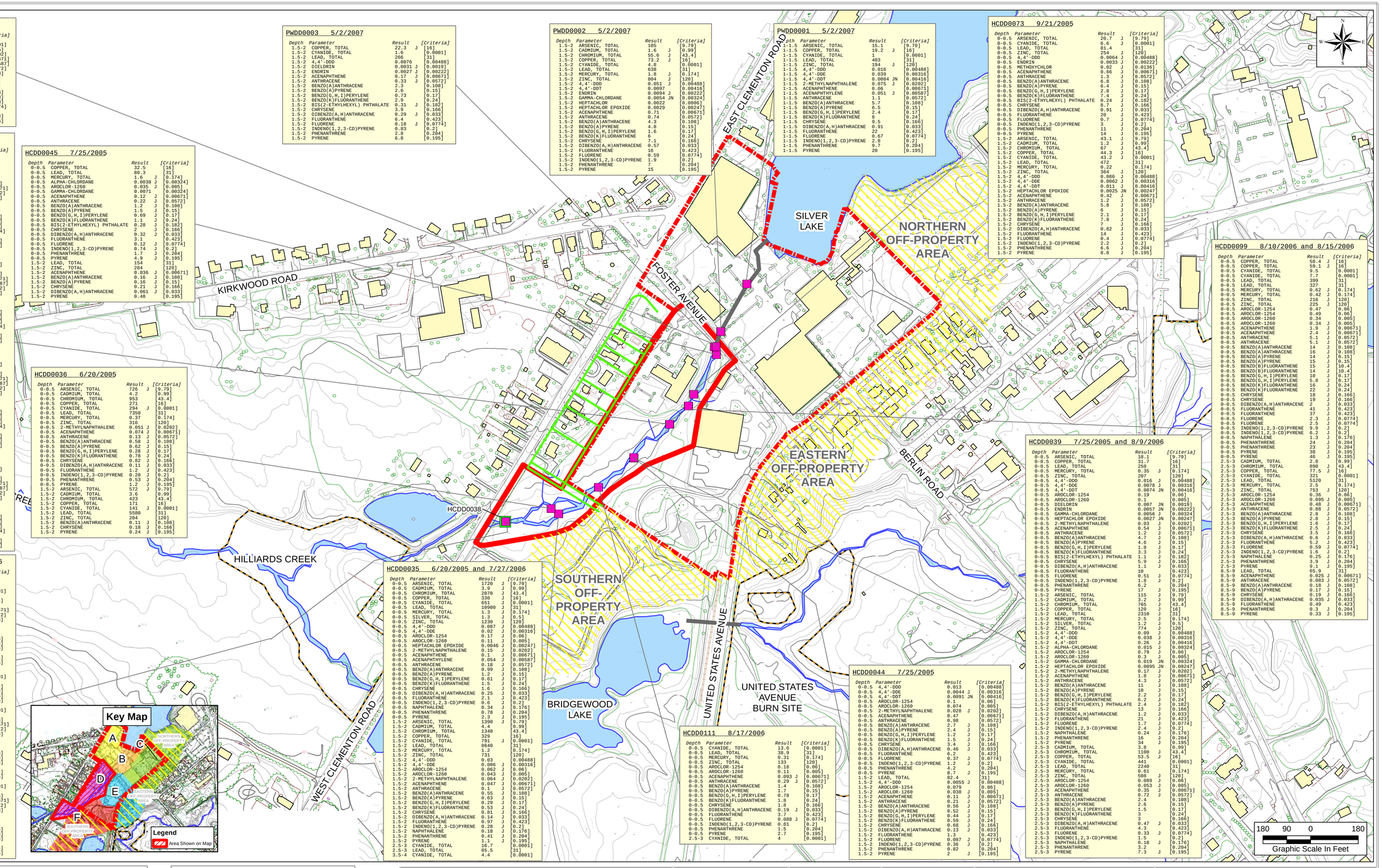
REPORT DATE: January 2019	PROJECT MANAGER: D. Kane
DRAWING: 23277_FMP_FS_Upper_Hilliards_As_Pb_Lab_XRF_2.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019

CLIENT NAME: The Sherwin-Williams Company

PROJECT NAME: Former Manufacturing Plant Feasibility Study

DRAWING TITLE:
HILLIARDS CREEK REMEDIAL UNIT
SOIL SAMPLES
ARSENIC AND LEAD RESULTS ONLY
LABORATORY AND XRF
[NJDEP RDCSRS]
MAP 2 OF 2

FIGURE:	SCALE:	DATE:
19	1 " = 40 '	1/10/2019



MPDD0001 2/4/2010

Depth	Parameter	Result		[Criteria]
0-0.5	COPPER, TOTAL	23.1		[16]
0-0.5	CYANIDE, TOTAL	0.17	J	[0.0001]
0-0.5	AROCLOR-1260	0.021	J	[0.005]
0-0.5	2-METHYLNAPHTHALENE	0.026	J	[0.0202]
0-0.5	ACENAPHTHENE	0.3	J	[0.00671]
0-0.5	ACENAPHTHYLENE	0.022	J	[0.00587]
0-0.5	ANTHRACENE	0.63		[0.0572]
0-0.5	BENZO(A)ANTHRACENE	3.8		[0.108]
0-0.5	BENZO(A)PYRENE	4.1		[0.15]
0-0.5	BENZO(G,H,I)PERYLENE	1		[0.17]
0-0.5	BENZO(K)FLUORANTHENE	4.7		[0.24]
0-0.5	CHRYSENE	5.8		[0.166]
0-0.5	DIBENZO(A,H)ANTHRACENE	0.33		[0.033]
0-0.5	FLUORANTHENE	16		[0.423]
0-0.5	FLUORENE	0.32		[0.0774]
0-0.5	INDENO(1,2,3-CD)PYRENE	1.2		[0.2]
0-0.5	PHENANTHRENE	6.3		[0.204]
0-0.5	PYRENE	7.5		[0.195]

PWDD0003 5/2/2007

Depth	Parameter	Result		[Criteria]
1.5-2	COPPER, TOTAL	22.3	J	[16]
1.5-2	CYANIDE, TOTAL	1.6		[0.0001]
1.5-2	LEAD, TOTAL	266		[31]
1.5-2	4,4'-DDD	0.0076		[0.00488]
1.5-2	DIELDRIN	0.0031	J	[0.0019]
1.5-2	ENDRIN	0.0027	J	[0.00222]
1.5-2	ACENAPHTHENE	0.17	J	[0.00671]
1.5-2	ANTHRACENE	0.33	J	[0.0572]
1.5-2	BENZO(A)ANTHRACENE	2.3		[0.108]
1.5-2	BENZO(A)PYRENE	2.6		[0.15]
1.5-2	BENZO(G,H,I)PERYLENE	0.73		[0.17]
1.5-2	BENZO(K)FLUORANTHENE	2.9		[0.24]
1.5-2	BIS(2-ETHYLHEXYL) PHTHALATE	0.31	J	[0.182]
1.5-2	CHRYSENE	3.9		[0.166]
1.5-2	DIBENZO(A,H)ANTHRACENE	0.29	J	[0.033]
1.5-2	FLUORANTHENE	6.4		[0.423]
1.5-2	FLUORENE	0.18	J	[0.0774]
1.5-2	INDENO(1,2,3-CD)PYRENE	0.83		[0.2]
1.5-2	PHENANTHRENE	2.8		[0.204]
1.5-2	PYRENE	6.8		[0.195]

PWDD0002 5/2/2007

Depth	Parameter	Result		[Criteria]
1.5-2	ARSENIC, TOTAL	105		[9.79]
1.5-2	CADMIUM, TOTAL	1.6	J	[0.99]
1.5-2	CHROMIUM, TOTAL	55.6	J	[43.4]
1.5-2	COPPER, TOTAL	73.2	J	[16]
1.5-2	CYANIDE, TOTAL	4.8		[0.0001]
1.5-2	LEAD, TOTAL	638		[31]
1.5-2	MERCURY, TOTAL	1.8	J	[0.174]
1.5-2	ZINC, TOTAL	804	J	[120]
1.5-2	4,4'-DDD	0.051	J	[0.00488]
1.5-2	4,4'-DDE	0.0097	J	[0.00416]
1.5-2	ENDRIN	0.0094	J	[0.00222]
1.5-2	GAMMA-CHLORDANE	0.0054	JN	[0.00324]
1.5-2	HEPTACHLOR	0.0022		[0.0006]
1.5-2	HEPTACHLOR EPOXIDE	0.0029		[0.00247]
1.5-2	ACENAPHTHENE	0.71		[0.00671]
1.5-2	ANTHRACENE	0.74		[0.0572]
1.5-2	BENZO(A)ANTHRACENE	4.3		[0.108]
1.5-2	BENZO(A)PYRENE	4.8		[0.15]
1.5-2	BENZO(G,H,I)PERYLENE	1.6		[0.17]
1.5-2	BENZO(K)FLUORANTHENE	6		[0.24]
1.5-2	CHRYSENE	7.1		[0.166]
1.5-2	DIBENZO(A,H)ANTHRACENE	0.57		[0.033]
1.5-2	FLUORANTHENE	16		[0.423]
1.5-2	FLUORENE	0.59		[0.0774]
1.5-2	INDENO(1,2,3-CD)PYRENE	1.9		[0.2]
1.5-2	PHENANTHRENE	7		[0.204]
1.5-2	PYRENE	15		[0.195]

PWDD0001 5/2/2007

Depth	Parameter	Result		[Criteria]
1-1.5	ARSENIC, TOTAL	15.1		[9.79]
1-1.5	COPPER, TOTAL	19.2	J	[16]
1-1.5	CYANIDE, TOTAL	1		[0.0001]
1-1.5	LEAD, TOTAL	403		[31]
1-1.5	ZINC, TOTAL	194	J	[120]
1-1.5	4,4'-DDD	0.016		[0.00488]
1-1.5	4,4'-DDE	0.039		[0.00316]
1-1.5	4,4'-DDT	0.0084	JN	[0.00416]
1-1.5	2-METHYLNAPHTHALENE	0.075	J	[0.0202]
1-1.5	ACENAPHTHENE	0.66		[0.00671]
1-1.5	ACENAPHTHYLENE	0.051	J	[0.00587]
1-1.5	ANTHRACENE	1.1		[0.0572]
1-1.5	BENZO(A)ANTHRACENE	5.7		[0.108]
1-1.5	BENZO(A)PYRENE	6.5		[0.15]
1-1.5	BENZO(G,H,I)PERYLENE	2.4		[0.17]
1-1.5	BENZO(K)FLUORANTHENE	8		[0.24]
1-1.5	CHRYSENE	9.5		[0.166]
1-1.5	DIBENZO(A,H)ANTHRACENE	0.91		[0.033]
1-1.5	FLUORANTHENE	22		[0.423]
1-1.5	FLUORENE	0.67		[0.0774]
1-1.5	INDENO(1,2,3-CD)PYRENE	2.8		[0.2]
1-1.5	PHENANTHRENE	9.7		[0.204]
1-1.5	PYRENE	20		[0.195]

HCDD0073 9/21/2005

Depth	Parameter	Result		[Criteria]
0-0.5	ARSENIC, TOTAL	20.7	J	[9.79]
0-0.5	CYANIDE, TOTAL	6.6	J	[0.0001]
0-0.5	LEAD, TOTAL	81.4		[31]
0-0.5	ZINC, TOTAL	254	J	[120]
0-0.5	4,4'-DDD	0.0064	J	[0.00488]
0-0.5	ENDRIN	0.0033	J	[0.00222]
0-0.5	METHOXYCHLOR	0.02	J	[0.0136]
0-0.5	ACENAPHTHENE	0.66	J	[0.00671]
0-0.5	ANTHRACENE	1.3	J	[0.0572]
0-0.5	BENZO(A)ANTHRACENE	6.8	J	[0.108]
0-0.5	BENZO(A)PYRENE	6.4	J	[0.15]
0-0.5	BENZO(G,H,I)PERYLENE	2.8	J	[0.17]
0-0.5	BENZO(K)FLUORANTHENE	7.4	J	[0.24]
0-0.5	BIS(2-ETHYLHEXYL) PHTHALATE	0.24	J	[0.182]
0-0.5	CHRYSENE	8.7	J	[0.166]
0-0.5	DIBENZO(A,H)ANTHRACENE	0.91	J	[0.033]
0-0.5	FLUORANTHENE	20	J	[0.423]
0-0.5	FLUORENE	0.7	J	[0.0774]
0-0.5	INDENO(1,2,3-CD)PYRENE	3	J	[0.2]
0-0.5	PHENANTHRENE	11	J	[0.204]
0-0.5	PYRENE	14	J	[0.195]
1.5-2	ARSENIC, TOTAL	43.1	J	[9.79]
1.5-2	CADMIUM, TOTAL	1.2	J	[0.99]
1.5-2	CHROMIUM, TOTAL	67		[43.4]
1.5-2	COPPER, TOTAL	44	J	[16]
1.5-2	CYANIDE, TOTAL	43.2	J	[0.0001]
1.5-2	LEAD, TOTAL	472		[31]
1.5-2	MERCURY, TOTAL	0.22	J	[0.174]
1.5-2	ZINC, TOTAL	364	J	[120]
1.5-2	4,4'-DDD	0.086	J	[0.00488]
1.5-2	4,4'-DDE	0.0062	J	[0.00316]
1.5-2	4,4'-DDT	0.011	J	[0.00416]
1.5-2	HEPTACHLOR EPOXIDE	0.0025	JN	[0.00247]
1.5-2	ACENAPHTHENE	0.42	J	[0.00671]
1.5-2	ANTHRACENE	1.2	J	[0.0572]
1.5-2	BENZO(A)ANTHRACENE	5.8	J	[0.108]
1.5-2	BENZO(A)PYRENE	6	J	[0.15]
1.5-2	BENZO(G,H,I)PERYLENE	2.1	J	[0.17]
1.5-2	BENZO(K)FLUORANTHENE	7.8	J	[0.24]
1.5-2	CHRYSENE	7	J	[0.166]
1.5-2	DIBENZO(A,H)ANTHRACENE	0.82	J	[0.033]
1.5-2	FLUORANTHENE	14	J	[0.423]
1.5-2	FLUORENE	0.4	J	[0.0774]
1.5-2	INDENO(1,2,3-CD)PYRENE	2.2	J	[0.2]
1.5-2	PHENANTHRENE	6.6	J	[0.204]
1.5-2	PYRENE	8.8	J	[0.195]

HCDD0100 8/15/2006

Depth	Parameter	Result		[Criteria]
0-0.5	ARSENIC, TOTAL	35.2		[9.79]
0-0.5	CHROMIUM, TOTAL	290		[43.4]
0-0.5	COPPER, TOTAL	18.4	J	[16]
0-0.5	LEAD, TOTAL	4280		[31]
0-0.5	ZINC, TOTAL	124	J	[120]
0-0.5	AROCLOR-1254	0.15	J	[0.06]
0-0.5	AROCLOR-1260	0.26		[0.005]
0-0.5	ACENAPHTHENE	0.58	J	[0.00671]
0-0.5	ANTHRACENE	1.4	J	[0.0572]
0-0.5	BENZO(A)ANTHRACENE	7		[0.108]
0-0.5	BENZO(A)PYRENE	8.6		[0.15]
0-0.5	BENZO(G,H,I)PERYLENE	5.6		[0.17]
0-0.5	BENZO(K)FLUORANTHENE	7.9		[0.24]
0-0.5	CHRYSENE	9.8		[0.166]
0-0.5	DIBENZO(A,H)ANTHRACENE	1.7	J	[0.033]
0-0.5	FLUORANTHENE	24		[0.423]
0-0.5	FLUORENE	0.62	J	[0.0774]
0-0.5	INDENO(1,2,3-CD)PYRENE	5.5		[0.2]
0-0.5	PHENANTHRENE	11		[0.204]
0-0.5	PYRENE	17		[0.195]
2.5-3	ARSENIC, TOTAL	35.8		[9.79]
2.5-3	COPPER, TOTAL	21.1	J	[16]
2.5-3	LEAD, TOTAL	583		[31]
2.5-3	MERCURY, TOTAL	0.34		[0.174]
2.5-3	ZINC, TOTAL	341	J	[120]
2.5-3	AROCLOR-1260	0.11		[0.005]
2.5-3	ACENAPHTHENE	0.31	J	[0.00671]
2.5-3	ACENAPHTHYLENE	0.044	J	[0.00587]
2.5-3	ANTHRACENE	0.61		[0.0572]
2.5-3	BENZO(A)ANTHRACENE	1.3		[0.108]
2.5-3	BENZO(A)PYRENE	1.3		[0.15]
2.5-3	BENZO(G,H,I)PERYLENE	0.55	J	[0.17]
2.5-3	BENZO(K)FLUORANTHENE	1.5		[0.24]
2.5-3	CHRYSENE	1.4		[0.166]
2.5-3	DIBENZO(A,H)ANTHRACENE	0.26	J	[0.033]
2.5-3	FLUORANTHENE	3.1		[0.423]
2.5-3	FLUORENE	0.26	J	[0.0774]
2.5-3	INDENO(1,2,3-CD)PYRENE	0.55	J	[0.2]
2.5-3	PHENANTHRENE	2		[0.204]
2.5-3	PYRENE	2.5		[0.195]
5.5-6	ARSENIC, TOTAL	155		[9.79]
5.5-6	CHROMIUM, TOTAL	144		[43.4]
5.5-6	COPPER, TOTAL	272	J	[16]
5.5-6	LEAD, TOTAL	2340		[31]
5.5-6	MERCURY, TOTAL	0.19		[0.174]
5.5-6	ZINC, TOTAL	270	J	[120]
5.5-6	AROCLOR-1260	0.068		[0.005]
5.5-6	ACENAPHTHENE	0.37	J	[0.00671]
5.5-6	ACENAPHTHYLENE	0.054	J	[0.00587]
5.5-6	ANTHRACENE	0.67		[0.0572]
5.5-6	BENZO(A)ANTHRACENE	1.3		[0.108]
5.5-6	BENZO(A)PYRENE	1.3		[0.15]
5.5-6	BENZO(G,H,I)PERYLENE	0.48		[0.17]
5.5-6	BENZO(K)FLUORANTHENE	1.2		[0.24]
5.5-6	CHRYSENE	1.3		[0.166]
5.5-6	DIBENZO(A,H)ANTHRACENE	0.18	J	[0.033]
5.5-6	FLUORANTHENE	2.8		[0.423]
5.5-6	FLUORENE	0.35	J	[0.0774]
5.5-6	INDENO(1,2,3-CD)PYRENE	0.53		[0.2]
5.5-6	NAPHTHALENE	0.32	J	[0.176]
5.5-6	PHENANTHRENE	1.9		[0.204]
5.5-6	PYRENE	2.1		[0.195]
6.5-7	ARSENIC, TOTAL	83.7		[9.79]
6.5-7	CHROMIUM, TOTAL	129		[43.4]
6.5-7	COPPER, TOTAL	151	J	[16]
6.5-7	LEAD, TOTAL	1840		[31]
6.5-7	MERCURY, TOTAL	0.47		[0.174]
6.5-7	ZINC, TOTAL	208	J	[120]
6.5-7	AROCLOR-1260	0.087		[0.005]
6.5-7	ACENAPHTHENE	0.16	J	[0.00671]
6.5-7	ACENAPHTHYLENE	0.045	J	[0.00587]
6.5-7	ANTHRACENE	0.39		[0.0572]
6.5-7	BENZO(A)ANTHRACENE	1		[0.108]
6.5-7	BENZO(A)PYRENE	1		[0.15]
6.5-7	BENZO(G,H,I)PERYLENE	0.39		[0.17]
6.5-7	BENZO(K)FLUORANTHENE	1.2		[0.24]
6.5-7	CHRYSENE	1.1		[0.166]
6.5-7	DIBENZO(A,H)ANTHRACENE	0.18	J	[0.033]
6.5-7	FLUORANTHENE	2.1		[0.423]
6.5-7	FLUORENE	0.14	J	[0.0774]
6.5-7	INDENO(1,2,3-CD)PYRENE	0.38	J	[0.2]
6.5-7	PHENANTHRENE	1.1		[0.204]
6.5-7	PYRENE	1.8		[0.195]

HCDD0045 7/25/2005

Depth	Parameter	Result		[Criteria]
0-0.5	COPPER, TOTAL	32.5		[16]
0-0.5	LEAD, TOTAL	80.3		[31]
0-0.5	MERCURY, TOTAL	1.6	J	[0.174]
0-0.5	ALPHA-CHLORDANE	0.0038	J	[0.00324]
0-0.5	AROCLOR-1260	0.035	J	[0.005]
0-0.5	GAMMA-CHLORDANE	0.0071	J	[0.00324]
0-0.5	ACENAPHTHENE	0.12	J	[0.00671]
0-0.5	ANTHRACENE	0.22	J	[0.0572]
0-0.5	BENZO(A)ANTHRACENE	1.2	J	[0.108]
0-0.5	BENZO(A)PYRENE	1.5	J	[0.15]
0-0.5	BENZO(G,H,I)PERYLENE	0.69	J	[0.17]
0-0.5	BENZO(K)FLUORANTHENE	1.1	J	[0.24]
0-0.5	BIS(2-ETHYLHEXYL) PHTHALATE	0.28	J	[0.182]
0-0.5	CHRYSENE	2	J	[0.166]
0-0.5	DIBENZO(A,H)ANTHRACENE	0.32	J	[0.033]
0-0.5	FLUORANTHENE	3.1	J	[0.423]
0-0.5	FLUORENE	0.12	J	[0.0774]
0-0.5	INDENO(1,2,3-CD)PYRENE	0.74	J	[0.2]
0-0.5	PHENANTHRENE	1.7	J	[0.204]
0-0.5	PYRENE	4.9	J	[0.195]
1.5-2	LEAD, TOTAL	154		[31]
1.5-2	ZINC, TOTAL	284		[120]
1.5-2	ACENAPHTHENE	0.036	J	[0.00671]
1.5-2	BENZO(A)ANTHRACENE	0.16	J	[0.108]
1.5-2	BENZO(A)PYRENE	0.16	J	[0.15]
1.5-2	CHRYSENE	0.21	J	[0.166]
1.5-2	DIBENZO(A,H)ANTHRACENE	0.061	J	[0.033]
1.5-2	PYRENE	0.48		[0.195]

HCDD0036 6/20/2005

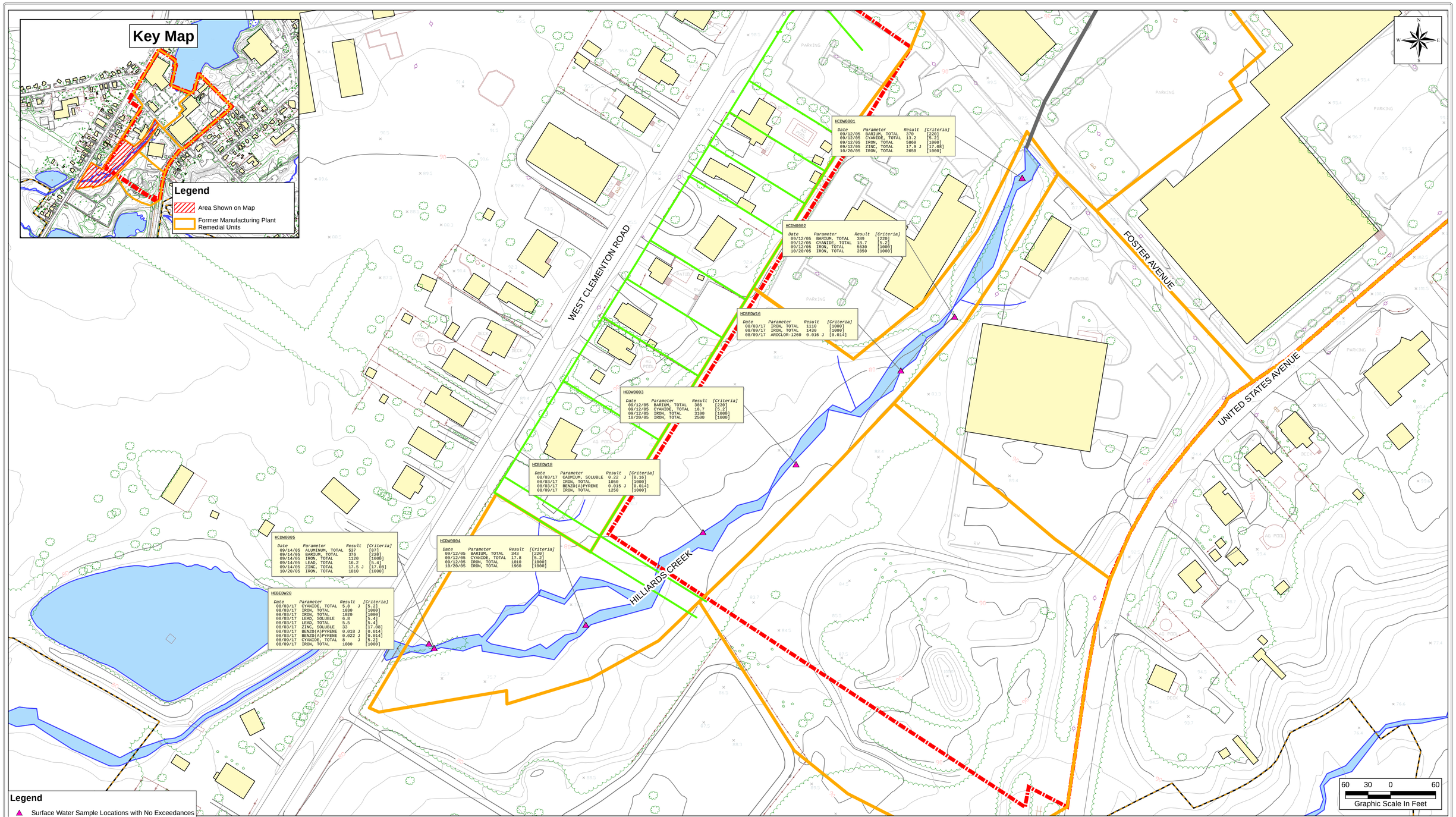
Depth	Parameter	Result		[Criteria]
0-0.5	ARSENIC, TOTAL	726	J	[9.79]
0-0.5	CADMIUM, TOTAL	4.2	J	[0.99]
0-0.5	CHROMIUM, TOTAL	953		[43.4]
0-0.5	COPPER, TOTAL	271		[16]
0-0.5	CYANIDE, TOTAL	294	J	[0.0001]
0-0.5	LEAD, TOTAL	7350		[31]
0-0.5	MERCURY, TOTAL	0.37		[0.174]
0-0.5	ZINC, TOTAL	316		[120]
0-0.5	2-METHYLNAPHTHALENE	0.051	J	[0.0202]
0-0.5	ACENAPHTHENE	0.074	J	[0.00671]
0-0.5	ANTHRACENE	0.13	J	[0.0572]
0-0.5	BENZO(A)ANTHRACENE	0.58	J	[0.108]
0-0.5	BENZO(A)PYRENE	0.62	J	[0.15]
0-0.5	BENZO(G,H,I)PERYLENE	0.28	J	[0.17]
0-0.5	BENZO(K)FLUORANTHENE	0.78	J	[0.24]
0-0.5	CHRYSENE	0.82	J	[0.166]
0-0.5	DIBENZO(A,H)ANTHRACENE	0.11	J	[0.033]
0-0.5	FLUORANTHENE	1.2	J	[0.423]
0-0.5	INDENO(1,2,3-CD)PYRENE	0.28	J	[0.2]
0-0.5	PHENANTHRENE	0.53	J	[0.204]
0-0.5	PYRENE	1.2	J	[0.195]
1.5-2	ARSENIC, TOTAL	572	J	[9.79]
1.5-2	CADMIUM, TOTAL	3.6	J	[0.99]
1.5-2	CHROMIUM, TOTAL	423		[43.4]
1.5-2	COPPER, TOTAL	171		[16]
1.5-2	CYANIDE, TOTAL	141	J	[0.0001]
1.5-2	LEAD, TOTAL	5580		[31]
1.5-2	ZINC, TOTAL	204		[120]
1.5-2	BENZO(A)ANTHRACENE	0.11	J	[0.108]
1.5-2	CHRYSENE	0.18	J	[0.166]
1.5-2	PYRENE	0.24	J	[0.195]

HCDD0039 7/25/2005 and 8/9/2006

Depth	Parameter	Result		[Criteria]
0-0.5	ARSENIC, TOTAL	18.1	J	[9.79]
0-0.5	COPPER, TOTAL	31.7		[16]
0-0.5	LEAD, TOTAL	250		[31]
0-0.5	MERCURY, TOTAL	0.35	J	[0.174]
0-0.5	ZINC, TOTAL	207		[120]
0-0.5	4,4'-DDD	0.016	J	[0.00488]
0-0.5	4,4'-DDE	0.0078	J	[0.00316]
0-0.5	4,4'-DDT	0.0074	JN	[0.00416]
0-0.5	AROCLOR-1254	0.19		[0.06]
0-0.5	AROCLOR-1260	0.1		[0.005]
0-0.5	DIELDRIN	0.007	JN	[0.0019]
0-0.5	ENDRIN	0.0057	JN	[0.00222]
0-0.5	GAMMA-CHLORDANE	0.0056	J	[0.00324]
0-0.5	HEPTACHLOR EPOXIDE	0.0027	JN	[0.00247]
0-0.5	2-METHYLNAPHTHALENE	0.03	J	[0.0202]
0-0.5	ACENAPHTHENE	0.07	J	[0.00671]
0-0.5	ANTHRACENE	1.2	J	[0.0572]
0-0.5	BENZO(A)ANTHRACENE	4.7	J	[0.108]
0-0.5	BENZO(A)PYRENE	4.6	J	[0.15]
0-0.5	BENZO(G,H,I)PERYLENE	1.8	J	[0.17]
0-0.5	BENZO(K)FLUORANTHENE	3.3	J	[0.24]
0-0.5	BIS(2-ETHYLHEXYL) PHTHALATE	1.1	J	[0.182]
0-0.5	CHRYSENE	5.9	J	[0.166]
0-0.5	DIBENZO(A,H)ANTHRACENE	1.1	J	[0.033]
0-0.5	FLUORANTHENE	10	J	[0.423]
0-0.5	FLUORENE	0.51	J	[0.0774]
0-0.5	INDENO(1,2,3-CD)PYRENE	1.8	J	[0.2]
0-0.5	PHENANTHRENE	6.2		[0.204]
0-0.5	PYRENE	17	J	[0.195]
1.5-2	ARSENIC, TOTAL	115	J	[9.79]
1.5-2	CADMIUM, TOTAL	3.2	J	[0.99]
1.5-2	CHROMIUM, TOTAL	765	J	[43.4]
1.5-2	COPPER, TOTAL	120	J	[16]
1.5-2	LEAD, TOTAL	2310	J	[31]
1.5-2	MERCURY, TOTAL	2.5	J	[0.174]
1.5-2	SILVER, TOTAL	1.2	J	[0.5]
1.5-2	ZINC, TOTAL	774	J	[120]
1.5-2	4,4'-DDD	0.09	J	[0.00488]
1.5-2	4,4'-DDE	0.038	J	[0.00316]
1.5-2	4,4'-DDT	0.26	J	[0.00416]
1.5-2	ALPHA-CHLORDANE	0.015	J	[0.00324]
1.5-2	AROCLOR-1254	0.79	J	[0.06]
1.5-2	AROCLOR-1260	0.3	J	[0.005]
1.5-2	GAMMA-CHLORDANE	0.019	JN	[0.00324]
1.5-2	HEPTACHLOR EPOXIDE	0.0095	JN	[0.00247]
1.5-2	2-METHYLNAPHTHALENE	0.17	J	[0.0202]
1.5-2	ACENAPHTHENE	1.8	J	[0.00671]
1.5-2	ANTHRACENE	4.3	J	[0.0572]
1.5-2	BENZO(A)ANTHRACENE	11	J	[0.108]
1.5-2	BENZO(A)PYRENE	10	J	[0.15]
1.5-2	BENZO(G,H,I)PERYLENE	2.2	J	[0.17]
1.5-2	BENZO(K)FLUORANTHENE	6.2	J	[0.24]
1.5-2	BIS(2-ETHYLHEXYL) PHTHALATE	2.4	J	[0.182]
1.5-2	CHRYSENE	13	J	[0.166]
1.5-2	DIBENZO(A,H)ANTHRACENE	1.2	J	[0.033]
1.5-2	FLUORANTHENE	21	J	[0.423]
1.5-2	FLUORENE	1.7	J	[0.0774]
1.5-2	INDENO(1,2,3-CD)PYRENE	2.4	J	[0.2]
1.5-2	NAPHTHALENE	0.24	J	[0.176]
1.5-2	PHENANTHRENE	16	J	[0.204]
1.5-2	PYRENE	34	J	[0.195]
2.5-3	ARSENIC, TOTAL	3.8	J	[9.79]
2.5-3	CHROMIUM, TOTAL	1100	J	[43.4]
2.5-3	COPPER, TOTAL	53.5	J	[16]
2.5-3	CYANIDE, TOTAL	441		[0.0001]
2.5-3	LEAD, TOTAL	2240		[31]
2.5-3	MERCURY, TOTAL	0.61		[0.174]
2.5-3	ZINC, TOTAL	500	J	[120]
2.5-3	AROCLOR-1254	0.089	J	[0.06]
2.5-3	AROCLOR-1260	0.053	J	[0.005]
2.5-3	ACENAPHTHENE	0.35	J	[0.00671]
2.5-3	ACENAPHTHYLENE	0.72	J	[0.0572]
2.5-3	ANTHRACENE	2.4	J	[0.108]
2.5-3	BENZO(A)PYRENE	2.6		[0.15]
2.5-3	BENZO(G,H,I)PERYLENE	1.5	J	[0.17]
2.5-3	BENZO(K)FLUORANTHENE	3		[0.24]
2.5-3	CHRYSENE	3	J	[0.166]
2.5-3	DIBENZO(A,H)ANTHRACENE	0.47	J	[0.033]
2.5-3	FLUORANTHENE	4.3	J	[0.423]
2.5-3	FLUORENE	0.33	J	[0.0774]
2.5-3	INDENO(1,2,3-CD)PYRENE	1.5	J	[0.2]
2.5-3	NAPHTHALENE	0.18	J	[0.176]
2.5-3	PHENANTHRENE	3.2		[0.204]
2.5-3	PYRENE	7.3	J	[0.195]

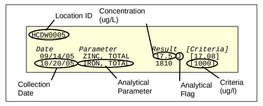
HCDD0099 8/10/2006 and 8/15/2006

Depth	Parameter	Result		[Criteria]
0-0.5	COPPER, TOTAL	58.4	J	[16]
0-0.5	COPPER, TOTAL	59.1	J	[16]
0-0.5	CYANIDE, TOTAL	9.5		[0.0001]
0-0.5	CYANIDE, TOTAL	7.7		[0.0001]
0-0.5	LEAD, TOTAL	399		[31]
0-0.5	LEAD, TOTAL	327		[31]
0-0.5	MERCURY, TOTAL	0.62	J	[0.174]
0-0.5	MERCURY, TOTAL	0.42	J	[0.174]
0-0.5	ZINC, TOTAL	216	J	[120]
0-0.5	ZINC, TOTAL	225	J	[120]
0-0.5	AROCLOR-1254	0.47		[0.06]
0-0.5	AROCLOR-1254	0.49		[0.06]
0-0.5	AROCLOR-1260	0.34		[0.005]
0-0.5	AROCLOR-1260	0.34	J	[0.005]
0-0.5	ACENAPHTHENE	1.9	J	[0.00671]
0-0.5	ACENAPHTHENE	2.4	J	[0.00671]
0-0.5	ANTHRACENE	5.1	J	[0.0572]
0-0.5	ANTHRACENE	5.1	J	[0.0572]
0-0.5	BENZO(A)ANTHRACENE	14	J	[0.108]
0-0.5	BENZO(A)ANTHRACENE	16	J	[0.108]
0-0.5	BENZO(A)PYRENE	14	J	[0.15]
0-0.5	BENZO(A)PYRENE	15	J	[0.15]
0-0.5	BENZO(B)FLUORANTHENE	15	J	[0.24]
0-0.5	BENZO(B)FLUORANTHENE	14	J	[0.24]
0-0.5	BENZO(G,H,I)PERYLENE	10	J	[0.17]
0-0.5	BENZO(G,H,I)PERYLENE	5.8	J	[0.17]
0-0.5	BENZO(K)FLUORANTHENE	16	J	[0.24]
0-0.5	BENZO(K)FLUORANTHENE	22	J	[0.24]
0-0.5	CHRYSENE	18	J	[0.166]
0-0.5	CHRYSENE	19	J	[0.166]
0-0.5	DIBENZO(A,H)ANTHRACENE	2	J	[0.033]
0-0.5	FLUORANTHENE	41	J	[0.423]
0-0.5	FLUORANTHENE	37	J	[0.423]
0-0.5	FLUORENE	2.3	J	[0.0774]
0-0.5	FLUORENE	2.5	J	[0.0774]
0-0.5	INDENO(1,2,3-CD)PYRENE	9.9	J	[0.2]
0-0.5	INDENO(1,2,3-CD)PYRENE	6.2	J	[0.2]
0-0.5	NAPHTHALENE	1.3	J	[0.176]
0-0.5	PHENANTHRENE	24	J	[0.204]
0-0.5	PHENANTHRENE	23	J	[0.204]
0-0.5	PYRENE	38	J	[0.195]
0-0.5	PYRENE	46	J	[0.195]
2.5-3	CADMIUM, TOTAL	2.8		[0.99]
2.5-3	CHROMIUM, TOTAL	890	J	[43.4]
2.5-3	COPPER, TOTAL	77.5	J	[16]
2.5-3	CYANIDE, TOTAL	321		[0.0001]
2.5-3	LEAD, TOTAL	5120		[31]
2.5-3	MERCURY, TOTAL	2.5		[0.174]
2.5-3	ZINC, TOTAL	753	J	[120]
2.5-3	AROCLOR-1254	0.36		[0.06]
2.5-3	AROCLOR-1260	0.095	J	[0.005]
2.5-3	ACENAPHTHENE	0.48	J	[0.00671]
2.5-3	ANTHRACENE	0.88	J	[0.0572]
2.5-3	BENZO(A)ANTHRACENE	2.8	J	[0.108]
2.5-3	BENZO(A)PYRENE	2.8	J	[0.15]
2.5-3	BENZO(G,H,I)PERYLENE	1.6	J	[0.17]
2.5-3	BENZO(K)FLUORANTHENE	2.5	J	[0.24]
2.5-3	CHRYSENE	3.5	J	[0.166]
2.5-3	DIBENZO(A,H)ANTHRACENE	0.6	J	[0.033]
2.5-3	FLUORANTHENE	5.2	J	[0.423]
2.5-3	FLUORENE	0.59	J	[0.0774]
2.5-3	INDENO(1,2,3-CD)PYRENE	1.6	J	[0.2]
2.5-3	NAPHTHALENE	0.25	J	[0.176]



Legend

- Surface Water Sample Locations with No Exceedances
- Surface Water Sample Locations with No Exceedances
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Former Manufacturing Plant Remedial Units
- Former Manufacturing Plant Extent
- Perennial Stream Channel
- Fence Boundary



Notes
1. All results compared against the New Jersey Department of Environmental Protection Surface Water Criteria for Freshwater (FW2).
2. Average hardness for Hilliards Creek surface water samples was used to calculate cadmium, chromium, copper, nickel, silver, and zinc criteria as required in the NJ Surface Water Quality Standards.
3. All results are in ug/L.
4. J - Estimated Concentration

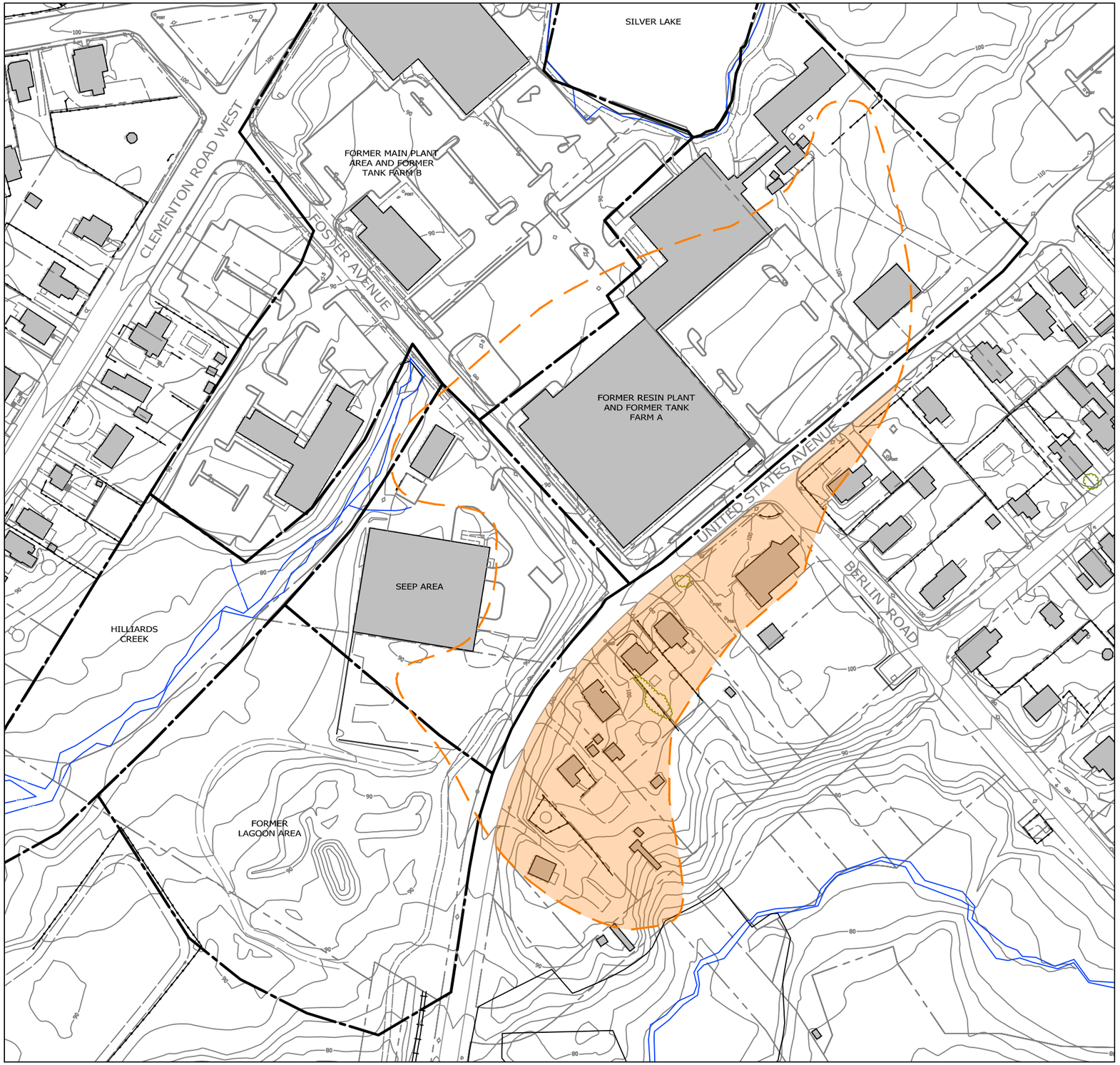
WESTON SOLUTIONS
Weston Solutions, Inc.
205 Campus Drive Edison, New Jersey 08837-3939
TEL: (732) 417-5800 Fax: (732) 417-5801
http://www.westonsolutions.com

SHERWIN Williams

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company
DRAWING: 23279_FMP_FS_Upper_HC_SW_All_Param_Exceed.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer	
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study
WORK ORDER No. 20076.022.090.0008	DRAWN/MOD/FIED BY: K. Heulitt DATE CREATED: 1/3/2019	

HILLIARDS CREEK
SURFACE WATER - EXCEEDANCES
[NJDEP SURFACE WATER CRITERIA]

FIGURE: 21 | SCALE: 1 " = 60 ' | DATE: 1/10/2019



LEGEND

- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- INTERPRETED EXTENT OF LNAPL FOR EASTERN OFF-PROPERTY AREA TO BE ADDRESS BY FEASIBILITY STUDY
- INTERPRETED EXTENT OF LNAPL
- SILVER LAKE CONVEYANCE

NOTES:

1. INTERPRETED EXTENT OF LNAPL BASED ON THE LNAPL INVESTIGATION COMPLETED IN ACCORDANCE WITH 2017 LNAPL INVESTIGATION WORK PLAN PREPARED BY EHS SUPPORT LLC THAT WAS ACCEPTED BY THE USEPA ON JULY 25, 2017.

SOURCE:

1. BASEMAP, WESTON SOLUTIONS, 2016.

0 150 300

SCALE: 1" = 150'

TITLE: FIGURE 22

INTERPRETED LNAPL EXTENT FOR EASTERN OFF-PROPERTY AREA

LOCATION:

THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

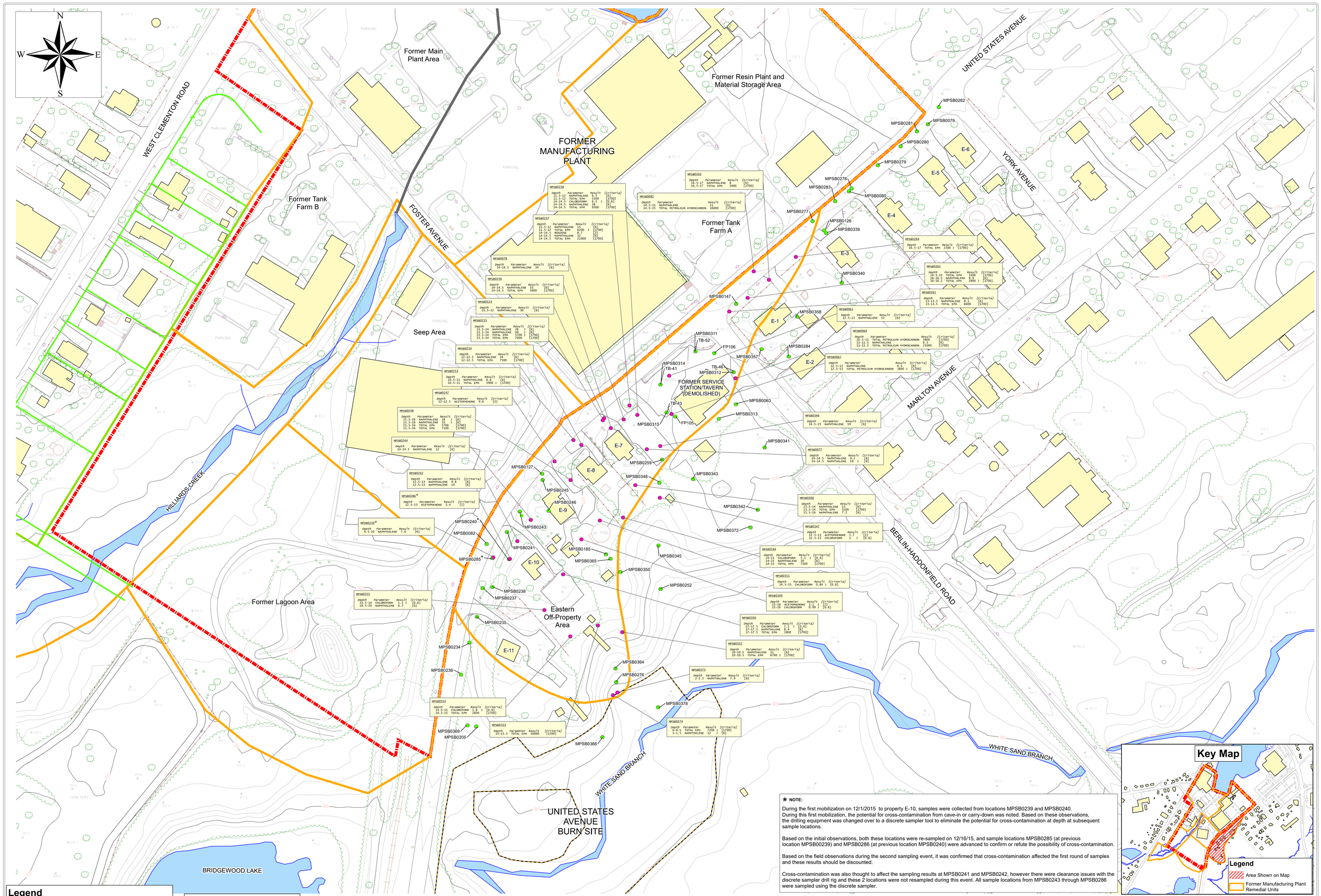
DATE: 01/10/2019

FILENAME: 204027_FMP_FS_REV1

LAYOUT: EOP_LNAPL

THE ELM GROUP
345 WALL STREET, PRINCETON, NEW JERSEY 08540
4936 YORK ROAD, SUITE 1000, HOLICONG, PENNSYLVANIA 18928
612 MAIN STREET, BOONTON, NEW JERSEY 07005
2436 EMRICK BOULEVARD, BETHLEHEM, PENNSYLVANIA 18020
www.ExploreELM.com

G:\204027_Sherwin-Williams_Gibbsboro\CADD\FMP\FS\204027_FMP_FS_REV1.dwg, EOP_LNAPL, 1/2/2019 12:56:58 PM, Lauren



★ NOTE:

During the first mobilization on 12/1/2015 to property E-10, samples were collected from locations MPSB0239 and MPSB0240. During this first mobilization, the potential for cross-contamination from cave-in or carry-down was noted. Based on these observations, the drilling equipment was changed over to a discrete sampler tool to eliminate the potential for cross-contamination at depth at subsequent sample locations.

Based on the initial observations, both these locations were re-sampled on 12/16/15, and sample locations MPSB0285 (at previous location MPSB00239) and MPSB0286 (at previous location MPSB0240) were advanced to confirm or refute the possibility of cross-contamination.

Based on the field observations during the second sampling event, it was confirmed that cross-contamination affected the first round of samples and these results should be discounted.

Cross-contamination was also thought to affect the sampling results at MPSB0241 and MPSB0242, however there were clearance issues with the discrete sampler drill rig and these 2 locations were not resampled during this event. All sample locations from MPSB0243 through MPSB0286 were sampled using the discrete sampler.

Key Map

Legend

- Soil Sample Location with Exceedance(s)
- Soil Sample Location with No Exceedance(s)
- Approximate Location of Silver Lake Conveyance
- Surveyed Property Boundary (2015)
- Former Manufacturing Plant Remedial Units
- Former Manufacturing Plant Extent
- Water Body/Stream Channel
- Fence Boundary

Location ID — Analytical Parameter

MPSB0353

Sample Depth (ft)	Analytical Parameter	Concentration (mg/kg)	Analytical Flag	Criteria (mg/kg)
Depth	Parameter	Result	[Criteria]	
13.5-14	CHLOROFORM	1.5	J	[0.6]
19.5-20	NAPHTHALENE	6.7		[6]

Notes:
1. All results compared against the 2017 NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS).
2. Total Petroleum Hydrocarbon (TPH) and Extractable Petroleum Hydrocarbons (EPH) results compared against the NJDEP EPH Ecological Screening Value of 1,700 mg/kg.
3. All results are in mg/kg.
4. J = Estimated Value

50 25 0 50
Scale in Feet

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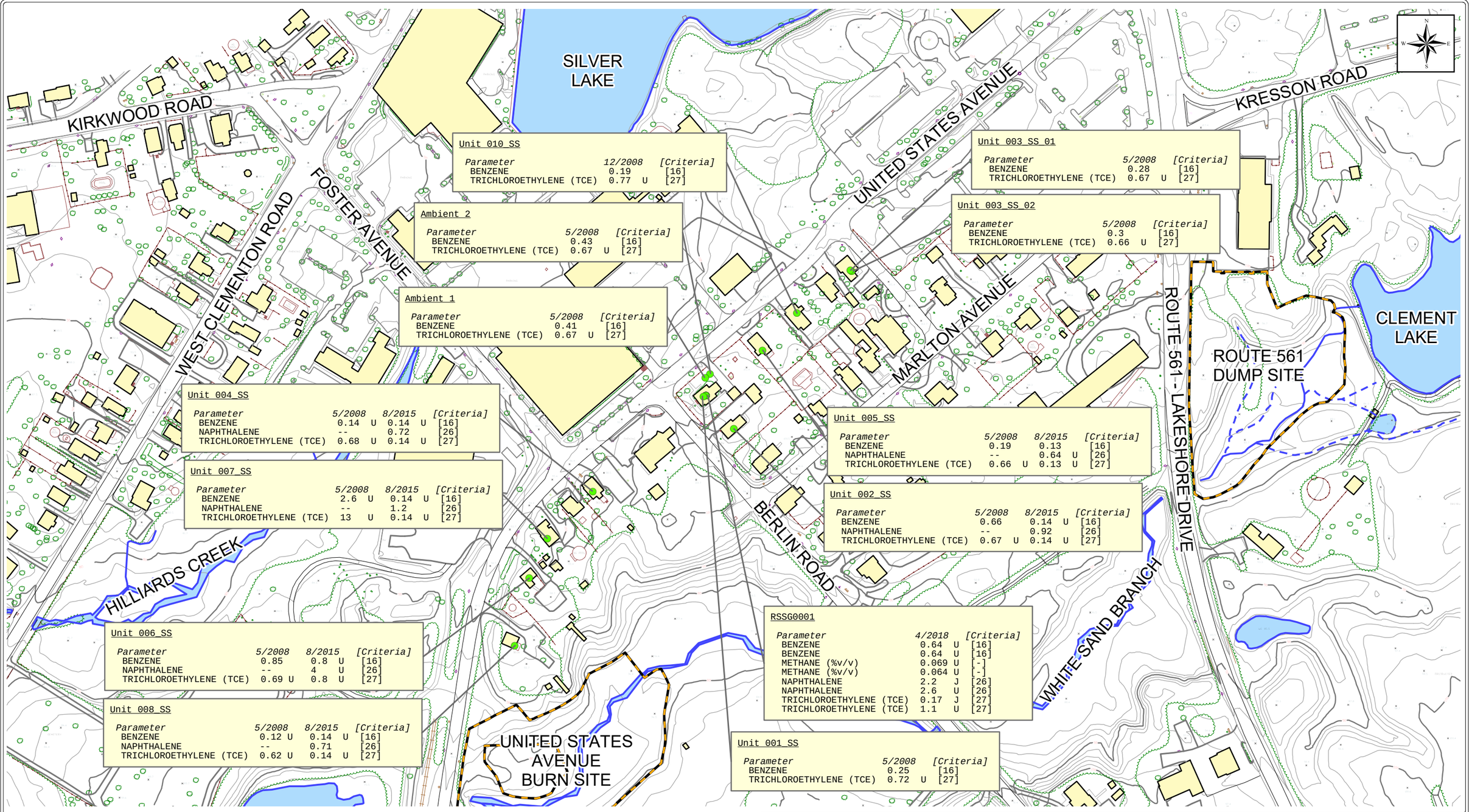
COVER THE EARTH
SHERWIN Williams

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: EASTERN OFF PROPERTY AREA SOIL SAMPLES - EXCEEDANCES [NJDEP RDCSRS]
DRAWING: 23288_FMP_EOP_Exceedances.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 23 / SCALE: 1 " = 50 ' / DATE: 1/10/2019



Unit 010 SS

Parameter	12/2008		[Criteria]
BENZENE	0.19		[16]
TRICHLOROETHYLENE (TCE)	0.77	U	[27]

Ambient 2

Parameter	5/2008		[Criteria]
BENZENE	0.43		[16]
TRICHLOROETHYLENE (TCE)	0.67	U	[27]

Ambient 1

Parameter	5/2008		[Criteria]
BENZENE	0.41		[16]
TRICHLOROETHYLENE (TCE)	0.67	U	[27]

Unit 004 SS

Parameter	5/2008		8/2015		[Criteria]
BENZENE	0.14	U	0.14	U	[16]
NAPHTHALENE	--		0.72		[26]
TRICHLOROETHYLENE (TCE)	0.68	U	0.14	U	[27]

Unit 007 SS

Parameter	5/2008		8/2015		[Criteria]
BENZENE	2.6	U	0.14	U	[16]
NAPHTHALENE	--		1.2		[26]
TRICHLOROETHYLENE (TCE)	13	U	0.14	U	[27]

Unit 006 SS

Parameter	5/2008		8/2015		[Criteria]
BENZENE	0.85		0.8	U	[16]
NAPHTHALENE	--		4	U	[26]
TRICHLOROETHYLENE (TCE)	0.69	U	0.8	U	[27]

Unit 008 SS

Parameter	5/2008		8/2015		[Criteria]
BENZENE	0.12	U	0.14	U	[16]
NAPHTHALENE	--		0.71		[26]
TRICHLOROETHYLENE (TCE)	0.62	U	0.14	U	[27]

Unit 003 SS 01

Parameter	5/2008		[Criteria]
BENZENE	0.28		[16]
TRICHLOROETHYLENE (TCE)	0.67	U	[27]

Unit 003 SS 02

Parameter	5/2008		[Criteria]
BENZENE	0.3		[16]
TRICHLOROETHYLENE (TCE)	0.66	U	[27]

Unit 005 SS

Parameter	5/2008		8/2015		[Criteria]
BENZENE	0.19		0.13		[16]
NAPHTHALENE	--		0.64	U	[26]
TRICHLOROETHYLENE (TCE)	0.66	U	0.13	U	[27]

Unit 002 SS

Parameter	5/2008		8/2015		[Criteria]
BENZENE	0.66		0.14	U	[16]
NAPHTHALENE	--		0.92		[26]
TRICHLOROETHYLENE (TCE)	0.67	U	0.14	U	[27]

RSSG0001

Parameter	4/2018		[Criteria]
BENZENE	0.64	U	[16]
BENZENE	0.64	U	[16]
METHANE (%v/v)	0.069	U	[-]
METHANE (%v/v)	0.064	U	[-]
NAPHTHALENE	2.2	J	[26]
NAPHTHALENE	2.6	U	[26]
TRICHLOROETHYLENE (TCE)	0.17	J	[27]
TRICHLOROETHYLENE (TCE)	1.1	U	[27]

Unit 001 SS

Parameter	5/2008		[Criteria]
BENZENE	0.25		[16]
TRICHLOROETHYLENE (TCE)	0.72	U	[27]

Legend

- Sub-Slab Soil Gas/Ambient Air Sample Location with No Exceedance(s)

Notes:
1. May/December 2008 samples were collected by EPA. All other samples were collected by Weston.
2. Benzene, Naphthalene, and Trichloroethylene results are in ug/m^3. Methane results are in %v/v.
3. All results are compared against the 2013 NJDEP Residential Soil Gas Screening Levels (RSGSL).
4. U – Undetected Value
5. J – Estimated
6. Red text indicates results that exceed NJDEP RSGSL.
7. Blue text indicates reporting limit that exceeds NJDEP RSGSL.

SCALE: 200 100 0 200
Graphic Scale In Feet

PROJECT: Former Manufacturing Plant Feasibility Study

CLIENT NAME: The Sherwin-Williams Company

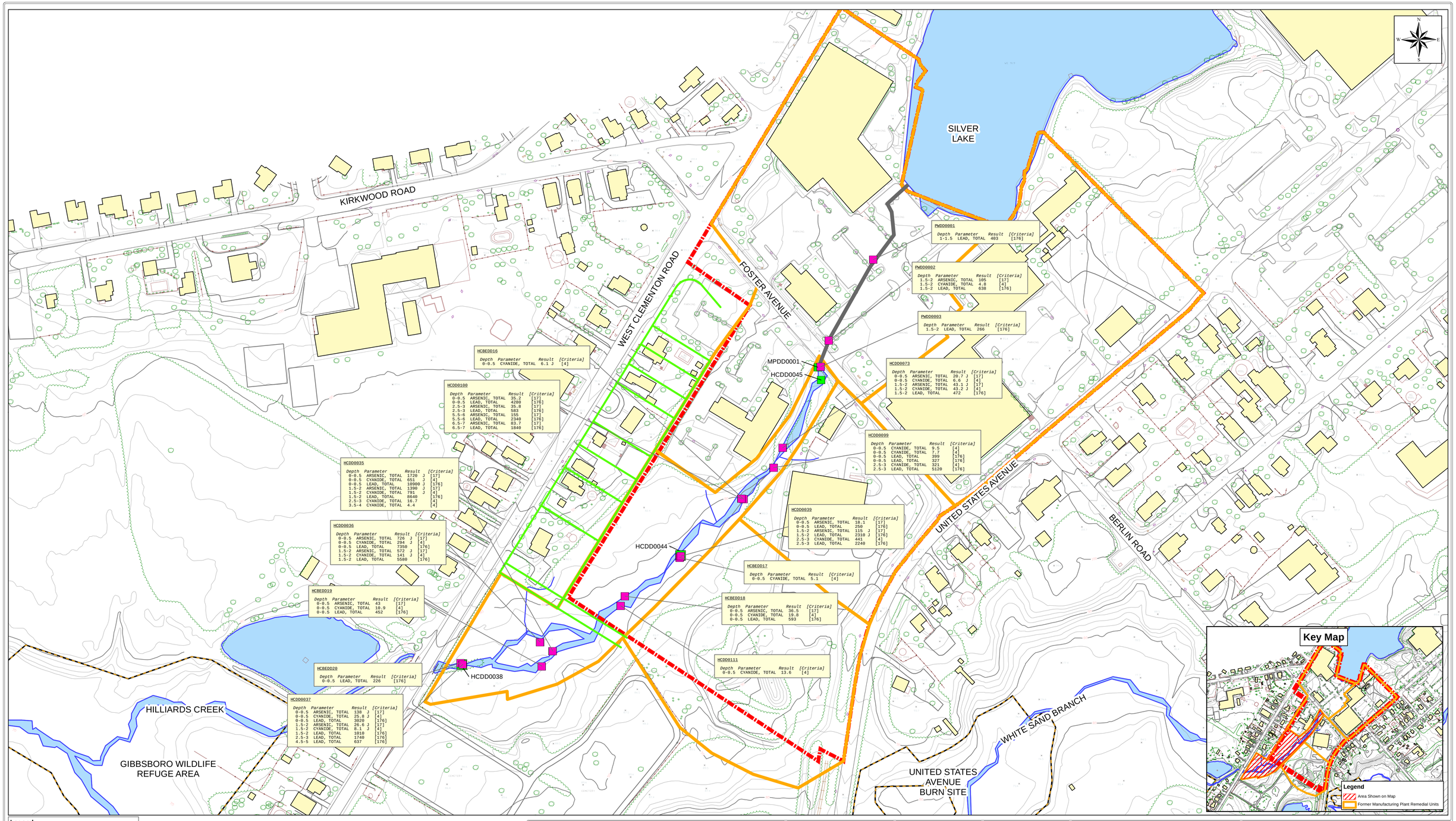
TITLE: EPA ERT VI INVESTIGATION
MAY AND DECEMBER 2008 EVENT
WESTON VI INVESTIGATION
AUGUST 2015 AND APRIL 2018 EVENTS
SUB-SLAB SOIL GAS RESULTS
BENZENE, METHANE, NAPHTHALENE, AND
TRICHLOROETHYLENE RESULTS ONLY

WESTON SOLUTIONS SM

DATE: January 2019

FIGURE #: 24

L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\23289_Res_2008_2015_2018_VI.mxd



Legend

- Sediment Sample Locations with Exceedance(s)
- Sediment Sample Locations with No Exceedance(s)
- Surveyed Property Boundary (2015)
- Former Manufacturing Plant Remedial Units
- Former Manufacturing Plant Extent
- Approximate Location of Silver Lake Conveyance
- Perennial Stream Channel
- Fence Boundary

100 50 0 100
Graphic Scale In Feet

Location ID — Analytical Flag

HCDD0037

Depth	Parameter	Result	[Criteria]
1.5-2	ARSENIC, TOTAL	1110 J	[17]
1.5-2	LEAD, TOTAL	4310 J	[176]

Collection Depth (ft) — Analytical Parameter — Concentration (mg/kg) — Criteria (mg/kg)

Notes
1. All results compared against the Sediment Ecological Preliminary Remediation Goals (PRGs).
2. All results are in mg/kg.
3. J - Estimated Result.
4. N - The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".

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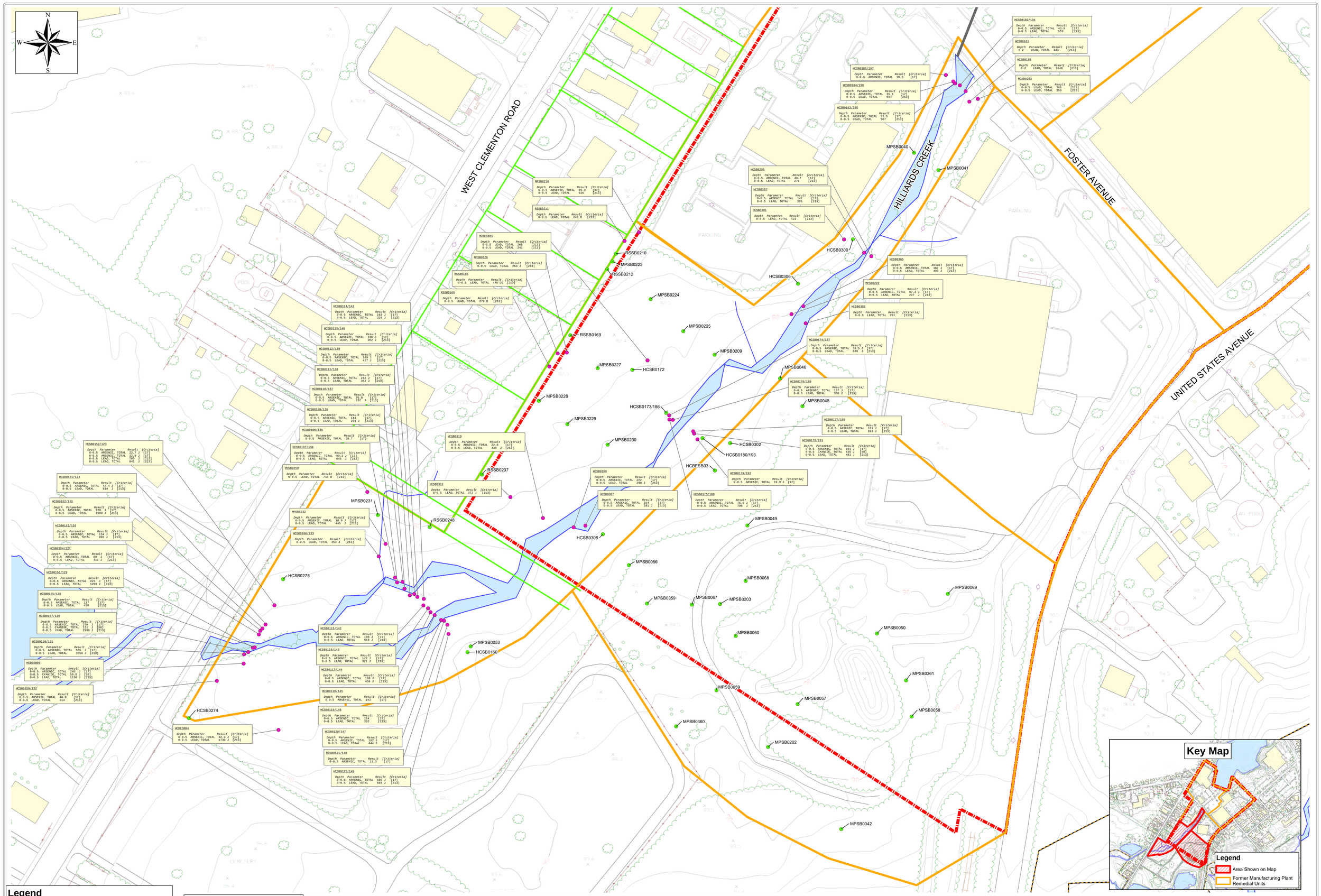
COVER THE EARTH
SHERWIN WILLIAMS

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: HILLIARDS CREEK SEDIMENT SAMPLES - EXCEEDANCES OF ARSENIC, CYANIDE, AND LEAD [SEDIMENT PRGs]
DRAWING: 23280_FMP_FS_Upper_HC_DD_Exceed_PRG.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 25 SCALE: 1 " = 100 ' DATE: 1/10/2019



Legend

- Soil Sample Location with Exceedance(s)
- Soil Sample Location with No Exceedance(s)
- Surveyed Property Boundary (2015)
- Former Manufacturing Plant Remedial Units
- Former Manufacturing Plant Extent
- Approximate Location of Silver Lake Conveyance
- Perennial Stream Channel
- Fence Boundary

Location ID — Analytical Parameter — Analytical Flag

HCBESB04

Depth Parameter Result [Criteria]
0-0.5 ARSENIC, TOTAL 32.3 J [17]

Sample Depth (ft) — Concentration (mg/kg) — Criteria (mg/kg)

Notes:
1. All results compared against the Ecological Preliminary Remediation Goals (PRGs) for Soil.
2. All results are in mg/kg.
3. U – Undetected Value
4. J – Estimated Value
5. JN – The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
6. UJ – The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
7. D – Diluted
8. R – Rejected Value
9. B – Analyte also detected in blank.

35 17.5 0 35
Scale in Feet

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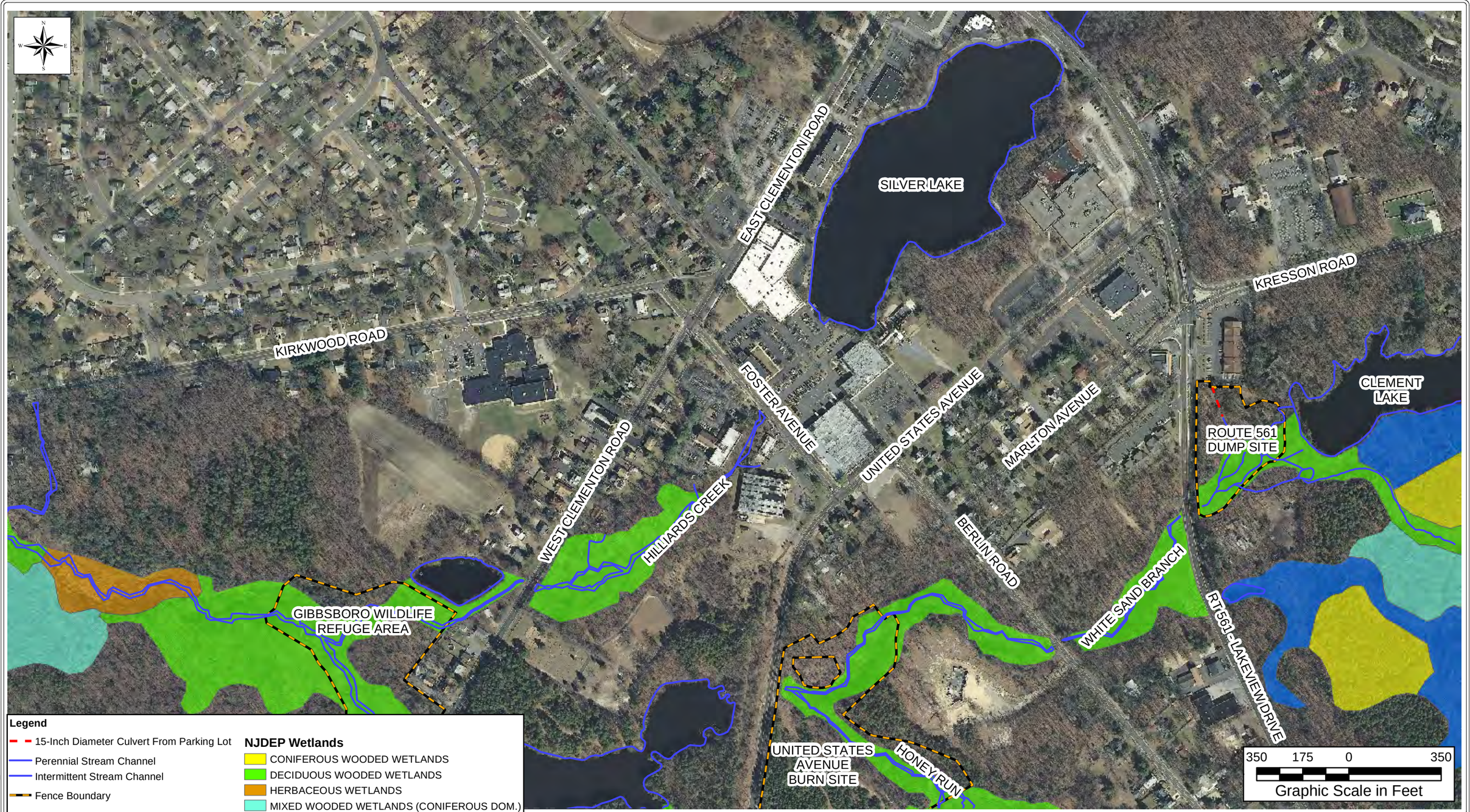
SHERWIN WILLIAMS

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: HILLIARDS CREEK AND LAGOON REMEDIAL UNITS SOIL SAMPLES - EXCEEDANCES OF ARSENIC, CYANIDE, AND LEAD UPPER 1-FOOT ONLY [SOIL PRGs]
DRAWING: 23281_FMP_FS_HC_Lagoon_Soil_PRG_Exceed_Top_Foot.mxd PATH: L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\	CHECKED BY: A. Fischer		
REVISION No. 0	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: K. Heulitt DATE CREATED: 1/3/2019		FIGURE: 26 SCALE: 1 " = 35 ' DATE: 1/10/2019



Legend

- 15-Inch Diameter Culvert From Parking Lot
- Perennial Stream Channel
- Intermittent Stream Channel
- Fence Boundary

NJDEP Wetlands

- CONIFEROUS WOODED WETLANDS
- DECIDUOUS WOODED WETLANDS
- HERBACEOUS WETLANDS
- MIXED WOODED WETLANDS (CONIFEROUS DOM.)
- MIXED WOODED WETLANDS (DECIDUOUS DOM.)

Notes:
1. Wetlands classifications are based on a NJDEP Modified Anderson System.
2. Wetland Classifications

Coniferous Wooded Wetlands - These wetlands are closed canopy, dominated by coniferous tree species associated with watercourses, seeps, and low topographic land. The northern areas will support Tsuga canadensis, Larix laricina, and Picea mariana as monotypic stands or mixed communities. The southern portion of the State has Pinus rigida and P. taeda in monotypic communities or co-dominate with Acer rubrum. Other species such as Nyssa sylvatica and Chamaecyparis thyoides may also be present. These species have photographic signatures that are varied in texture and are red to dark red on CIR imagery.

Deciduous Wooded Wetlands - These wetlands are closed canopy swamps dominated by deciduous trees normally associated with watercourses, edges of marshes, and isolated wetlands. The important canopy species includes Acer rubrum, Nyssa sylvatica, Fraxinus pennsylvanica, Salix nigra, Quercus bicolor, Q. phellos, Q. falcata, Liquidambar styraciflua, and Platanus occidentalis. These species combine to form a series of mixed hardwood lowland habitats throughout the entire state. These species have photographic signatures that exhibit height, rough texture, and are dark blue-gray to dark gray or black on CIR imagery (leaf-off conditions).

Herbaceous Wetlands - These are wetlands dominated by various herbaceous species that are not connected or associated with tidal waters. Lake edges, open flood plains and abandoned wetland agricultural fields are locations for this cover type. Leersia oryzoides, Phalaris arundinacea, Nuphar lutea, Polygonum arifolium, P. sagittatum, Typha latifolia and Phragmites are species that may dominate this cover type. Bog herbaceous vegetation will be covered by this section includes numerous Cyperaceae genera, Juncus sp. and the carnivorous genera of Drosera and Sarracenia. This cover type will have a similar photographic signature as 6120, varied texture, and light blue-gray or tan color on CIR imagery.

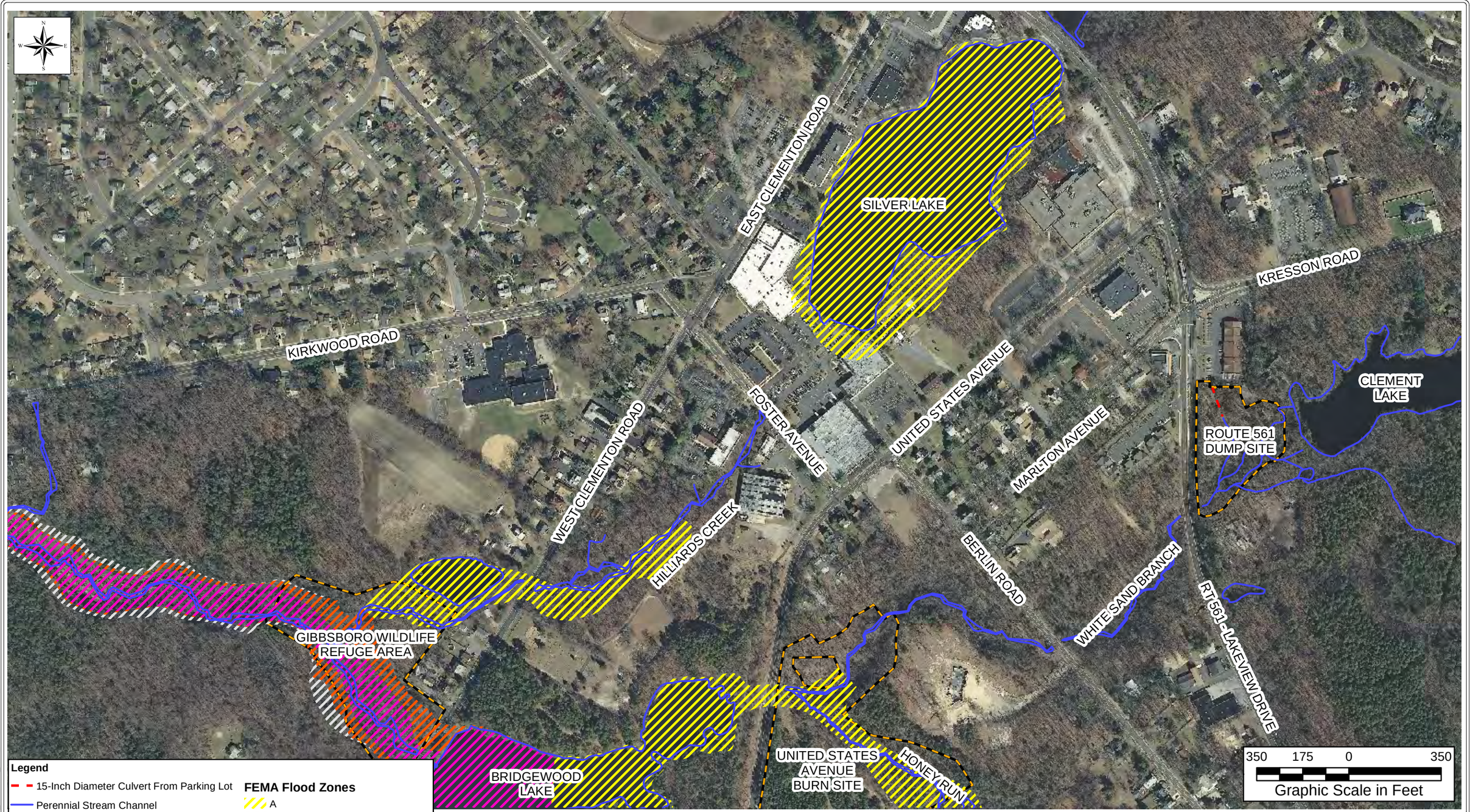
Mixed Wooded Wetlands (Coniferious Dominant) - This category contains mixed wooded wetlands with the coniferous tree species greater than 50% but less than 75%.

Mixed Wooded Wetlands (Deciduous Dominant) - This category contains mixed wooded wetlands with the deciduous tree species greater than 50% but less than 75%.

Sources:
1. NJDEP Office of Information Resources Management, Bureau of Geographic Information Systems. NJDEP 2012 Land Use/Land Cover Update, Edition 20150217 Subbasin 02040202 - Lower Delaware. http://www.nj.gov/dep/gis/lulc12c.html. February 2015.
2. NJ Office of Information Technology, Office of Geographic Information Systems. 2012 - 2013 High Resolution Orthophotography, http://njgin.nj.gov/OIT_IW/index.jsp. March 2013

PROJECT NAME:	Former Manufacturing Plant Feasibility Study
CLIENT NAME:	The Sherwin-Williams Company
REPORT DATE:	January 2019
TITLE:	FORMER MANUFACTURING PLANT WETLANDS MAP
DATE:	1/10/2019
FIGURE #:	27

L:\SHERWIN\GIS\MXD\2019_01_FMP_FS23282_FMP_RIR_Wetlands_Map.mxd



Legend

- 15-Inch Diameter Culvert From Parking Lot
- Perennial Stream Channel
- Intermittent Stream Channel
- Fence Boundary

FEMA Flood Zones

- A
- AE
- AE (Floodway)
- X (Area of Moderate Flood Hazard)

Notes:
1. FEMA Flood Zone Designations
   A - Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies.
   AE - Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods.
   X (shaded) - Moderate flood hazard areas. Areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood.
   X (not shaded) - Areas of minimal flood hazard. Areas outside the Special Flood Hazard Area and higher than the elevation of the 0.2-percent-annual-chance flood.

Sources:
1. FEMA. National Flood Hazard Layer. https://hazards.fema.gov/femaportal/NFHL/. June 2009.
2. NJ Office of Information Technology, Office of Geographic Information Systems. 2012 - 2013 High Resolution Orthophotography, http://njgin.nj.gov/OIT_IW/index.jsp. March 2013

L:\SHERWINGIS\MXD\2019_01_FMP_FS23283_FMP_RIR_FloodZone_Map.mxd

PROJECT NAME:	Former Manufacturing Plant Feasibility Study
CLIENT NAME:	The Sherwin-Williams Company
REPORT DATE:	January 2019
TITLE:	FORMER MANUFACTURING PLANT FLOOD ZONE MAP
DATE:	1/10/2019
FIGURE #:	28

Legend

- Fence Boundary
- Approximate Boundary of Former Manufacturing Plant

Source:
NJ Office of Information Technology, Office of Geographic Information Systems. 2012 - 2013 High Resolution Orthophotography, http://njgin.nj.gov/OIT_IW/index.jsp. March 2013.

L:\SHERWIN\GIS\MXD\2019_01_FMP_FS23284_FMP_RIR_Site_Coastal_Plain.mxd

PROJECT NAME:	Former Manufacturing Plant Feasibility Study
CLIENT NAME:	The Sherwin-Williams Company
REPORT DATE:	January 2019
TITLE:	FORMER MANUFACTURING PLANT NEW JERSEY COASTAL PLAIN PHYSIOGRAPHIC PROVINCES MAP
DATE:	1/10/2019
FIGURE #:	29

REGIONAL AQUIFER SYSTEM ANALYSIS

(Table 2 - Geologic and hydrogeologic units in the New Jersey Coastal Plain)

SYSTEM	SERIES	GEOLOGIC UNIT	LITHOLOGY	HYDROGEOLOGIC UNIT		HYDROGEOLOGIC CHARACTERISTICS
Quaternary	Holocene	Alluvial deposits	Sand, silt, and black mud	Undifferentiated		Surfical material, often connected to underlying aquifers. Locally some units may act as confining beds. Thicker sands are capable of yielding large quantities of water
		Beach sand and gravel	Sand, quartz, light colored, medium- to coarse grained, pebbly.			
	Pleistocene	Cape May Formation	Sand, quartz, light colored, heterogeneous, pebbly			
Tertiary	Miocene	Pennsauken Formation				
		Bridgetown Formation		Kirkwood-Cohansey Aquifer System		A major aquifer system. Ground water occurs generally under water table conditions. In Cape May County, the Cohansey Sand is a confined aquifer.
		Beacon Hill Gravel	Gravel, quartz, light colored, sandy			
		Cohansey Sand	Sand, quartz, light colored, medium- to coarse grained, pebbly; local clay beds			
		Kirkwood Formation	Sand, quartz, gray and tan, very fine to medium-grained, micaceous, and dark colored diatomaceous clay	Confining Bed		Thick diatomaceous clay bed occurs along coast and for a short distance inland. A thin water-bearing sand occurs within the middle of this unit.
				Rio Grande w-b (1,2)		
				Confining Bed (2)		
				Atlantic City 800-foot sand		A major aquifer along the coast.
				Composite Confining Bed		Alloway Clay Member or equivalent
	Eocene	Piney Point Formation	Sand, quartz and glauconite, fine to coarse grained		Piney Point Aquifer	Yields moderate quantities of water locally
		Shark River Formation	Clay, silty and sandy, glauconitic, green, gray, and brown, fine-grained quartz sand			Poorly permeable sediments
		Manasquan Formation				
	Paleocene	Vincentown Formation	Sand, quartz, gray and green, fine- to coarse-grained, glauconitic, and brown, clayey, very fossiliferous, glauconite and quartz calcarenite		Vincentown Aquifer	Yields small to moderate quantities of water in and near its outcrop area.
		Hornerstown Sand	Sand, clayey, glauconitic, dark green, fine- to coarse-grained			Poorly permeable sediments
Cretaceous	Upper Cretaceous	Tinton Sand	Sand, quartz, and glauconite, brown and gray, fine- to coarse-grained, clayey, micaceous			
		Red Bank Sand			Red Bank Sand (2)	Yields small to moderate quantities of water in and near its outcrop area.
		Navesink Formation	Sand, clayey, glauconitic, green and black, medium- to coarse-grained			Poorly permeable sediments
		Mount Laurel Sand	Sand, quartz, brown and gray, fine- to coarse-grained, slightly glauconitic	Wenonah-Mount Laurel Aquifer		A major aquifer
		Wenonah Formation	Sand, very fine to fine-grained, gray and brown, silty, slightly glauconitic			
		Marshalltown Formation	Clay, silty, dark greenish-gray, glauconitic quartz sand	Marshalltown-Wenonah Confining Bed		A leaky confining bed
		Englishtown Formation	Sand, quartz, tan and gray, fine- to medium-grained; local clay beds	Englishtown Aquifer System		A major aquifer. Two sand units in Monmouth and Ocean Counties.
		Woodbury Clay	Clay, green and black, micaceous silt	Merchantville-Woodbury Confining Bed		A major confining bed. Locally the Merchantville Fm. may contain a thin water-bearing sand.
		Merchantville Formation	Clay, glauconitic, micaceous, gray and black; locally very fine grained quartz and glauconitic sand			
		Magothy Formation	Sand, quartz, light-gray, fine- to coarse-grained; local beds of dark-gray lignitic clay	Potomic-Raritan-Magothy Aquifer	Upper Aquifer	A major aquifer system. In the Northern Coastal Plain, the upper aquifer is equivalent to the Old Bridge aquifer, and the middle aquifer is the equivalent of the Farrington aquifer. In the Delaware River Valley, three aquifers are recognized. In the deeper subsurface, units below the upper aquifer are undifferentiated.
		Raritan Formation	Sand, quartz, light-gray, fine- to coarse-grained, pebbly, arkosic, red, white, and variegated clay.		Conf. Bed	
		Potomac Group	Alternating clay, silt, sand, and gravel		Middle Aquifer	
					Conf. Bed	
	Lower Cretaceous				Lower Aquifer	
Pre-Cretaceous		Bedrock	Precambrian and lower Paleozoic crystalline rocks, metamorphic schist, and gneiss; locally Triassic basalt, sandstone, and shale and Jurassic diabase	Bedrock confining bed		No wells obtain water from these consolidated rocks, except the fall line.

Modified from Seaber, 1965, table 3

Footnotes:
1 - Rio Grande water-bearing zone
2 - Minot aquifer not mapped in this report.

PROJECT NAME:
Former Manufacturing Plant Feasibility Study

CLIENT NAME:
The Sherwin-Williams Company

TITLE:
FORMER MANUFACTURING PLANT GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE NJ COASTAL PLAIN

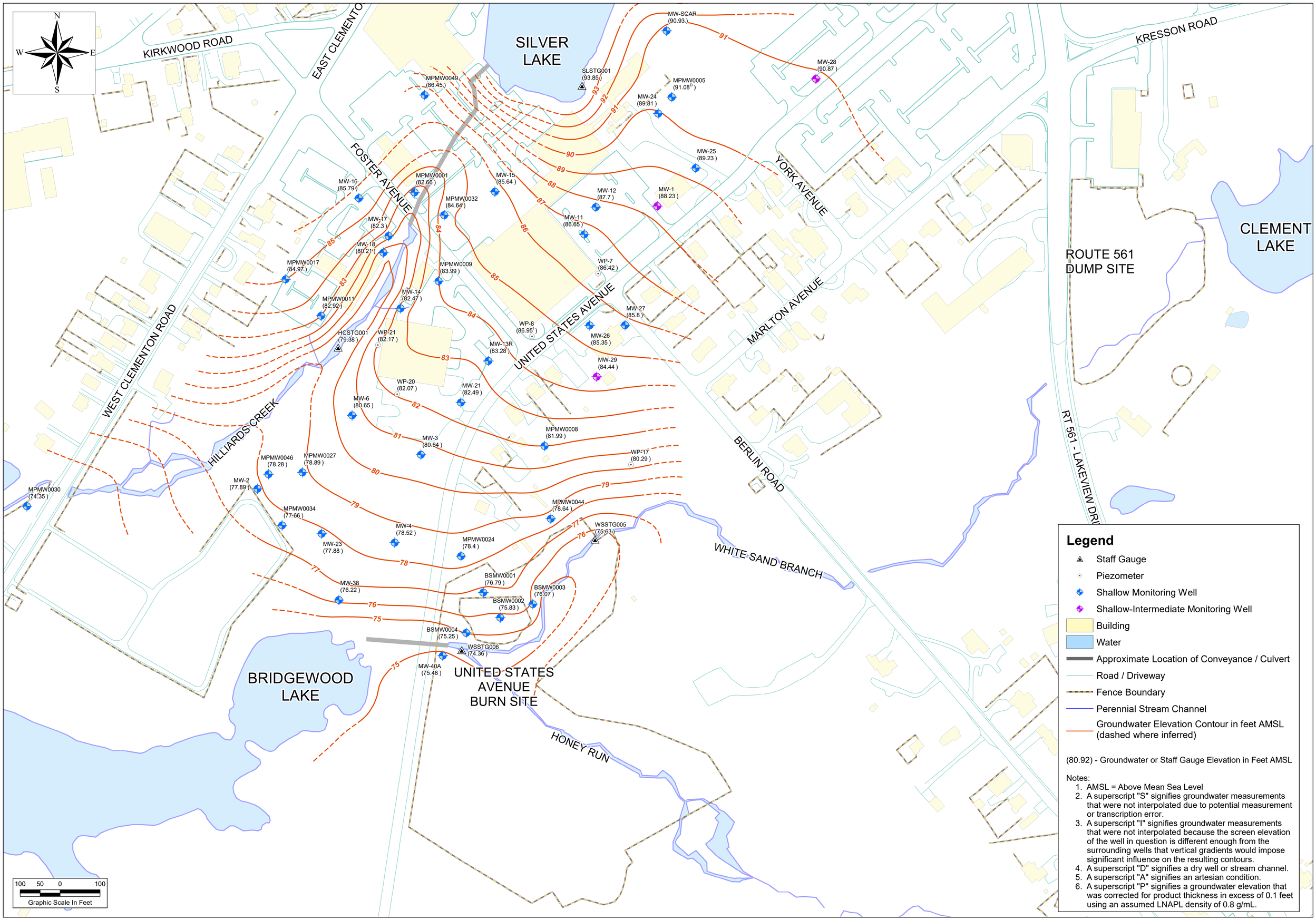
REFERENCE:
Zapecza, O.S., 1989, Hydrogeologic Framework of the New Jersey Coastal Plain, U.S. Geological Survey Professional Paper 1404-B, 49 p., 24 plates.

WESTON SOLUTIONS

DATE: 1/10/2019

FIGURE #: 30

L:\SHERWIN\GIS\MXD\2019_01_FMP_FS\23285_FMP_RIR_Geo_Hydrogeo_Units.mxd



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205 Campus Drive Edison, New Jersey 08837-3939
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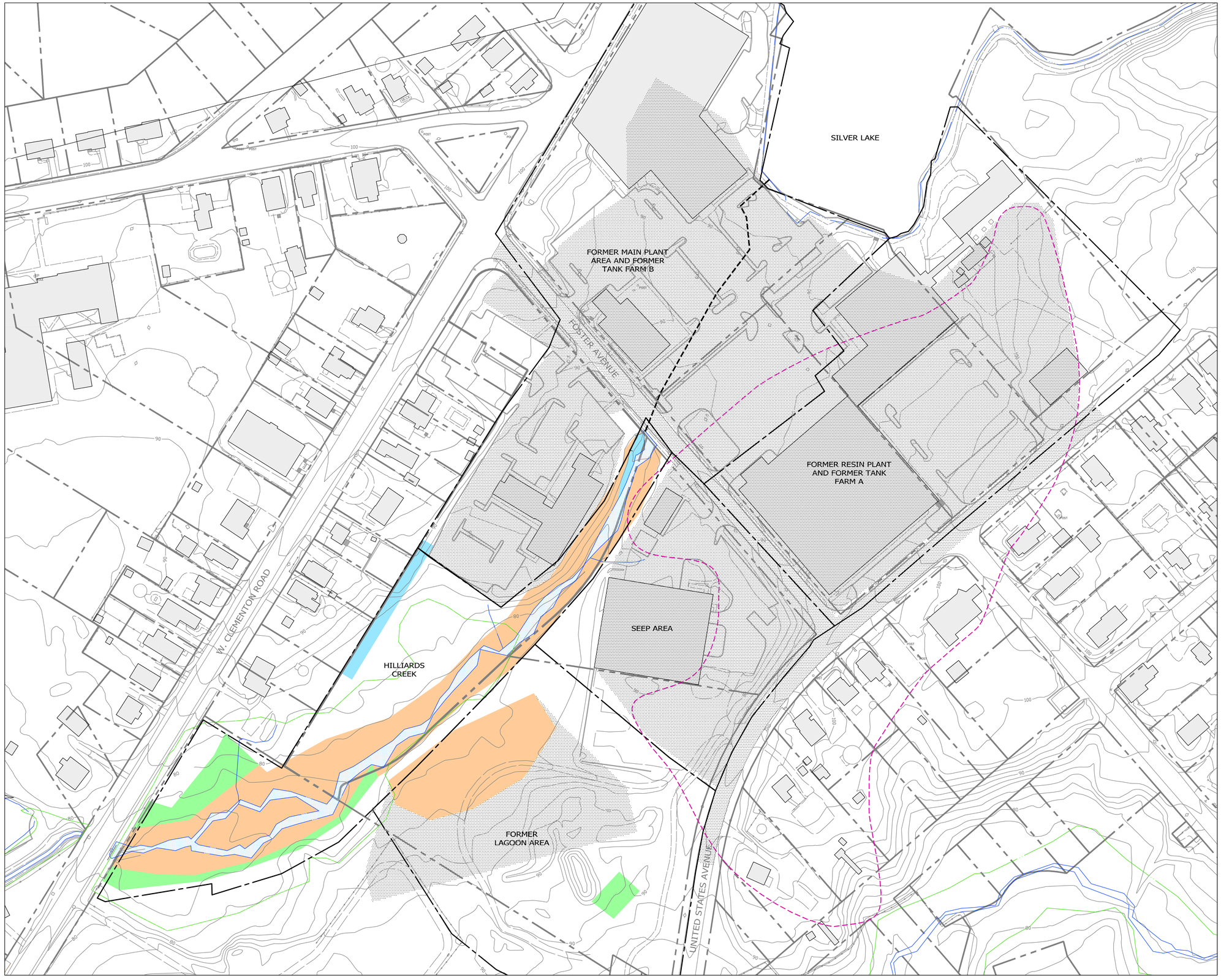
http://www.westonsolutions.com

SHERWIN WILLIAMS

REPORT DATE: January 2019	PROJECT MANAGER: D. Kane	CLIENT NAME: The Sherwin-Williams Company	DRAWING TITLE: GROUNDWATER CONTOURS SHALLOW WELLS 2017-08-18 SYNOPTIC ROUND SHERWIN-WILLIAMS/HILLIARDS CREEK SITE GIBBSBORO, NEW JERSEY
DRAWING: SW_Shallow_Aug2017b.mxd PATH: C:\Projects\Gibbsboro\GIS\mxd\2017_FMP_GW_TechMemo	CHECKED BY: P. Landry		
REVISION No. 1	CONTRACT No. DELIVERY ORDER NO.	PROJECT NAME: Former Manufacturing Plant Feasibility Study	
WORK ORDER No. 20076.022.090.0008	DRAWN/MODIFIED BY: D. Strobridge DATE CREATED: 1/4/2018		FIGURE: 31 / SCALE: 1 " = 100 ' / DATE: 1/10/2019



LEGEND

- INTERPRETED EXTENT OF LNAPL
- PROPERTY LINE
- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- 1-FOOT EXCAVATION FOR PRGs AND NO CAP
- 2-FOOT EXCAVATION FOR PRGs AND RDCSRS AND NO CAP
- 2-FOOT EXCAVATION FOR PRGs AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 2 FEET
- EXISTING SURFACE COVER REMAINS AND IS MAINTAINED AS CAP

NOTES:

1. PRG - PRELIMINARY REMEDIATION GOALS.
2. RDCSRS - NEW JERSEY DEPARTMENT ENVIRONMENTAL PROTECTION RESIDENTIAL DIRECT CONTACT SOIL REMEDIATION STANDARDS.
3. ALL CAPS REPRESENT ENGINEERING CONTROLS.
4. DEED NOTICES ARE TO BE ESTABLISHED AS INSTITUTIONAL CONTROLS FOR ALL PROPERTIES WITH A CAP.
5. LNAPL MANUAL RECOVERY TO BE IMPLEMENTED FOR THE SEEP AREA AND THE FORMER RESIN PLANT AND TANK FARM A UTILIZING EXISTING MONITORING WELLS.

SOURCE:

1. BASEMAP, WESTON SOLUTIONS, 2016.
2. PARCELS OF CAMDEN COUNTY, NEW JERSEY 2016, CAMDEN COUNTY IMPROVEMENT AUTHORITY, 2/26/2014, GIS SHP FILE http://njgin.state.nj.us/NJ_NJGINExplorer/DataDownloads.jsp

0 70 140

SCALE: 1" = 70'

TITLE:

FIGURE 32
SOIL REMEDIAL ALTERNATIVE 2

LOCATION:

THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

DATE: 1/10/19

FILENAME: 204027_FMP_FS_SOIL

LAYOUT: SOIL_ALT2_R1

THE ELM GROUP
345 WALL STREET, PRINCETON, NEW JERSEY 08540
4936 YORK ROAD, SUITE 1000, HOLICONG, PENNSYLVANIA 18928
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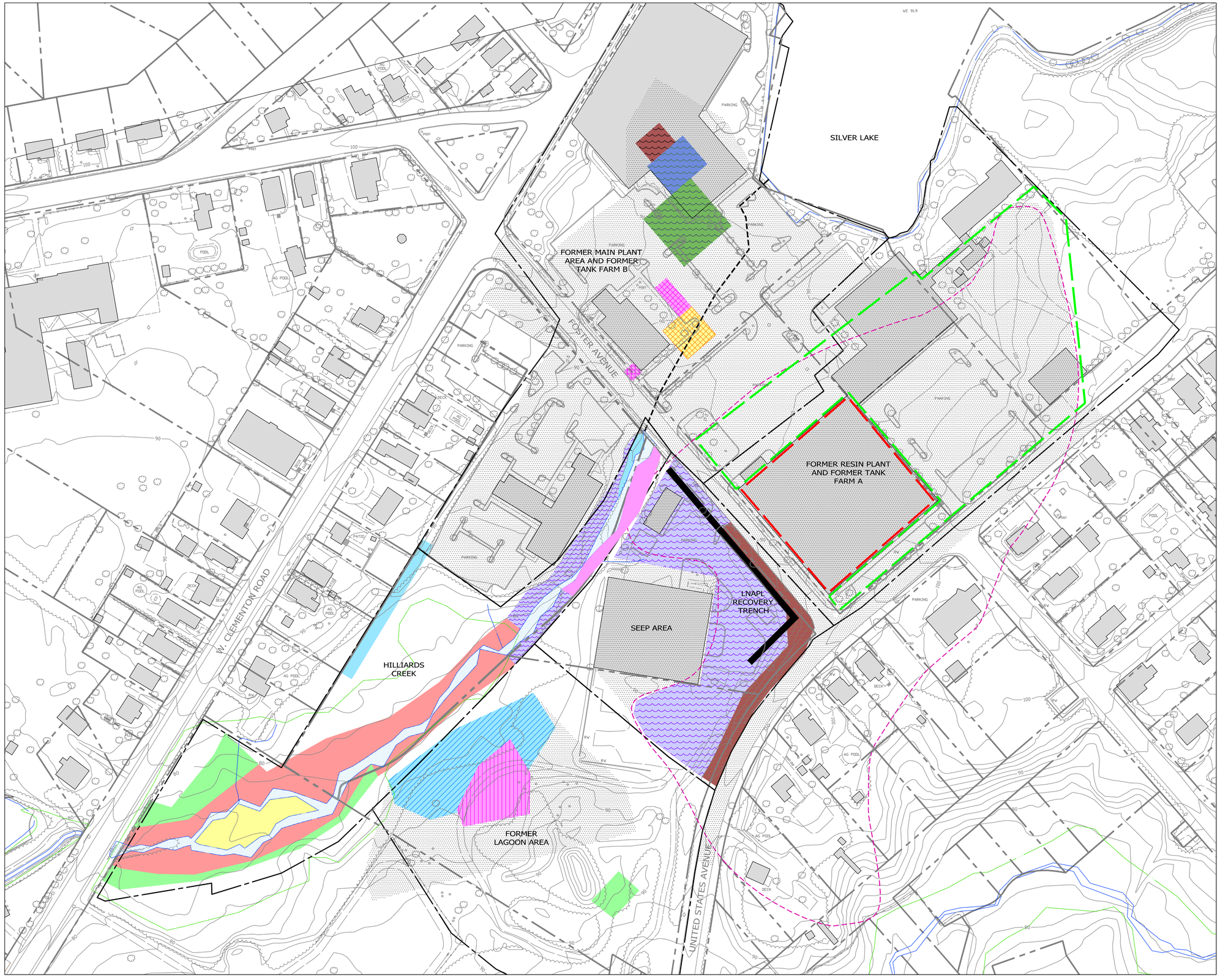

LEGEND

- INTERPRETED EXTENT OF LNAPL
- PROPERTY LINE
- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- 1-FOOT EXCAVATION FOR PRGs AND NO CAP
- 2-FOOT EXCAVATION FOR PRGs AND RDCSRS AND NO CAP
- 3-FOOT EXCAVATION FOR PRGs AND RDCSRS AND NO CAP
- 4-FOOT EXCAVATION FOR PRGS AND RDCSRS AND NO CAP
- 5-FOOT EXCAVATION FOR PRGs AND RDCSRS AND NO CAP
- 6-FOOT EXCAVATION FOR PRGS AND RDCSRS AND NO CAP
- 2-FOOT EXCAVATION FOR PRGs AND RDCSRS AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 2 FEET
- 6-FOOT EXCAVATION FOR PRGS AND RDCSRS AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 6 FEET
- 4-FOOT EXCAVATION FOR TSCA COMPLIANCE AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 4 FEET
- 6-FOOT EXCAVATION FOR TSCA COMPLIANCE AND CAP FOR CONSTITUENTS GREATER THAN RDCSRS AT DEPTHS GREATER THAN 6 FEET
- 5-FOOT EXCAVATION FOR GROUND WATER SOURCE CONTROL AND NO CAP
- 10-FOOT EXCAVATION FOR GROUND WATER SOURCE CONTROL AND NO CAP
- 12-FOOT EXCAVATION FOR GROUND WATER SOURCE CONTROL AND NO CAP
- 15-FOOT EXCAVATION FOR GROUND WATER SOURCE CONTROL AND NO CAP
- EXISTING SURFACE COVER REMAINS AND IS MAINTAINED AS CAP
- EXTENT OF LNAPL EXTRACTION RECOVERY SYSTEM
- EXTENT OF LNAPL BIOREMEDIATION TREATMENT AREA

NOTES:
1. PRG - PRELIMINARY REMEDIATION GOALS.
2. RDCSRS - NEW JERSEY DEPARTMENT ENVIRONMENTAL PROTECTION RESIDENTIAL DIRECT CONTACT SOIL REMEDIATION STANDARDS.
3. ALL CAPS REPRESENT ENGINEERING CONTROLS.
4. DEED NOTICES ARE TO BE ESTABLISHED AS INSTITUTIONAL CONTROLS FOR PORTIONS OF FOSTER AVENUE AND UNITED STATES AVENUE.
5. PRGs APPLY TO THE TOP 1 FOOT OF SOIL IN UNDEVELOPED AREAS.
6. TSCA-EPA TOXIC SUBSTANCE COMPLIANCE ACT (40 CFR 760) - REMOVAL OF POLYCHLORINATED BIPHENYLS (PCBs) ABOVE 50 mg/Kg.

SOURCE:
1. BASEMAP, WESTON SOLUTIONS, 2016.
2. PARCELS OF CAMDEN COUNTY, NEW JERSEY 2016, CAMDEN COUNTY IMPROVEMENT AUTHORITY, 2/26/2014, GIS SHP FILE http://njgin.state.nj.us/NJ_NJGINExplorer/DataDownloads.jsp

0 70 140
SCALE: 1" = 70'

TITLE:
FIGURE 33
SOIL REMEDIAL ALTERNATIVE 3

LOCATION:
THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

DATE: 7/19/19

FILENAME: 204027_FMP_FS_SOIL_REV3

LAYOUT: SOIL ALT3 R2

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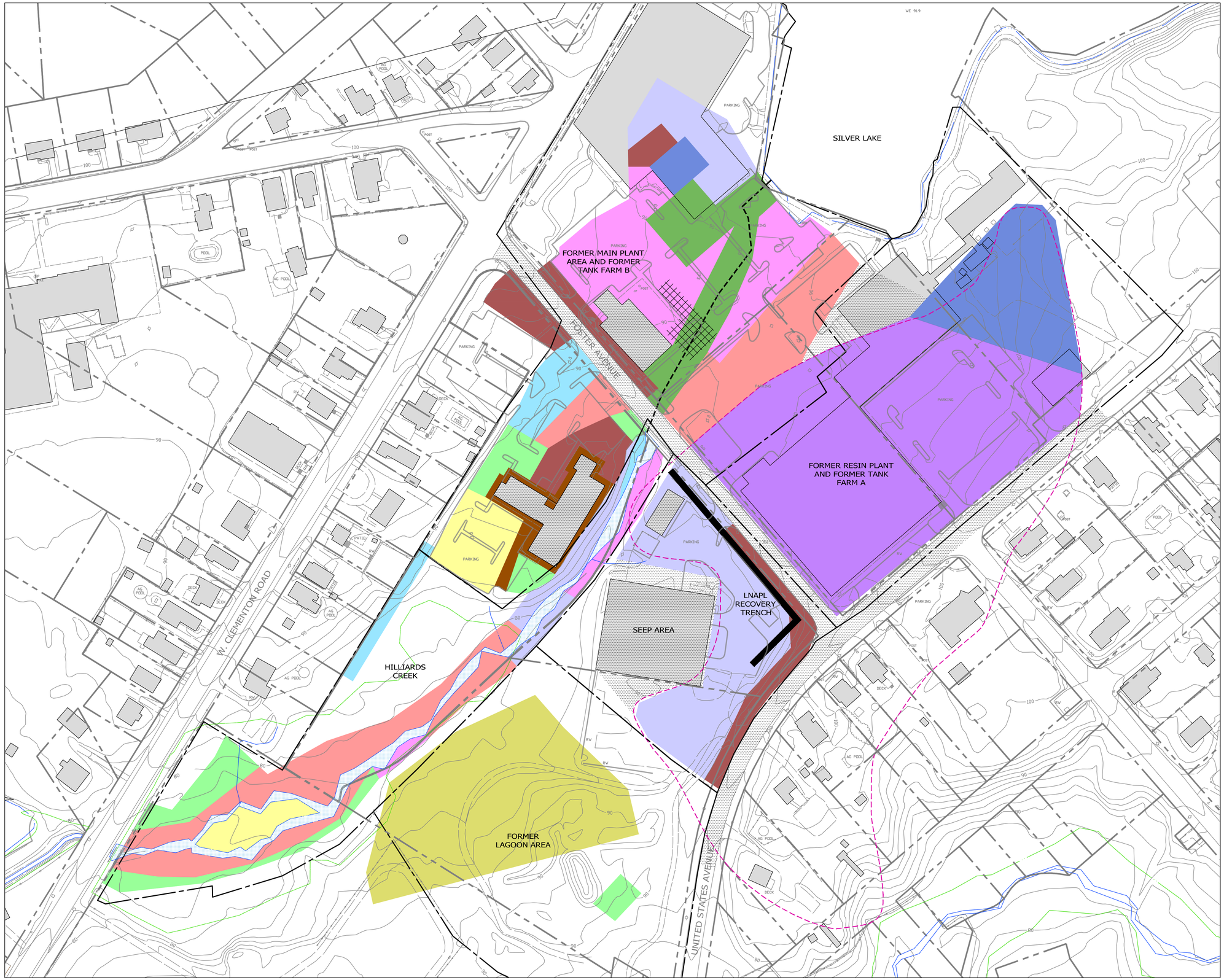

LEGEND

- INTERPRETED EXTENT OF LNAPL
- PROPERTY LINE
- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- 1-FOOT EXCAVATION AND NO CAP
- 2-FOOT EXCAVATION AND NO CAP
- 3-FOOT EXCAVATION AND NO CAP
- 4-FOOT EXCAVATION AND NO CAP
- 5-FOOT EXCAVATION AND NO CAP
- 6-FOOT EXCAVATION AND NO CAP
- 8-FOOT EXCAVATION AND NO CAP
- 10-FOOT EXCAVATION AND NO CAP
- 12-FOOT EXCAVATION AND NO CAP
- 15-FOOT EXCAVATION AND NO CAP
- 20-FOOT EXCAVATION AND NO CAP
- 25-FOOT EXCAVATION AND NO CAP
- TSCA PCB 4 AND 6-FOOT EXCAVATIONS
- EXISTING SURFACE COVER REMAINS AND IS MAINTAINED AS CAP

NOTES:

1. PRG - PRELIMINARY REMEDIATION GOALS.
2. RDCSRS - NEW JERSEY DEPARTMENT ENVIRONMENTAL PROTECTION RESIDENTIAL DIRECT CONTACT SOIL REMEDIATION STANDARDS.
3. ALL CAPS REPRESENT ENGINEERING CONTROLS.
4. DEED NOTICES ARE TO BE ESTABLISHED AS INSTITUTIONAL CONTROLS FOR PORTION OF FOSTER AVENUE AND UNITED STATES AVENUE.
5. PRGs APPLY TO THE TOP 1 FOOT OF SOIL IN UNDEVELOPED AREAS.
6. TSCA-EPA TOXIC SUBSTANCE COMPLIANCE ACT (40 CFR 760) - REMOVAL OF POLYCHLORINATED BIPHENYLS (PCBs) ABOVE 50 mg/Kg.

SOURCE:

1. BASEMAP, WESTON SOLUTIONS, 2016.
2. PARCELS OF CAMDEN COUNTY, NEW JERSEY 2016, CAMDEN COUNTY IMPROVEMENT AUTHORITY, 2/26/2014, GIS SHP FILE http://njgin.state.nj.us/NJ_NJGINExplorer/DataDownloads.jsp

0 70 140

SCALE: 1" = 70'

TITLE:

FIGURE 34
SOIL REMEDIAL ALTERNATIVE 4

LOCATION:

THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

DATE: 7/19/19

FILENAME: 204027_FMP_FS_SOIL_REV3

LAYOUT: SOIL_ALT4_R2

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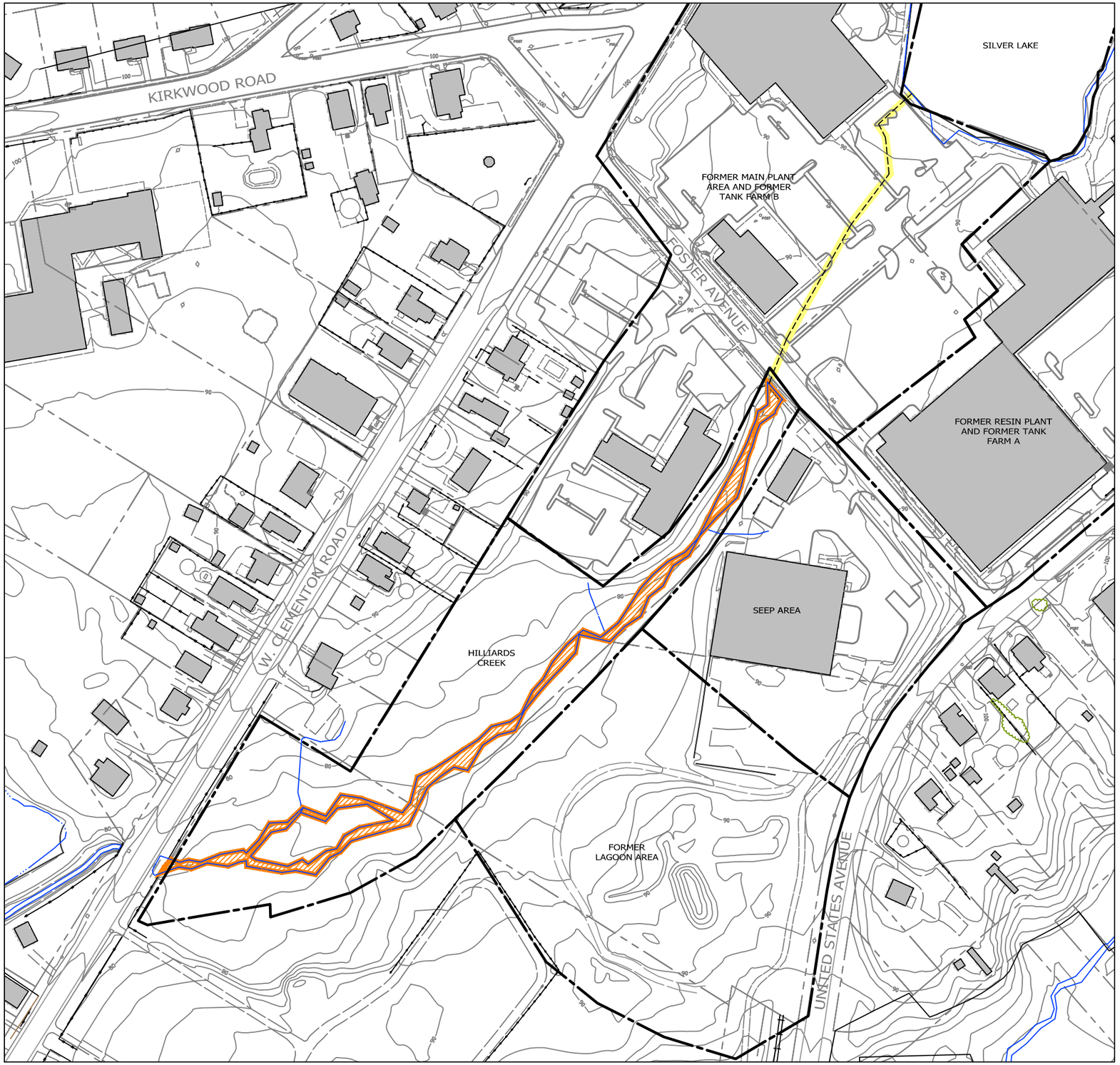

LEGEND

- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- 1-FOOT EXCAVATION DEPTH AND 0.75-FOOT CAP
- SILVER LAKE CONVEYANCE
- REMOVAL OF ALL SEDIMENT FROM CONVEYANCE LINE

NOTES:
1. PRGs - PRELIMINARY REMEDIATION GOALS.
2. REMEDIAL ALTERNATIVE INCLUDES TARGETED REMOVAL OF SURFACE SEDIMENT WITH CONTAMINANT CONCENTRATIONS GREATER THAN PRGs, CAPPING AND NATURAL RECOVERY.

SOURCE:
1. BASEMAP, WESTON SOLUTIONS, 2016.

0 150 300

SCALE: 1" = 150'

TITLE: FIGURE 35

SEDIMENT ALTERNATIVE 2

LOCATION:

THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

DATE: 1/10/19

FILENAME: 204027_FMP_SED

LAYOUT: FS_FMP_SED_ALT2_R1

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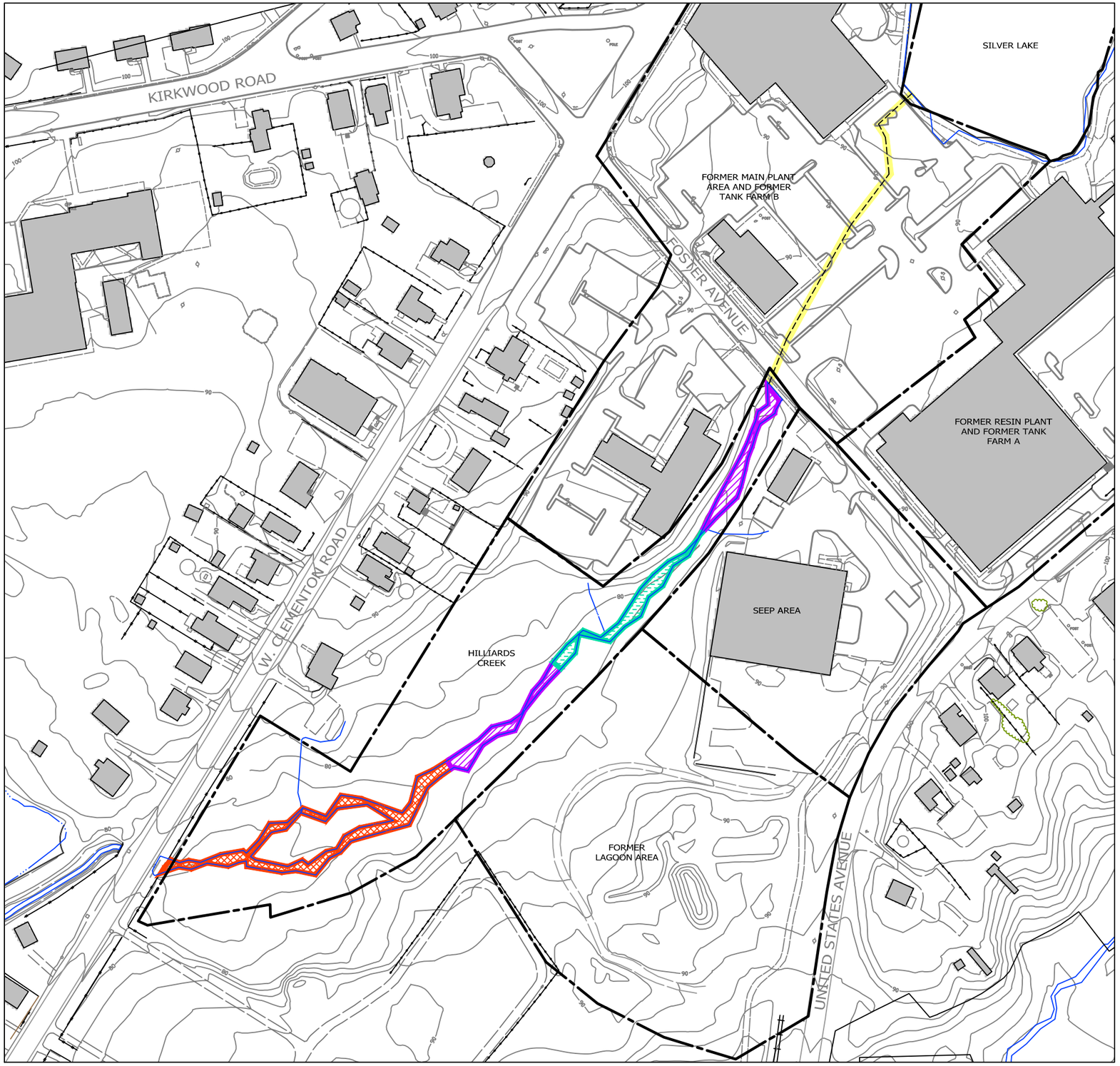

LEGEND

- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- 2-FOOT EXCAVATION DEPTH
- 5-FOOT EXCAVATION DEPTH AND 4-FOOT BACKFILL
- 7-FOOT EXCAVATION DEPTH AND 6-FOOT BACKFILL
- SILVER LAKE CONVEYANCE
- REMOVAL OF ALL SEDIMENT FROM CONVEYANCE LINE

NOTES:
1. PRGs - PRELIMINARY REMEDIATION GOALS.
2. PROPOSED EXCAVATIONS ARE TO REMEDIATE ALL SEDIMENT WITH CONTAMINANT CONCENTRATIONS EXCEEDING THE PRGs.

SOURCE:
1. BASEMAP, WESTON SOLUTIONS, 2016.

0 150 300

SCALE: 1" = 150'

TITLE: FIGURE 36

SEDIMENT ALTERNATIVE 3

LOCATION:

THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

DATE: 1/10/19

FILENAME: 204027_FMP_SED

LAYOUT: FS_FMP_SED_ALT3_R1

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Comparison of FMP Site Soil Alternatives

Soil Alternative	Protection of Public Health and the Environment	Compliance with ARARs	Permanence and Long-Term Effectiveness	Reduction of Toxicity, Mobility, Volume through Treatment	Short Term Effectiveness	Implementability	Cost
No Action	○	○	○	◔	●	●	●
Surface Soil Removal and Capping	◕	◑	◑	◔	◕	◕	◕
GW Source, Surface Soil	●	●	●	◑	◑	◑	◔
Extensive Excavation	●	●	●	○	○	○	○

LEGEND

● ◕ ◑ ◔ ○

Good ----------→ Poor

TITLE:	FIGURE 37 EVALUATION OF SITE SOIL ALTERNATIVES
LOCATION:	FORMER MANUFACTURING PLANT SITE GIBBSBORO, CAMDEN COUNTY, NEW JERSEY
DATE:	1/10/19
FILENAME:	2040247_FMP_FS_FIG_37_EVAL_SOIL_ALT.VSD

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Comparison of FMP Sediment Alternatives

Sediment Alternative	Protection of Public Health and the Environment	Compliance with ARARs	Permanence and Long-Term Effectiveness	Reduction of Toxicity, Mobility, Volume through Treatment	Short Term Effectiveness	Implementability	Cost
No Action	○	○	○	○	●	●	●
Surface Removal and Capping	●	●	●	○	◐	◐	◐
Removal to PRGs	●	●	●	○	◐	◐	◕

LEGEND

TITLE: FIGURE 38

EVALUATION OF SEDIMENT ALTERNATIVES

LOCATION: FORMER MANUFACTURING PLANT SITE GIBBSBORO, CAMDEN COUNTY, NEW JERSEY

DATE: 1/10/19

FILENAME: 2040247_FMP_FS_FIG_38_EVAL_SED_ALT.VSD

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Comparison of FMP Surface Water Alternatives

Surface Water Alternative	Protection of Public Health and the Environment	Compliance with ARARs	Permanence and Long-Term Effectiveness	Reduction of Toxicity, Mobility, Volume through Treatment	Short Term Effectiveness	Implementability	Cost
No Action	●	●	●	○	●	●	●
Institutional Controls	●	●	●	○	◔	●	◑

LEGEND

● ◔ ◑ ◕ ○

Good ----------→ Poor

TITLE: FIGURE 39

EVALUATION OF SURFACE WATER ALTERNATIVES

LOCATION:
FORMER MANUFACTURING PLANT SITE
GIBBSBORO, CAMDEN COUNTY,
NEW JERSEY

DATE: 1/10/19

FILENAME:
2040247_FMP_FS_FIG_39_EVAL_SW_ALT.VSD

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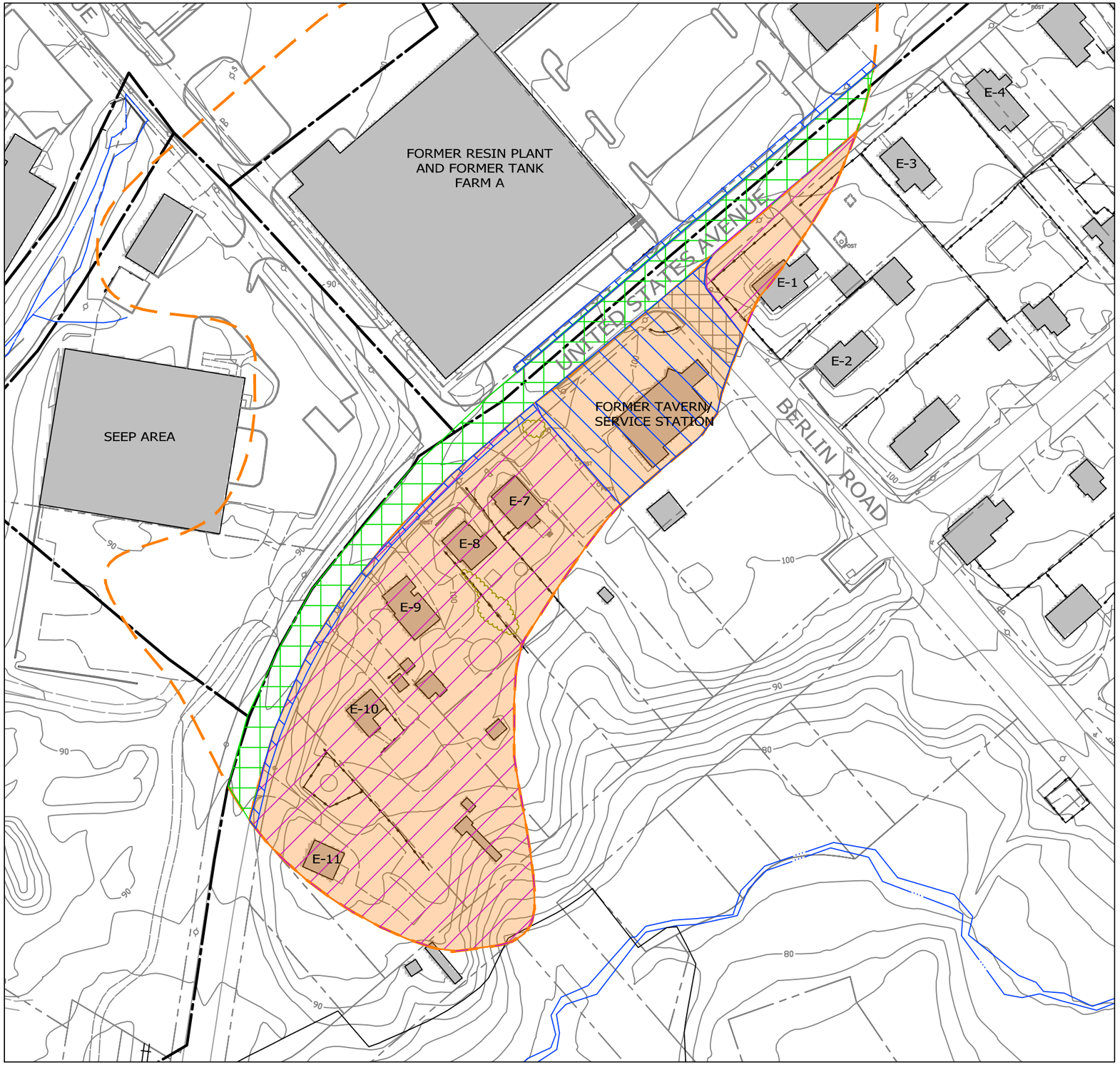

LEGEND

- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- INTERPRETED EXTENT OF LNAPL FOR EASTERN OFF-PROPERTY AREA TO BE ADDRESS BY FEASIBILITY STUDY
- INTERPRETED EXTENT OF LNAPL
- AMENDMENT INJECTIONS USING DIRECT-PUSH
- SOIL GAS EXTRACTION AND PRESSURIZED AMENDMENT INJECTIONS
- CONTINGENT AMENDMENT INJECTIONS USING DIRECT-PUSH
- EXISTING SURFACE COVER REMAINS AND IS MAINTAINED AS A CAP

NOTES:

1. ALTERNATIVE 2 IS ENHANCED LNAPL BIODEGRADATION AND SOIL GAS REMOVAL.
2. INJECTION WELLS AND SOIL GAS EXTRACTIONS WELLS TO BE INSTALLED ON THE FORMER TAVERN/SERVICE STATION PROPERTY AND ON WEST SIDE OF UNITED STATES AVENUE.
3. PRESSURIZED NUTRIENT INJECTION WELLS TO BE INSTALLED ALONG THE UNITED STATES AVENUE RIGHT OF WAY EAST OF UNITED STATES AVENUE AND SOUTH OF THE FORMER TAVERN/SERVICE STATION.
4. DIRECT-PUSH NUTRIENT INJECTIONS WOULD BE INSTALLED BENEATH PROPERTIES E-1, E-7, E-8, E-9, E-10 AND E-11 WHERE LNAPL IS PRESENT.
5. OPERATION OF A NUTRIENT INJECTION AND SOIL GAS RECOVERY SYSTEMS.

SOURCE:

1. BASEMAP, WESTON SOLUTIONS, 2016.

0 100 200

SCALE: 1" = 100'

TITLE: FIGURE 40

EASTERN OFF-PROPERTY AREA ALTERNATIVE 2

LOCATION:

THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

DATE: 01/10/2019

FILENAME: 204027_FMP_FS_REV1

LAYOUT: EOP_LNAPL_ALT2

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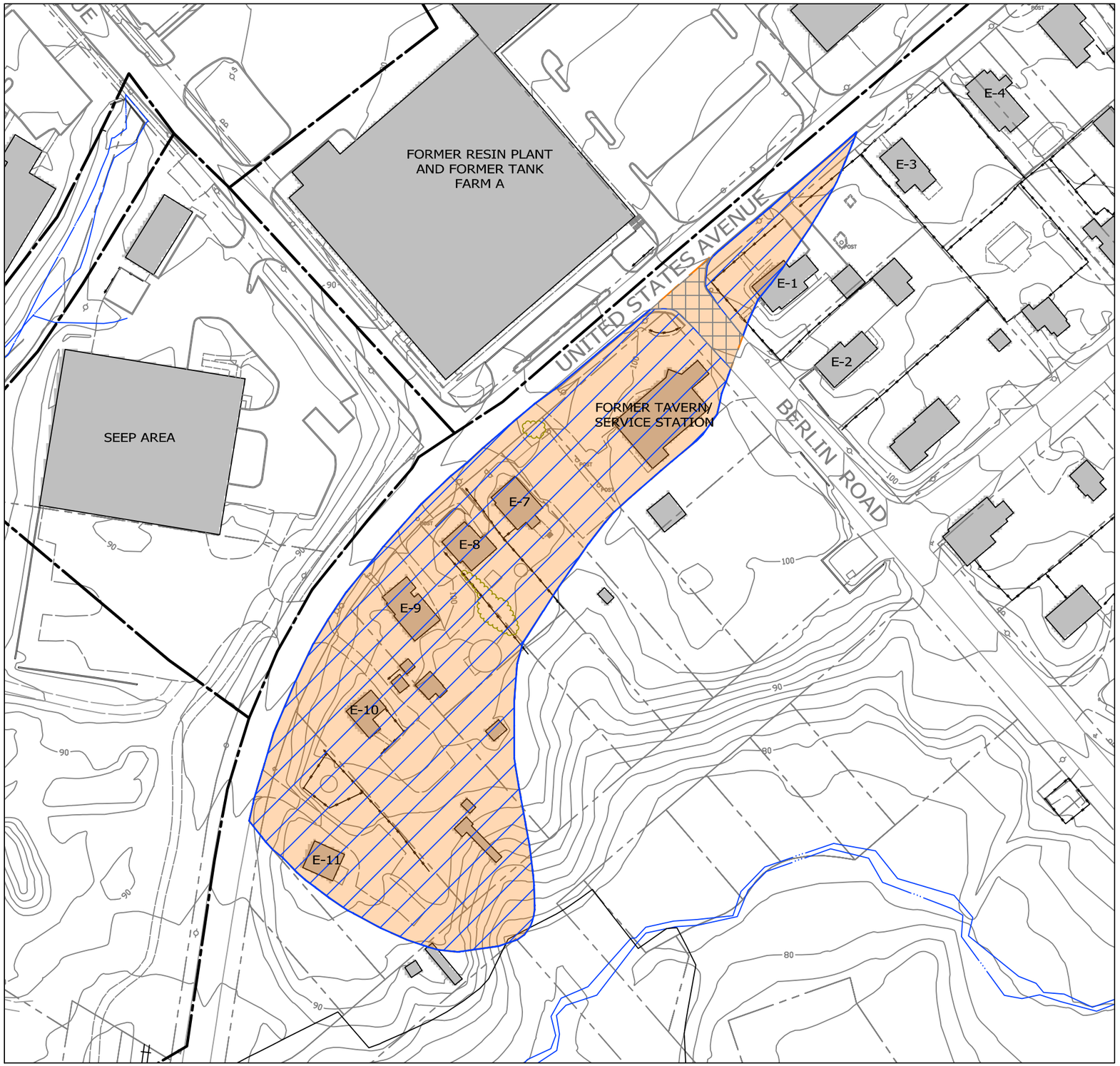

LEGEND

- FORMER MANUFACTURING PLANT REMEDIAL UNITS
- INTERPRETED EXTENT OF LNAPL FOR EASTERN OFF-PROPERTY AREA TO BE ADDRESS BY FEASIBILITY STUDY
- INTERPRETED EXTENT OF LNAPL
- EXCAVATION EXTENT FOR LNAPL 16-FOOT EXCAVATION DEPTH (AVERAGE)
- EXISTING SURFACE COVER REMAINS AND IS MAINTAINED AS A CAP

NOTES:

1. EASTERN OFF PROPERTY LNAPL ALTERNATIVE 3 - EXTENSIVE EXCAVATION TO DEPTH.
2. ALL SOIL ON PROPERTIES E-1, E-7, E-8, E-9, E-10, E-11 AND FORMER TAVERN SERVICE STATION IN WHICH LNAPL IS PRESENT WOULD BE REMOVED AND DISPOSED OFFSITE.
3. EXCAVATED SOIL NOT IMPACTED BY LNAPL WOULD BE REUSED ON SITE AS BACKFILL WHERE POSSIBLE.
4. ALL EXISTING STRUCTURES WOULD BE TEMPORARY RELOCATED, FOUNDATIONS/BASEMENTS REMOVED, SOIL EXCAVATED, EXCAVATIONS BACKFILLED, FOUNDATIONS/BASEMENTS CONSTRUCTED AND STRUCTURES RETURNED TO ORIGINAL FOOTPRINT.
5. SHEETING AND SHORING TO BE USED TO PROTECT UNITED STATES AVENUE AND EXCAVATION WALLS.
6. EXCAVATION WILL BE TO 20 FEET BELOW GROUND SURFACE.

SOURCE:

1. BASEMAP, WESTON SOLUTIONS, 2016.

0 100 200

SCALE: 1" = 100'

TITLE: FIGURE 41

EASTERN OFF-PROPERTY AREA ALTERNATIVE 3

LOCATION:

THE SHERWIN-WILLIAMS COMPANY
FORMER MANUFACTURING PLANT
GIBBSBORO, NEW JERSEY

DATE: 01/10/2019

FILENAME: 204027_FMP_FS_REV1

LAYOUT: EOP_LNAPL_ALT3

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Comparison of Eastern Off Property Alternatives

Remedial Alternative	Protection of Public Health and the Environment	Compliance with ARARs	Permanence and Long-Term Effectiveness	Reduction of Toxicity, Mobility, Volume through Treatment	Short Term Effectiveness	Implementability	Cost
No Action	●	◕	◔	◑	●	●	●
Bioremediation	●	●	●	●	◔	◔	◔
Extensive Excavation	●	●	●	○	○	○	○

LEGEND

● ◔ ◑ ◕ ○

Good ----------→ Poor

TITLE: FIGURE 42

EVALUATION OF EASTERN OFF PROPERTY ALTERNATIVES

LOCATION:
FORMER MANUFACTURING PLANT SITE
GIBBSBORO, CAMDEN COUNTY,
NEW JERSEY

DATE: 1/10/19

FILENAME: 2040247_FMP_FS_FIG_42_EVAL_EOP_ALT.VSD

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Table 1
Ecological Preliminary Remediation Goals for Soil and Sediment
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Constituent of Concern	Soil PRGs (mg/Kg) (see Appendix A)	Sediment PRGs (mg/Kg) (see Appendix A)
Arsenic	**17**	**17**
Lead	**213**	**176**
Cyanide	**58**	**3.8**

Table 2
Remedial Goals for Soil, Sediment, and Surface Water
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Constituent of Concern	Soil				Sediment	Surface Water[1,5]			Vapor Intrusion			
						SWQS, ug/L			Soil Gas		Indoor Air	
						Aquatic Life		Human Health				
	RDCSRS (mg/Kg)	NRDCSRS (mg/Kg)	IGWSRS[2] (mg/Kg)	PRGs (mg/Kg) (see Appendix A)	PRGs (mg/Kg) (see Appendix A)	Acute	Chronic		RSGSL[8] (ug/m^3)	NRSGSL[9] (ug/m^3)	RIASL[10] (ug/m^3)	NRIASL[11] (ug/m^3)
Arsenic[3]	19	19	19	17	17	340(d)(s)	150(d)(s)	0.017[4](hc)(T)	NA	NA	NA	NA
Lead	400	800	90	213	176	38(d)(s)	5.4(d)(s)	5.0(h)(T)	NA	NA	NA	NA
Cyanide	1,600	23,000	13	58	4	22(fc)	5.2(fc)	140(h)	NA	NA	NA	NA
PCBs[6]	0.2	1	0.2	NA	NA	4	0.014	0.000064(hc)	NA	NA	NA	NA
Benzo(a)Pyrene	0.5	2	0.2	NA	NA	NA	NA	0.0038(hc)	NA	NA	NA	NA
Benzo(a)Anthracene	5	17	0.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)Fluoranthene	5	17	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)Anthracene	0.5	2	0.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)Pyrene	5	17	7	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	6	17	25	NA	NA	NA	NA	NA	26	26	3	3
Benzene	2	5	0.005	NA	NA	NA	NA	NA	16	79	2	2
Trichloroethene	3	10	0.01	NA	NA	NA	NA	NA	27	15	3	3
Pentachlorophenol	0.9	3	0.3	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total EPH[7]	1,700 - 17,000			NA	NA	NA	NA	NA	NA	NA	NA	NA
LNAPL	measured thickness less than 0.01 feet			NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes
[1] Criteria for FW2-NT (non-trout) waters
[2] Default IGW Soil Screening Levels, site-specific evaluation depending. Applicable to unsaturated soil only.
[3] Arsenic values based on the New Jersey background levels
[4] For potable use, to be achieved after treatment
[5] There is no potable water use of Upper Hilliards Creek
[6] PCBs - Polychlorinated Biphenyls
[7] EPH - Extractable Petroleum Hydrocarbons, If EPH result is greater than 1,700 mg EPH/kg then fractionation analyis is required for calculated EPH Soil Remediation Criterion
[8] RSGSL - Residential Soil Gas Screening Levels
[9] NRSGSL - Nonresidential Soil Gas Screening Levels
[10] RIRSL - Residential Indoor Air Screening Levels
[11] NRIASL - Nonresisdential Indoor Air Screening Levels
NA - Not Applicable
(d) - Criterion is expressed as a function of the Water Effects Ratio (WER). For criterion in the table, WER equiates to the default value of 1.0
(s) - Dissolved criterion
(h) - Human Health non-carcinogen
(hc) - Human Health carcinogen
(T) - Total recoveral criterion
(fc) - Criteria expressed as free cyanide (as CN)/L

Table 3
Estimated Area and Volume of Contaminated Soils and Sediment
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

	Former Manufacturing Plant and Tank Farm B	Former Resin Plant and Tank Farm A	Seep Area	Former Lagoon Area	Hilliards Creek	Eastern Off Property	Total Site
Soil Exceeding PRGs (Top 1 Foot)							
Total Area, square feet	--	--	--	2,780	88,470	--	91,250
Total In Place Volume, cubic yards	--	--	--	110	3,280	--	3,390
Soil Exceeding RDCSRS Excluding Soil Exceeding PRGs in the Top 1 Foot							
Total Area, square feet	200,120	201,400	69,000	84,070	72,240	--	626,830
Total In Place Volume, cubic yards	46,230	171,450	15,210	62,180	6,970	--	302,040
Sediment Exceeding PRGs							
Hilliards Creek,Total Area, square feet	--	--	--	--	8,450	--	8,450
Hilliards Creek, Total In Place Volume, cubic yards	--	--	--	--	1420	--	1420
Silver Lake Conveyance,Total In Place Volume, cubic yards	--	--	--	--	280	--	280
LNAPL							
Total Area, square feet	--	286,570		--	--	137,000	423,570
Total LNAPL Impacted Soil, cubic yards	--	138,930		--	--	20,000	158,930

Notes:
-All values are rounded to the tenths

Table 4
Screening of Technologies and Process Options - Soils
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
SOILS				
No Action	No Action	Not Applicable	No Action	Required under CERCLA by NCP
Institutional Controls	Access Restriction	Land Use Control/Deed Restriction	Restriction of permissible use of the property to limit access/exposures to contaminated soils and to notify future property owners/users of the restriction in the form of legal documents (Deed Notices) filed with the Camden County Clerk's Office.	Potentially applicable where property owner(s) consent has been obtained.
		Fencing	Security fence to provide a physical barrier to restrict exposure to contaminated soils. Signage on fence would be used to notify persons of restriction.	Potentially applicable where property owner(s) consent has been obtained.
		Security Controls	Electronic security (e.g. cameras, alarms or similar) or personnel to identify security breaches.	Potentially applicable where property owner(s) consent has been obtained.
Containment	Capping/Cover	Soil Cap	Permeable constructed soil cover to provide physical barrier against exposure to contaminated soil.	Potentially Applicable
		Multilayer Impermeable Cap	Multilayer cap with impermeable layer(s) (i.e. geotextile, bentonite) to prevent physical access to soil and to minimize surface water infiltration to groundwater through soil.	Potentially Applicable
		Asphalt Cap	Asphalt layer to prevent physical access to soil and to minimize surface water infiltration to groundwater through soil.	Potentially Applicable
		Concrete Cap	Concrete layer to prevent physical access to soil and to minimize surface water infiltration to groundwater through soil.	Potentially Applicable
Excavation	Excavation	Excavation	Excavation of contaminated soil using mechanical equipment	Potentially Applicable. Site conditions such as access limitations, soil conditions (saturated soils/wetlands) may require special constructions methods and excavation techniques.
Dewatering	Construction Dewatering	Well Points, Sumps, Waterway Diversion	Well points and sumps installed to dewater excavation areas. Surface waterways (streams) can be temporarily diverted to dewater excavation and work areas.	Potentially Applicable
Disposal	Disposal	On-Site Disposal	Consolidation and disposal of excavated contaminated soil in a constructed secure consolidation cell on site.	Not Feasible. Sherwin Williams does not own or control the properties where consolidation and disposal would be implemented. Action would potentially restrict the reuse of the site.
		Off-Site Disposal	Transport and disposal of excavated soil at a permitted off-site disposal facility	Potentially Applicable

Table 4
Screening of Technologies and Process Options - Soils
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment	In Situ Treatment	In Situ Stabilization	Use of chemical reagent to precipitate, immobilize and bind contaminants in soil matrix. Concurrent immobilization of arsenic, lead and other contaminants may be difficult. Permanence of treatment uncertain.	Potentially applicable to minimize partitioning of inorganic contaminants to groundwater. May not be effective for organic contaminants.
Treatment	In Situ Treatment	Phytoremediation	Use of plants to degrade or extract contaminants from soils or to limit infiltration of stormwater; applicable primarily to relatively low levels of contaminants and shallow (root zone) soils. Testing would be needed to evaluate potential phytotoxicity, identify plant types and evaluate performance.	Potentially applicable to specific areas of low level contamination or as a means of hydraulic control.
		In Situ Soil Flushing	Use of chemical extractants to flush contaminants from subsurface soils In Situ. Performance and time required is uncertain and test for remedial effectiveness would be required.	Not feasible based on-site conditions. Construction of collection system not practical and/or technology would transfer contaminants from one matrix (soil) to another (groundwater).
		In Situ Oxidation/Reduction	Use of chemical oxidant to destroy/convert contaminants.	Not applicable to inorganic contaminants. Potentially applicable technology for organic (VOCs, SVOCs, PCBs) contaminants.
		Vitrification	Use of thermal technology to solidify soil and contaminants such that contaminants are immobilized and bounded in the soil matrix.	Not feasible based on cost (electrical) for the remedial technology. Dispersion of chemicals in soil matrix may not be complete. Action would potentially restrict the reuse of the site.
	Ex Situ Treatment	Stabilizations/Solidification	Use of chemical reagents to precipitate, immobilize and bind contaminants in soil matrix. Reagents can include cement, cement kiln dust, apatite, asphalt cement or similar.	Potentially Applicable
		Chemical Oxidation/Reduction	Use of chemical oxidants to destroy contaminants.	Not Applicable. Primary contaminants to be remediated will be inorganic constituents.
		Soil Washing	Removal of contamination from bulk soils based on physical (particle size) separation and/or chemical (surfactant) extraction. Separated contaminated fraction requires additional treatment and disposal.	Potentially Applicable
		Bioleaching	Use of biologically produced extractants to leach contaminants from soil.	Not Feasible. Limited published performance data.
		Phytoremediation	Use of plants to degrade or extract contaminants from soils; applicable primarily to relatively low levels of contaminants.	Not feasible for off-site treatment due to space requirements, contaminant concentrations and time required for treatment.
		Incineration	Destruction of contaminants at high temperature.	Not applicable to inorganic contaminants at the site.

Table 5
Screening of Technologies and Process Options - Sediment
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
SEDIMENT				
No Action	No Action	Not Applicable	No Action	Required under CERCLA by NCP
Institutional Controls	Access Restriction	Deed Restriction	Legal documents and restrictions to limit access/exposures to contaminated sediments and to inform future property owners/users of the restrictions.	Potentially applicable to limited areas of the site where property owner(s) consent has been obtained.
		Water Body Use Restriction	Prohibitions against use of surface water, as well as recreation activities (swimming, boating, wading and fishing). Notifications may include signage regarding restrictions.	Potentially applicable where property owner(s) consent has been obtained. Applicability limited in open/public areas. Action would result in loss of public use of water way.
		Fencing	Security fence to provide a physical barrier to restrict exposure to contaminated soils. Signage on fence would be used to notify persons of restriction.	Potentially applicable where property owner(s) consent has been obtained. Applicability may be limited in open/public areas.
		Security Controls	Electronic security (e.g. cameras, alarms or similar) or personnel to identify security breaches.	Potentially applicable where property owner(s) consent has been obtained. Applicability may be limited in open/public areas.
	Monitoring	Monitoring	Periodic sampling and analysis of sediment to evaluate conditions.	Potentially Applicable
		Monitored Natural Recovery (MNR)	Use of natural processes (i.e. natural sedimentation) to form a barrier to contamination.	Potentially Applicable. Evaluation of ongoing MNR processes such as sediment deposition would be required.
Containment	In Situ Subaqueous Capping	Permeable Cap	Passive or active subaqueous barriers comprised of natural materials (e.g. sand, gravel, clay) and/or engineered materials or geomembrane/granular cover.	Not feasible without compensatory excavation due to shallow sediment depth and regulatory requirements.
		Impermeable Cap	Cap using impermeable layer (anchored by sand or gravel) to minimize migration of contaminated water through sediment.	Not feasible without compensatory excavation due to shallow depth of streams and regulatory requirements.
Excavation	Excavation	Excavation	Removal of sediment using mechanical equipment under dewatered scenario.	Potentially Applicable. Site conditions (access limitations and wetlands/saturated sediment conditions) may complicate excavation and required special construction methods.
		Dredging	Removal of sediment from water body (under water), using specialized mechanical equipment.	Potentially Applicable. Evaluation of the most effective method of sediment removal will be required.
Dewatering	Construction Dewatering	Channel Diversion/Bypass, Collection Sumps	Sheet piling, temporary dams, bypass pumping, sumps or similar methods installed to facilitate dewatering of streams for dry excavation of sediment.	Potentially Applicable

Table 5
Screening of Technologies and Process Options - Sediment
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Disposal	Disposal	On Site Disposal	Consolidation and disposal of excavated sediment in a constructed secure consolidation cell on site.	Not Feasible. Sherwin Williams does not own or control the properties where consolidation and disposal would be implemented. Action would potentially restrict the reuse of the site.
		Off Site Disposal	Transport and disposal of excavated sediment at a permitted off-site disposal facility.	Potentially Applicable
Treatment	In Situ Treatment	Phytoremediation	Use of plants to degrade or extract contaminants from sediments.	Potentially applicable to specific areas of low level contamination. Feasibility and effectiveness unknown. Testing would be needed to evaluate potential phytotoxicity, identify plant types and evaluate performance.
		In Situ Sediment Flushing	Use of chemical extractants to flush contaminants from subsurface sediments In Situ. Performance and time required is uncertain and testing would be required.	Not feasible under site conditions. Not applicable to surficial sediments.
		In Situ Stabilization	Use of chemical reagent to precipitate, immobilize and bind contaminants in sediment matrix. Concurrent immobilization of arsenic, lead and other contaminants may be difficult. Performance of treatment uncertain.	Potentially applicable to minimize partitioning of contaminants to groundwater and surface water. May not be feasible due to regulatory requirements.
		In Situ Oxidation/Reduction	Use of chemical oxidant to destroy contaminants.	Not applicable. Primary contaminants to be addressed are inorganics.
	Ex Situ Treatment	Stabilization/Solidification	Use of chemical reagents to precipitate, immobilize and bind contaminants in soil matrix. Reagents can include cement, cement kiln dust, apatite, asphalt cement or similar.	Potentially Applicable
		Sediment Washing	Removal of contamination from bulk sediments based on physical (particle size) separation and/or chemical (surfactant) extraction. Separated contaminated fraction requires additional treatment and disposal.	Potentially Applicable
		Bioleaching	Use to biologically produce extractants to leach contaminants from sediments. Limited performance data.	Not Feasible
		Chemical Oxidation/Reduction	Use of chemical oxidants to destroy contaminants.	Not applicable. Primary contaminants to be addressed are inorganic.
		Incineration	Destruction of contaminants at high temperature.	Not applicable for inorganic contaminants.

Table 6
Screening of Technologies and Process Options - Surface Water
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
SURFACE WATER				
No Action	No Action	Not Applicable	No Action	Required under CERCLA by NCP
Institutional Controls	Access Restriction	Deed Restriction	Legal documents and restrictions to limit access/exposures to contaminated water and to inform future property owners/users of the restrictions.	Potentially applicable where property owner(s) consent and NJDEP approval have been obtained.
		Water Use Restriction	Prohibitions against use of surface water, as well as recreation activities (swimming, boating, wading and fishing). Notifications may include signage regarding restrictions.	Potentially applicable where property owner(s) consent and NJDEP approval been obtained. Applicability limited in open/public areas. Action would result in loss of public use of water way.
	Monitoring	Surface Water Monitoring	Periodic sampling and analysis of surface water to evaluate conditions.	Potentially Applicable
	Alternate Water Supply	Municipal Water Supply	Connection of potable surface water users to an existing municipal/public supply.	Not Applicable. No current surface water users. Users are served by municipal supply or private potable wells.
		New Community Water Supply	Construction of a new water supply system for potable surface water users in a community.	Not Applicable. No current surface water users. Users are served by municipal supply or private potable wells.
		Bottled Water	Provision of bottled water to potable surface water users in a community.	Not Applicable. No current surface water users. Users are served by municipal supply or private potable wells.
Collection	Collection	Surface Water Diversion, Capture and Pumping	Surface water collection systems (dams, channels, piping or similar) installed to provide for collection of surface water via pumping.	Potentially applicable but not feasible. Potential negative impacts on wetlands, wildlife due to removal of surface water.
Treatment	Ex Situ Treatment	Ion Exchange	Use of ion exchange (activated alumina and specialty adsorbents) and related mechanisms to remove ionic constituents from water.	Potentially applicable but may be unfeasible due to the level of effort for construction of treatment facility and long-term operation costs for collection, treatment and discharge of water. Ability to meet discharge criteria uncertain and pilot testing would be required.
		Membrane Technology	Use of membrane technology (e.g. reverse osmosis, electrodialysis or similar) to remove ionic inorganics from water.	Not feasible due to the level of effort for construction of treatment facility and long-term operation costs for collection, treatment and discharge of water. Ability to meet discharge criteria uncertain and pilot testing would be required.

Table 6
Screening of Technologies and Process Options - Surface Water
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment	Ex Situ Treatment	Oxidation/Reduction, Precipitation/Coprecipitation	Chemical oxidation and/or chemical reduction to precipitate/coprecipitate constituents from water followed by filtration/separation for removal from water.	Potentially applicable but may be unfeasible due to the level of effort for construction of treatment facility and long-term operation costs for collection, treatment and discharge of water. Ability to meet discharge criteria uncertain and pilot testing would be required.
Treatment	Ex Situ Treatment	Constructed Wetlands	Use of constructed wetlands to precipitate/adsorb and remove metals from the water to the plant tissue and plant root zone soils in the treatment area.	Likely not feasible on site since Sherwin Williams does not own or control the properties and possible space restrictions. Ability to meet discharge criteria uncertain and pilot testing would be required.
		Phytoremediation	Use of vegetation (grasses, shrubs, trees) in contained wetland cells to precipitate/adsorb and remove metals from the water to the plant tissue and plant root zone soils in the treatment area.	Likely not feasible on site since Sherwin Williams does not own or control the properties and possible space restrictions. Ability to meet discharge criteria uncertain and pilot testing would be required.
Disposal/Discharge	Discharge	Discharge to Publicly Owned Treatment Works (POTW)	Collected surface water discharged to local POTW following pretreatment as required to meet POTW acceptance criteria.	Potentially applicable but not feasible. Local POTW unlikely to accept large volume of surface water. Construction of conveyance system infeasible due to costs. Potential negative impacts on wetlands, wildlife due to removal of surface water.
		Surface Water Discharge by Surface or Subsurface Irrigation System	Surface water discharged to local groundwater using surface or subsurface irrigation systems after treatment to meet all applicable groundwater discharge criteria (presumably NJDEP GWQS).	Not Applicable. Discharge of large volume of surface water to groundwater not feasible.

Table 7
Screening of Technologies and Process Options – LNAPL
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
LNAPL				
No Action	No Action	Not Applicable	No Action	Required under CERCLA by NCP
Institutional Controls	Access Restriction	Land Use Control/Deed Restriction	Restriction of permissible use of the property to limit access/exposures to contaminated soils and to notify future property owners/users of the restriction in the form of legal documents (Deed Notices) filed with the Camden County Clerk's Office.	Potentially applicable where property owner(s) consent has been obtained.
		Fencing	Security fence to provide a physical barrier to restrict exposure to contaminated soils. Signage on fence would be used to notify persons of restriction.	Potentially applicable where property owner(s) consent has been obtained.
		Security Controls	Electronic security (e.g. cameras, alarms or similar) or personnel to identify security breaches.	Potentially applicable where property owner(s) consent has been obtained.
Containment	Capping/Cover	Soil Cap	Permeable constructed soil cover to provide physical barrier against exposure to LNAPL.	Potentially Applicable. May be a need for mitigation/control of soil gas.
		Multilayer Impermeable Cap	Multilayer cap with impermeable layer(s) (i.e. geotextile, bentonite) to prevent physical access to soil and to minimize surface water infiltration to groundwater through soil.	Potentially Applicable. May be a need for mitigation/control of soil gas.
		Asphalt Cap	Asphalt layer to prevent physical access to LNAPL and to minimize surface water infiltration to groundwater through soil.	Potentially Applicable. May be a need for mitigation/control of soil gas.
		Concrete Cap	Concrete layer to prevent physical access to LNAPL and to minimize surface water infiltration to groundwater through soil.	Potentially Applicable. May be a need for mitigation/control of soil gas.

Table 7
Screening of Technologies and Process Options – LNAPL
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Excavation	Excavation	Excavation	Excavation of soil containing LNAPL using mechanical equipment	Potentially Applicable. Site conditions such as access limitations (presence of buildings and other structures), soil conditions (saturated soils/wetlands), and depth of contamination may require special constructions methods and excavation techniques or prevent use of technology.
Disposal	Disposal	On-Site Disposal	Consolidation and disposal of excavated contaminated soil in a constructed secure consolidation cell on site.	Not feasible. Sherwin Williams does not own or control the properties where consolidation and disposal would be implemented. Action would potentially restrict the reuse of the site.
		Off-Site Disposal	Transport and disposal of excavated soil at a permitted off-site disposal facility	Potentially Applicable. Pre-treatment likely needed prior to transport.
Treatment	In Situ Treatment	In Situ Stabilization	Use of chemical reagent to stabilize bind LNAPL within a stabilized soil matrix to reduce mobility.	Potentially applicable to minimize dissolution of organic contaminants from LNAPL to groundwater. Treatability testing needed to determine efficacy. Presence of buildings and other access limitations may limit the ability to use the technology.

Table 7
Screening of Technologies and Process Options – LNAPL
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
		Phytoremediation	Use of plants to degrade or extract contaminants from soils or to limit infiltration of stormwater; applicable primarily to relatively low levels of contaminants and shallow (root zone) soils. Testing would be needed to evaluate potential phytotoxicity, identify plant types and evaluate performance.	Potentially applicable to specific areas of low level contamination or as a means of hydraulic control. Not applicable in areas where buildings, roadways and parking areas are present.
		In Situ Oxidation	Use of chemical oxidant to destroy/convert contaminants.	Potentially applicable. Presence of buildings and other structures may prevent use of technology in those locations. Mass of LNAPL combined with natural oxidant demand may make use of technology infeasible. May interfere with anaerobic biodegradation currently active at site.
		Natural Source Zone Depletion	LNAPL is naturally depleted from the subsurface over time by volatilization, dissolution, absorption and degradation.	Potentially applicable. There is current evidence that natural source zone depletion is ongoing. Estimates of degradation rate are required.
		Biostimulation	Additional of soil and/or groundwater amendments to increase biomass and increase rate of biodegradation.	Potentially applicable. Soil and groundwater evaluation will be required to determine what amendments may be effective.
	Ex Situ Treatment	Stabilizations/Solidification	Use of chemical reagents to precipitate, immobilize and bind contaminants in soil matrix. Reagents can include cement, cement kiln dust, apatite, asphalt cement or similar.	Potentially applicable for any excavated soil containing LNAPL. Treatability studies will be needed to determine the most effective treatment reagent. Likely needed prior to off-site transport of soil containing LNAPL for disposal.
		Chemical Oxidation/Reduction	Use of chemical oxidants to destroy contaminants.	Potentially applicable to excavated soil containing LNAPL. However, since disposal of soil will likely be required after treatment, technology may not be feasible based on costs.
Treatment	Ex Situ Treatment	Soil Washing	Removal of contamination from bulk soils based on physical (particle size) separation and/or chemical (surfactant) extraction. Separated contaminated fraction requires additional treatment and disposal.	Potentially applicable to excavated soil containing LNAPL. Treatability studies would be needed to determine applicable surfactant(s) and treatment for water/LNAPL produced by washing. Soil will likely be disposed of after treatment, so technology may not be feasible based on cost. A large dedicated area for soil staging and washing would be required to support the technology.

Table 7
Screening of Technologies and Process Options – LNAPL
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
		Phytoremediation	Use of plants to degrade or extract contaminants from soils; applicable primarily to relatively low levels of contaminants.	Not applicable. A large area would be required, as would an extended treatment time period, and other methods of treating excavated soil would be preferred.
		Low Temperature Thermal Desorption	Use of heat to remove volatile constituents from soil. Vapors would be collected or treated. Soil would be disposed of or reused.	Potentially applicable to excavated soil containing LNAPL. However, costs, permitting requirements and the need for a dedicated treatment area may make the technology infeasible.
		Incineration	Destruction of contaminants at high temperature. Soil would be disposed of or reused.	Potentially applicable to excavated soil containing LNAPL. However, costs, permitting requirements and the need for a dedicated treatment area (if conducted on-Site) may make the technology infeasible.
LNAPL Recovery	LNAPL Removal	Manual Recovery	Accumulated LNAPL is removed from wells or trenches using bailers, pumps or vacuum trucks.	Potentially applicable in those locations where recoverable LNAPL is present. Use of technology not applicable to areas where there is no recoverable product.
		LNAPL Skimming	LNAPL is hydraulically recovered from the top of the groundwater column within a well or a trench.	Potentially applicable in those locations where recoverable LNAPL is present. Use of technology not applicable to areas where there is no recoverable product.
		Bioslurping	LNAPL is removed by a combination of vacuum-enhanced recovery and bioventing.	Potentially applicable. Operation and maintenance requires adjustment of drop tubes to account for groundwater fluctuations, so use of technology may be limited by the presence of buildings or high traffic areas. Residual LNAPL will remain after application of technology.

Table 7
Screening of Technologies and Process Options – LNAPL
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
LNAPL Recovery	LNAPL Removal	Dual (or multi-) Phase Extraction	Groundwater is extracted to reduce the water table and remove the hydraulic forces containing trapped LNAPL, and the accumulated LNAPL is removed at the same location. Vapor extraction may also be implemented.	Potentially applicable. Pumping tests needed to estimate groundwater extraction rates to achieve drawdown; very deep LNAPL will remain inaccessible. Dedicated groundwater treatment plant will be required. Presence of buildings may limit the use of the technology. Residual LNAPL will remain after application of technology.
	LNAPL Stripping/Flushing	Air Sparging	Air is injected into subsurface to volatilize the LNAPL.	Potentially applicable. Likely needs to be accompanied by vapor extraction to collect vapors generated by air sparging. Air sparging effectiveness limited by the presence of lower permeability zones. Only volatile fraction will be removed. Residual LNAPL will remain after application of technology. Need to collect/treat vapors may make technology economically infeasible.
		Surfactant-Enhanced Flushing	A surfactant is injected to increase LNAPL solubility and mobility. The LNAPL/surfactant/water mixture is then recovered and treated or disposed of.	Potentially applicable. Additional treatability studies needed to assess most effective surfactant, design recovery system and design treatment system(s). Residual LNAPL will remain after application of technology.
		Heat-Enhanced Recovery	Heat (steam, hot water, electricity) is applied to the LNAPL to reduce viscosity and enhance recovery. Used in conjunction with another recovery technology.	Potentially applicable. Residual LNAPL will remain following application of technology. Cost for energy may make technology economically infeasible.

Table 8
Screening of Technologies and Process Options – Vapor Intrusion
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Vapor Intrusion				
No Action	No Action	Not Applicable	No Action	Required under CERCLA by NCP
Treatment	Biodegradation	Sub-Slab Ventilation	Air is circulated into the vadose zone beneath the building slab and parking lot to increase oxygen levels and initiate aerobic biodegradation of the methane.	Potentially applicable. Methane degrades rapidly in the presence of oxygen, so technology is likely to be effective. Testing is needed to support design. VOCs found in indoor air (benzene and naphthalene) are expected to biodegrade aerobically.
	Isolation	Sub-Slab Depressurization	Air is extracted from the vadose zone below the building slab to establish a pressure gradient that goes from the building into the vadose zone, preventing subsurface vapors from entering the building.	Potentially applicable. Sub-slab depressurization systems are established technologies for controlling vapor intrusion. May not, however, provide adequate mass reduction in the vadose zone to remove methane.
	Mass Removal	Soil Vapor Extraction	Air is extracted from the vadose zone beneath the building and parking area to remove the accumulated methane and VOCs. The captured vapors are treated to remove contaminants prior to discharge to the atmosphere.	Potentially applicable. Soil vapor extraction is an established technology for removing volatile organic compound from the subsurface. However, use of the technology may be limited by the presence of groundwater, which prevents extraction of vapors. Permitting may represent an implementation obstacle.

Table 9
Preliminary Evaluation of Process Options – Soil and LNAPL
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
For Human Health Protection: Mitigate unacceptable Human Health Risk. Prevent ingestion, inhalation, or direct contact with surface and/or subsurface soils that contain COPCs at concentrations exceeding ARARs and/or risk-based concentrations. Minimize transport and migration of COPCs in soils to nearby surface water bodies. For Environmental Protection: Mitigate unacceptable Ecological Risk. Minimize transport and migration of COPCs in soils to nearby surface water bodies. Manage risks to ecological receptors from ingestion/direct contact with COPCs in surface soil and food items.	No Action	No Action	Not Applicable	No	Yes	None	Does not achieve Remedial Action Objectives. May not be acceptable to property owners. Required under CERCLA. Retained for comparative purposes.
	Institutional Controls	Deed Restrictions/Land Use Controls	Not Applicable	Yes	Yes	Low	Reduces or eliminates human exposures by limiting or preventing access to contamination. Not effective for ecological exposures. Effectiveness depends on continued future control. Does not reduce contaminant levels. Implementable where property owner(s) consent has been obtained. Required where constituents are to be left in place at concentrations above the RDCSRS. Long term monitoring required.
		Fencing	Not Applicable	Yes	Yes	Low	Eliminates human exposures by preventing access to areas where contaminants are present at concentrations above standards. Does not prevent ecological exposures. Effectiveness depends on continued future control. Does not reduce contaminant levels. Implementable where property owner(s) consent has been obtained. Long term monitoring required. Relatively low cost for construction and periodic maintenance of fencing.
		Security	Not Applicable	Yes	Yes	Low	Prevents human exposures by preventing access to areas of site contaminants are present at concentrations greater than standards. Does not prevent ecological exposure. Implementable where property owner(s) consent has been obtained. Effectiveness depends on continued future control. Does not reduce contaminant levels. Long term monitoring required.
	Containment	Capping	Soil Cap	Yes	Yes	Moderate	Effective in minimizing human and ecological exposures to contaminated soils. Must be accompanied by soil removal in wetlands and other regulated areas. May need to be supplemented with removal for groundwater source control.
			Impermeable Cap	Yes	Yes	Moderate	Effective in minimizing human and ecological exposures to contaminated soil and will prevent storm water infiltration. Not feasible in wetlands and ecologically sensitive areas due to land use regulations.
		Subsurface barriers	Slurry walls, sheet piling	Unknown	Yes	Moderate to high	May prevent migration of LNAPL and/or contaminated groundwater from source areas, however water management behind the barriers would be needed. Under current conditions, the LNAPL and most groundwater contaminants exhibit limited mobility in groundwater.
	Excavation	Excavation	Excavation	Yes	Yes	Moderate to high	Special construction methods needed for excavation in stream/wetland areas and other restricted areas, and near buildings and roads. Excavation feasibility is affected by depth of the excavation and the presence of groundwater. No ability to excavate beneath buildings and roadways.

Table 9
Preliminary Evaluation of Process Options – Soil and LNAPL
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
For Human Health Protection: Mitigate unacceptable Human Health Risk. Prevent ingestion, inhalation, or direct contact with surface and/or subsurface soils that contain COPCs at concentrations exceeding ARARs and/or risk-based concentrations. Minimize transport and migration of COPCs in soils to nearby surface water bodies. For Environmental Protection: Mitigate unacceptable Ecological Risk. Minimize transport and migration of COPCs in soils to nearby surface water bodies. Manage risks to ecological receptors from ingestion/direct contact with COPCs in surface soil and food items.	Disposal	Disposal	On-site disposal	No	No	Moderate to high	No ability to use any portion of the FMP as a disposal location.
			Off-site disposal	Yes	Yes	Moderate to high	Disposal at permitted disposal facility would be required and pretreatment may be needed to meet disposal criteria. May not be acceptable to community due to safety, noise, and increased traffic issues.
	Treatment	Ex Situ Treatment Technologies	Stabilization/Solidification (e.g. cement, cement kiln dust (CKD), apatite, asphalt cement or other reagents)	Yes	Yes	Moderate to high	May be effective if a suitable stabilization process/chemistry for all contaminants can be identified. May be difficult to implement on site due to space requirements, so there may be a need to construct and operate a treatment system on site or in the vicinity. May be necessary as a pre-disposal step. Landowner approval for conducting operation on property is needed.
			Phytoremediation	Low	No	Low to moderate	Would need large area to manage excavated soil for purposes of installing phytoremediation system. Not effective for inorganic constituents, PAHs.
			Soil washing	No	No	High	Treatability testing would be required. Management of produced washwater would be needed. Effectiveness of soil washing to reduce concentrations of inorganic constituents to a point where on-site reuse is possible is unknown but unlikely.
			Incineration	Yes - LNAPL	Yes	High	Effective only for organic constituents. Requires soil excavation and replaces off-site disposal, so costs may make it use infeasible.
		In-Situ Treatment Technologies	LNAPL Recovery(skimming)	Unknown	Yes	Moderate	Recovery rates have declined as a result of historical LNAPL recovery activities and natural processes. In locations where petrochemical analyses were performed, residual saturation levels are well below those where recovery is possible. However, no recovery has been attempted beneath the 2 and 4 Foster Avenue buildings, so it is unknown as to whether LNAPL recovery may be effective in these locations.
			LNAPL Recovery (Dual Phase Extraction)	No	Yes	High	Dual phase extraction can provide additional LNAPL mass removal by stripping of high volatility components and depressing the water table to reduce the hydraulic pressures on the LNAPL. However, it cannot overcome the low saturation levels observed at the site. The LNAPL is dominated by C9-C14 aliphatic compounds, so stripping is not likely. A very large pumping rate would be needed to reduce the water table throughout the LNAPL area, and, based on the low saturation levels, it is unlikely that any significant LNAPL recovery would be achieved.

Table 9
Preliminary Evaluation of Process Options – Soil and LNAPL
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
For Human Health Protection: Mitigate unacceptable Human Health Risk. Prevent ingestion, inhalation, or direct contact with surface and/or subsurface soils that contain COPCs at concentrations exceeding ARARs and/or risk-based concentrations. Minimize transport and migration of COPCs in soils to nearby surface water bodies. For Environmental Protection: Mitigate unacceptable Ecological Risk. Minimize transport and migration of COPCs in soils to nearby surface water bodies. Manage risks to ecological receptors from ingestion/direct contact with COPCs in surface soil and food items.	Treatment	In Situ Treatment Technologies	Thermal Enhanced LNAPL Recovery	No	Partial	High	Based on the boiling point (140º to 200º C) of the mineral spirits at the site, high temperatures are needed to provide for LNAPL removal. These high temperatures generally prevent the use of the technology near roadways where buried utilities are present, or in residential areas. Therefore, there are large areas of the site, including the entire eastern off-property area, a buffer between the former Resin Plant/Tank Farm A Area and U.S. Avenue/Foster Avenue, and beneath these two roadways, where the technology could not be employed. Therefore, it would not be an effective technology for the site as a whole.
			In situ soil flushing	No	No	High	Based on imbibition testing, LNAPL is not likely to be removed from soil pores. Unlikely to removal inorganic contaminants from soil.
			In situ stabilization, via reagent injection/soil mixing	No	No	Moderate to high	Potentially feasible where source material is present at depth and excavation is infeasible or too expensive
			Chemical Oxidation	Yes	Yes	High	Would not address inorganic constituents. Very large oxidant mass needed to treat LNAPL. Potentially applicable in targeted locations where excavation is not possible or is economically infeasible. Would need to be evaluated against biostimulation of the existing anaerobic processes that are occurring.
			Natural Source Zone Depletion	Yes	Yes	Low	Applicable only to LNAPL. LNAPL Report documented lines of evidence for NSZD at the site. Additional evaluation needed to document mass loss rates. Would need to be accompanied by technology to address methane generated by biodegradation.
			Biostimulation	Yes	Yes	Moderate	Applicable only to LNAPL. LNAPL Report documented limitations on biodegradation due to absence of key electron donors. Additional evaluation needed to identify which electron donors are needed and how to deliver them to the LNAPL.

Table 10
Preliminary Evaluation of Process Options – Sediment
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
For Human Health Protection: Prevent direct human contact with contaminated sediments Minimize releases of COPCs from sediments that would result in surface water levels in excess of ARARs and/or risk-based concentrations For Environmental Protection: Minimize releases of COPCs from sediments that would result in surface water levels in excess of ARARs and/or risk-based concentrations. Manage risks to ecological receptors from ingestion/direct contact with COPCs in sediments and food items.	No Action	No Action	Not Applicable	No	Yes	None	Does not achieve Remedial Action Objectives. May not be acceptable to property owners. Required under CERCLA. Retained for comparative purposes.
	Institutional Controls	Deed Restrictions/Land Use Controls	Not Applicable	Yes	Yes	Low	Reduces or eliminates human exposures by limiting or preventing access to contamination. Not effective for ecological exposures. Effectiveness depends on continued future control. Does not reduce contaminant levels. Implementable where property owner(s) consent has been obtained. Long term monitoring required.
		Fencing	Not Applicable	Yes	Yes	Low	Eliminates human exposures by preventing access to areas where contaminants are present at concentrations above standards. Does not prevent ecological exposures. Effectiveness depends on continued future control. Does not reduce contaminant levels. Implementable where property owner(s) consent has been obtained. Long term monitoring required. Relatively low cost for construction and periodic maintenance of fencing.
		Security	Not Applicable	Yes	Yes	Low	Prevents human exposures by preventing access to areas of site contaminants are present at concentrations greater than standards. Does not prevent ecological exposure. Implementable where property owner(s) consent has been obtained. Effectiveness depends on continued future control. Does not reduce contaminant levels. Long term monitoring required.
	Containment	Capping	Subaqueous Capping	Yes	Yes	Moderate	Effective, if implementable, in minimizing exposure to contaminated sediment. Effectiveness also depends on the exposure scenarios. In-water capping needs to be accompanied by sediment removal to meet no net fill requirements.
	Excavation	Excavation	Excavation	Yes	Yes	Moderate to high	Implementable; special construction methods needed for excavation in stream/wetland areas and other restricted areas.
	Dewatering	Construction Dewatering	Well points, sumps, sheet piling	Yes	Yes	High	Implementable, but large volumes of water may be generated; special construction methods needed for excavation in stream/wetland areas and other restricted areas.
	Disposal	Disposal	On-site disposal	Yes	No	Moderate to high	No ability to use any portion of the FMP as a disposal unit.
			Off-site disposal	Yes	Yes	Moderate to high	Disposal at permitted disposal facility would be required and pretreatment may be needed to meet disposal criteria.

Table 10
Preliminary Evaluation of Process Options – Sediment
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
For Human Health Protection: Prevent direct human contact with contaminated sediments Minimize releases of COPCs from sediments that would result in surface water levels in excess of ARARs and/or risk-based concentrations For Environmental Protection: Minimize releases of COPCs from sediments that would result in surface water levels in excess of ARARs and/or risk-based concentrations. Manage risks to ecological receptors from ingestion/direct contact with COPCs in sediments and food items.	Treatment	Ex Situ Treatment Technologies	Stabilization/Solidification (e.g. cement, cement kiln dust (CKD), apatite, asphalt cement or other reagents)	Yes	No	Moderate to high	May be required to meet disposal facility requirements. Difficult to implement on site due to space requirements and the need to construct and operate a treatment system on site or in the vicinity. May be effective if a suitable stabilization process/chemistry for all contaminants can be identified.
			Phytoremediation	No	Yes	Low to moderate	Not likely to be effective in removing inorganic contaminants from excavated sediment. Limited implementability due to large area required for treatment and long time required. Suitable reuse of treated sediment would have to be identified.
			Soil washing	Unknown	No	High	Infeasible due to high costs to construct a system and anticipated low volumes of sediment. Effectiveness of soil washing for inorganic constituents in sediment unknown. Management of washwater would be needed. Difficult to implement on site due to space requirements and the need to construct and operate a treatment system on site or in the vicinity. Approval of treatment system construction would require property owner approval as Sherwin-Williams does not own the property.
			Incineration	No	Not implementable on site; Offsite incineration at a permitted facility may be implementable.	High	Likely effective for organic contaminants only, but would not address inorganic contaminants (arsenic and lead) that are primary contaminants in sediment.
			Chemical Oxidation	No	No	High	Effective only for inorganic contaminants, but would not address inorganic contaminants that will also be present in removed sediment.
		In Situ Treatment Technologies	In situ stabilization, via reagent injection/soil mixing	Unknown	No	Moderate to High	Ability to maintain stabilization in an aqueous environment is unknown. Not implementable in water bodies due to need to restore ecological habitat and requirement for no net fill.

Table 11
Preliminary Evaluation of Process Options – Surface Water
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
For Human Health Protection: Prevent direct contact of COPCs from impacted water bodies. For Environmental Protection: Manage risks to ecological receptors from ingestion/direct contact with COPCs in surface water and food items	No Action	No Action	Not Applicable	Yes	Yes	None	Would achieve Remedial Action Objectives if combined with soil and sediment source control measures.
	Institutional Controls	Deed Restrictions/Land Use Controls	Not Applicable	No	No	Low	Reduces exposures by preventing access to surface water containing constituents at concentrations greater than standards. Surface water in Upper Hilliards Creek not used for potable purposes and exposure via wading does not result in an unacceptable risk. Therefore, implementation would provide no benefit over current conditions.
		Water Use Restrictions	Not Applicable	No	No	Low	Reduces exposures by preventing access to surface water containing constituents at concentrations greater than standards. Upper Hilliards Creek is not used for drinking water so use restrictions would not change current conditions.
	Collection	Collection	Stream Diversion/Collection, and pumping	No	No	High	While theoretically feasible, without control of sources to surface water, collection and diversion would not change surface water conditions – the same constituents would remain in surface water. Infeasible due to the volume of water that would need to be collected. May be difficult to implement if there are multiple discharge points to surface water and diffuse and braided nature of surface waters.
	Treatment	Treatment	Chemical Precipitation/Coprecipitation	No	No	High	Same implementability and effectiveness issues as collection and diversion – a large volume of water would need to be collected and treated, and without remediation of the sources to surface water, conditions would not be changed.
			Ion exchange (also activated alumina and specialty adsorbents)	No	No	High	Same implementability and effectiveness issues as collection and diversion – a large volume of water would need to be collected and treated, and without remediation of the sources to surface water, conditions would not be changed.
			Membrane Technology (Reverse Osmosis, Electrodialysis)	No	No	High	Same implementability and effectiveness issues as collection and diversion – a large volume of water would need to be collected and treated, and without remediation of the sources to surface water, conditions would not be changed.

Table 11
Preliminary Evaluation of Process Options – Surface Water
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
For Human Health Protection: Prevent direct contact of COPCs from impacted water bodies. For Environmental Protection: Manage risks to ecological receptors from ingestion/direct contact with COPCs in surface water and food items	Treatment	Treatment	Constructed Wetlands	No	No	High	Would not change presence of constituents in surface water unless accompanied by source control measures. If source control measures were implemented, there would be no need for treatment. Not implementable due to space constraints and property ownership by a third party.
	Disposal	Disposal	Discharge to surface water	Yes	No	Moderate	Discharge to surface water would be an effective mechanism by which to dispose of treated water. However, it presumes collection and treatment which, as discussed above, are not implementable.
			Discharge to Publicly Owned Treatment Works (POTW)	Yes	No	Moderate	Discharge to a POTW would be an effective method by which to discharge treated water. However, this presumes collection and treatment of surface water which is not implementable. Additionally, it is unlikely that a POTW would accept the volume of water that would be collected.
			Groundwater injection	No	No	High	Unlikely to be able to physically inject the volume of water that would be collected.
			Irrigation	No	No	Moderate	Not effective during the non-growing season. Not implementable due to volume of water that would need to be managed. Not effective unless accompanied by source control measures.

Table 12
Preliminary Evaluation of Process Options – Methane and Soil Gas
Former Manufacturing Plant
Gibbsboro, New Jersey

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
For Human Health Protection: Prevent exposure to unacceptable levels of vapors in indoor air and prevent risks associate with methane in soil gas. For Environmental Protection: No ecological receptors threatened by methane/soil gas vapors	No Action	No Action	Not Applicable	Unknown	Yes	Low	Methane in subsurface does not represent an explosion risk and indoor air monitoring has not found elevated levels of methane. Although constituents have been detected in indoor air at concentrations greater than screening levels, it is unclear that these constituents originate in the subsurface. Costs incurred for ongoing monitoring.
	Institutional Controls	Deed Restrictions/Land Use Controls	Not Applicable	No	No	Low	Reduces exposures by preventing access to areas where methane and vapors are present in soil gas or in indoor air. This would mean eliminating access to the 2 and 4 Foster Avenue and 3 U.S. Avenue buildings, which is not feasible.
	Collection	Collection and Discharge	Soil Vapor Extraction	Yes	Yes	Moderate to High	SVE would remove vapors from beneath the buildings and parking areas. In addition, introduction of oxygen to the subsurface would create conditions amenable to biodegradation of the methane. Use of SVE, given its relatively high extraction rates, could result in the need to install vapor phase treatment and obtain air quality permits.
			Sub-Slab Depressurization	Yes	Yes	Moderate	A sub-slab depressurization system (SSDS) would remove vapors from the subsurface, create a differential pressure such that vapors from the subsurface would not enter the buildings, and would create an oxygenated atmosphere conducive to the biodegradation of methane. SSDS typically operate a low flow rate, so vapor phase controls and air quality permits may not be required.
	Treatment	Treatment	Soil Ventilation	Yes	Yes	Low to moderate	A soil ventilation system would use low flow extraction points to bring oxygenated air into the subsurface, thereby creating conditions amenable for the biodegradation of methane and other petroleum-related compounds. The system should also remove vapors form the subsurface and create a differential pressure, similar to the SSDA.

Table 13
Estimated Costs for Remedial Alternatives
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Soil and LNAPL Alternatives	Former Main Plant Area	Former Resin Plant Area and Tank Farm A	Former Lagoon Area	Seep Area	Hilliards Creek	Total Cost
Alternative 1 - No Action	$142,416					$142,416
Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls	$203,263	$228,783	$1,053,423	$203,263	$4,088,737	$5,777,469
Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls	$3,414,906	$5,751,561	$1,433,352	$7,464,315	$6,029,847	$24,093,981
Alternative 4 - Extensive Excavation to Depth and Institutional Controls	$14,446,188	$42,931,126	$16,297,947	$7,464,315	$6,029,847	$87,169,423

Eastern Off Property LNAPL Alternatives	
Alternative 1 - No Action	$ 142,416
Alternative 2 - Enhanced LNAPL Biodegradation and Soil Gas Removal	$ 4,480,520
Alternative 3 - Extensive Excavation to Depth	$ 18,404,357

Sediment Alternatives	
Alternative 1 - No Action	$28,483
Alternative 2 -Capping and Monitored Natural Recovery	$1,610,472
Sediment Alternative 3 - Removal of Surface Sediment with Contaminants Greater than PRGs, Capping and Natural Recovery	$1,758,649

Surface Water Alternatives	
Alternative 1 - No Action	$28,483
Alternative 2 Institutional Controls with Monitoring	$123,529

APPENDIX A

Ecological Preliminary Remediation Goals

Appendix A

Ecological Preliminary Remediation Goals for the Former Manufacturing Plant Site Gibbsboro, New Jersey

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Abbreviations

95% UCL	95% Upper Confidence Level
µmol	Micromole
ac	Acre
Ag	Silver
Al	Aluminum
ARAR	Applicable or Relevant and Appropriate Requirement
As	Arsenic
AVS	Acid Volatile Sulfide
Ba	Barium
BAF	Bioaccumulation Factor
Be	Beryllium
BERA	Baseline Ecological Risk Assessment
Cd	Cadmium
CN-	Cyanide
COPC	Chemical of Potential Concern
Cr	Chromium
Cu	Copper
EPA	United States Environmental Protection Agency
FMP Area	Former Manufacturing Plant Area
f_{OC}	Fraction of Organic Carbon
FS	Feasibility Study
g_{OC}	Gram of Organic Carbon
HC	Hilliards Creek
HPAH	High Molecular Weight Polycyclic Aromatic Hydrocarbon
HQ	Hazard Quotient
LHC	Lower Hilliards Creek
LOAEL	Lowest Observed Adverse Effect Level
LOE	Line of Evidence
LOEC	Lowest Observed Effect Concentration
MHC	Middle Hilliards Creek
Mn	Manganese
mPECQ	Mean Probable Effect Concentration Quotient
Ni	Nickel
NJDEP	New Jersey Department of Environmental Protection
NOAEL	No Observed Adverse Effect Level

NOEC	No Observed Effect Concentration
Pb	Lead
PEC	Probable Effect Concentration
PECQ	Probable Effect Concentration Quotient
PRG	Preliminary Remediation Goal
Sb	Antimony
Se	Selenium
SEM	Simultaneously Extracted Metals
SQG	Sediment Quality Guideline
Tl	Thallium
TRV	Toxicity Reference Value
UHC	Upper Hilliards Creek
V	Vanadium
WOE	Weight of Evidence
Zn	Zinc

A.1 Introduction

A Baseline Ecological Risk Assessment (BERA) was conducted for the Former Manufacturing Plant Area (hereafter referred to as the FMP Area) (Gradient, 2018; US EPA Region II, 2018). The FMP Area BERA considered one ecological exposure area: Upper Hilliards Creek (UHC). This terrestrial and aquatic exposure area encompasses habitat located south of Foster Avenue, west of United States Avenue, and east of West Clementon Road, consisting of undeveloped palustrine forested wetlands along the stream course of Hilliards Creek (HC) and adjacent upland areas, including the former lagoon area (Weston, 2009). This exposure area is approximately 17.1 acres (ac) in size, with approximately 0.4 ac of stream.

Sufficient information was available to provide a thorough characterization of ecological risks at the FMP Area in the BERA (Gradient, 2018). The BERA concluded, based on a weight-of-evidence (WOE) analysis of multiple lines of evidence (LOEs), that chemicals of potential concern (COPCs) in UHC potentially pose an unacceptable ecological risk. Ecological risks identified in the BERA for key inorganic COPCs (primarily arsenic [As], lead [Pb], and cyanide [CN-]) are primarily associated with localized elevated concentrations in soil and sediment within and near HC, whereas concentrations are much lower in upland areas away from HC in the FMP Area.

This document derives ecological preliminary remediation goals (PRGs) for soil and sediment, based on the BERA (Gradient, 2018), that will be used in the Feasibility Study (FS). Specifically, this document derives PRGs for the protection of benthic invertebrates and aquatic-dependent wildlife in UHC, and PRGs for the protection of terrestrial wildlife in UHC.[1] Site-specific PRGs were not derived for soil invertebrate and terrestrial plant communities.[2]

Given that the BERA identified ecological risks primarily associated with As, Pb, and CN-, these COPCs were considered the primary COPCs that required risk management and were used for the derivation of PRGs for both sediment (Sections A.2 and A.3) and soil (Section A.4). Final proposed PRGs are presented in Section A.5. Wildlife PRGs for secondary COPCs identified in the BERA (*i.e.*, COPCs that resulted in elevated risk estimates for some ecological receptor groups for one LOE, but for which either the effect or exposure metric had substantial uncertainties) were also calculated for the most sensitive aquatic-dependent (Spotted Sandpiper) and terrestrial (American Robin and Short-Tailed Shrew) wildlife receptors (see Sections A.3 and A.4).

Ecological PRGs were derived following New Jersey Department of Environmental Protection (NJDEP) guidance for the determination of risk-based remediation goals (NJDEP, 2015). These are consistent with the risk management section (Step 8) of the United States Environmental

[1] EPA directed Sherwin-Williams to also include samples collected in Middle Hilliards Creek (MHC) and Lower Hilliards Creek (LHC) as part of the Waterbodies BERA to derive PRGs that would apply to all of HC and not just UHC.

[2] While barium (Ba) and zinc (Zn) were also identified as primary COPCs for terrestrial plants (Table 10 in FMP Area BERA; Gradient, 2018), concentrations of these two metals are significantly correlated, and they are also correlated with the primary soil COPCs for wildlife (As, Pb, and CN-), as shown in Table A.4b. Therefore, no terrestrial plant PRGs were derived for Ba and Zn. Removal of soils with As, Pb, and CN- concentrations above the wildlife PRGs is expected to reduce soil COPC concentrations to levels that are protective of all terrestrial receptors, including plants.

Protection Agency's (EPA's) Superfund ecological risk assessment guidance (US EPA, 1997). Numerical PRGs serve as delineation criteria for sediments and soils, which enable the determination of the contaminant footprint, volume of contaminated media, and potential remedial action costs (NJDEP, 2015). Benthic invertebrate PRGs were developed using the results of the sediment toxicity testing that was conducted as part of the BERA.[3] The aquatic-dependent and terrestrial wildlife PRGs were developed using food chain models and site-specific information (*e.g.*, tissue concentration data) that was collected as part of the BERA. The following sections describe how the PRGs were derived, the uncertainties associated with the PRGs (*e.g.*, toxicity reference values [TRVs]), the proposed numerical PRGs for the protection of ecological receptors present at the FMP Area, and the ecological protectiveness of the soil and sediment alternatives identified in the FS.

Site-specific surface water PRGs were not developed herein, because the New Jersey Water Quality Standards are considered Applicable or Relevant and Appropriate Requirements (ARARs) for UHC.[4]

[3] The FMP BERA relied on several lines of evidence to evaluate risks to benthic invertebrates, including sediment chemistry, chemical bioavailability (*i.e.*, using SEM/AVS and TOC), comparison to sediment quality guidelines (*i.e.*, using mPECQ), and site-specific sediment toxicity (Gradient, 2018). Site-specific sediment toxicity testing was considered the primary line of evidence and was used for the derivation of benthic PRGs, consistent with the approach used in the Dump Site FS (Weston, 2016) and Burn Site FS (ELM, 2017).

[4] Manganese was identified as a primary COPC based on a weight-of-evidence evaluation for fish (Table 9 in FMP Area BERA; Gradient, 2018). Given that surface water is the primary environmental medium of exposure for fish and given that the New Jersey Water Quality Standards are ARARs for surface water, no site-specific PRGs were developed for manganese in surface water.

A.2 Sediment PRGs for the Protection of Benthic Invertebrates

The FMP Area BERA examined several LOEs to evaluate the potential for COPCs to adversely affect the survival, growth, or reproduction of benthic invertebrate populations in UHC (Gradient, 2018). Each LOE provided information to address the following ecological risk questions:

- Are the concentrations of COPCs in sediment, pore water, surface water, and benthic invertebrate tissue from aquatic portions of the FMP Area predicted to cause adverse effects on the survival, growth, or reproduction of benthic invertebrates?
- Is the survival or growth (*i.e.*, weight or biomass) of benthic invertebrates, as indicated by *Hyalella azteca*, exposed to bulk sediment significantly different from that of background samples (*i.e.*, a ≥20% reduction in survival or growth of organisms exposed to FMP Area sediments relative to organisms exposed to background sediments as measured in a 28-day sediment toxicity bioassay)?

Measures of exposure and effect were used to assess the above risk questions for benthic invertebrates. These included sediment, surface, and pore water chemistry; toxicity tests; and tissue chemistry.

- **Measures of Exposure:**
  - COPC concentrations in sediment (including acid volatile sulfide [AVS]/ simultaneously extracted metals [SEM])
  - COPC concentrations in pore water
  - COPC concentrations in surface water (total and dissolved)
  - COPC concentrations in invertebrate tissue
- **Measures of Effect:**
  - Literature-derived toxicity data (*i.e.*, sediment toxicity benchmarks)
  - Sediment toxicity tests (28-day growth and survival) with *Hyalella azteca*

Based on the overall WOE, there was sufficient information to conclude in the FMP Area BERA that there is the potential for unacceptable risks to benthic invertebrates in UHC (even though the sediment toxicity LOE showed no toxicity in any of the tested locations). The results of the WOE analysis provided a strong basis for identifying the primary COPCs (As, Pb, and CN-) and assessing risks to benthic invertebrates. A subset of additional sediment toxicity samples collected in MHC and LHC as part of the Waterbodies BERA found significant toxicity, indicating the potential for unacceptable risks to benthic invertebrates in these areas. At EPA's direction, the sediment toxicity samples collected in MHC and LHC as part of the Waterbodies BERA were included here and used to derive benthic PRGs that would apply to all of HC and not just UHC.

Sediment Toxicity Test and Chemistry Results

Sediment samples from 15 locations in HC and 10 locations from the background area were assessed for toxicity using a 28-day growth and mortality test with *Hyalella azteca*. A summary of the toxicity test results and co-located sediment chemistry data is presented in Table A.1. In addition to comparing measured COPC concentrations in the sediment used for toxicity testing to the sediment quality benchmarks (sediment quality guidelines [SQGs]) used in the BERA (Gradient, 2018), the sediment toxicity test responses (*i.e.,* survival and growth) were evaluated statistically (using SigmaPlot V13.0) to aid in the development of sediment PRGs (Attachment 1).

Background sediment toxicity samples did not result in significant toxicity (see Table A.1). Similarly, none of the UHC (mean survival = 94%, mean weight = 0.44 mg, mean biomass = 0.41 mg) sediment samples resulted in significant toxicity. Further, mean weight and mean biomass results were significantly greater ($p < 0.05$) in samples collected from UHC when compared to background samples (see Table A.1 and Attachment 1 for statistical output). Three sediment samples from MHC (HCBEDD21, HCBEDD23, and HCBEDD25) and one sediment sample from LHC (HCBEDD26) showed a statistically significant reduction in survival that was more than 20% lower than the average survival in the background samples. One of these four sediment samples showed no survival (HCBEDD21 in MHC). Observed weights in the MHC and LHC bioassay samples were all much greater than in the background samples. Sediment characteristics (*e.g.*, grain size, organic carbon) were comparable between UHC and the background areas (see Gradient, 2018). The organic content of samples collected in MHC and LHC were also comparable to the background areas, although some sediment locations contained higher levels of organic carbon (*i.e*., >6%).

Sediment chemistry results were also compared to SQGs to assess potential risks. The primary SQGs used in the BERA were the probable effect concentrations (PECs) developed by MacDonald *et al.* (2000). The sediment PECs represent a concentration above which adverse effects are expected to occur more often than not (MacDonald *et al*., 2000). Chemical concentrations in each sediment location were compared to the SQG. In addition, to evaluate toxicity due to mixtures, the mean probable effect concentration quotient (mPECQ) method was performed following the procedures described by the United States Geological Survey (USGS, 2000), as follows: the mPECQ is the mean exceedance of the probable effect concentration quotient (PECQ) for all COPCs for which a PEC exists, an mPECQ <0.5 is considered to have a low probability of toxicity, and an mPECQ >1.0 is associated with a moderate probability of sediment toxicity. In one sample from UHC (HCBEDD18-SD-AA-AB-0), the mPECQ, but not the AVS/SEM[5] results, suggested the potential for sediment toxicity; however, no toxicity was observed in the bioassays for that sample (Tables A.1 and A.2). In two MHC sediment samples (HCBEDD21 and HCBEDD23), the mPECQ and the AVS/SEM results suggested the potential for sediment toxicity and significant toxicity was observed. In two samples (HCBDEDD25 in MHC and HCBEDD26 in LHC), the mPECQ, but not the AVS/SEM results, suggested the potential for sediment toxicity and sediment toxicity was observed. In one sample from MHC (HCBEDD24), the mPECQ, but not the AVS/SEM results, suggested the potential for sediment

[5] The AVS/SEM benchmark relates potential sediment toxicity to seven divalent metals (cadmium [Cd], copper [Cu], chromium [Cr], Pb, nickel [Ni], silver [Ag], and Zn) as follows: sediments with AVS/SEM >0.0, but which have substantial AVS present, should not be toxic due to Cr or Ag; sediments with ΣSEM-AVS/fraction of organic carbon (f_{OC}) <130 micromoles per gram of organic carbon (μmol/g_{OC}) are expected to pose a low risk of adverse biological effects due to Cd, Cr, Cu, Pb, Ni, and Zn; sediments with ΣSEM-AVS/f_{OC} between 130 and 3,000 μmol/g_{OC} may have adverse biological effects due to Cd, Cu, Pb, Ni, or Zn; and sediments with ΣSEM-AVS/f_{OC} >3,000 μmol/g_{OC} are expected to cause adverse biological effects due to Cd, Cu, Pb, Ni, or Zn (US EPA, 2005).

toxicity; however, no toxicity was observed in the bioassay for that sample. Similarly, in one sample from LHC (HCBEDD28), the AVS/SEM, but not the mPECQ results, suggested the potential for sediment toxicity; however, no toxicity was observed in the bioassay for that sample. The field duplicate sample collected in LHC (HCBEDD26-SD-AA-AB-1) showed a very similar, statistically significant reduction in survival to that of the parent sample (HCBEDD26-SD-AA-AB-0).

Statistical correlations between the sediment metal concentrations and the toxicity responses were evaluated in Table A.3. From this analysis, it is clear that several metals (*i.e.*, Ba, chromium [Cr], CN-, and Pb) are significantly correlated with the observed survival responses. Significant correlations between most metals concentrations (including the key COPCs identified in the FMP Area BERA: As, Pb, and CN-) were observed in HC sediment (Table A.4a). This provides further support that reducing exposure associated with the primary sediment COPCs (As, Pb, and CN-) will also result in reducing exposures to the correlated secondary sediment COPCs (*e.g.*, Ba, Cr). The available sediment toxicity dataset was used to derive site-specific toxicity thresholds as described below.

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The site-specific sediment toxicity test results were considered a primary line of evidence and were used to derived benthic PRGs consistent with the approach used to derived benthic PRGs in the Dump Site FS (Weston, 2016) and Burn Site FS (ELM, 2017). Site-specific sediment PRGs were developed using the sediment data collected in the BERA as follows:

1. The highest concentration of a COPC at which no effect was observed in the toxicity bioassays (a no observed effect concentration [NOEC]); or
2. The lowest concentration of a COPC at which minimal or low toxicity was observed in the toxicity bioassays (a lowest observed effect concentration [LOEC]).

The NOEC was identified as the highest concentration from sediment samples that exhibited no significant toxicity (consistent with NJDEP, 2015). The LOEC was defined as the concentration at which an effect level of greater than 20% was observed in the bioassays. This effect level is commonly used as a *de minimis* risk level for ecological risk assessments. Suter *et al.* (2000) considered effect levels greater than 20% to be of environmental significance and changes in natural populations of less than 20% to not generally be differentiated from natural variability. Field *et al.* (2002) also considered an effect level of 20% from the control, in combination with statistical significance, to designate samples as toxic.

Four samples (three in MHC [HCBEDD21, 23, and 25] and one in LHC [HCBEDD26]) resulted in a statistically significant reduction in survival that was greater than 20% as compared to the background. No survival was observed in sample HCBEDD21. In sample HCBEDD23, there was a reduction in biomass that was not statistically significant, but greater than 20%, as compared to the background. Overall, survival was the most sensitive toxicity endpoint and it was therefore used to determine the LOEC and NOEC values. The lowest As and Pb concentrations measured in samples resulting in a greater than 20% reduction in survival, as compared to the background, were selected as the LOEC, *i.e.*, 20.7 mg/kg (As) and 812 mg/kg (Pb). The lowest CN- concentration measured in a sample resulting in a greater than 20% reduction in survival, as compared to the background, was 2.7 mg/kg (HCBEDD26). However, the next higher CN- concentration (24 mg/kg), observed at location HCBEDD23 was selected as the LOEC. While both locations showed statistically significant toxicity and a greater than 20%

reduction in survival as compared to the background, the toxicity in location HCBEDD26 was attributed to As and Pb, given that concentrations of these two metals exceed their selected LOECs (*i.e.*, 86 mg/kg of As and 1,300 mg/kg of Pb). Further, several samples with much higher CN- concentrations (≤ 19.8 mg/kg) did not result in toxicity. The next lowest As, Pb, and CN- concentrations in the HC sample dataset were selected as the PRG values (*i.e.*, 20.5 mg/kg for As, 593 mg/kg for PB, and 19.8 mg/kg for CN-; Table A.5). The selected PRG values are considered a conservative estimate of COPC concentrations not expected to result in adverse effects to the benthic invertebrate community in HC. As shown in Table A.2, several samples contain As, Pb, and CN- concentrations that exceed the selected benthic PRGs but still show acceptable survival. Given that concentrations of As, Pb, and CN- were frequently above sediment benchmarks[6] and these metals were correlated with other metals (Table A.4a), removal of sediments with As, Pb, and CN- concentrations above the proposed PRGs is expected to reduce sediment COPC concentrations to levels that are protective of benthic invertebrates.

The proposed sediment PRGs for the protection of the benthic invertebrate community in HC are: As – 20.5 mg/kg, Pb – 593 mg/kg, and CN- – 19.8 mg/kg (Table A.5).

[6] CN- does not have a PEC and therefore exceedances are not shown in Table A.2. However, Table C.6 in the FMP BERA shows that all of the five sediment sample locations in UHC had exceedances of the CN- sediment screening benchmark (*i.e.*, 0.1 mg/kg) (Gradient, 2018).

A.3 Sediment PRGs for the Protection of Aquatic-dependent Wildlife

Food web modeling was conducted in the BERA to examine potential risks to aquatic-dependent wildlife receptors that may be exposed to COPCs in UHC (Gradient, 2018). The assessment included an estimate of total dietary exposure (including prey items, surface water, and sediment ingestion) for a number of surrogate avian and mammalian aquatic-dependent wildlife receptors representing different feeding guilds (*i.e.*, Mallard, Great Blue Heron, Spotted Sandpiper, Raccoon, Mink, and Muskrat). The total dietary intake (or total dietary dose) was then compared to a TRV representing the potential for adverse effects to growth, survival, or reproduction. The following COPCs were identified as posing a potential risk to aquatic-dependent wildlife in UHC, as reported in the BERA (Gradient, 2018).

- **Mallard:** Risk results were below 1.0 for most COPCs. Only CN- yielded a hazard quotient (HQ) > 1 based on both the no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL). Additionally, Pb yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Great Blue Heron:** Risk results were below 1.0 for most COPCs. Only CN- yielded an HQ > 1 based on both the NOAEL and LOAEL. Additionally, Pb yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Spotted Sandpiper:** Total dietary exposure for the following COPCs yielded HQs > 1 based on both the NOAEL and LOAEL: As, Ba, Cr, Cu, Pb, vanadium (V), CN-, and total high molecular weight polycyclic aromatic hydrocarbons (HPAHs). Additionally, aluminum (Al), selenium (Se), and di-n-butylphthalate yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Raccoon:** Risk results for all COPCs were below 1.0.
- **Mink:** Risk results for all COPCs were below 1.0.
- **Muskrat:** Total dietary exposure for the following COPCs yielded HQs > 1 based on both the NOAEL and LOAEL: antimony (Sb), As, Cr, Pb, and thallium (Tl). Additionally, Al yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.

Several sources of uncertainty related to wildlife exposure estimates, modeled tissue concentrations, and TRVs were noted in the BERA (Gradient, 2018). For example, the TRV for CN- resulted in risk estimates greater than 1 for all avian receptors. Due to the lack of chronic avian toxicity data for CN-, a TRV was developed based on an acute mortality study with a 100-fold uncertainty factor. Therefore, there is significant uncertainty in the avian risk estimates for CN-. Similarly, the mammalian TRV for Al was considered uncertain. Further, the BERA found that Al concentrations in UHC soil, surface water, and sediment were below background, indicating that risks estimated for Al are largely contributable to background.

As documented in the BERA, the most sensitive aquatic wildlife receptor was the Spotted Sandpiper. This aquatic surrogate wildlife receptor has HQs that are an order of magnitude higher than those of other aquatic surrogate wildlife receptors, has the highest modeled

exposure to benthic organisms (100% of its diet), has the highest incidental sediment ingestion rate (10%), and is sensitive to the primary COPCs. Thus, for the development of wildlife sediment PRGs, the Spotted Sandpiper was selected, because it is the most sensitive surrogate aquatic wildlife receptor, and PRGs developed using this surrogate receptor will be protective of other aquatic wildlife. Sediment wildlife PRGs were developed using the BERA food web models (Gradient, 2018), consistent with NJDEP guidance (NJDEP, 2015).

The PRG calculation below incorporates site-specific and receptor-specific exposures as well as receptor feeding preferences, as described in the BERA (Gradient, 2018). This calculation is performed to estimate the sediment concentration that yields an HQ of 1.0, a value that is intended to represent *de minimis* risk.

$$Sediment\ Concentration\ \left(\frac{mg}{kg}\right) = \frac{(HQ \times TRV)}{\left[\left(FIR \times BAF \times ABS_{food}\right) + \left(SIR \times ABS_{s}\right)\right] \times AUF}$$

where:

HQ	=	Hazard Quotient (unitless, 1.0)
TRV	=	Toxicity Reference Value, representing a daily dose that will result in minimal adverse effects (mg/kg body weight/day)
FIR	=	Food Ingestion Rate (kg food dry weight/body weight/day), calculated based on food ingestion rates and body weights as reported in Appendix D of the BERA (Gradient, 2018)
BAF	=	Sediment Bioaccumulation Factor (unitless)
ABS_{food}	=	Bioavailable Fraction Absorbed from Ingested Prey Items (unitless)
SIR	=	Sediment Ingestion Rate (10% of food ingestion rate)
ABS_s	=	Bioavailable Fraction Absorbed from Ingested Sediment (unitless)
AUF	=	Area Use Factor (unitless), fraction of time that a receptor spends foraging in the exposure area relative to the entire home range (assumed to be 1.0)

All the parameters in the above equation are based on the assumptions provided in the BERA, except for food concentration and bioavailability assumptions (see Table A.6 for a summary of the exposure parameters). All the TRVs used were as reported in Appendix D (Table D.3) of the BERA (Gradient, 2018).

The diet of the Spotted Sandpiper is assumed to consist of 100% benthic invertebrates. Therefore, a site-specific bioaccumulation factor (BAF) was used to estimate COPC uptake from sediment into benthic invertebrate tissues. A median BAF was calculated using individual BAFs from the paired sediment and benthic invertebrate tissues collected from all of HC (including tissues collected from UHC, Middle Hilliards Creek [MHC], and Lower Hilliards Creek [LHC]), comprising three samples of snails, four samples of clams, five samples of crayfish, and three samples of assorted macroinvertebrates (shown in in Table A.7). The BAFs for each paired sediment-tissue sample and the median BAFs are presented in Table A.7. Given the similarity in COPCs, the fact that MHC and LHC are immediately downstream of UHC and part of the same stream, and the limited sample size, it was deemed appropriate to combine the UHC, MHC, and LHC sediment-tissue datasets for the purpose of deriving site-specific BAFs for UHC. Table A.7 shows median BAFs for UHC (N = 5), MHC (N = 5), LHC (N = 5), as well as all of HC (N = 15). Some locations included a duplicate sample, which was averaged with the parent sample in order to estimate a sample-specific BAF. The sediment-tissue data collected from UHC location 20 (snail and crayfish tissue samples) appear to be outliers when compared to

sediment-tissue data and median BAFs collected from elsewhere in HC and in prior BERAs (Dump Site and Burn Site; Gradient 2015, 2016). Figures 1-4 illustrate how the sediment-tissue data collected from UHC location 20 skew the dataset and how median BAFs without including the UHC location 20 sediment-tissue data were used to derive PRGs. For completeness, median BAFs and the resulting wildlife PRGs using only UHC, all of HC, and all of HC minus UHC location 20, are shown in Table A.7 and Table A.9, respectively.

The wildlife sediment PRGs, based on the most sensitive aquatic wildlife receptor (the Spotted Sandpiper) are described for each key COPC below (see also Table A.9).

- **Arsenic:** The PRG for As is estimated as 17 mg/kg
- **Lead:** The PRG for Pb is estimated as 176 mg/kg
- **Cyanide:** The PRG for CN- is estimated as 3.8 mg/kg

Wildlife PRGs were also derived for the secondary metal COPCs identified in the BERA (see Table A.9). The secondary COPCs are chemicals that may have an elevated risk estimated from one or more LOEs, but either the effect or exposure metric had substantial uncertainties. As shown in Table A.4a, some of these secondary metal COPCs were not correlated with the concentrations of the primary COPCs, may be representative of background or other sources (*e.g.*, Al, beryllium [Be]), and/or their risk estimates carry significant uncertainty. As a result, the sediment wildlife PRGs presented for secondary metal COPCs were not considered for remedial decision-making, but are presented for informational purposes.

The proposed sediment PRGs for the protection of aquatic-dependent wildlife are: As – 17 mg/kg, Pb – 176 mg/kg, and CN- – 3.8 mg/kg (Table A.10).

A.4 Soil PRGs for the Protection of Terrestrial Wildlife

Food web modeling was conducted in the BERA to examine potential risks to terrestrial wildlife receptors that may be exposed to COPCs in the UHC exposure area (Gradient, 2018). The assessment included an estimate of total dietary exposure (including prey items, surface water, and soil ingestion) for a number of surrogate avian and mammalian terrestrial receptors (American Robin, Northern Bobwhite, Red-Tailed Hawk, Short-Tailed Shrew, Meadow Vole, Red Fox, and Raccoon). The total dietary intake (or total dietary dose) was then compared to a TRV representing the potential for adverse effects to growth, survival, or reproduction. The following COPCs were identified as posing a potential risk to terrestrial wildlife, as reported in the BERA (Gradient, 2018).

- **American Robin:** Total dietary exposure for several inorganic COPCs (As, Ba, Cr, Pb, Se, V, and CN-) and total HPAHs yielded HQs > 1 based on both the NOAEL and LOAEL. In addition, Al, Cd, Cu, and di-n-butylphthalate yielded HQs > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Northern Bobwhite:** Total dietary exposure for several inorganic COPCs (As, Cr, Pb, and CN-) and total HPAHs yielded HQs > 1 based on both the NOAEL and LOAEL. In addition, Al, Ba, and V yielded HQs > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Red-Tailed Hawk:** Risk results were below 1.0 for most COPCs. Only CN- yielded an HQ > 1 based on the NOAEL, but the HQ was below 1 based on the LOAEL.
- **Short-Tailed Shrew:** Total dietary exposure for several inorganic COPCs (Al, Sb, As, Ba, Cr, Cu, Pb, manganese [Mn], and Se) yielded HQs > 1 based on both the NOAEL and LOAEL. In addition, the following COPCs yielded HQs > 1 based on the NOAEL, but below 1 based on the LOAEL: Cd, Tl, total HPAHs, and 1,2-dichlorobenzene.
- **Meadow Vole:** Risk results were greater than 1.0 for several inorganic COPCs. Only Al yielded an HQ > 1 based on both the NOAEL and LOAEL. Additionally, Sb, As, Pb, Aroclor-1248, 4-chloroaniline, atrazine, and total HPAHs yielded HQs > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Red Fox:** Risk results were below 1.0 for all COPCs, except Al, which yielded an HQ > 1 based on the NOAEL, but below 1 based on the LOAEL.
- **Raccoon:** Risk results for all COPCs were below 1.0.

Several sources of uncertainty related to the wildlife exposure estimates, modeled tissue concentrations, and TRVs were noted in the BERA (Gradient, 2018). As noted in Section A.3, CN- risk estimates for avian receptors are uncertain due to an uncertain TRV. Furthermore, Al risk estimates are considered uncertain and largely attributable to background.

As documented in the BERA, the most sensitive terrestrial surrogate wildlife receptors were the American Robin and Short-Tailed Shrew (Gradient, 2018). These receptors have HQs that are similar to or an order of magnitude higher than those of other terrestrial surrogate wildlife

receptors, have the highest modeled exposure to soil invertebrates (100% of its diet), have substantial incidental soil ingestion rates (2.4-10.4%), have small home ranges, and are sensitive to the primary COPCs. Thus, for the development of wildlife PRGs, the American Robin and Short-Tailed Shrew were selected, because they are the most sensitive terrestrial surrogate wildlife receptors, and PRGs developed using these surrogate receptors will be protective of other terrestrial wildlife. Wildlife PRGs were developed using the BERA food web models (Gradient, 2018), consistent with NJDEP guidance (NJDEP, 2015).

The PRG calculation below incorporates site-specific and receptor-specific exposure and feeding preferences, as described in the BERA (Gradient, 2018). This calculation is performed to estimate the soil concentration that yields an HQ of 1.0, a value that is intended to represent *de minimis* risk.

$$Soil\ Concentration\ \left(\frac{mg}{kg}\right) = \frac{(HQ \times TRV)}{\left[\left(FIR \times BAF \times ABS_{food}\right) + (SIR \times ABS_s)\right] \times AUF}$$

where:

HQ	=	Hazard Quotient (unitless, 1.0)
TRV	=	Toxicity Reference Value, representing a daily dose that will result in minimal adverse effects (mg/kg body weight/day)
FIR	=	Food Ingestion Rate (kg food dry weight/body weight/day), calculated based on food ingestion rates and body weights as reported in Appendix D of the BERA (Gradient, 2018)
BAF	=	Soil Bioaccumulation Factor (unitless)
ABS_{food}	=	Bioavailable Fraction Absorbed from Ingested Prey Items (unitless)
SIR	=	Soil Ingestion Rate (percentage of food ingestion rate)
ABS_s	=	Bioavailable Fraction Absorbed from Ingested Sediment (unitless)
AUF	=	Area Use Factor (unitless), fraction of time that a receptor spends foraging in the exposure area relative to the entire home range (assumed to be 1.0)

All the parameters in the above equation are based on the assumptions provided in the BERA, except for food concentrations. All the TRVs used were as reported in Appendix D (Table D.3) of the BERA (Gradient, 2018).

The diets of the American Robin and Short-Tailed Shrew consist of 100% soil invertebrates. Therefore, site-specific BAFs were used to estimate uptake from the soil to soil invertebrates (*i.e.*, earthworms). A median BAF (consistent with the approach used for benthic invertebrates, see Section A.3) was calculated using individual BAFs from 15 paired soil and soil invertebrate (earthworm) tissue samples collected from all of HC (including five tissues each collected from UHC, MHC, and LHC; see Table A.8). Some locations included a duplicate sample, which was averaged with the parent sample in order to estimate a sample-specific BAF. Given the similarity in COPCs, the fact that MHC and LHC upland areas are similar in habitat and contiguous with upland areas in UHC, and the limited sample size, it was deemed appropriate to combine the UHC, MHC, and LHC soil-tissue datasets for the purpose of deriving site-specific BAFs for UHC. The median BAF using all 15 sample-specific BAFs was used in the PRG calculations. For completeness, median BAFs and the resulting wildlife PRGs using only UHC and all of HC are shown in Table A.8 and Table A.9, respectively.

The wildlife soil PRGs based on the most sensitive terrestrial wildlife receptors are described for each key COPC below (see also Table A.9).

- **Arsenic:** The lowest PRG for As is estimated as 12 mg/kg (based on the Short-Tailed Shrew). This value is below the site-specific 95% upper confidence level (UCL) background soil concentration; thus, the background value of 17 mg/kg for As was selected as the PRG (Table A.10).
- **Lead:** The lowest PRG for Pb is estimated as 91 mg/kg (based on the Short-Tailed Shrew). This value is also below the site-specific 95% UCL background soil concentration; thus, the background value of 213 mg/kg for Pb was selected as the PRG (Table A.10).
- **Cyanide:** The lowest PRG for CN- is estimated as 4 mg/kg (based on the American Robin). This value is also below the site-specific 95% UCL background soil concentration; thus, the background value of 58 mg/kg for CN- was selected as the PRG (Table A.10).

Wildlife PRGs were also derived for the secondary metal COPCs identified in the BERA (see Table A.9). The secondary metal COPCs are chemicals that may have an elevated risk estimated from one or more LOEs, but for which either the effect or exposure metric has substantial uncertainties. As a result, the soil wildlife PRGs presented for secondary metal COPCs were not considered for remedial decision-making, but are presented for informational purposes in Table A.9.

The proposed soil PRGs for the protection of terrestrial wildlife are: As – 17 mg/kg, Pb – 213 mg/kg, and CN- – 58 mg/kg (Table A.10).[7]

[7] While Ba and Zn were also identified as primary COPCs for terrestrial plants (Table 10 in FMP Area BERA; Gradient, 2018), concentrations of these two metals are significantly correlated, and they are also correlated with the primary soil COPCs for wildlife (As, Pb, and CN-), as shown in Table A.4b. Therefore, no terrestrial plant PRGs were derived for Ba and Zn. Removal of soils with As, Pb, and CN- concentrations above the wildlife PRGs is expected to reduce soil COPC concentrations to levels that are protective of all terrestrial receptors, including plants.

A.5 Proposed Ecological PRGs

Table A.10 presents a summary of the proposed benthic invertebrate and wildlife sediment and the soil PRGs developed in the previous sections. These values were compared to site-specific background concentrations, which resulted in the following final proposed PRGs.

- **Sediment:**
  - As – 17 mg/kg
  - Pb – 176 mg/kg
  - CN- – 3.8 mg/kg
- **Soil:**
  - As – 17 mg/kg
  - Pb – 213 mg/kg
  - CN- – 58 mg/kg

These values are intended to be protective of ecological receptors potentially exposed to COPCs in soils and sediment at the FMP Area. Note that, for sediment, the benthic invertebrate PRGs are considered more robust than the aquatic-dependent wildlife PRGs. This is due to the multiple lines of site-specific evidence (toxicity, chemistry, and bioavailability) available for benthic invertebrates that are expected to more closely reflect site conditions. By comparison, the wildlife PRGs incorporate several generic and intentionally conservative assumptions, resulting in greater uncertainty. Furthermore, the benthic sediment PRG values apply to small areal exposures, given that benthic organisms are typically sessile, whereas wildlife exposures occur over the entire foraging area of the receptor.

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Tables

Table A.1 Summary of Sediment Lines of Evidence for Benthic Invertebrates in Hilliards Creek

Sample ID	*H. azteca* , 28-Day Survival/Growth						f_{OC}	∑SEM-AVS/f_{OC} (µmol/g_{OC})	mPECQ Metals[b]	Sediment Concentrations (mg/kg)		
	Survival		Mean Replicate Weight		Mean Replicate Biomass							
	Value (%)	RR[a]	Value (mg)	RR[a]	Value (mg)	RR[a]				As	Pb	CN-
Background Area												
BKBEDD11	92	97%	0.33	130%	0.29	121%	3.47%	-3.73	0.09	2.7	29.2	0.87 U
BKBEDD11_Dup	91	96%	0.29	114%	0.26	109%	3.08%	4.06	0.08	2.5	28.7	0.85 U
BKBEDD12	92	97%	0.26	102%	0.24	102%	0.91%	9.0	0.04	0.78 J	9.8	0.68 U
BKBEDD13	97	102%	0.21	83%	0.21	88%	0.15%	-50.9	0.02	0.37 J	6.1	0.6 U
BKBEDD14	89	94%	0.23	91%	0.2	84%	1.34%	2.57	0.03	0.74 J	11.3	0.71 U
BKBEDD15	96	101%	0.28	110%	0.27	113%	0.46%	-9.65	0.03	0.34 J	9	0.54 U
BKBEDD16	96	101%	0.22	87%	0.21	88%	2.07%	-5.02	0.04	1.1 J	8.2	0.76 U
BKBEDD17	94	99%	0.28	110%	0.26	109%	3.43%	4.21	0.10	3.1 J	39.4 J	0.84 UJ
BKBEDD18	97	102%	0.25	98%	0.24	100%	3.40%	1.04	0.06	1.6	18.1	0.7 U
BKBEDD19	100	105%	0.24	94%	0.24	100%	2.24%	2.41	0.05	1.4 U	16.6	0.56 U
BKBEDD20	97	102%	0.24	94%	0.23	96%	2.70%	5.98	0.06	1.7	21.8	0.65 U
Pooled[c]	95		0.25		0.24		2.02%	-4.41	0.05	1.3	17.0	0.3
Upper Hilliards Creek (UHC)												
HCBEDD16-SD-AA-AB-0	94	99%	0.38	148%	0.35	148%	1.96%	-130	0.16	7.7	67.6 J	6.1 J
HCBEDD16-SD-AA-AB-1	NA[d]	NA	NA[d]	NA	NA[d]	NA	1.46%	-129	0.23	9.1	134 J	3.5 J
HCBEDD17-SD-AA-AB-0	92	97%	0.47	185%	0.43	181%	2.33%	85	0.42	15.8	170	5.1
HCBEDD18-SD-AA-AB-0	95	100%	0.47	183%	0.44	183%	2.27%	-417	**1.2**	36.5	593	19.8
HCBEDD19-SD-AA-AB-0	93	98%	0.41	159%	0.38	158%	3.98%	42	0.92	43.0	452	10.9
HCBEDD20-SD-AA-AB-0	96	101%	0.47	183%	0.44	186%	1.77%	79	0.37	12.8	226	1.8 J
Middle Hilliards Creek (MHC)												
HCBEDD21-SD-AA-AB-0	**0**	**0%** *	-	-	-	-	3.83%	**2606**	**14**	114	12200 J	153
HCBEDD22-SD-AA-AB-0	96	101%	0.45	176%	0.43	178%	2.48%	-57	0.72	68.3 J	207 J	0.75 J
HCBEDD23-SD-AA-AB-0	**16**	**17%** *	0.51	200%	0.083	35%	2.26%	**205**	**1.1**	20.7	812	24[e]
HCBEDD24-SD-AA-AB-0	93	98%	0.39	154%	0.37	153%	7.28%	64	**1.4**	53.2 J	989 J	9.9 J
HCBEDD25-SD-AA-AB-0	**74**	**78%** *	0.47	185%	0.341	142%	7.15%	-8.2	**4.2**	108	3210	46.7
Lower Hilliards Creek (LHC)												
HCBEDD26-SD-AA-AB-0	**56**	**59%** *	0.66	259%	0.34	144%	4.06%	19	**1.9**	86.1 J	1300 J	2.7[e]
HCBEDD26-SD-AA-AB-1	**57**	**60%** *	0.69	273%	0.39	163%	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
HCBEDD27-SD-AA-AB-0	88	93%	0.43	170%	0.37	155%	0.52%	92	0.71	17.2	517	4.2
HCBEDD28-SD-AA-AB-0	94	99%	0.43	169%	0.40	167%	1.34%	**150**	0.70	65.7	375	0.64 U
HCBEDD29-SD-AA-AB-0	87	92%	0.46	181%	0.40	165%	6.25%	-65	0.38	20.5	111	1.3 U
HCBEDD30-SD-AA-AB-0	95	100%	0.46	182%	0.44	183%	1.90%	67	0.23	8.2	106	0.75 U

Notes:

µmol – Micromole; ANOVA – Analysis of Variance; As – Arsenic; AVS – Acid-Volatile Sulfide; BERA – Baseline Ecological Risk Assessment; Cd – Cadmium; CN- – Cyanide; Cr – Chromium; Cu – Copper; f_{OC} – Fraction of Total Organic Carbon; g_{OC} – Gram of Organic Carbon; Hg – Mercury; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; NA – Not Applicable; Ni – Nickel; Pb – Lead; mPECQ – Mean Probable Effect Concentration Quotient; SEM – Simultaneously Extracted Metals; UHC – Upper Hilliards Creek; Zn – Zinc.

Data Qualifiers:

J – Estimated value.

U – Undetected.

Field Sample IDs that end in "dup" or "-1" are field duplicates.

***** Statistically significant reduction in survival compared to the background based on a Kruskal-Wallis ANOVA followed by Dunn's test ($p < 0.05$; see Attachment 1). All samples that were statistically significantly lower compared to the background were also statistically significantly lower as compared to the laboratory control, with one exception. Biomass in sample HCBEDD23 was statistically significantly lower as compared to the laboratory control, but not as compared to the background. See Aquatec Environmental [2017] for statistical output, included with the FMP BERA (Gradient, 2018).

Bolded/dark shaded values indicate a potential adverse effect (see Gradient [2018] for details on these results).

(a) RR = Relative response of sample compared to background mean values.

(b) mPECQ for metals includes the following metals: As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn (see Table A.2).

(c) Pooled background represents the mean of the replicates from 10 samples (excluding the duplicate sample) from the reference area.

(d) A field duplicate sample for chemistry was collected at "HCBEDD16," however, no duplicate sediment toxicity testing was performed at this location. Rather, a duplicate sample for sediment toxicity testing was collected from a different location in LHC ("HCBEDD26").

(e) The LOEC for CN- was selected as 24 mg/kg instead of 2.7 mg/kg. While both locations HCBEDD23 and HCBEDD26 showed statistically significant toxicity, the toxicity in location HCBEDD26 is attributed to As and Pb, given that concentrations of these metals exceed their selected LOECs. By comparison, the CN- concentration at location HCBEDD26*(i.e.* , 2.7 mg/kg) is lower than observed in six other sampled locations (3.5-19.8 mg/kg) where toxicity was not observed. Therefore, CN- is unlikely to have caused the observed toxicity at location HCBEDD26, and the CN- concentration at location HCBEDD23 was used as the LOEC.

Table A.2 Comparison of Hilliards Creek Sediment Metals Concentrations to Sediment PECs

Location Sample ID	Sample Date	Mean PECQ	As mg/kg	Q	PECQ 33	Cd mg/kg	Q	PECQ 4.98	Cr mg/kg	Q	PECQ 111	Cu mg/kg	Q	PECQ 149	Hg mg/kg	Q	PECQ 1.06	Ni mg/kg	Q	PECQ 49	Pb mg/kg	Q	PECQ 128	Zn mg/kg	Q	PECQ 459
Background Area																										
BKBEDD11-SD-AA-AB-0	10/13/2014	0.09	2.7		0.08	0.66	J	0.13	3.7		0.03	3.5	J	0.02	0.17	U	0.08	3.3	J	0.07	29.2		0.23	27.7		0.06
BKBEDD11-SD-AA-AB-1	10/13/2014	0.08	2.5		0.08	0.6	J	0.12	3.5		0.03	3	J	0.02	0.17	U	0.08	2.7	J	0.06	28.7		0.22	24.8		0.05
BKBEDD12-SD-AA-AB-0	10/13/2014	0.04	0.78	J	0.02	0.24	J	0.05	4.3		0.04	1.1	J	0.01	0.13	U	0.06	0.8	J	0.02	9.8		0.08	9.4		0.02
BKBEDD13-SD-AA-AB-0	10/14/2014	0.02	0.37	J	0.01	0.17	J	0.03	2.3		0.02	0.47	J	0.00	0.12	U	0.06	0.35	J	0.01	6.1		0.05	2.2	J	0.00
BKBEDD14-SD-AA-AB-0	10/14/2014	0.03	0.74	J	0.02	0.12	J	0.02	3.2		0.03	1.2	J	0.01	0.14	U	0.07	0.58	J	0.01	11.3		0.09	7.2		0.02
BKBEDD15-SD-AA-AB-0	10/14/2014	0.03	0.34	J	0.01	0.14	J	0.03	2.1		0.02	0.61	J	0.00	0.1	U	0.05	0.56	J	0.01	9		0.07	5.1	J	0.01
BKBEDD16-SD-AA-AB-0	10/14/2014	0.04	1.1	J	0.03	0.38	J	0.08	4.8		0.04	1.1	J	0.01	0.15	U	0.07	0.97	J	0.02	8.2		0.06	5.7	J	0.01
BKBEDD17-SD-AA-AB-0	10/14/2014	0.10	3.1	J	0.09	0.45	J	0.09	5.4	J	0.05	5.1	J	0.03	0.19	UJ	0.09	3.3	J	0.07	39.4	J	0.31	25.6	J	0.06
BKBEDD18-SD-AA-AB-0	10/14/2014	0.06	1.6		0.05	0.28	J	0.06	4.2		0.04	2.3	J	0.02	0.15	U	0.07	3.4	J	0.07	18.1		0.14	15.1		0.03
BKBEDD19-SD-AA-AB-0	10/15/2014	0.05	1.4	U	0.02	0.7	U	0.07	3.8		0.03	1.9	J	0.01	0.14	U	0.07	1.8	J	0.04	16.6		0.13	10.8		0.02
BKBEDD20-SD-AA-AB-0	10/15/2014	0.06	1.7		0.05	0.25	J	0.05	5.3		0.05	2.6	J	0.02	0.15	U	0.07	2.7	J	0.06	21.8		0.17	20.1		0.04
Upper Hilliards Creek (UHC)																										
HCBEDD16-SD-AA-AB-0	8/7/2017	0.16	7.7		0.23	0.21	J	0.04	15		0.14	9.3		0.06	0.094	J	0.09	2.1		0.04	67.6	J	0.53	72.6		0.16
HCBEDD16-SD-AA-AB-1	8/7/2017	0.23	9.1		0.28	0.27	J	0.05	14.7		0.13	10.6		0.07	0.037	J	0.03	2.1		0.04	134	J	**1.0**	101		0.22
HCBEDD17-SD-AA-AB-0	8/7/2017	0.42	15.8		0.48	0.43	J	0.09	15.7		0.14	24.4		0.16	0.67		0.63	4.1		0.08	170		**1.3**	209		0.46
HCBEDD18-SD-AA-AB-0	8/7/2017	**1.2**	36.5		**1.1**	0.61	J	0.12	207		**1.9**	34.5		0.23	1.1		**1.0**	3.2		0.07	593		**4.6**	217		0.47
HCBEDD19-SD-AA-AB-0	8/7/2017	0.92	43		**1.3**	1.2		0.24	142		**1.3**	22.4		0.15	0.28		0.26	2.3		0.05	452		**3.5**	252		0.55
HCBEDD20-SD-AA-AB-0	8/7/2017	0.37	12.8		0.39	0.26	J	0.05	37.7	J	0.34	9.4		0.06	0.19		0.18	1.1		0.02	226		**1.8**	69.2	J	0.15
HCBEDDUH-SD-AA-AB-0	9/6/2017	0.47	13.4		0.41	0.49	J	0.10	23.5		0.21	19.4	J	0.13	0.4		0.38	2.2	J	0.05	266	J	**2.1**	180		0.39
Middle Hilliards Creek (MHC)																										
HCBEDD21-SD-AA-AB-0	8/16/2017	**14**	114		**3.5**	4.6		0.92	1310		**12**	77.5		0.52	0.47		0.44	2.1		0.04	12200	J	**95**	366		0.80
HCBEDD22-SD-AA-AB-0	8/16/2017	0.72	68.3	J	**2.1**	2.7	J	0.54	38.7	J	0.35	32.7	J	0.22	0.052	J	0.05	9.6	J	0.20	207	J	**1.6**	323	J	0.70
HCBEDD23-SD-AA-AB-0	8/15/2017	**1.1**	20.7		0.63	0.39	J	0.08	152		**1.4**	20.9		0.14	0.19		0.18	2.3		0.05	812		**6**	101		0.22
HCBEDD24-SD-AA-AB-0	8/15/2017	**1.4**	53.2	J	**1.6**	0.95	J	0.19	116		**1.0**	21.7	J	0.15	0.14	J	0.13	3.5	J	0.07	989	J	**8**	114	J	0.25
HCBEDD25-SD-AA-AB-0	8/15/2017	**4.2**	108		**3.3**	1.1		0.22	415		**3.7**	45.1		0.30	0.19		0.18	3.8		0.08	3210		**25**	168		0.37
Lower Hilliards Creek (LHC)																										
HCBEDD26-SD-AA-AB-0	8/14/2017	**1.9**	86.1	J	**2.6**	0.54	J	0.11	132	J	**1.2**	65.5		0.44	0.094	J	0.09	3.6		0.07	1300	J	**10**	84.2		0.18
HCBEDD27-SD-AA-AB-0	8/14/2017	0.71	17.2		0.52	0.32	J	0.06	85.3	J	0.77	13.5		0.09	0.048	J	0.05	1.2		0.02	517		**4.0**	42.2		0.09
HCBEDD28-SD-AA-AB-0	8/14/2017	0.70	65.7		**2.0**	0.28	J	0.06	39.7	J	0.36	11.7		0.08	0.028	J	0.03	1.5		0.03	375		**2.9**	42.1		0.09
HCBEDD29-SD-AA-AB-0	8/14/2017	0.38	20.5		0.62	1.9		0.38	20.6	J	0.19	32.1		0.22	0.16	J	0.15	8.9		0.18	111		0.87	193		0.42
HCBEDD30-SD-AA-AB-0	8/14/2017	0.23	8.2		0.25	0.62	J	0.12	11	J	0.10	18.3		0.12	0.055	J	0.05	3.1		0.06	106		0.83	145		0.32

Notes:

As – Arsenic; Cd – Cadmium; Cr – Chromium; Cu – Copper; Hg – Mercury; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; mPECQ – Mean Probable Effect Concentration Quotient; Ni – Nickel; Pb – Lead; PEC – Probable Effect Concentration; PECQ – Probable Effect Concentration Quotient; UHC – Upper Hilliards Creek; Zn – Zinc.

Field Sample IDs that end in "-1" are field duplicates.

Units of mPECQs and PECQs are mg/kg.

mPECQ > 1.0 indicates a moderate probability (>50%) of sediment toxicity.

Q – Data Qualifier:

U – Undetected. The detection limit (DL) is presented. The PECQ was calculated using half the DL.

J – Estimated.

Bolded/dark shaded values indicate a concentration greater than the sediment PEC (PECs from MacDonald *et al.,* 2000) or a mPECQ greater than 1.0.

Table A.3 Statistical Correlations for Hilliards Creek Sediment Toxicity Test Results

Parameter	*H. azteca* , 28-Day Survival/Growth					
	Survival		Mean Weight		Mean Biomass	
	Correlation[a,b]	*p* Value	Correlation	*p* Value	Correlation	*p* Value
f_{OC} (%)	-0.405	0.131	0.130	0.648	-0.367	0.189
mPECQ (metals)	**-0.570**	**0.025**	0.367	0.189	-0.490	0.072
∑SEM-AVS/f_{OC} (µmol/g_{OC})	-0.366	0.176	0.141	0.615	-0.059	0.832
Aluminum	-0.231	0.396	0.167	0.552	-0.099	0.727
Antimony	0.204	0.457	0.110	0.693	0.416	0.134
Arsenic	-0.423	0.113	0.216	0.444	-0.376	0.178
Barium	**-0.552**	**0.031**	0.378	0.173	-0.424	0.125
Beryllium	0.330	0.224	0.044	0.868	0.446	0.105
Cadmium	-0.235	0.388	0.020	0.940	-0.002	0.988
Chromium	**-0.527**	**0.041**	0.323	0.251	-0.442	0.109
Cobalt	0.117	0.667	-0.064	0.820	0.079	0.773
Copper	-0.471	0.073	**0.535**	**0.047**	-0.152	0.594
Cyanide	**-0.513**	**0.048**	0.198	0.482	-0.495	0.069
Iron	-0.074	0.783	0.139	0.626	0.077	0.785
Lead	**-0.600**	**0.018**	0.398	0.152	-0.512	0.059
Manganese	-0.022	0.934	-0.330	0.238	-0.191	0.501
Mercury	-0.233	0.396	0.381	0.173	0.124	0.659
Nickel	-0.090	0.743	0.286	0.308	-0.059	0.832
Selenium	0.275	0.312	-0.262	0.356	0.156	0.583
Silver	0.116	0.676	-0.302	0.286	0.253	0.373
Thallium	0.206	0.449	-0.132	0.637	0.225	0.425
Vanadium	0.452	0.086	-0.189	0.501	0.437	0.113
Zinc	-0.086	0.753	0.092	0.738	0.218	0.444

Notes:

µmol – Micromole; AVS – Acid-Volatile Sulfide; f_{OC} – Fraction of Total Organic Carbon; g_{OC} – Gram of Organic Carbon; HC – Hilliards Creek; mPECQ – Mean Probable Effect Concentration Quotient; SEM – Simultaneously Extracted Metals.

(a) Correlations performed on 15 primary HC sediment samples combined (no field duplicates). Half of the detection limit was substituted for non-detected samples.

(b) Correlation coefficient (r2) estimate is based on Spearman rank non-parametric correlation (**bolded** values are significant, $p < 0.05$).

Table A.4a Correlation Between Variables in 2017 Hilliards Creek Sediment Samples

Parameter[a,b]	f_{OC}	Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	CN-	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	V	Zn
f_{OC}		**0.80**	0.057	**0.56**	**0.64**	0.25	**0.70**	0.38	0.45	**0.70**	0.38	**0.72**	0.41	**0.59**	0.35	**0.70**	-0.19	-0.20	0.31	0.30	**0.55**
Al	**0.80**		-0.095	**0.58**	**0.65**	0.43	**0.87**	0.27	0.34	**0.71**	0.079	**0.83**	0.31	0.40	0.11	**0.71**	0.19	0.23	**0.71**	0.40	**0.61**
Sb	0.057	-0.095		-0.093	0.13	0.22	0.12	0.12	-0.014	0.15	0.47	0.17	-0.014	0.11	**0.76**	-0.059	-0.14	-0.31	-0.088	0.14	**0.53**
As	**0.56**	**0.58**	-0.093		**0.72**	-0.13	**0.59**	**0.76**	-0.048	**0.74**	0.35	0.51	**0.78**	0.19	0.068	0.28	0.093	0.23	0.29	-0.33	0.37
Ba	**0.64**	**0.65**	0.13	**0.72**		0.11	**0.64**	**0.82**	0.14	**0.74**	**0.69**	**0.64**	**0.78**	0.28	0.44	0.35	-0.056	0.11	0.29	-0.17	**0.53**
Be	0.25	0.43	0.22	-0.13	0.11		0.26	-0.32	0.45	0.13	-0.25	0.42	-0.24	0.42	0.093	0.45	0.13	0.052	**0.55**	**0.56**	0.21
Cd	**0.70**	**0.87**	0.12	**0.59**	**0.64**	0.26		0.37	0.32	**0.75**	0.23	**0.75**	0.29	0.47	0.25	**0.59**	0.040	0.42	**0.52**	0.27	**0.84**
Cr	0.38	0.27	0.12	**0.76**	**0.82**	-0.32	0.37		-0.16	**0.60**	**0.76**	0.31	**0.92**	0.0036	0.43	-0.050	-0.23	0.036	-0.081	**-0.57**	0.31
Co	0.45	0.34	-0.014	-0.048	0.14	0.45	0.32	-0.16		0.27	-0.039	**0.56**	-0.21	**0.68**	0.16	**0.74**	-0.30	0.059	0.031	**0.67**	0.40
Cu	**0.70**	**0.71**	0.15	**0.74**	**0.74**	0.13	**0.75**	**0.60**	0.27		0.42	**0.69**	**0.59**	0.20	0.44	**0.62**	-0.21	0.093	0.21	0.025	**0.71**
CN-	0.38	0.079	0.47	0.35	**0.69**	-0.25	0.23	**0.76**	-0.039	0.42		0.16	**0.66**	0.14	**0.68**	-0.036	-0.37	-0.28	-0.26	-0.37	0.40
Fe	**0.72**	**0.83**	0.17	0.51	**0.64**	0.42	**0.75**	0.31	**0.56**	**0.69**	0.16		0.29	0.48	0.34	**0.68**	0.15	0.13	0.51	**0.53**	**0.70**
Pb	0.41	0.31	-0.014	**0.78**	**0.78**	-0.24	0.29	**0.92**	-0.21	**0.59**	**0.66**	0.29		-0.0089	0.29	-0.048	-0.072	-0.11	-0.074	**-0.61**	0.13
Mn	**0.59**	0.40	0.11	0.19	0.28	0.42	0.47	0.0036	**0.68**	0.20	0.14	0.48	-0.0089		0.054	0.47	-0.095	0.063	0.14	0.36	0.39
Hg	0.35	0.11	**0.76**	0.068	0.44	0.093	0.25	0.43	0.16	0.44	**0.68**	0.34	0.29	0.054		0.14	**-0.51**	-0.35	-0.18	0.086	**0.58**
Ni	**0.70**	**0.71**	-0.059	0.28	0.35	0.45	**0.59**	-0.050	**0.74**	**0.62**	-0.036	**0.68**	-0.048	0.47	0.14		-0.14	0.059	0.39	**0.65**	**0.56**
Se	-0.19	0.19	-0.14	0.093	-0.056	0.13	0.040	-0.23	-0.30	-0.21	-0.37	0.15	-0.072	-0.095	**-0.51**	-0.14		0.21	**0.55**	0.13	-0.13
Ag	-0.20	0.23	-0.31	0.23	0.11	0.052	0.42	0.036	0.059	0.093	-0.28	0.13	-0.11	0.063	-0.35	0.059	0.21		0.44	-0.0089	0.25
Tl	0.31	**0.71**	-0.088	0.29	0.29	**0.55**	**0.52**	-0.081	0.031	0.21	-0.26	0.51	-0.074	0.14	-0.18	0.39	**0.55**	0.44		0.43	0.29
V	0.30	0.40	0.14	-0.33	-0.17	**0.56**	0.27	**-0.57**	**0.67**	0.025	-0.37	**0.53**	**-0.61**	0.36	0.086	**0.65**	0.13	-0.0089	0.43		0.39
Zn	**0.55**	**0.61**	**0.53**	0.37	**0.53**	0.21	**0.84**	0.31	0.40	**0.71**	0.40	**0.70**	0.13	0.39	**0.58**	**0.56**	-0.13	0.25	0.29	0.39	

Notes:

f_{OC} – Fraction of Total Organic Carbon; HC – Hilliards Creek.

Chemicals: Ag – Silver; Al – Aluminum; As – Arsenic; Ba – Barium; Be – Beryllium; Cd – Cadmium; Cr – Chromium; Co – Cobalt; Cu – Copper; CN- – Cyanide; Fe – Iron; Hg – Mercury; Mn – Manganese; Ni – Nickel; Pb – Lead; Sb – Antimony; Se – Selenium; Tl – Thallium; V – Vanadium; Zn – Zinc.

(a) Correlations performed on 15 primary HC sediment samples combined (no field duplicates). Half of the detection limit was substituted for non-detected samples.

(b) Correlation coefficient (r^2) estimate is based on Spearman rank non-parametric correlation (**bolded** values are significant, $p < 0.05$).

Table A.4b Correlation Between Variables in 2017 Hilliards Creek Soil Samples

Parameter[a,b]	f_{OC}	Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	CN-	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	V	Zn
f_{OC}		0.40	**0.54**	0.14	0.23	0.41	0.20	0.33	0.25	0.32	0.32	0.18	0.18	0.089	0.28	0.47	**0.66**	0.49	-0.18	**0.51**	0.22
Al	0.40		**0.68**	**0.63**	**0.62**	**0.93**	**0.65**	**0.80**	**0.72**	**0.69**	**0.66**	**0.70**	**0.68**	**0.63**	**0.72**	**0.74**	0.45	**0.65**	0.10	**0.82**	**0.66**
Sb	**0.54**	**0.68**		**0.85**	**0.79**	**0.63**	**0.81**	**0.81**	**0.81**	**0.75**	**0.88**	**0.83**	**0.74**	**0.75**	**0.80**	**0.91**	**0.62**	**0.90**	0.31	**0.81**	**0.82**
As	0.14	**0.63**	**0.85**		**0.85**	**0.63**	**0.93**	**0.83**	**0.93**	**0.77**	**0.90**	**0.93**	**0.85**	**0.93**	**0.82**	**0.88**	0.31	**0.76**	0.40	**0.72**	**0.88**
Ba	0.23	**0.62**	**0.79**	**0.85**		**0.59**	**0.83**	**0.91**	**0.83**	**0.92**	**0.88**	**0.71**	**0.89**	**0.84**	**0.89**	**0.78**	0.41	**0.76**	0.21	**0.68**	**0.88**
Be	0.41	**0.93**	**0.63**	**0.63**	**0.59**		**0.64**	**0.80**	**0.76**	**0.57**	**0.62**	**0.69**	**0.68**	**0.60**	**0.58**	**0.74**	0.32	**0.54**	0.047	**0.70**	**0.53**
Cd	0.20	**0.65**	**0.81**	**0.93**	**0.83**	**0.64**		**0.78**	**0.89**	**0.76**	**0.80**	**0.81**	**0.94**	**0.90**	**0.84**	**0.88**	0.38	**0.72**	**0.56**	**0.69**	**0.76**
Cr	0.33	**0.80**	**0.81**	**0.83**	**0.91**	**0.80**	**0.78**		**0.87**	**0.86**	**0.88**	**0.76**	**0.84**	**0.82**	**0.88**	**0.83**	0.41	**0.76**	0.086	**0.72**	**0.84**
Co	0.25	**0.72**	**0.81**	**0.93**	**0.83**	**0.76**	**0.89**	**0.87**		**0.73**	**0.82**	**0.87**	**0.82**	**0.91**	**0.77**	**0.94**	0.24	**0.66**	0.30	**0.68**	**0.83**
Cu	0.32	**0.69**	**0.75**	**0.77**	**0.92**	**0.57**	**0.76**	**0.86**	**0.73**		**0.82**	**0.65**	**0.82**	**0.76**	**0.91**	**0.73**	**0.56**	**0.84**	0.21	**0.77**	**0.90**
CN-	0.32	**0.66**	**0.88**	**0.90**	**0.88**	**0.62**	**0.80**	**0.88**	**0.82**	**0.82**		**0.86**	**0.79**	**0.80**	**0.88**	**0.80**	0.46	**0.83**	0.15	**0.82**	**0.90**
Fe	0.18	**0.70**	**0.83**	**0.93**	**0.71**	**0.69**	**0.81**	**0.76**	**0.87**	**0.65**	**0.86**		**0.71**	**0.84**	**0.70**	**0.81**	0.34	**0.73**	0.30	**0.73**	**0.81**
Pb	0.18	**0.68**	**0.74**	**0.85**	**0.89**	**0.68**	**0.94**	**0.84**	**0.82**	**0.82**	**0.79**	**0.71**		**0.82**	**0.87**	**0.79**	0.39	**0.72**	0.36	**0.70**	**0.74**
Mn	0.089	**0.63**	**0.75**	**0.93**	**0.84**	**0.60**	**0.90**	**0.82**	**0.91**	**0.76**	**0.80**	**0.84**	**0.82**		**0.83**	**0.85**	0.35	**0.61**	0.41	**0.58**	**0.84**
Hg	0.28	**0.72**	**0.80**	**0.82**	**0.89**	**0.58**	**0.84**	**0.88**	**0.77**	**0.91**	**0.88**	**0.70**	**0.87**	**0.83**		**0.79**	**0.52**	**0.81**	0.28	**0.79**	**0.90**
Ni	0.47	**0.74**	**0.91**	**0.88**	**0.78**	**0.74**	**0.88**	**0.83**	**0.94**	**0.73**	**0.80**	**0.81**	**0.79**	**0.85**	**0.79**		0.44	**0.74**	0.38	**0.75**	**0.80**
Se	**0.66**	0.45	**0.62**	0.31	0.41	0.32	0.38	0.41	0.24	**0.56**	0.46	0.34	0.39	0.35	**0.52**	0.44		**0.59**	0.030	**0.57**	0.42
Ag	0.49	**0.65**	**0.90**	**0.76**	**0.76**	**0.54**	**0.72**	**0.76**	**0.66**	**0.84**	**0.83**	**0.73**	**0.72**	**0.61**	**0.81**	**0.74**	**0.59**		0.25	**0.85**	**0.82**
Tl	-0.18	0.10	0.31	0.40	0.21	0.047	**0.56**	0.086	0.30	0.21	0.15	0.30	0.36	0.41	0.28	0.38	0.030	0.25		0.14	0.20
V	**0.51**	**0.82**	**0.81**	**0.72**	**0.68**	**0.70**	**0.69**	**0.72**	**0.68**	**0.77**	**0.82**	**0.73**	**0.70**	**0.58**	**0.79**	**0.75**	**0.57**	**0.85**	0.14		**0.79**
Zn	0.22	**0.66**	**0.82**	**0.88**	**0.88**	**0.53**	**0.76**	**0.84**	**0.83**	**0.90**	**0.90**	**0.81**	**0.74**	**0.84**	**0.90**	**0.80**	0.42	**0.82**	0.20	**0.79**	

Notes:

f_{OC} – Fraction of Total Organic Carbon; HC – Hilliards Creek.

Chemicals: Ag – Silver; Al – Aluminum; As – Arsenic; Ba – Barium; Be – Beryllium; Cd – Cadmium; Cr – Chromium; Co – Cobalt; Cu – Copper; CN- – Cyanide; Fe – Iron; Hg – Mercury; Mn – Manganese; Ni – Nickel; Pb – Lead; Sb – Antimony; Se – Selenium; Tl – Thallium; V – Vanadium; Zn – Zinc.

(a) Correlations performed on 15 primary HC soil samples combined (no field duplicates). Half of the detection limit was substituted for non-detected samples.

(b) Correlation coefficient (r^2) estimate is based on Spearman rank non-parametric correlation (**bolded** values are significant, $p < 0.05$).

Table A.5 Summary of Preliminary Remediation Goals for Benthic Invertebrates in Hilliards Creek

Area of Concern	Endpoint	Sediment PRGs (mg/kg)					
		As	Sample ID[a]	Pb	Sample ID[a]	CN-	Sample ID[a]
Hilliards Creek	Survival (NOEC)	20.5	HCBEDD29-SD-AA-AB-0	593	HCBEDD18-SD-AA-AB-0	19.8	HCBEDD20-SD-AA-AB-0
Background	Sediment Background 95% USL[b]	3.3	NA	40	NA	NA	NA
	Sediment PECs (MacDonald *et al.* , 2000)	33	NA	128	NA	NA	NA
	Sediment PRGs for the Protection of Benthic Invertebrates	**20.5**		**593**		**19.8**	

Notes:

As – Arsenic; BERA – Baseline Ecological Risk Assessment; CN- – Cyanide; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; NA – Not Applicable/Could Not Be Calculated; NOEC – No Observed Effect Concentration; Pb – Lead; PEC – Probable Effect Concentration; PRG – Preliminary Remediation Goal; UHC – Upper Hilliards Creek.

(a) Sample IDs corresponding to the NOEC values are indicated and toxicity test results are shown in Table A.1.

(b) The 95% upper simultaneous limit (95% USL) was calculated to represent the background sediment concentrations in the BERA (Gradient, 2018).

Table A.6 Exposure and Toxicity Parameters for the Sediment or Soil Wildlife Preliminary Remediation Goals

Parameter	Units	Spotted Sandpiper	American Robin	Short-Tailed Shrew	Source
Exposure Medium	mg/kg	Sediment	Soil	Soil	BERA Appendix Table D.2
Hazard Quotient	unitless	1.0	1.0	1.0	Default Assumption
Food Ingestion Rate (per day)	kg/day	0.010	0.0104	0.003	BERA Appendix Table D.2
Body Weight (BW)	kg	0.043	0.079	0.017	BERA Appendix Table D.2
Food Ingestion Rate (per BW-day)	kg/kg-day	0.239	0.131	0.173	Calculated
Sediment Ingestion Proportion	%	10	0	0	BERA Appendix Table D.2
Soil Ingestion Proportion	%	0	10.4	2.4	BERA Appendix Table D.2
Sediment Ingestion Rate (per BW-day)	kg/kg-day	0.0239	0	0	Calculated
Soil Ingestion Rate (per BW-day)	kg/kg-day	0	0.0137	0.0042	Calculated
Food Source	-	100% Benthic Invertebrates	100% Soil Invertebrates	100% Soil Invertebrates	BERA Appendix Table D.2
Biota Bioaccumulation Factor	unitless	Chemical-specific	Chemical-specific	Chemical-specific	Tables A.7-A.8
Biota Bioavailable Fraction (ABS_{food})	%	100	100	100	Default Assumption
Sediment/Soil Bioavailable Fraction (ABS_s)	%	100	100	100	Default Assumption
Area Use Factor	unitless	1.0	1.0	1.0	Default Assumption
Toxicity Reference Value	mg/kg-day	Chemical-specific (BERA)	Chemical-specific (BERA)	Chemical-specific (BERA)	BERA Appendix Table D.3

Notes:

See Sections A.3 and A.4 for details on the preliminary remediation goal (PRG) calculation for wildlife.

Source: BERA – Baseline Ecological Risk Assessment (Gradient, 2018).

Table A.7 Site-specific Bioaccumulation Factors for Benthic Invertebrates

AOC	Upper Hilliards Creek (UHC)															
Station	(-17)			(-19)			(-20)					(-UH)[a]		
Media	Sediment	Snails	BAF[b]	Sediment	Crayfish	BAF[b]	Sediment	Snails	Snails BAF[b]	Crayfish	Crayfish BAF[b]	Sediment	Assorted Benthic Inv.	BAF[b]
Analyte	mg/kg-dw	mg/kg-dw		mg/kg-dw	mg/kg-dw		mg/kg-dw	mg/kg-dw		mg/kg-dw		mg/kg-dw	mg/kg-dw	
ALUMINUM	1530.00 J	63.98	0.04	1760.00 J	145.26	0.08	1180.00 J	183.64	0.16	162.87	0.14	1520.00	282.03	0.19
ANTIMONY	4.90	0.50 U	0.05	2.90	0.86 U	0.15	5.90	2.17	0.37	0.97	0.16	2.80	1.48 U	0.27
ARSENIC	15.80	47.86	3.03	43.00	34.05	0.79	12.80	181.97	14.22	114.35	8.93	13.40	25.78	1.92
BARIUM	89.50	80.60	0.90	117.00	629.31	5.38	63.20	92.32	1.46	308.44	4.88	106.00 J	42.19	0.40
BERYLLIUM	0.21 J	0.25 U	0.60	0.08 J	0.43 U	2.81	0.66 U	0.16 U	0.25	0.41 U	0.63	0.08 J	0.73 U	4.65
CADMIUM	0.43 J	0.25 U	0.29	1.20	0.47	0.40	0.26 J	0.16 U	0.31	0.41 U	0.80	0.49 J	0.73 U	0.75
CHROMIUM	15.70	3.78	0.24	142.00	7.76	0.05	37.70 J	16.53	0.44	15.61	0.41	23.50	22.66	0.96
COBALT	7.70	0.88	0.11	1.30	0.73	0.56	0.61 J	1.25	2.05	0.97	1.59	1.30 J	1.33	1.02
COPPER	24.40	42.57	1.74	22.40	101.72	4.54	9.40	93.49 J	9.95	129.11	13.74	19.40 J	89.84	4.63
CYANIDE	5.10	2.27	0.44	10.90	2.89	0.26	1.80 J	5.34	2.97	9.70	5.39	3.80	7.73	2.04
IRON	5000.00	2871.54	0.57	5260.00	1784.48	0.34	4040.00	14657.76	3.63	2481.01	0.61	3980.00	3953.13	0.99
LEAD	170.00	10.08	0.06	452.00	48.28	0.11	226	166.61	0.74	258.23	1.14	266.00 J	81.25	0.31
MANGANESE	40.90	279.60	6.84	71.20	237.07	3.33	20.9	340.57 J	16.30	367.51	17.58	22.20 J	559.38	25.20
MERCURY	0.67	0.55 U	0.41	0.28	1.03 U	1.85	0.19	0.37 U	0.97	0.89 U	2.33	0.40	1.64 U	2.05
NICKEL	4.10	2.77	0.68	2.30	2.46	1.07	1.10	1.84	1.67	2.45	2.22	2.20 J	4.06	1.85
SELENIUM	0.60 J	1.26 U	1.05	0.42 J	2.16 U	2.57	3.30 U	0.82 U	0.25	2.07 U	0.63	2.70 U	3.67 U	1.36
SILVER	0.05 J	0.25 U	2.80	0.06 J	0.43 U	3.81	0.03 J	0.16 U	2.89	0.41 U	7.38	0.07 J	0.73 U	5.10
THALLIUM	0.61 U	0.25 U	0.41	0.60 U	0.43 U	0.71	0.66 U	0.16 U	0.25	0.41 U	0.63	0.55 U	0.73 U	1.34
VANADIUM	10.30	2.52	0.24	3.10	4.74	1.53	2.70 J	4.34	1.61	4.64	1.72	6.80	9.38	1.38
ZINC	209.00	78.84 J	0.38	252.00	72.41 J	0.29	69.20 J	159.93 J	2.31	105.91 J	1.53	180.00	160.94 J	0.89

Table A.7 Site-specific Bioaccumulation Factors for Benthic Invertebrates

AOC	Middle Hilliards Creek (MHC)																	
Station	(-22)						(-23)			(-24)					(-MH)[a]			
Media	Sediment	Snails	Snails BAF[b]	Clams	Clams BAF[b]		Sediment	Clams	BAF[b]	Sediment	Crayfish	Crayfish (duplicate)	BAF[b,c]		Sediment	Assorted Benthic Inv.	BAF[b]	
Analyte	mg/kg-dw	mg/kg-dw		mg/kg-dw			mg/kg-dw	mg/kg-dw		mg/kg-dw	mg/kg-dw	mg/kg-dw			mg/kg-dw	mg/kg-dw		
ALUMINUM	3350.00	J 314.00	0.09	90.68	0.03		1690.00	49.32	0.03	6490.00	J 193.85	199.64	0.03		3880.00	461.11	0.12	
ANTIMONY	2.00	J 0.48	0.24	0.28	U 0.07		1.50	0.30	U 0.10	1.20	J 0.77	U 0.72	U 0.31		1.30	J 1.46	U 0.56	
ARSENIC	68.30	J 146.20	2.14	38.98	0.57		20.70	64.99	3.14	53.20	J 30.38	32.49	0.59		72.20	45.83	0.63	
BARIUM	175.00	J 150.20	0.86	185.03	1.06		461.00	197.87	0.43	291.00	J 923.08	790.61	2.94		726.00	J 126.39	0.17	
BERYLLIUM	0.32	J 0.20	U 0.31	0.14	U 0.22		0.079	J 0.15	U 0.96	0.24	J 0.38	U 0.36	U 0.78		0.17	J 0.69	U 2.04	
CADMIUM	2.70	J 0.20	U 0.04	0.14	0.05		0.39	J 0.18	0.47	0.95	J 0.65	0.61	0.67		1.30	J 0.69	U 0.27	
CHROMIUM	38.70	J 12.60	0.33	26.84	0.69		152.00	46.58	0.31	116.00	8.85	10.11	0.08		218	33.33	0.15	
COBALT	4.70	J 1.40	0.30	0.96	0.20		0.87	1.26	1.45	1.70	J 0.88	0.90	0.53		1.30	1.11	0.85	
COPPER	32.70	J 109.00	3.33	4.66	0.14		20.9	6.54	0.31	21.70	J 134.23	136.46	6.24		46.10	J 37.50	0.81	
CYANIDE	0.75	J 1.38	1.84	0.69	U 0.46		24.2	0.84	0.03	9.90	J 3.50	3.29	0.34		33.70	9.72	0.29	
IRON	16900.00	J 18820	1.11	2415.25	0.14		4360.00	2390	0.55	12200.00	J 2050	2227.44	0.18		6510.00	5604.17	0.86	
LEAD	207.00	J 31.20	0.15	11.30	0.05		812.00	129.07	0.16	989.00	J 100.77	106.50	0.10		1540	J 322.22	0.21	
MANGANESE	147.00	J 103.40	0.70	18.79	0.13		13.90	29.98	2.16	91.30	J 212.69	175.81	2.13		34.10	J 85.42	2.50	
MERCURY	0.05	J 0.42	U 4.04	0.30	U 2.85		0.19	0.30	U 0.80	0.14	J 0.92	U 0.79	U 3.07		0.16	1.53	U 4.77	
NICKEL	9.60	J 6.00	0.63	11.02	1.15		2.30	17.20	7.48	3.50	J 1.46	1.70	0.45		3.40	J 3.82	1.12	
SELENIUM	6.80	UJ 1.00	U 0.15	0.72	U 0.11		3.20	U 0.76	U 0.24	5.50	UJ 1.96	U 1.81	U 0.34		0.42	J 3.61	U 4.30	
SILVER	1.40	UJ 0.20	U 0.14	0.14	U 0.10		0.05	J 0.15	U 1.62	0.05	J 0.38	U 0.36	U 4.14		0.04	J 0.69	U 7.89	
THALLIUM	1.40	UJ 0.20	U 0.14	0.14	U 0.10		0.64	U 0.15	U 0.24	1.10	UJ 0.38	U 0.36	U 0.34		0.85	U 0.69	U 0.82	
VANADIUM	11.10	J 4.00	0.36	2.26	0.20		2.10	J 2.89	1.38	8.80	J 4.62	5.05	0.55		5.00	7.64	1.53	
ZINC	323.00	J 184.20	J 0.57	12.01	J 0.04		101.00	16.13	J 0.16	114.00	J 126.54	J 121.66	J 1.09		126.00	148.61	J 1.18	

Table A.7 Site-specific Bioaccumulation Factors for Benthic Invertebrates

AOC	Lower Hilliards Creek (LHC)														
Station	(-26)			(-27)			(-28)			(-30)			(-LH)[a]		
Media	Sediment	Clams	BAF[b]	Sediment	Clams	BAF[b]	Sediment	Crayfish	BAF[b]	Sediment	Crayfish	BAF[b]	Sediment	Assorted Benthic Inv.	BAF[b]
Analyte	mg/kg-dw	mg/kg-dw		mg/kg-dw	mg/kg-dw		mg/kg-dw	mg/kg-dw		mg/kg-dw	mg/kg-dw		mg/kg-dw	mg/kg-dw	
ALUMINUM	2330.00	74.08	0.03	987.00	48.72	0.05	1490.00	108.25	0.07	2180.00	191.55	0.09	3690.00	340.77	0.09
ANTIMONY	0.55 J	0.29 U	0.27	0.43 J	0.30 U	0.35	0.43 J	0.69 U	0.80	1.20 J	0.74 U	0.31	0.97 J	1.54 U	0.79
ARSENIC	86.10 J	43.48	0.51	17.20	46.32	2.69	65.70	27.84	0.42	8.20	28.17	3.44	83.00	26.15	0.32
BARIUM	145.00	224.01	1.54	116.00	154.89	1.34	58.60	453.61	7.74	38.60	669.01	17.33	410.00 J	105.38	0.26
BERYLLIUM	0.09 J	0.15 U	0.85	0.09 J	0.15 U	0.81	0.084 J	0.34 U	2.03	0.11 J	0.39 U	1.76	0.22 J	0.77 U	1.75
CADMIUM	0.54 J	0.26	0.49	0.32 J	0.23	0.70	0.28 J	0.96	3.44	0.62 J	0.39 U	0.31	1.20	1.15	0.96
CHROMIUM	132 J	17.72	0.13	85.30 J	37.14	0.44	39.70 J	7.22	0.18	11.00 J	3.87	0.35	164.00	19.23	0.12
COBALT	1.10	1.61	1.46	1.20	1.19	0.99	0.60	1.24	2.06	0.67	0.70	1.05	1.10 J	2.08	1.89
COPPER	65.50	4.98	0.08	13.5	8.72	0.65	11.70	209.62	17.92	18.30	69.01	3.77	93.10 J	58.46	0.63
CYANIDE	2.70	0.70 U	0.13	4.20	1.20	0.29	0.64 U	1.68 U	2.63	0.75 U	1.69 U	2.25	23.90	3.46 U	0.07
IRON	5580.00	1237	0.22	2910.00	1594	0.55	3010.00	1536	0.51	3720.00	2341.55	0.63	5020.00	2515.38	0.50
LEAD	1300.00 J	54.61	0.04	517.00	70.08	0.14	375.00	67.01	0.18	106.00	30.99	0.29	1960.00 J	174.62	0.09
MANGANESE	20.60 J	314.79	15.28	34.70 J	20.00	0.58	12.50 J	192.10	15.37	6.30 J	107.04	16.99	23.80 J	649.23	27.28
MERCURY	0.09 J	0.31 U	1.64	0.048 J	0.32 U	3.29	0.028 J	0.82 U	14.73	0.06 J	0.85 U	7.68	0.13 J	2.15 U	8.28
NICKEL	3.60	8.35	2.32	1.20	14.29	11.90	1.50	2.71	1.81	3.10	2.25	0.73	5.20 J	4.62	0.89
SELENIUM	3.10 U	0.75 U	0.24	2.70 U	0.77 U	0.28	3.50 U	1.72 U	0.49	3.50 U	1.87 U	0.53	0.55 J	3.92 U	3.57
SILVER	0.03 J	0.15 U	2.93	0.55 U	0.15 U	0.27	0.70 U	0.34 U	0.49	0.13 J	0.39 U	1.49	0.41 J	0.77 U	0.94
THALLIUM	0.61 U	0.15 U	0.24	0.55 U	0.15 U	0.27	0.70 U	0.34 U	0.49	0.70 U	0.39 U	0.55	0.93 U	0.77 U	0.83
VANADIUM	2.50 J	2.64	1.05	0.82 J	2.86	3.48	2.00 J	3.78	1.89	7.90	5.28	0.67	4.80	9.23	1.92
ZINC	84.20	15.67 J	0.19	42.20	14.89 J	0.35	42.10	105.84 J	2.51	145.00	127.82 J	0.88	174.00 J	155.38 J	0.89

Table A.7 Site-specific Bioaccumulation Factors for Benthic Invertebrates

AOC	Median BAFs								
Station	Hilliards Creek (HC)						UHC	MHC	LHC
Media / Analyte	Snails (N = 3)	Clams (N = 4)	Crayfish (N = 5)	Assorted Benthic (N = 3)	All Tissues (N = 15)	All Tissues No '-20 (N = 13)	All Tissues (N = 5)	All Tissues (N = 5)	All Tissues (N = 5)
ALUMINUM	0.09	0.03	0.08	0.12	0.08	**0.07**	0.14	0.03	0.07
ANTIMONY	0.24	0.18	0.31	0.56	0.27	**0.27**	0.16	0.24	0.35
ARSENIC	3.03	1.63	0.79	0.63	1.92	**0.79**	3.03	0.63	0.51
BARIUM	0.90	1.20	5.38	0.26	1.34	**1.06**	1.46	0.86	1.54
BERYLLIUM	0.31	0.83	1.76	2.04	0.85	**0.96**	0.63	0.78	1.75
CADMIUM	0.29	0.48	0.67	0.75	0.47	**0.47**	0.40	0.27	0.70
CHROMIUM	0.33	0.37	0.18	0.15	0.31	**0.24**	0.41	0.31	0.18
COBALT	0.30	1.22	1.05	1.02	1.02	**0.99**	1.02	0.53	1.46
COPPER	3.33	0.23	6.24	0.81	3.33	**1.74**	4.63	0.81	0.65
CYANIDE	1.84	0.21	2.25	0.29	0.44	**0.34**	2.04	0.34	0.29
IRON	1.11	0.38	0.51	0.86	0.55	**0.55**	0.61	0.55	0.51
LEAD	0.15	0.10	0.18	0.21	0.15	**0.14**	0.31	0.15	0.14
MANGANESE	6.84	1.37	15.37	25.20	6.84	**3.33**	16.30	2.13	15.37
MERCURY	0.97	2.24	3.07	4.77	2.85	**3.07**	1.85	3.07	7.68
NICKEL	0.68	4.90	1.07	1.12	1.15	**1.12**	1.67	1.12	1.81
SELENIUM	0.25	0.24	0.53	3.57	0.49	**0.49**	1.05	0.24	0.49
SILVER	2.80	0.95	3.81	5.10	2.80	**1.62**	3.81	1.62	0.94
THALLIUM	0.25	0.24	0.55	0.83	0.41	**0.41**	0.63	0.24	0.49
VANADIUM	0.36	1.22	1.53	1.53	1.38	**1.38**	1.53	0.55	1.89
ZINC	0.57	0.17	1.09	0.89	0.88	**0.57**	0.89	0.57	0.88

Notes:

AOC – Area of Concern; BAF – Bioaccumulation Factor; BERA – Baseline Ecological Risk Assessment; dw – Dry Weight; HC – Hilliards Creek; PRG – Preliminary Remediation Goal.

Data Qualifiers:

J – Estimated value.

U – Undetected. The detection limit is presented.

Bolded values (median BAFs for all of HC and using all tissue types) used to derive proposed wildlife PRGs (Table A.9).

(a) To ensure sufficient biomass was available for chemical analysis, composite tissue samples were prepared from tissues collected at multiple stations. Matching sediment samples were created by compositing an equal amount of sediment (10 g) from the same stations used to create the tissue composite sample. See BERA (Gradient, 2018) for further details.

(b) One half the detection limit was used for non-detected samples.

(c) Duplicate tissue samples were averaged.

Table A.8 Site-specific Bioaccumulation Factors for Soil Invertebrates

AOC	Upper Hilliards Creek (UHC)																
Station	HCBESB01	HCBESB01-Dup	HCBESI01	UHC-01	HCBESB02	HCBESI02	UHC-02	HCBESB03	HCBESI03	HCBESI03- Dup	UHC-03	HCBESB04	HCBESI04	UHC-04	HCBESB05	HCBESI05	UHC-05
Media	Soil		EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW		BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]
Analyte	8/7/2017		8/29/2017		8/2/2017	8/29/2017		8/2/2017	8/29/2017			8/2/2017	8/29/2017		8/2/2017	8/29/2017	
pH					4.9 J			6.4 J				5.9 J			6.0 J		
ALUMINUM	1630 J	1610 J	1104.97 J	0.68	1460 J	243.61 J	0.17	3420	1549.0 J	1344.4 J	0.42	15200 J	1840.8 J	0.12	9040 J	3062.0 J	0.34
ANTIMONY	1.2 J	1.1 J	1.27	1.10	2.3 J	1.05 J	0.46	0.86 J	0.78 J	0.48 J	0.73	11.2 J	2.04	0.18	24.1 J	7.4	0.31
ARSENIC	4.8	4.4	8.29	1.80	3.2 J	2.26	0.70	5.6	8.33	7.22	1.39	32.3 J	30.57	0.95	245 J	141.9	0.58
BARIUM	204	178	723.76	3.79	82.2 J	163.91	1.99	320	365.2	288.9	1.02	582 J	649.7	1.12	534 J	672.9	1.26
BERYLLIUM	0.18 J	0.19 J	0.55 U	1.48	0.13 J	0.75 U	2.89	0.14 J	0.49 U	0.55 U	1.73	0.66 J	0.62 U	0.47	0.5 J	0.2 J	0.47
CADMIUM	0.48 J	0.43 J	5.08	11.17	0.59 J	5.34	9.05	0.47 J	8.82	8.33	18.25	1.6 J	10.19	6.37	2.3 J	15.5	6.74
CHROMIUM	21.5	19.7	39.78	1.93	4.8 J	1.43 J	0.30	12.5	15.20	12.22	1.10	404 J	57.96	0.14	243 J	132.6	0.55
COBALT	1.4	1.2	2.32	1.78	1.4 J	1.58	1.13	2.1	1.47	1.22	0.64	5.3 J	4.14	0.78	10.1 J	5.3	0.52
COPPER	22.7	21.1	38.12	1.74	11.8 J	26.32	2.23	89	50.00	43.89	0.53	122 J	35.67	0.29	96.6 J	63.6	0.66
CYANIDE	1.2	1.3	2.38 J	1.90	0.28 J	3.68 U	6.58	0.45 J	2.35 U	2.67 U	2.79	49.1 J	10.19	0.21	59.8 J	27.1 J	0.45
IRON	4770	5170	3707.18	0.75	5260 J	1165.41	0.22	8280	4166.7	3227.8	0.45	19800 J	4121.0	0.21	60600 J	17441.9	0.29
LEAD	265	241	320.44	1.27	181 J	52.63	0.29	77	53.43	43.33	0.63	1730 J	563.1	0.33	1150 J	1077.5	0.94
MANGANESE	88	70.3	76.80	0.97	14 J	67.67	4.83	132	73.53	62.78	0.52	146 J	107.6	0.74	1560 J	632.6 J	0.41
MERCURY	0.4	0.41	0.99 J	2.46	0.15 J	1.80 U	6.02	0.18	0.48 J	0.56 J	2.86	4.3 J	0.83 J	0.19	0.81 J	1.2 J	1.44
NICKEL	4.1	3.7	11.05	2.83	4.2 J	2.18	0.52	3.6	5.39	4.61	1.39	14.7 J	4.90	0.33	15.5 J	7.4	0.48
SELENIUM	1.2 J	1.3 J	2.54 J	2.03	1 J	1.73 J	1.73	0.75 J	1.37 J	0.89 J	1.51	2.4 J	5.35	2.23	2.1 J	5.3	2.51
SILVER	0.085 J	0.086 J	0.13 J	1.49	0.16 J	0.17 J	1.08	0.14 J	0.22 J	0.18 J	1.42	0.36 J	0.15 J	0.42	0.38 J	0.3 J	0.82
THALLIUM	0.72 U	0.73 U	0.55 U	0.75	1.2 UJ	0.75 U	0.63	0.72 U	0.49 U	0.55 U	0.72	0.48 UJ	0.62 U	1.29	1.6 UJ	0.7 U	0.47
VANADIUM	11.6	10.9	8.29	0.74	13 J	2.56	0.20	12	6.37	4.67	0.46	44.8 J	8.28	0.18	39.2 J	16.3	0.42
ZINC	132	116	201.10	1.62	65.2 J	180.45	2.77	379	229.4	198.33	0.56	824 J	266.9	0.32	870 J	356.6	0.41

Table A.8 Site-specific Bioaccumulation Factors for Soil Invertebrates

AOC	Middle Hillards Creek (MHC)														
Station	HCBESB06	HCBESI06	MHC-06	HCBESB07	HCBESI07	MHC-07	HCBESB08	HCBESI08	MHC-08	HCBESB09	HCBESI09	MHC-09	HCBESB10	HCBESI10	MHC-10
Media	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]
Analyte	8/22/2017	8/29/2017		8/22/2017	8/29/2017		8/22/2017	8/29/2017		8/22/2017	8/29/2017		8/21/2017	8/29/2017	
pH	6.4 J			6.1 J			5.6 J			6.4 J			3.6 J		
ALUMINUM	7910 J	3209.3 J	0.41	9840 J	1435.7 J	0.15	8700 J	511.3 J	0.06	8040 J	2408 J	0.30	1450	200.0 J	0.14
ANTIMONY	17.3 J	7.7	0.44	15.5 J	2.0	0.13	3.4 J	1.27 J	0.37	12.4 J	5.12	0.41	1.5 J	0.6 J	0.37
ARSENIC	296 J	197.7	0.67	132 J	70.0	0.53	80.9 J	42.96	0.53	276 J	239.2	0.87	1.2 J	1.4	1.20
BARIUM	2280 J	1899.2	0.83	563 J	1350	2.40	316 J	518.3	1.64	3420 J	2896	0.85	36.7 J	99.3	2.71
BERYLLIUM	0.39 J	0.3 J	0.74	0.88 J	0.24 J	0.27	0.72 J	0.70 U	0.49	0.59 J	0.296 J	0.50	0.069 J	0.7 U	4.95
CADMIUM	2.5 J	30.2	12.09	2 J	16.43	8.21	1.3 J	7.75	5.96	3.3 J	18.4	5.58	0.2 J	6.9	34.53
CHROMIUM	358 J	149.6	0.42	1030 J	61.43	0.06	160 J	5.70	0.04	708 J	212.8	0.30	3 J	2.1	0.70
COBALT	10.8 J	5.7	0.53	14.6 J	7.86	0.54	2.7 J	4.51	1.67	13.3 J	7.76	0.58	0.32 J	1.2	3.60
COPPER	118 J	85.3	0.72	90.1 J	45.0	0.50	44.5 J	26.76	0.60	115 J	68.8	0.60	9.9 J	25.9	2.62
CYANIDE	51.2 J	33.3	0.65	22.5 J	7.0	0.31	10.4 J	3.38 U	0.16	105 J	54.4	0.52	0.17 J	3.5 U	10.16
IRON	48300 J	21627.9	0.45	34400 J	6592.9	0.19	30100 J	1605.6	0.05	50700 J	14720	0.29	2410	553.2	0.23
LEAD	2740 J	2015.5	0.74	1650 J	246.4	0.15	1290 J	290.8	0.23	4710 J	2240	0.48	57.7	41.0	0.71
MANGANESE	1690 J	969	0.57	865 J	349.3	0.40	81.7 J	103.5	1.27	2460 J	944	0.38	32.4	133.1	4.11
MERCURY	1.1 J	0.8 J	0.70	0.54 J	0.35 J	0.65	0.18 J	0.34 J	1.88	1.2 J	0.8 J	0.67	0.099 J	1.5 U	7.63
NICKEL	15.3 J	11.6	0.76	21.4 J	5.43	0.25	9.8 J	3.66	0.37	15.1 J	11.2	0.74	3.6 J	2.9	0.80
SELENIUM	2.1 J	6.4	3.06	1.8 J	3.64 J	2.02	2 J	4.44	2.22	1.9 J	5.28	2.78	4.4 U	3.5	1.57
SILVER	0.49 J	0.7 J	1.38	0.19 J	0.15 J	0.79	0.18 J	0.32 J	1.76	0.3 J	0.424 J	1.41	0.11 J	0.2 J	1.50
THALLIUM	0.94 UJ	0.8 U	0.82	0.48 UJ	0.79 U	1.64	0.47 UJ	0.70 U	1.50	1.1 UJ	0.8 U	0.73	0.87 U	0.7 U	0.79
VANADIUM	37.7 J	17.8	0.47	23.2 J	5.29	0.23	38.2 J	3.31	0.09	20 J	10.4	0.52	5.5	1.0	0.18
ZINC	878 J	790.7	0.90	602 J	283.6	0.47	171 J	252.1	1.47	812 J	556	0.68	33.2	202.9	6.11

Table A.8 Site-specific Bioaccumulation Factors for Soil Invertebrates

AOC	Lower Hilliards Creek (LHC)															Median BAFs			
Station	HCBESB11	HCBESI11	LHC-11	HCBESB12	HCBESI12	LHC-12	HCBESB13	HCBESI13	LHC-13	HCBESB14	HCBESI14	LHC-14	HCBESB15	HCBESI15	LHC-15	UHC (N = 5)	MHC (N = 5)	LHC (N = 5)	HC (N = 15)
Media	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]	Soil	EW	BAF[a]				
Analyte	8/21/2017	8/29/2017		8/24/2017	8/29/2017		8/24/2017	8/29/2017		8/23/2017	8/29/2017		8/21/2017	8/29/2017					
pH	6.1 J			6.2 J			5.8 J			5.3 J			5.1 J						
ALUMINUM	5840	683.9 J	0.12	12300 J	3506.4 J	0.29	10700 J	1595.9 J	0.15	3590	1012.3 J	0.28	3640	1487.2 J	0.41	0.34	0.15	0.28	**0.28**
ANTIMONY	2.9	0.66 J	0.23	3.9 J	1.4	0.36	3.4 J	0.89 J	0.26	1.4 J	0.80 J	0.57	0.61 J	0.45 J	0.74	0.46	0.37	0.36	**0.37**
ARSENIC	106 J	60.92	0.57	198 J	210.9	1.07	92.9 J	62.33	0.67	3	2.41	0.80	1.8 J	2.91	1.61	0.95	0.67	0.80	**0.80**
BARIUM	546	288.5	0.53	513 J	852.6	1.66	545 J	99.32	0.18	25.3	54.32	2.15	15.1	56.41	3.74	1.26	1.64	1.66	**1.64**
BERYLLIUM	0.43 J	1.15 U	1.34	0.75 J	0.3 J	0.40	0.86 J	0.68 U	0.40	0.21 J	0.62 U	1.47	0.24 J	0.85 U	1.78	1.48	0.50	1.34	**0.74**
CADMIUM	2.2	58.62	26.65	2.9 J	25.6	8.84	2.4 J	30.14	12.56	0.19 J	8.02	42.24	0.18 J	6.50	36.09	9.05	8.21	26.65	**11.17**
CHROMIUM	184 J	27.59	0.15	219 J	42.3	0.19	285 J	36.99	0.13	10.4	12.96	1.25	6.9 J	10.26	1.49	0.55	0.30	0.19	**0.30**
COBALT	7.2	3.56	0.49	14.3 J	7.7	0.54	6.4 J	4.11	0.64	0.49 J	1.79	3.65	0.73	0.94	1.29	0.78	0.58	0.64	**0.64**
COPPER	55.6	37.93	0.68	75.6 J	45.5	0.60	115 J	38.36	0.33	6.7	23.46	3.50	7.8 J	31.62	4.05	0.66	0.60	0.68	**0.66**
CYANIDE	9.7	7.70	0.79	7.9 J	2.9 J	0.37	5.1 J	1.71 J	0.34	0.27 J	2.96 U	5.49	0.23 J	4.19 U	9.10	1.90	0.52	0.79	**0.65**
IRON	24300	3137.9	0.13	40000 J	9679.5	0.24	22000 J	4363.0	0.20	5300	1487.7	0.28	14700	5205.1	0.35	0.29	0.23	0.24	**0.24**
LEAD	1720	926.4	0.54	1760 J	750.0	0.43	2630 J	1349.3	0.51	76.1	193.8	2.55	17	44.44	2.61	0.63	0.48	0.54	**0.54**
MANGANESE	582	87.36	0.15	1740 J	320.5	0.18	407 J	134.9	0.33	15.2	100	6.58	18.3	42.74	2.34	0.74	0.57	0.33	**0.57**
MERCURY	0.27	1.15 J	4.26	0.59 J	0.5 J	0.83	0.55 J	1.44 U	1.31	0.1 J	0.32 J	3.21	0.033 J	1.79 U	27.20	2.46	0.70	3.21	**1.88**
NICKEL	10.7 J	4.48	0.42	17.2 J	7.1	0.41	15 J	6.10	0.41	3	7.41	2.47	2.4 J	5.38	2.24	0.52	0.74	0.42	**0.52**
SELENIUM	0.99 J	12.64	12.77	1.8 J	12.2	6.77	2 J	12.33	6.16	0.39 J	1.67 J	4.27	2.4 U	1.37 J	1.14	2.03	2.22	6.16	**2.23**
SILVER	0.12 J	1.49	12.45	0.16 J	0.3 J	1.80	0.24 J	0.40 J	1.68	0.14 J	0.43 J	3.04	0.065 J	0.45 J	6.97	1.08	1.41	3.04	**1.49**
THALLIUM	0.68 J	1.15 U	0.85	1.5 UJ	0.6 U	0.43	1.6 UJ	0.68 U	0.43	0.85 U	0.62 U	0.73	0.48 U	0.85 U	1.78	0.72	0.82	0.73	**0.75**
VANADIUM	17.8	2.87	0.16	32.8 J	10.3	0.31	30 J	4.66	0.16	11	3.40	0.31	9.9	4.70	0.47	0.42	0.23	0.31	**0.31**
ZINC	378	506.9	1.34	498 J	387.8	0.78	359 J	456.2	1.27	39.6	249.4	6.30	40.2	197.4	4.91	0.56	0.90	1.34	**1.27**

Notes:

AOC – Area of Concern; BAF – Bioaccumulation Factor; dw – Dry Weight; EW – Earthworm; ND – Not Detected; PRG – Preliminary Remediation Goal.

Data Qualifiers:

J – Estimated value.

U – Undetected. The detection limit is presented.

Bolded values (median BAFs for all of HC) used to derive proposed wildlife PRGs (Table A.9)

(a) One half the detection limit used for non-detected samples.

Table A.9 Summary of Wildlife Preliminary Remediation Goals

Receptor	COPC	Media	TRV (mg/kg-day)	TRV Source	UHC Site-specific Tissue Bioaccumulation Factors		Eco. PRG (HQ = 1)
Spotted Sandpiper	Aluminum	Sediment	1100	LOAEL (BERA Table D.3)	0.14	Median BAF from all UHC Samples (Table A.7)	19335
	Antimony	Sediment	NC	LOAEL (BERA Table D.3)	0.16	Median BAF from all UHC Samples (Table A.7)	na
	Arsenic	Sediment	3.6	LOAEL (BERA Table D.3)	3.0	Median BAF from all UHC Samples (Table A.7)	4.7
	Barium	Sediment	42	LOAEL (BERA Table D.3)	1.5	Median BAF from all UHC Samples (Table A.7)	112
	Cadmium	Sediment	2.4	LOAEL (BERA Table D.3)	0.40	Median BAF from all UHC Samples (Table A.7)	20
	Chromium	Sediment	2.8	LOAEL (BERA Table D.3)	0.41	Median BAF from all UHC Samples (Table A.7)	23
	Copper	Sediment	12	LOAEL (BERA Table D.3)	4.6	Median BAF from all UHC Samples (Table A.7)	11
	Cyanide	Sediment	0.40	LOAEL (BERA Table D.3)	2.0	Median BAF from all UHC Samples (Table A.7)	0.78
	Lead	Sediment	9.9	ED_{20} (BERA Table D.3)	0.31	Median BAF from all UHC Samples (Table A.7)	102
	Manganese	Sediment	348	LOAEL (BERA Table D.3)	16	Median BAF from all UHC Samples (Table A.7)	89
	Selenium	Sediment	0.58	LOAEL (BERA Table D.3)	1.0	Median BAF from all UHC Samples (Table A.7)	2.1
	Thallium	Sediment	3.5	LOAEL (BERA Table D.3)	0.63	Median BAF from all UHC Samples (Table A.7)	20
	Vanadium	Sediment	0.69	LOAEL (BERA Table D.3)	1.5	Median BAF from all UHC Samples (Table A.7)	1.8
American Robin	Aluminum	Soil	1100	LOAEL (BERA Table D.3)	0.34	Median BAF from all UHC Samples (Table A.8)	18924
	Antimony	Soil	NC	LOAEL (BERA Table D.3)	0.46	Median BAF from all UHC Samples (Table A.8)	na
	Arsenic	Soil	3.6	LOAEL (BERA Table D.3)	0.95	Median BAF from all UHC Samples (Table A.8)	26
	Barium	Soil	42	LOAEL (BERA Table D.3)	1.3	Median BAF from all UHC Samples (Table A.8)	233
	Cadmium	Soil	2.4	LOAEL (BERA Table D.3)	9.0	Median BAF from all UHC Samples (Table A.8)	2.0
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.55	Median BAF from all UHC Samples (Table A.8)	33
	Copper	Soil	12	LOAEL (BERA Table D.3)	0.66	Median BAF from all UHC Samples (Table A.8)	121
	Cyanide	Soil	0.40	LOAEL (BERA Table D.3)	1.9	Median BAF from all UHC Samples (Table A.8)	1.5
	Lead	Soil	9.9	ED_{20} (BERA Table D.3)	0.63	Median BAF from all UHC Samples (Table A.8)	103
	Manganese	Soil	348	LOAEL (BERA Table D.3)	0.74	Median BAF from all UHC Samples (Table A.8)	3150
	Selenium	Soil	0.58	LOAEL (BERA Table D.3)	2.0	Median BAF from all UHC Samples (Table A.8)	2.1
	Thallium	Soil	3.5	LOAEL (BERA Table D.3)	0.72	Median BAF from all UHC Samples (Table A.8)	32
	Vanadium	Soil	0.69	LOAEL (BERA Table D.3)	0.42	Median BAF from all UHC Samples (Table A.8)	10
Short-Tailed Shrew	Aluminum	Soil	100	LOAEL (BERA Table D.3)	0.34	Median BAF from all UHC Samples (Table A.8)	1589
	Antimony	Soil	0.59	LOAEL (BERA Table D.3)	0.46	Median BAF from all UHC Samples (Table A.8)	7.1
	Arsenic	Soil	1.7	LOAEL (BERA Table D.3)	0.95	Median BAF from all UHC Samples (Table A.8)	9.9
	Barium	Soil	121	LOAEL (BERA Table D.3)	1.3	Median BAF from all UHC Samples (Table A.8)	543
	Cadmium	Soil	7.7	LOAEL (BERA Table D.3)	9.0	Median BAF from all UHC Samples (Table A.8)	4.9
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.55	Median BAF from all UHC Samples (Table A.8)	29
	Copper	Soil	9.3	LOAEL (BERA Table D.3)	0.66	Median BAF from all UHC Samples (Table A.8)	79
	Cyanide	Soil	687	LOAEL (BERA Table D.3)	1.9	Median BAF from all UHC Samples (Table A.8)	2058
	Lead	Soil	8.9	LOAEL (BERA Table D.3)	0.63	Median BAF from all UHC Samples (Table A.8)	79
	Manganese	Soil	65	LOAEL (BERA Table D.3)	0.74	Median BAF from all UHC Samples (Table A.8)	492
	Selenium	Soil	0.22	LOAEL (BERA Table D.3)	2.0	Median BAF from all UHC Samples (Table A.8)	0.60
	Thallium	Soil	0.071	LOAEL (BERA Table D.3)	0.72	Median BAF from all UHC Samples (Table A.8)	0.55
	Vanadium	Soil	8.3	LOAEL (BERA Table D.3)	0.42	Median BAF from all UHC Samples (Table A.8)	109

Notes:
BAF – Bioaccumulation Factor; COPC – Chemical of Potential Concern; ED_{20} – 20% Effective Dose; HC – Hilliards Creek; HQ – Hazard Quotient; LOAEL – Lowest Observed Adverse Effect Level; na – Not Analyzed; PRG – See Tables A.6, A.7, and A.8 for exposure parameters, and Sections A.3 and A.4 for discussion of the PRG methodology.
Source: BERA – Baseline Ecological Risk Assessment (Gradient, 2018).
Bolded values proposed as wildlife PRGs.

Table A.9 Summary of Wildlife Preliminary Remediation Goals

Receptor	COPC	Media	TRV (mg/kg-day)	TRV Source	HC Site-specific Tissue Bioaccumulation Factors		Eco. PRG (HQ = 1)
Spotted Sandpiper	Aluminum	Sediment	1100	LOAEL (BERA Table D.3)	0.083	Median BAF from all HC Samples (Table A.7)	25213
	Antimony	Sediment	NC	LOAEL (BERA Table D.3)	0.27	Median BAF from all HC Samples (Table A.7)	na
	Arsenic	Sediment	3.6	LOAEL (BERA Table D.3)	1.9	Median BAF from all HC Samples (Table A.7)	7.3
	Barium	Sediment	42	LOAEL (BERA Table D.3)	1.3	Median BAF from all HC Samples (Table A.7)	121
	Cadmium	Sediment	2.4	LOAEL (BERA Table D.3)	0.47	Median BAF from all HC Samples (Table A.7)	17
	Chromium	Sediment	2.8	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.7)	29
	Copper	Sediment	12	LOAEL (BERA Table D.3)	3.3	Median BAF from all HC Samples (Table A.7)	15
	Cyanide	Sediment	0.40	LOAEL (BERA Table D.3)	0.44	Median BAF from all HC Samples (Table A.7)	3.1
	Lead	Sediment	9.9	ED_{20} (BERA Table D.3)	0.15	Median BAF from all HC Samples (Table A.7)	165
	Manganese	Sediment	348	LOAEL (BERA Table D.3)	6.8	Median BAF from all HC Samples (Table A.7)	210
	Selenium	Sediment	0.58	LOAEL (BERA Table D.3)	0.49	Median BAF from all HC Samples (Table A.7)	4.1
	Thallium	Sediment	3.5	LOAEL (BERA Table D.3)	0.41	Median BAF from all HC Samples (Table A.7)	29
	Vanadium	Sediment	0.69	LOAEL (BERA Table D.3)	1.4	Median BAF from all HC Samples (Table A.7)	1.9
American Robin	Aluminum	Soil	1100	LOAEL (BERA Table D.3)	0.28	Median BAF from all HC Samples (Table A.8)	21705
	Antimony	Soil	NC	LOAEL (BERA Table D.3)	0.37	Median BAF from all HC Samples (Table A.8)	na
	Arsenic	Soil	3.6	LOAEL (BERA Table D.3)	0.80	Median BAF from all HC Samples (Table A.8)	30
	Barium	Soil	42	LOAEL (BERA Table D.3)	1.6	Median BAF from all HC Samples (Table A.8)	182
	Cadmium	Soil	2.4	LOAEL (BERA Table D.3)	11	Median BAF from all HC Samples (Table A.8)	1.6
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.30	Median BAF from all HC Samples (Table A.8)	52
	Copper	Soil	12	LOAEL (BERA Table D.3)	0.66	Median BAF from all HC Samples (Table A.8)	121
	Cyanide	Soil	0.40	LOAEL (BERA Table D.3)	0.65	Median BAF from all HC Samples (Table A.8)	4.0
	Lead	Soil	9.9	ED_{20} (BERA Table D.3)	0.54	Median BAF from all HC Samples (Table A.8)	117
	Manganese	Soil	348	LOAEL (BERA Table D.3)	0.57	Median BAF from all HC Samples (Table A.8)	3913
	Selenium	Soil	0.58	LOAEL (BERA Table D.3)	2.2	Median BAF from all HC Samples (Table A.8)	1.9
	Thallium	Soil	3.5	LOAEL (BERA Table D.3)	0.75	Median BAF from all HC Samples (Table A.8)	31
	Vanadium	Soil	0.69	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.8)	13
Short-Tailed Shrew	Aluminum	Soil	100	LOAEL (BERA Table D.3)	0.28	Median BAF from all HC Samples (Table A.8)	1884
	Antimony	Soil	0.59	LOAEL (BERA Table D.3)	0.37	Median BAF from all HC Samples (Table A.8)	8.5
	Arsenic	Soil	1.7	LOAEL (BERA Table D.3)	0.80	Median BAF from all HC Samples (Table A.8)	12
	Barium	Soil	121	LOAEL (BERA Table D.3)	1.6	Median BAF from all HC Samples (Table A.8)	419
	Cadmium	Soil	7.7	LOAEL (BERA Table D.3)	11	Median BAF from all HC Samples (Table A.8)	4.0
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.30	Median BAF from all HC Samples (Table A.8)	50
	Copper	Soil	9.3	LOAEL (BERA Table D.3)	0.66	Median BAF from all HC Samples (Table A.8)	79
	Cyanide	Soil	687	LOAEL (BERA Table D.3)	0.65	Median BAF from all HC Samples (Table A.8)	5866
	Lead	Soil	8.9	LOAEL (BERA Table D.3)	0.54	Median BAF from all HC Samples (Table A.8)	91
	Manganese	Soil	65	LOAEL (BERA Table D.3)	0.57	Median BAF from all HC Samples (Table A.8)	627
	Selenium	Soil	0.22	LOAEL (BERA Table D.3)	2.2	Median BAF from all HC Samples (Table A.8)	0.55
	Thallium	Soil	0.071	LOAEL (BERA Table D.3)	0.75	Median BAF from all HC Samples (Table A.8)	0.53
	Vanadium	Soil	8.3	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.8)	144

Notes:
BAF – Bioaccumulation Factor; COPC – Chemical of Potential Concern; ED_{20} – 20% Effective Dose; HC – Hilliards Creek; HQ – Hazard Quotient; LOAEL – Lowest Observed Adverse Effect Level; na – Not Analyzed; PRG –
See Tables A.6, A.7, and A.8 for exposure parameters, and Sections A.3 and A.4 for discussion of the PRG methodology.
Source: BERA – Baseline Ecological Risk Assessment (Gradient, 2018).
Bolded values proposed as wildlife PRGs.

Table A.9 Summary of Wildlife Preliminary Remediation Goals

Receptor	COPC	Media	TRV (mg/kg-day)	TRV Source	HC Site-specific Tissue Bioaccumulation Factors (No '-20)		Eco. PRG (HQ = 1)
Spotted Sandpiper	Aluminum	Sediment	1100	LOAEL (BERA Table D.3)	0.073	Median BAF from all HC Samples, except '-20 (Table A.7)	**26656**
	Antimony	Sediment	NC	LOAEL (BERA Table D.3)	0.27	Median BAF from all HC Samples, except '-20 (Table A.7)	**na**
	Arsenic	Sediment	3.6	LOAEL (BERA Table D.3)	0.79	Median BAF from all HC Samples, except '-20 (Table A.7)	**17**
	Barium	Sediment	42	LOAEL (BERA Table D.3)	1.1	Median BAF from all HC Samples, except '-20 (Table A.7)	**151**
	Cadmium	Sediment	2.4	LOAEL (BERA Table D.3)	0.47	Median BAF from all HC Samples, except '-20 (Table A.7)	**17**
	Chromium	Sediment	2.8	LOAEL (BERA Table D.3)	0.24	Median BAF from all HC Samples, except '-20 (Table A.7)	**34**
	Copper	Sediment	12	LOAEL (BERA Table D.3)	1.7	Median BAF from all HC Samples, except '-20 (Table A.7)	**27**
	Cyanide	Sediment	0.40	LOAEL (BERA Table D.3)	0.34	Median BAF from all HC Samples, except '-20 (Table A.7)	**3.8**
	Lead	Sediment	9.9	ED_{20} (BERA Table D.3)	0.14	Median BAF from all HC Samples, except '-20 (Table A.7)	**176**
	Manganese	Sediment	348	LOAEL (BERA Table D.3)	3.3	Median BAF from all HC Samples, except '-20 (Table A.7)	**425**
	Selenium	Sediment	0.58	LOAEL (BERA Table D.3)	0.49	Median BAF from all HC Samples, except '-20 (Table A.7)	**4.1**
	Thallium	Sediment	3.5	LOAEL (BERA Table D.3)	0.41	Median BAF from all HC Samples, except '-20 (Table A.7)	**29**
	Vanadium	Sediment	0.69	LOAEL (BERA Table D.3)	1.4	Median BAF from all HC Samples, except '-20 (Table A.7)	**1.9**
American Robin	Aluminum	Soil	1100	LOAEL (BERA Table D.3)	0.28	Median BAF from all HC Samples (Table A.8)	**21705**
	Antimony	Soil	NC	LOAEL (BERA Table D.3)	0.37	Median BAF from all HC Samples (Table A.8)	**na**
	Arsenic	Soil	3.6	LOAEL (BERA Table D.3)	0.80	Median BAF from all HC Samples (Table A.8)	**30**
	Barium	Soil	42	LOAEL (BERA Table D.3)	1.6	Median BAF from all HC Samples (Table A.8)	**182**
	Cadmium	Soil	2.4	LOAEL (BERA Table D.3)	11	Median BAF from all HC Samples (Table A.8)	**1.6**
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.30	Median BAF from all HC Samples (Table A.8)	**52**
	Copper	Soil	12	LOAEL (BERA Table D.3)	0.66	Median BAF from all HC Samples (Table A.8)	**121**
	Cyanide	Soil	0.40	LOAEL (BERA Table D.3)	0.65	Median BAF from all HC Samples (Table A.8)	**4.0**
	Lead	Soil	9.9	ED_{20} (BERA Table D.3)	0.54	Median BAF from all HC Samples (Table A.8)	**117**
	Manganese	Soil	348	LOAEL (BERA Table D.3)	0.57	Median BAF from all HC Samples (Table A.8)	**3913**
	Selenium	Soil	0.58	LOAEL (BERA Table D.3)	2.2	Median BAF from all HC Samples (Table A.8)	**1.9**
	Thallium	Soil	3.5	LOAEL (BERA Table D.3)	0.75	Median BAF from all HC Samples (Table A.8)	**31**
	Vanadium	Soil	0.69	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.8)	**13**
Short-Tailed Shrew	Aluminum	Soil	100	LOAEL (BERA Table D.3)	0.28	Median BAF from all HC Samples (Table A.8)	**1884**
	Antimony	Soil	0.59	LOAEL (BERA Table D.3)	0.37	Median BAF from all HC Samples (Table A.8)	**8.5**
	Arsenic	Soil	1.7	LOAEL (BERA Table D.3)	0.80	Median BAF from all HC Samples (Table A.8)	**12**
	Barium	Soil	121	LOAEL (BERA Table D.3)	1.6	Median BAF from all HC Samples (Table A.8)	**419**
	Cadmium	Soil	7.7	LOAEL (BERA Table D.3)	11	Median BAF from all HC Samples (Table A.8)	**4.0**
	Chromium	Soil	2.8	LOAEL (BERA Table D.3)	0.30	Median BAF from all HC Samples (Table A.8)	**50**
	Copper	Soil	9.3	LOAEL (BERA Table D.3)	0.66	Median BAF from all HC Samples (Table A.8)	**79**
	Cyanide	Soil	687	LOAEL (BERA Table D.3)	0.65	Median BAF from all HC Samples (Table A.8)	**5866**
	Lead	Soil	8.9	LOAEL (BERA Table D.3)	0.54	Median BAF from all HC Samples (Table A.8)	**91**
	Manganese	Soil	65	LOAEL (BERA Table D.3)	0.57	Median BAF from all HC Samples (Table A.8)	**627**
	Selenium	Soil	0.22	LOAEL (BERA Table D.3)	2.2	Median BAF from all HC Samples (Table A.8)	**0.55**
	Thallium	Soil	0.071	LOAEL (BERA Table D.3)	0.75	Median BAF from all HC Samples (Table A.8)	**0.53**
	Vanadium	Soil	8.3	LOAEL (BERA Table D.3)	0.31	Median BAF from all HC Samples (Table A.8)	**144**

Notes:
BAF – Bioaccumulation Factor; COPC – Chemical of Potential Concern; ED_{20} – 20% Effective Dose; HC – Hilliards Creek; HQ – Hazard Quotient; LOAEL – Lowest Observed Adverse Effect Level; na – Not Analyzed; PRG –
See Tables A.6, A.7, and A.8 for exposure parameters, and Sections A.3 and A.4 for discussion of the PRG methodology.
Source: BERA – Baseline Ecological Risk Assessment (Gradient, 2018).
Bolded values proposed as wildlife PRGs.

Table A.10 Ecological Preliminary Remediation Goals for Sediments and Soils

COPC	Benthic Invertebrate PRG[a]	Spotted Sandpiper PRG[b]	Background Sediment 95% USL[c]	Final Sediment Eco. PRGs	American Robin PRG[b]	Short-Tailed Shrew PRG[b]	Background Soil 95% USL[c]	Final Soil Eco. PRGs
Arsenic	20.5	17	3.3	**17**	30	12	17	**17**
Lead	593	176	40	**176**	117	91	213	**213**
Cyanide	19.8	3.8	NA	**3.8**	4.0	5866	58	**58**

Notes:

95% UCL – 95% Upper Confidence Level; 95% USL – 95% Upper Simultaneous Limit; BERA – Baseline Ecological Risk Assessment; COPC – Chemical of Potential Concern; PRG – Preliminary Remediation Goal.

Units are mg/kg-day.

(a) See Table A.5. To be met within a small areal extent, because benthic invertebrates are sessile.

(b) See Table A.9. To be met on average (*i.e.* , 95% UCL) over the entire exposure area. The wildlife PRGs were derived using the median BAFs from all HC samples as shown in Table A.7 (benthic invertebrates; excluding outlier sample -20) and Table A.8 (soil invertebrates).

(c) See BERA Appendix Tables B.9 (soil) and B.10 (sediment) for background summary statistics (Gradient, 2018).

Figures

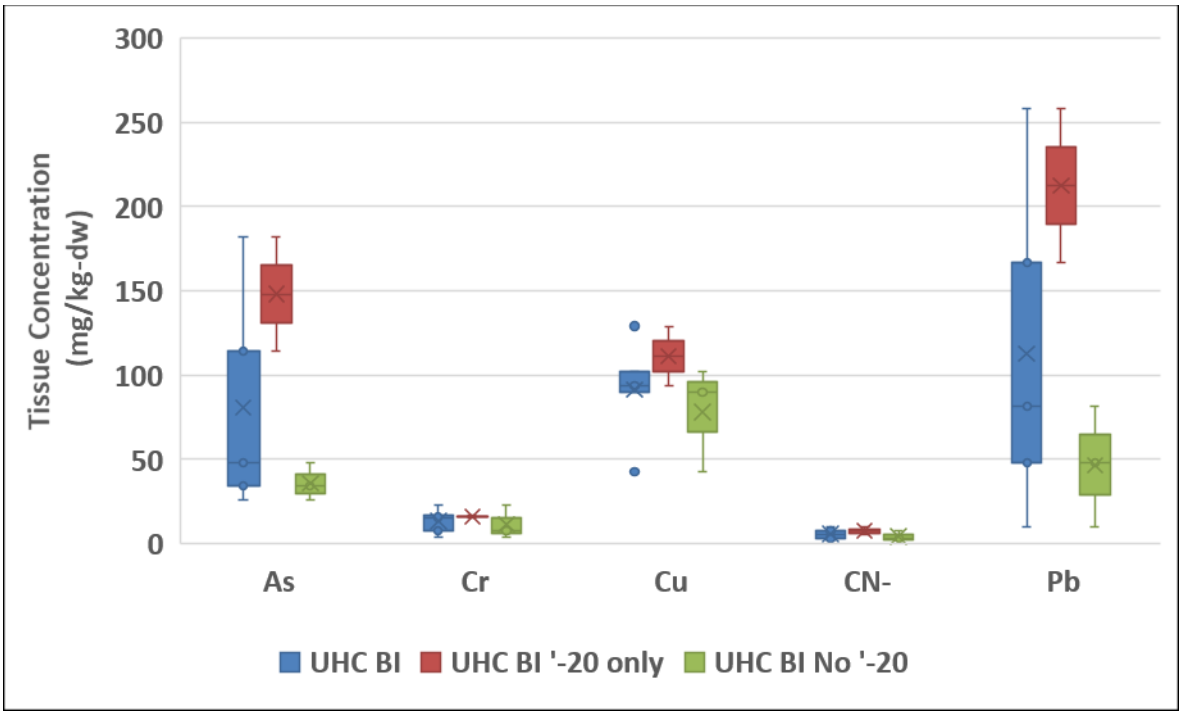


Figure 1 Benthic Invertebrate Tissue Concentrations in UHC. As – Arsenic; BI – Benthic Invertebrate; CN- – Cyanide; Cr – Chromium; Cu – Copper; dw – Dry Weight; Pb – Lead; UHC – Upper Hilliards Creek.

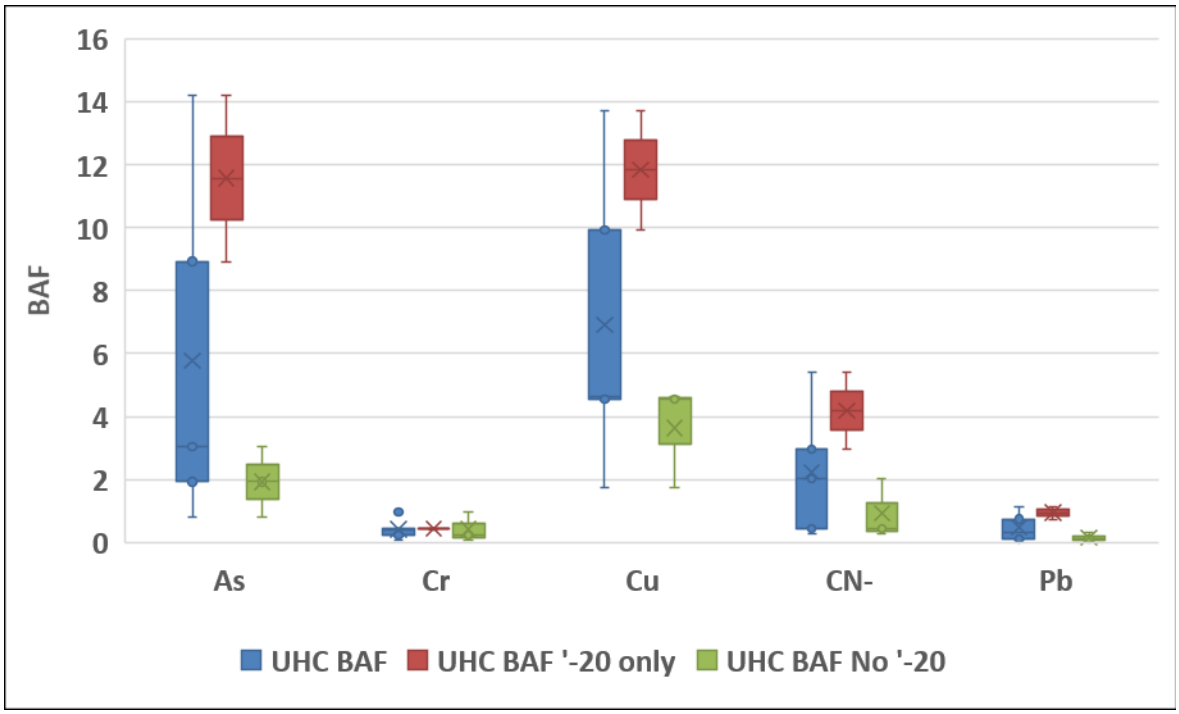


Figure 2 Bioaccumulation Factors in UHC. As – Arsenic; BAF – Bioaccumulation Factor; CN- – Cyanide; Cr – Chromium; Cu – Copper; Pb – Lead; UHC –Upper Hilliards Creek.

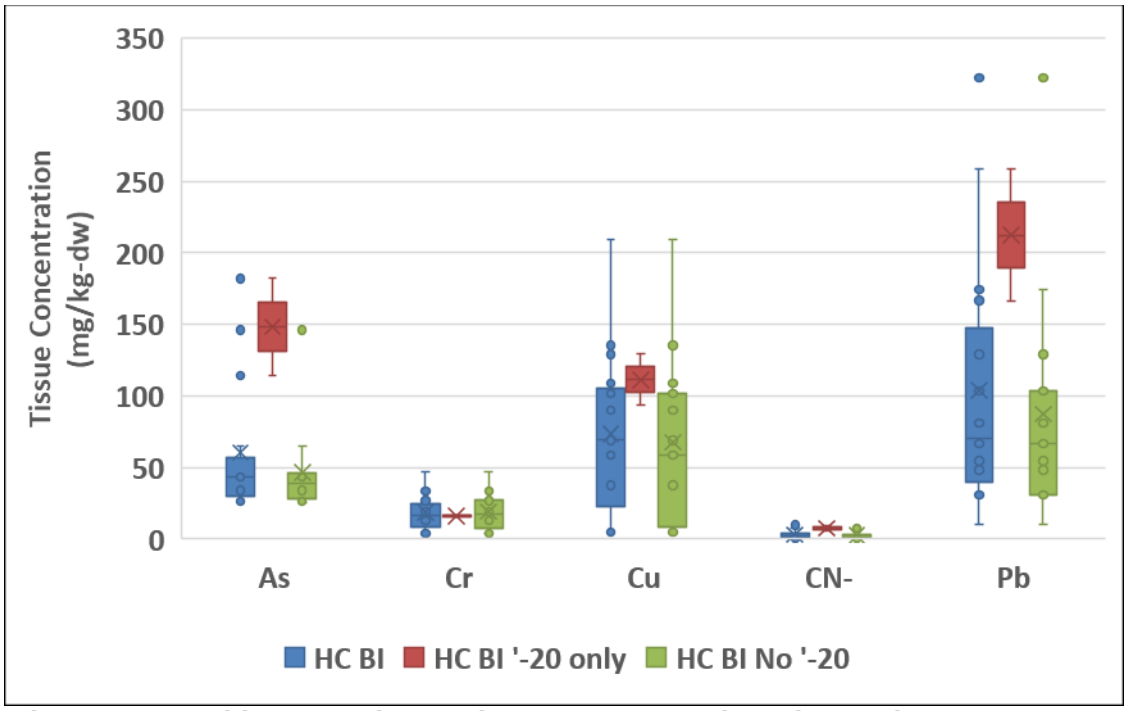


Figure 3 Benthic Invertebrate Tissue Concentrations in HC (UHC + MHC + LHC). As – Arsenic; BI – Benthic Invertebrate; CN- – Cyanide; Cr – Chromium; Cu – Copper; dw – Dry Weight; HC – Hilliards Creek; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; Pb – Lead; UHC – Upper Hilliards Creek.

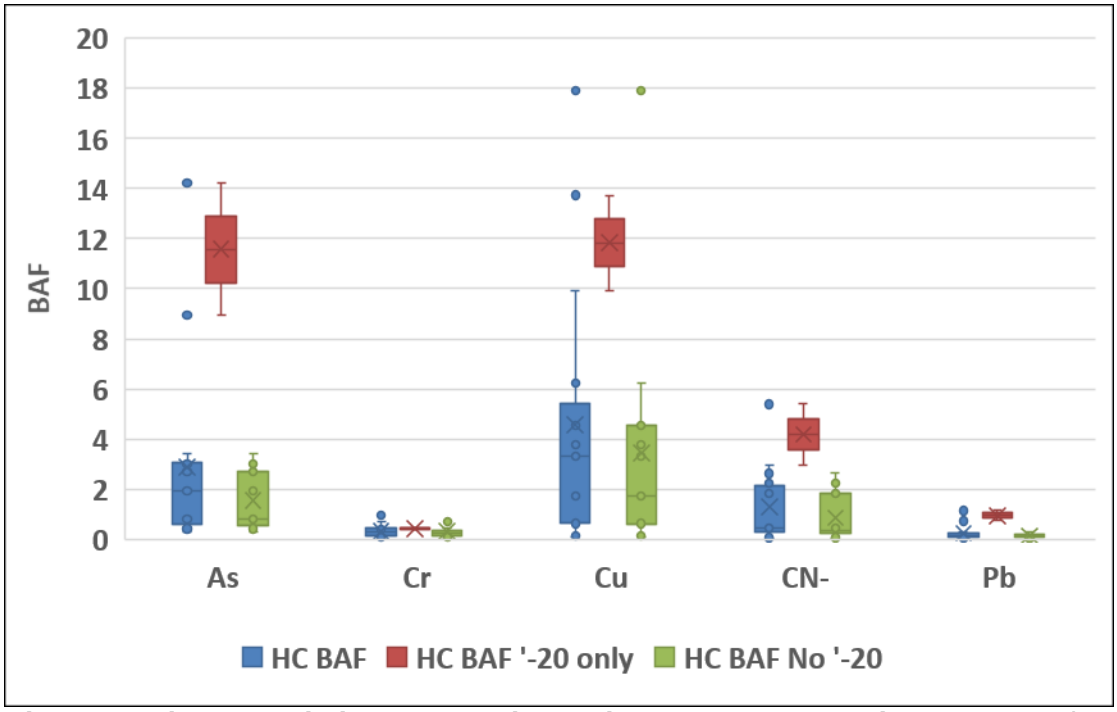


Figure 4 Bioaccumulation Factors in HC (UHC + MHC + LHC). As – Arsenic; BAF – Bioaccumulation Factors; CN- – Cyanide; Cr – Chromium; Cu – Copper; HC – Hilliards Creek; LHC – Lower Hilliards Creek; MHC – Middle Hilliards Creek; Pb – Lead; UHC – Upper Hilliards Creek.

Attachment 1

Statistical Analysis Output

Statistical Analysis Methods and Results

This attachment provides the methods and results of statistical analyses performed in support of the ecological preliminary remediation goal (PRG) development.

Sediment Chemistry and Toxicity Analysis

A statistical comparison was conducted between sediment toxicity test results and sediment chemistry results for the samples collected from HC (Upper Hilliards Creek [UHC], Middle Hilliards Creek [MHC], and Lower Hilliards Creek [LHC]) and the background area. Fifteen locations in HC and ten sediment locations from the background area were assessed for toxicity using a 28-day growth and mortality test using *Hyalella azteca*. In order to test for differences between datasets, the sediment toxicity test responses (*i.e.,* survival, growth, and biomass) were evaluated statistically (using SigmaPlot V13.0). A Kruskal-Wallis one-way analysis of variance (ANOVA) on ranks was performed for each HC sediment bioassay compared to the pooled results for the background samples. The ANOVA was conducted using the data for each replicate tested in the bioassays. Following the ANOVA test and Shapiro-Wilk test for normality, a pairwise multiple comparison (Dunn's Method) was used to identify significant differences between the HC samples and the pooled background samples. The Dunn's test was used due to non-normal data (*i.e.*, failure of the Shapiro-Wilk test) and the unequal group sizes (HC *vs*. pooled background). Further, a Spearman correlation test was used to evaluate the strength of the relationships between each of the toxicity endpoints and the chemical and physical variables in all of the HC 2017 sediment samples. Additionally, a Spearman correlation test was used to evaluate the strength of the relationships between the chemical and physical variables in all of the HC 2017 soil samples. An overall significance level of 0.05 was used for the ANOVA and correlation analysis. The results of this analysis are summarized in Tables A.1 through A.4b, and copies of the statistical output are provided in the following pages.

Kruskal-Wallis One Way Analysis of Variance on Ranks Tuesday, September 25, 2018, 6:48:44 PM

Data source: Data 1 in BKGD comparison_09.25.18

Dependent Variable: Survival

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Background	100	0	100.000	90.000	100.000
HCBEDD16-SD-AA-AB-010		0	90.000	90.000	100.000
HCBEDD17-SD-AA-AB-010		0	95.000	87.500	100.000
HCBEDD18-SD-AA-AB-010		0	100.000	90.000	100.000
HCBEDD19-SD-AA-AB-010		0	95.000	87.500	100.000
HCBEDD20-SD-AA-AB-010		0	100.000	90.000	100.000
HCBEDD26-SD-AA-AB-010		0	60.000	37.500	72.500
HCBEDD27-SD-AA-AB-010		0	90.000	82.500	100.000
HCBEDD28-SD-AA-AB-010		0	95.000	90.000	100.000
HCBEDD29-SD-AA-AB-010		0	90.000	70.000	100.000
HCBEDD30-SD-AA-AB-010		0	100.000	87.500	100.000
HCBEDD26-SD-AA-AB-110		0	60.000	50.000	62.500
HCBEDD23-SD-AA-AB-010		0	10.000	0.000	30.000
HCBEDD24-SD-AA-AB-010		0	90.000	90.000	100.000
HCBEDD25-SD-AA-AB-010		0	70.000	60.000	90.000
HCBEDD21-SD-AA-AB-010		0	0.000	0.000	0.000
HCBEDD22-SD-AA-AB-010		0	100.000	90.000	100.000

H = 131.615 with 16 degrees of freedom (P = <0.001).

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

To isolate the group or groups that differ from the others, use a multiple comparison procedure.

Multiple Comparisons *versus* Control Group (Dunn's Method):

Comparison	Diff of Ranks	Q	P	P<0.050
HCBEDD21-SD-A vs Background	156.220	6.264	<0.001	Yes
HCBEDD23-SD-A vs Background	147.770	5.925	<0.001	Yes
HCBEDD26-SD-A vs Background	127.020	5.093	<0.001	Yes
HCBEDD26-SD-A vs Background	121.020	4.852	<0.001	Yes
HCBEDD25-SD-A vs Background	101.320	4.062	<0.001	Yes
HCBEDD29-SD-A vs Background	40.220	1.613	1.000	No
HCBEDD27-SD-A vs Background	35.720	1.432	1.000	Do Not Test
HCBEDD24-SD-A vs Background	26.670	1.069	1.000	Do Not Test
HCBEDD17-SD-A vs Background	22.670	0.909	1.000	Do Not Test
HCBEDD16-SD-A vs Background	22.520	0.903	1.000	Do Not Test
HCBEDD19-SD-A vs Background	21.270	0.853	1.000	Do Not Test
HCBEDD28-SD-A vs Background	17.120	0.686	1.000	Do Not Test
HCBEDD18-SD-A vs Background	7.570	0.304	1.000	Do Not Test
HCBEDD20-SD-A vs Background	3.420	0.137	1.000	Do Not Test
HCBEDD30-SD-A vs Background	2.170	0.0870	1.000	Do Not Test
HCBEDD22-SD-A vs Background	1.980	0.0794	1.000	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Tuesday, September 25, 2018, 6:51:00 PM

Data source: Data 1 in BKGD comparison_09.25.18

Dependent Variable: Weight

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Background	100	0	0.254	0.220	0.282
HCBEDD16-SD-AA-AB-010		0	0.353	0.309	0.455
HCBEDD17-SD-AA-AB-010		0	0.473	0.433	0.508
HCBEDD18-SD-AA-AB-010		0	0.466	0.442	0.513
HCBEDD19-SD-AA-AB-010		0	0.397	0.373	0.440
HCBEDD20-SD-AA-AB-010		0	0.458	0.430	0.513
HCBEDD26-SD-AA-AB-010		0	0.625	0.520	0.752
HCBEDD27-SD-AA-AB-010		0	0.417	0.359	0.514
HCBEDD28-SD-AA-AB-010		0	0.459	0.332	0.516
HCBEDD29-SD-AA-AB-010		0	0.456	0.426	0.516
HCBEDD30-SD-AA-AB-010		0	0.471	0.418	0.492
HCBEDD26-SD-AA-AB-110		0	0.692	0.619	0.782
HCBEDD23-SD-AA-AB-010		0	0.413	0.000	0.605
HCBEDD24-SD-AA-AB-010		0	0.390	0.319	0.469
HCBEDD25-SD-AA-AB-010		0	0.464	0.394	0.558
HCBEDD21-SD-AA-AB-010		0	0.000	0.000	0.000
HCBEDD22-SD-AA-AB-010		0	0.458	0.368	0.519

H = 182.310 with 16 degrees of freedom (P = <0.001).

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

To isolate the group or groups that differ from the others, use a multiple comparison procedure.

Multiple Comparisons *versus* Control Group (Dunn's Method) :

Comparison	Diff of Ranks	Q	P	P<0.050
HCBEDD26-SD-A vs Background	179.730	7.206	<0.001	Yes
HCBEDD26-SD-A vs Background	166.630	6.681	<0.001	Yes
HCBEDD17-SD-A vs Background	120.530	4.833	<0.001	Yes
HCBEDD30-SD-A vs Background	117.680	4.718	<0.001	Yes
HCBEDD29-SD-A vs Background	116.480	4.670	<0.001	Yes
HCBEDD20-SD-A vs Background	116.280	4.662	<0.001	Yes
HCBEDD25-SD-A vs Background	114.980	4.610	<0.001	Yes
HCBEDD18-SD-A vs Background	112.880	4.526	<0.001	Yes
HCBEDD22-SD-A vs Background	110.280	4.422	<0.001	Yes
HCBEDD27-SD-A vs Background	102.480	4.109	<0.001	Yes
HCBEDD28-SD-A vs Background	100.780	4.041	<0.001	Yes
HCBEDD19-SD-A vs Background	84.880	3.403	0.011	Yes
HCBEDD24-SD-A vs Background	82.030	3.289	0.016	Yes
HCBEDD16-SD-A vs Background	75.980	3.046	0.037	Yes
HCBEDD21-SD-A vs Background	62.070	2.489	0.205	No
HCBEDD23-SD-A vs Background	57.630	2.311	0.334	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Tuesday, September 25, 2018, 6:49:44 PM

Data source: Data 1 in BKGD comparison_09.25.18

Dependent Variable: Biomass

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
Background	100	0	0.242	0.214	0.264
HCBEDD16-SD-AA-AB-010		0	0.345	0.278	0.430
HCBEDD17-SD-AA-AB-010		0	0.445	0.373	0.472
HCBEDD18-SD-AA-AB-010		0	0.446	0.423	0.460
HCBEDD19-SD-AA-AB-010		0	0.393	0.313	0.420
HCBEDD20-SD-AA-AB-010		0	0.434	0.419	0.494
HCBEDD26-SD-AA-AB-010		0	0.356	0.231	0.406
HCBEDD27-SD-AA-AB-010		0	0.382	0.320	0.400
HCBEDD28-SD-AA-AB-010		0	0.417	0.313	0.466
HCBEDD29-SD-AA-AB-010		0	0.400	0.334	0.446
HCBEDD30-SD-AA-AB-010		0	0.451	0.381	0.486
HCBEDD26-SD-AA-AB-110		0	0.403	0.387	0.422
HCBEDD23-SD-AA-AB-010		0	0.0595	0.000	0.140
HCBEDD24-SD-AA-AB-010		0	0.362	0.308	0.423
HCBEDD25-SD-AA-AB-010		0	0.343	0.278	0.384
HCBEDD21-SD-AA-AB-010		0	0.000	0.000	0.000
HCBEDD22-SD-AA-AB-010		0	0.439	0.368	0.489

H = 182.487 with 16 degrees of freedom (P = <0.001).

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

To isolate the group or groups that differ from the others, use a multiple comparison procedure.

Multiple Comparisons *versus* Control Group (Dunn's Method) :

Comparison	Diff of Ranks	Q	P	P<0.050
HCBEDD20-SD-A vs Background	138.850	5.567	<0.001	Yes
HCBEDD30-SD-A vs Background	136.250	5.463	<0.001	Yes
HCBEDD17-SD-A vs Background	133.500	5.353	<0.001	Yes
HCBEDD22-SD-A vs Background	129.350	5.186	<0.001	Yes
HCBEDD18-SD-A vs Background	129.000	5.172	<0.001	Yes
HCBEDD28-SD-A vs Background	112.050	4.493	<0.001	Yes
HCBEDD29-SD-A vs Background	111.750	4.481	<0.001	Yes
HCBEDD26-SD-A vs Background	101.700	4.078	<0.001	Yes
HCBEDD19-SD-A vs Background	96.200	3.857	0.002	Yes
HCBEDD27-SD-A vs Background	94.400	3.785	0.002	Yes
HCBEDD24-SD-A vs Background	90.700	3.637	0.004	Yes
HCBEDD16-SD-A vs Background	86.450	3.466	0.008	Yes
HCBEDD25-SD-A vs Background	73.800	2.959	0.049	Yes
HCBEDD21-SD-A vs Background	70.650	2.833	0.074	No
HCBEDD26-SD-A vs Background	64.600	2.590	0.154	Do Not Test
HCBEDD23-SD-A vs Background	53.850	2.159	0.493	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Spearman Rank Order Correlation

Tuesday, April 17, 2018, 1:33:23 PM

Data source: Hilliards Creek Sediment Correlations

Cell Contents:
Correlation Coefficient
P Value
Number of Samples

	Weight	Biomass	SEM/AVS	TOC	Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	CN-	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	V	Zn
Survival	-0.424 0.125 14	0.788 0.0000868 14	-0.366 0.176 15	-0.405 0.131 15	-0.231 0.396 15	0.204 0.457 15	-0.423 0.113 15	-0.552 0.0312 15	0.33 0.224 15	-0.235 0.388 15	-0.527 0.0413 15	0.117 0.667 15	-0.471 0.0732 15	-0.513 0.048 15	-0.0735 0.783 15	-0.6 0.0175 15	-0.0224 0.934 15	-0.233 0.396 15	-0.0898 0.743 15	0.275 0.312 15	0.116 0.676 15	0.206 0.449 15	0.452 0.0861 15	-0.086 0.753 15
Weight		-0.0792 0.773 14	0.141 0.615 14	0.13 0.648 14	0.167 0.552 14	0.11 0.693 14	0.216 0.444 14	0.378 0.173 14	0.044 0.868 14	0.0198 0.94 14	0.323 0.251 14	-0.0639 0.82 14	0.535 0.047 14	0.198 0.482 14	0.139 0.626 14	0.398 0.152 14	-0.33 0.238 14	0.381 0.173 14	0.286 0.308 14	-0.262 0.356 14	-0.302 0.286 14	-0.132 0.637 14	-0.189 0.501 14	0.0924 0.738 14
Biomass			-0.0593 0.832 14	-0.367 0.189 14	-0.0989 0.727 14	0.416 0.134 14	-0.376 0.178 14	-0.424 0.125 14	0.446 0.105 14	-0.0022 0.988 14	-0.442 0.109 14	0.0792 0.773 14	-0.152 0.594 14	-0.495 0.069 14	0.0769 0.785 14	-0.512 0.0585 14	-0.191 0.501 14	0.124 0.659 14	-0.0594 0.832 14	0.156 0.583 14	0.253 0.373 14	0.225 0.425 14	0.437 0.113 14	0.218 0.444 14
SEM/AVS				-0.368 0.171 15	-0.254 0.353 15	-0.0465 0.863 15	0.0893 0.743 15	0.05 0.852 15	-0.327 0.224 15	-0.161 0.558 15	0.157 0.566 15	-0.513 0.048 15	-0.182 0.506 15	0.0643 0.812 15	-0.293 0.281 15	0.289 0.287 15	-0.306 0.257 15	-0.0466 0.863 15	-0.508 0.0517 15	0.341 0.209 15	0.109 0.686 15	-0.162 0.558 15	-0.525 0.0429 15	-0.225 0.41 15
TOC					0.804 0.0000002 15	0.0572 0.832 15	0.557 0.0299 15	0.636 0.0104 15	0.252 0.353 15	0.7 0.00326 15	0.379 0.158 15	0.447 0.0917 15	0.696 0.00352 15	0.382 0.154 15	0.718 0.00215 15	0.414 0.12 15	0.588 0.0201 15	0.353 0.189 15	0.698 0.00352 15	-0.185 0.498 15	-0.202 0.457 15	0.312 0.252 15	0.3 0.269 15	0.546 0.0339 15
Al						-0.0948 0.724 15	0.575 0.0241 15	0.65 0.00832 15	0.429 0.107 15	0.871 0.0000002 15	0.271 0.319 15	0.338 0.209 15	0.711 0.00256 15	0.0786 0.773 15	0.832 0.0000002 15	0.311 0.252 15	0.399 0.134 15	0.113 0.676 15	0.708 0.00278 15	0.192 0.481 15	0.231 0.396 15	0.706 0.00278 15	0.395 0.138 15	0.607 0.0158 15
Sb							-0.093 0.734 15	0.134 0.62 15	0.216 0.433 15	0.118 0.667 15	0.123 0.648 15	-0.0143 0.954 15	0.152 0.575 15	0.469 0.0757 15	0.166 0.54 15	-0.0143 0.954 15	0.109 0.686 15	0.76 0.00048 15	-0.0591 0.822 15	-0.138 0.611 15	-0.312 0.252 15	-0.0881 0.743 15	0.143 0.602 15	0.526 0.0429 15
As								0.718 0.00215 15	-0.132 0.629 15	0.589 0.0201 15	0.757 0.000575 15	-0.0483 0.852 15	0.739 0.00116 15	0.346 0.199 15	0.507 0.0517 15	0.779 0.0000944 15	0.193 0.481 15	0.0682 0.802 15	0.275 0.312 15	0.0933 0.734 15	0.232 0.396 15	0.285 0.293 15	-0.327 0.224 15	0.368 0.171 15
Ba									0.109 0.686 15	0.639 0.00988 15	0.818 0.0000002 15	0.136 0.62 15	0.736 0.0013 15	0.686 0.00439 15	0.643 0.00934 15	0.782 0.0000337 15	0.284 0.293 15	0.439 0.0975 15	0.354 0.189 15	-0.0556 0.832 15	0.105 0.695 15	0.294 0.281 15	-0.17 0.532 15	0.529 0.0413 15
Be										0.259 0.339 15	-0.324 0.23 15	0.447 0.0917 15	0.127 0.639 15	-0.247 0.367 15	0.42 0.113 15	-0.243 0.374 15	0.418 0.117 15	0.0934 0.734 15	0.445 0.0917 15	0.127 0.639 15	0.0519 0.842 15	0.548 0.0339 15	0.561 0.0287 15	0.213 0.433 15
Cd											0.368 0.171 15	0.315 0.246 15	0.754 0.000677 15	0.232 0.396 15	0.754 0.000677 15	0.293 0.281 15	0.47 0.0732 15	0.251 0.359 15	0.589 0.0201 15	0.0395 0.883 15	0.415 0.12 15	0.517 0.0463 15	0.268 0.325 15	0.843 0.0000002 15
Cr												-0.164 0.549 15	0.604 0.0166 15	0.757 0.000575 15	0.314 0.246 15	0.921 0.0000002 15	0.00357 0.985 15	0.43 0.104 15	-0.0501 0.852 15	-0.233 0.396 15	0.0357 0.893 15	-0.0808 0.763 15	-0.567 0.0263 15	0.307 0.257 15
Co													0.273 0.312 15	-0.0393 0.883 15	0.558 0.0299 15	-0.206 0.449 15	0.68 0.00504 15	0.155 0.575 15	0.739 0.00116 15	-0.295 0.275 15	0.059 0.822 15	0.0314 0.903 15	0.67 0.00575 15	0.4 0.134 15
Cu														0.418 0.117 15	0.693 0.0038 15	0.586 0.0211 15	0.198 0.465 15	0.439 0.0975 15	0.615 0.0143 15	-0.213 0.433 15	0.0929 0.734 15	0.205 0.457 15	0.025 0.923 15	0.711 0.00256 15
CN-															0.161 0.558 15	0.657 0.00739 15	0.143 0.602 15	0.683 0.00471 15	-0.0358 0.893 15	-0.371 0.167 15	-0.279 0.306 15	-0.26 0.339 15	-0.374 0.162 15	0.4 0.134 15
Fe																0.286 0.293 15	0.479 0.0685 15	0.335 0.214 15	0.676 0.00539 15	0.149 0.584 15	0.129 0.639 15	0.506 0.0517 15	0.531 0.0397 15	0.7 0.00326 15
Pb																	-0.00894 0.964 15	0.287 0.293 15	-0.0483 0.852 15	-0.0717 0.793 15	-0.111 0.686 15	-0.0736 0.783 15	-0.606 0.0158 15	0.132 0.629 15
Mn																		0.0539 0.842 15	0.47 0.0732 15	-0.0952 0.724 15	0.0626 0.812 15	0.137 0.62 15	0.362 0.18 15	0.386 0.15 15
Hg																			0.143 0.602 15	-0.51 0.0498 15	-0.354 0.189 15	-0.179 0.514 15	0.0862 0.753 15	0.583 0.022 15
Ni																				-0.137 0.62 15	0.0591 0.822 15	0.39 0.146 15	0.645 0.00882 15	0.562 0.0287 15
Se																					0.208 0.449 15	0.551 0.0325 15	0.133 0.629 15	-0.127 0.639 15
Ag																						0.443 0.0946 15	-0.00894 0.964 15	0.25 0.359 15
Tl																							0.428 0.107 15	0.291 0.287 15
V																								0.386 0.15 15
Zn																								

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.

Spearman Rank Order Correlation Wednesday, February 20, 2019, 4:34:12 PM

Data source: Hilliards Creek Soil Correlations

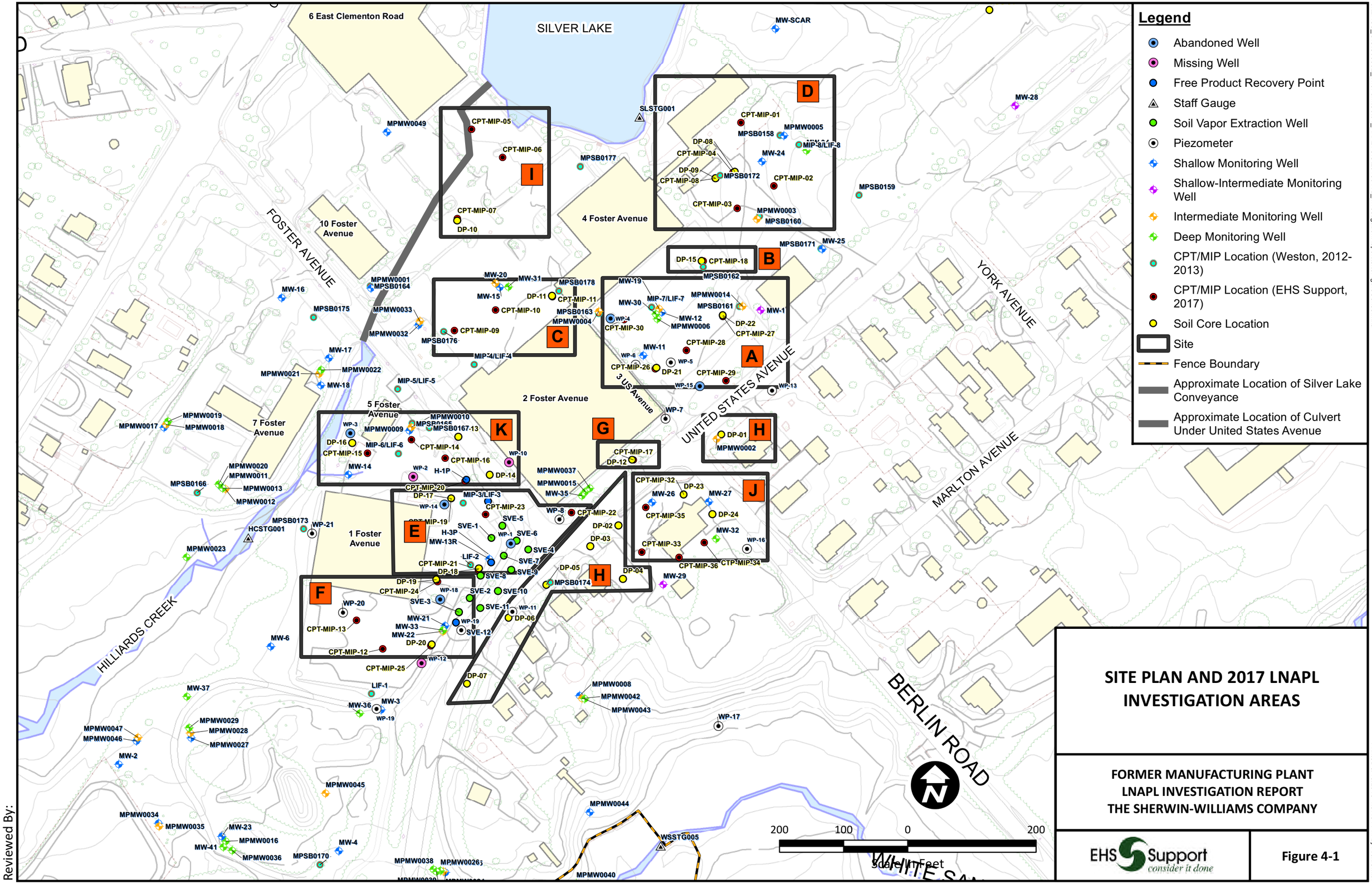
Cell Contents:
Correlation Coefficient
P Value
Number of Samples

	TOC	Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	CN	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	V	Zn
TOC		0.404 0.131 15	0.538 0.0367 15	0.143 0.602 15	0.225 0.41 15	0.414 0.12 15	0.2 0.465 15	0.325 0.23 15	0.248 0.359 15	0.318 0.24 15	0.318 0.24 15	0.179 0.514 15	0.179 0.514 15	0.0893 0.743 15	0.275 0.312 15	0.468 0.0757 15	0.663 0.00654 15	0.492 0.0597 15	-0.178 0.514 15	0.514 0.048 15	0.221 0.418 15
Al			0.681 0.00471 15	0.629 0.0116 15	0.621 0.0129 15	0.929 0.0000002 15	0.65 0.00832 15	0.796 0.0000002 15	0.724 0.00178 15	0.69 0.00409 15	0.661 0.00695 15	0.7 0.00326 15	0.682 0.00471 15	0.629 0.0116 15	0.715 0.00235 15	0.735 0.0013 15	0.45 0.0889 15	0.653 0.00785 15	0.102 0.705 15	0.821 0.0000002 15	0.657 0.00739 15
Sb				0.849 0.0000002 15	0.786 0.0000002 15	0.633 0.011 15	0.81 0.0000002 15	0.811 0.0000002 15	0.81 0.0000002 15	0.752 0.000677 15	0.878 0.0000002 15	0.829 0.0000002 15	0.738 0.00116 15	0.754 0.000677 15	0.804 0.0000002 15	0.909 0.0000002 15	0.615 0.0143 15	0.895 2E-07 15	0.308 0.257 15	0.813 0.0000002 15	0.82 0.0000002 15
As					0.85 0.0000002 15	0.629 0.0116 15	0.925 0.0000002 15	0.829 0.0000002 15	0.931 0.0000002 15	0.767 0.000308 15	0.896 0.0000002 15	0.925 0.0000002 15	0.854 0.0000002 15	0.925 0.0000002 15	0.819 0.0000002 15	0.881 0.0000002 15	0.306 0.257 15	0.757 0.000575 15	0.4 0.134 15	0.721 0.00196 15	0.879 0.0000002 15
Ba						0.586 0.0211 15	0.832 0.0000002 15	0.914 0.0000002 15	0.831 0.0000002 15	0.917 0.0000002 15	0.879 0.0000002 15	0.711 0.00256 15	0.893 0.0000002 15	0.839 0.0000002 15	0.888 0.0000002 15	0.779 0.0000944 15	0.414 0.12 15	0.76 0.00048 15	0.214 0.433 15	0.679 0.00504 15	0.875 0.0000002 15
Be							0.643 0.00934 15	0.796 0.0000002 15	0.758 0.000575 15	0.568 0.0263 15	0.618 0.0136 15	0.693 0.0038 15	0.679 0.00504 15	0.604 0.0166 15	0.584 0.0211 15	0.74 0.00116 15	0.323 0.235 15	0.542 0.0353 15	0.0467 0.863 15	0.7 0.00326 15	0.525 0.0429 15
Cd								0.779 0.0000944 15	0.885 0.0000002 15	0.76 0.00048 15	0.8 0.0000002 15	0.814 0.0000002 15	0.936 0.0000002 15	0.896 0.0000002 15	0.835 0.0000002 15	0.881 0.0000002 15	0.38 0.158 15	0.719 0.00215 15	0.564 0.0275 15	0.689 0.00409 15	0.761 0.00048 15
Cr									0.869 0.0000002 15	0.863 0.0000002 15	0.879 0.0000002 15	0.764 0.000391 15	0.843 0.0000002 15	0.818 0.0000002 15	0.879 0.0000002 15	0.833 0.0000002 15	0.41 0.124 15	0.762 0.00048 15	0.0862 0.753 15	0.721 0.00196 15	0.843 0.0000002 15
Co										0.728 0.00161 15	0.819 0.0000002 15	0.87 0.0000002 15	0.817 0.0000002 15	0.91 0.0000002 15	0.771 0.000231 15	0.941 0.0000002 15	0.241 0.374 15	0.658 0.00739 15	0.303 0.263 15	0.679 0.00504 15	0.831 0.0000002 15
Cu											0.819 0.0000002 15	0.651 0.00832 15	0.819 0.0000002 15	0.761 0.00048 15	0.914 0.0000002 15	0.728 0.00161 15	0.559 0.0299 15	0.84 2E-07 15	0.211 0.441 15	0.772 0.000231 15	0.899 0.0000002 15
CN												0.861 0.0000002 15	0.793 0.0000002 15	0.804 0.0000002 15	0.881 0.0000002 15	0.797 0.0000002 15	0.457 0.0834 15	0.826 2E-07 15	0.151 0.584 15	0.818 0.0000002 15	0.904 0.0000002 15
Fe													0.707 0.00278 15	0.843 0.0000002 15	0.695 0.00352 15	0.808 0.0000002 15	0.335 0.214 15	0.726 0.00178 15	0.302 0.269 15	0.725 0.00178 15	0.811 0.0000002 15
Pb														0.818 0.0000002 15	0.865 0.0000002 15	0.786 0.0000002 15	0.387 0.15 15	0.719 0.00215 15	0.359 0.18 15	0.696 0.00352 15	0.736 0.0013 15
Mn															0.826 0.0000002 15	0.845 0.0000002 15	0.349 0.194 15	0.608 0.0158 15	0.406 0.127 15	0.582 0.022 15	0.839 0.0000002 15
Hg																0.793 0.0000002 15	0.519 0.0463 15	0.808 2E-07 15	0.283 0.3 15	0.786 0.0000002 15	0.895 0.0000002 15
Ni																	0.436 0.101 15	0.744 0.00103 15	0.382 0.154 15	0.751 0.000786 15	0.797 0.0000002 15
Se																		0.588 0.0201 15	0.0297 0.913 15	0.568 0.0263 15	0.421 0.113 15
Ag																			0.253 0.353 15	0.846 0.0000002 15	0.818 0.0000002 15
Tl																				0.138 0.611 15	0.199 0.465 15
V																					0.793 0.0000002 15
Zn																					

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.

APPENDIX B

LNAPL Report Exhibits


Legend
Abandoned Well
Missing Well
Free Product Recovery Point
Staff Gauge
Soil Vapor Extraction Well
Piezometer
Shallow Monitoring Well
Shallow-Intermediate Monitoring Well
Intermediate Monitoring Well
Deep Monitoring Well
CPT/MIP Location (Weston, 2012-2013)
CPT/MIP Location (EHS Support, 2017)
Soil Core Location
Site
Fence Boundary
Approximate Location of Silver Lake Conveyance
Approximate Location of Culvert Under United States Avenue
SILVER LAKE
6 East Clementon Road
10 Foster Avenue
4 Foster Avenue
2 Foster Avenue
5 Foster Avenue
7 Foster Avenue
1 Foster Avenue
3 US Avenue
FOSTER AVENUE
YORK AVENUE
UNITED STATES AVENUE
MARLTON AVENUE
BERLIN ROAD
HILLIARDS CREEK
A
B
C
D
E
F
G
H
I
J
K
200 100 0 200
Scale in Feet
SITE PLAN AND 2017 LNAPL INVESTIGATION AREAS
FORMER MANUFACTURING PLANT
LNAPL INVESTIGATION REPORT
THE SHERWIN-WILLIAMS COMPANY
EHS Support consider it done
Figure 4-1
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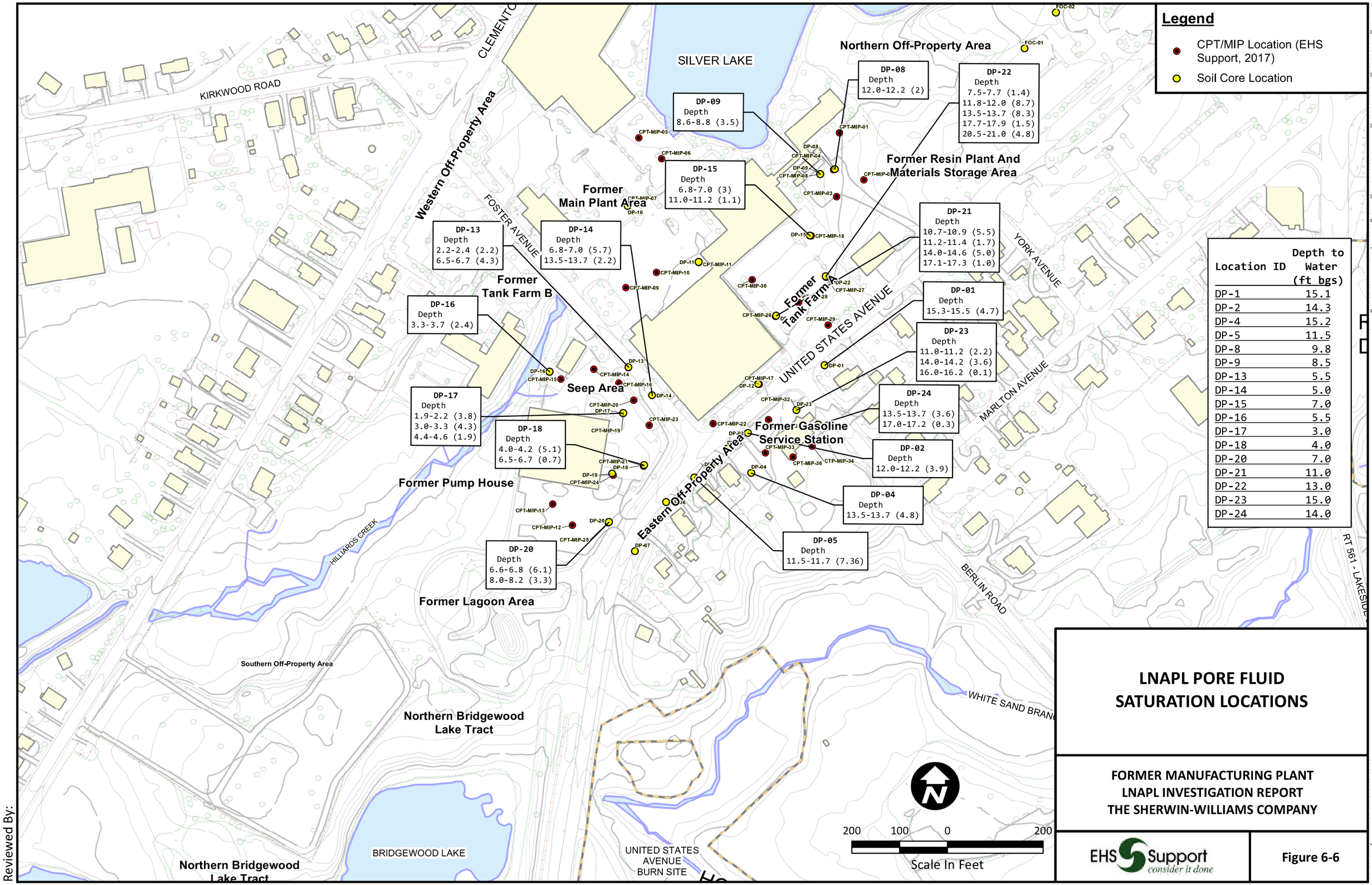

Location ID	Depth to Water (ft bgs)
DP-1	15.1
DP-2	14.3
DP-4	15.2
DP-5	11.5
DP-8	9.8
DP-9	8.5
DP-13	5.5
DP-14	5.0
DP-15	7.0
DP-16	5.5
DP-17	3.0
DP-18	4.0
DP-20	7.0
DP-21	11.0
DP-22	13.0
DP-23	15.0
DP-24	14.0

LNAPL PORE FLUID SATURATION LOCATIONS

FORMER MANUFACTURING PLANT
LNAPL INVESTIGATION REPORT
THE SHERWIN-WILLIAMS COMPANY

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Figure 6-6

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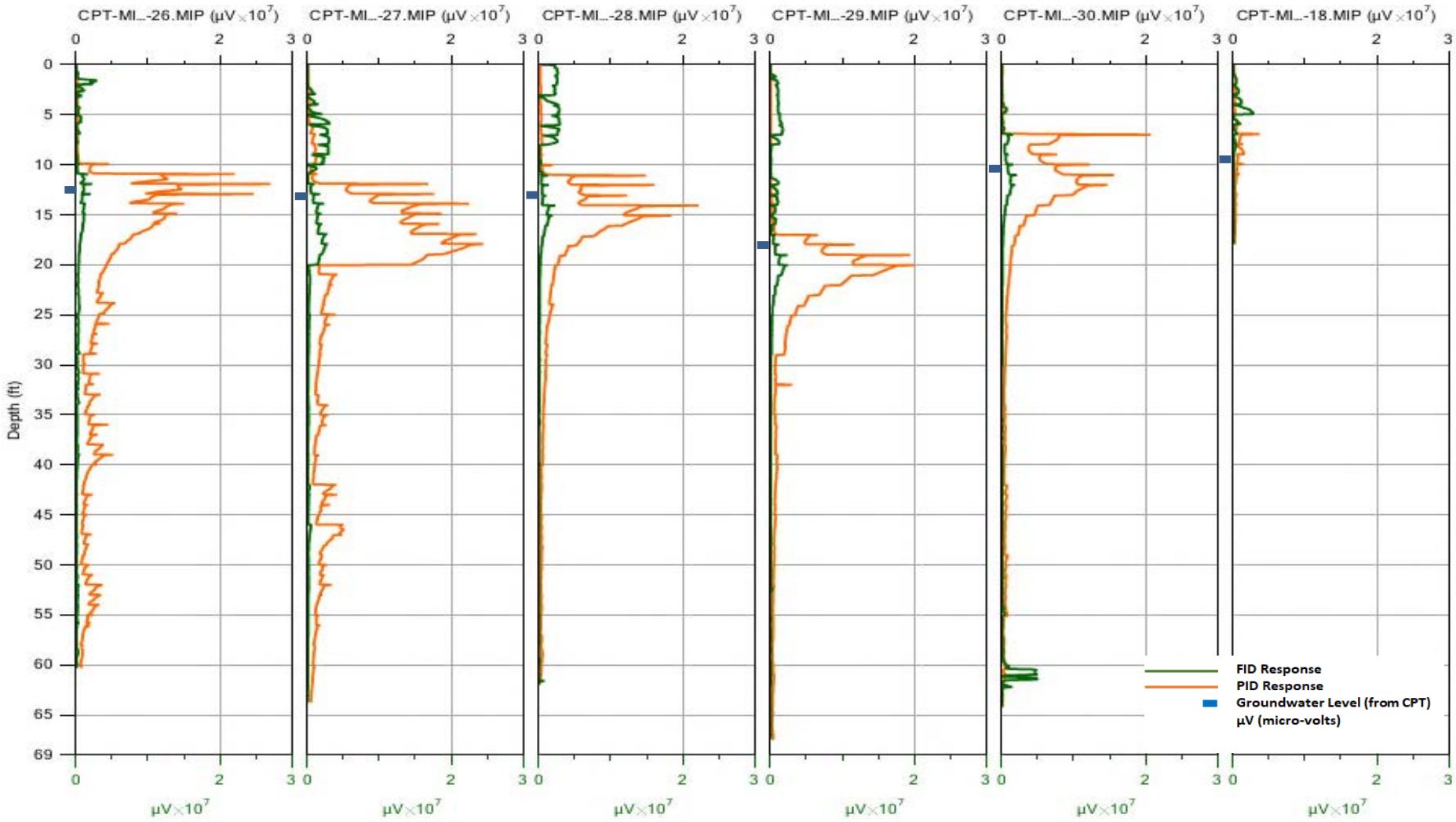

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Figure 6-10A
Areas A and B PID Max / FID Max
The Sherwin-Williams Company
Gibbsboro, New Jersey

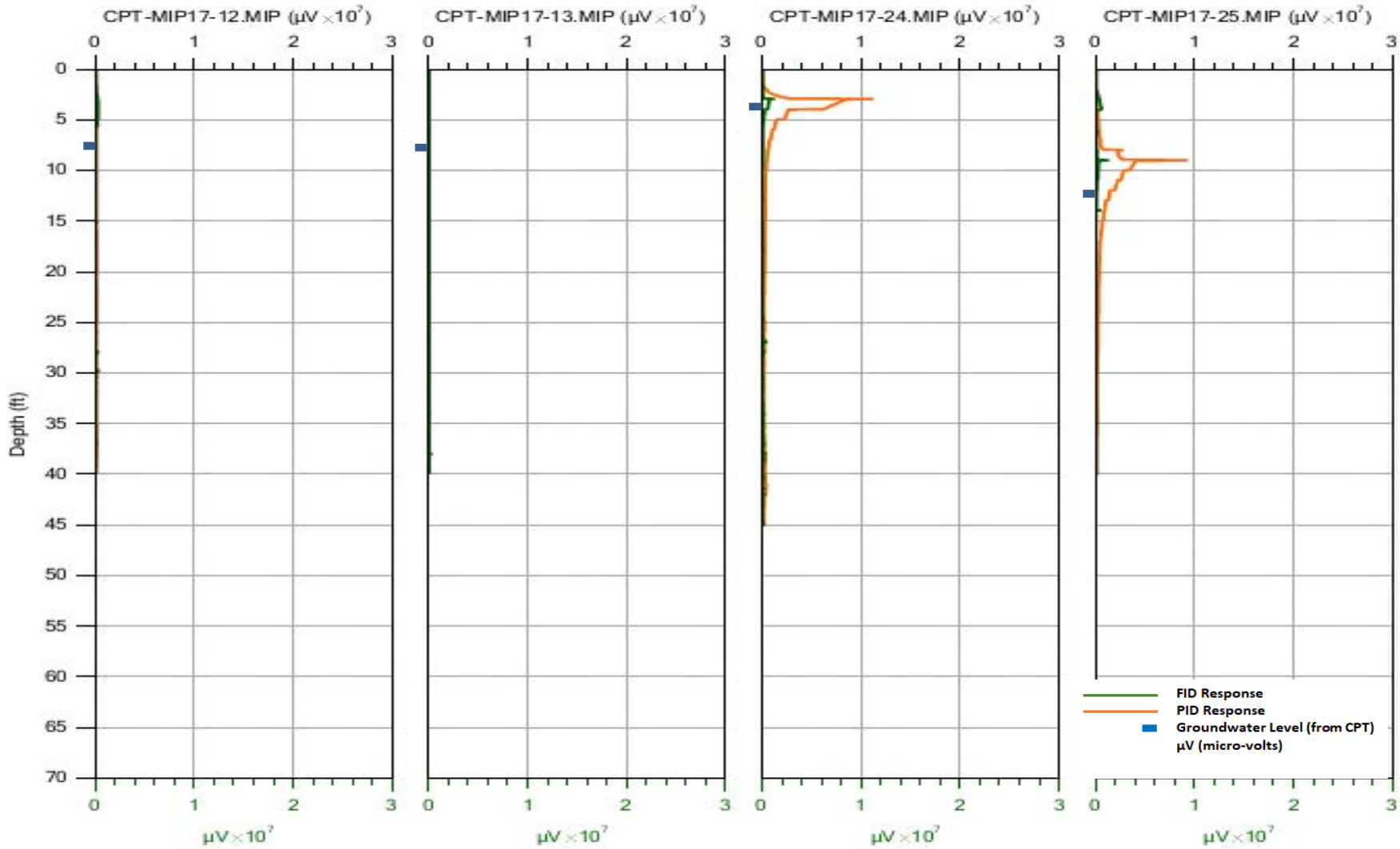

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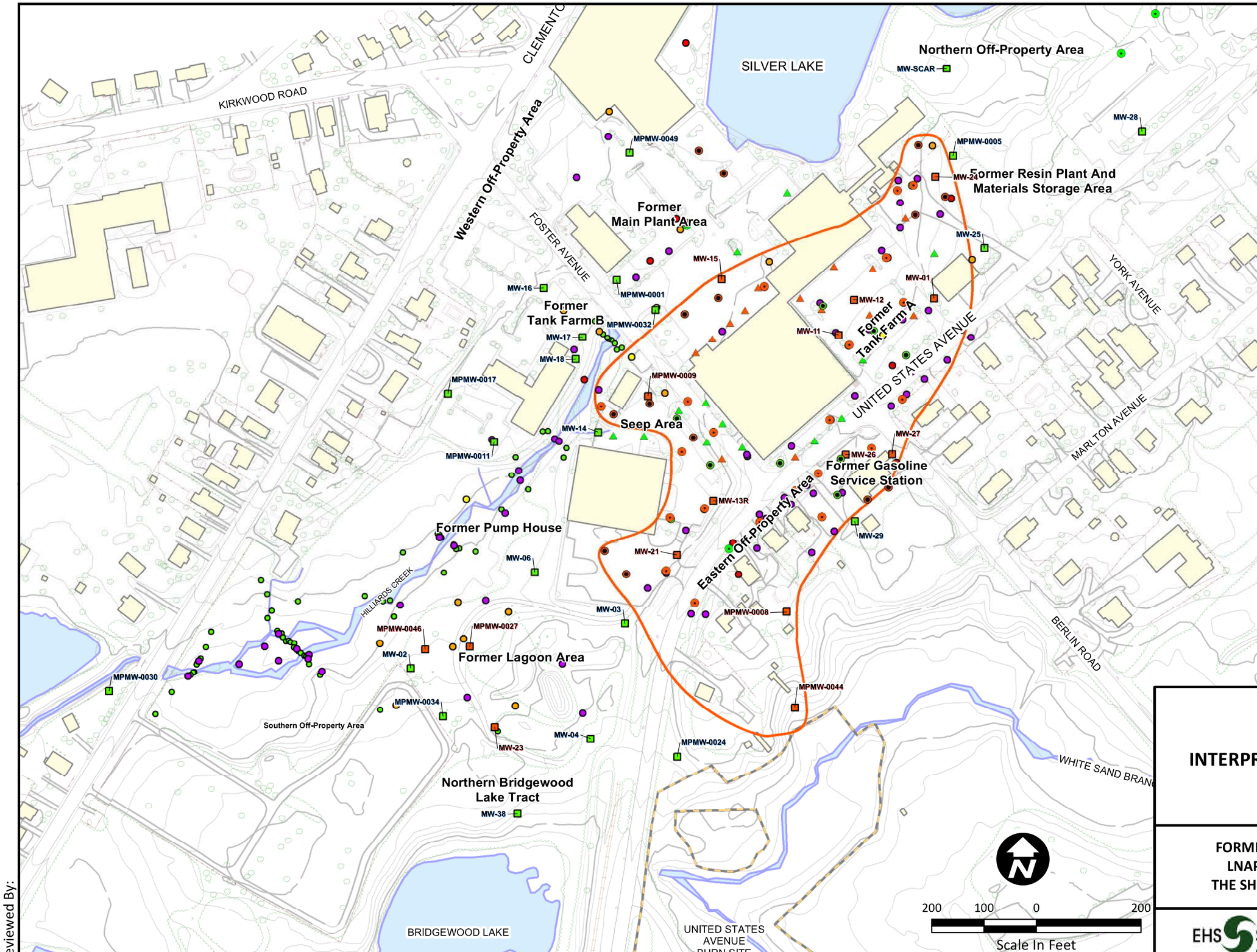
Figure 6-10E
Area F PID Max / FID Max
The Sherwin-Williams Company
Gibbsboro, New Jersey



Legend

- Interpreted Extent of LNAPL
- CPT/MIP Location Elevated responses (>5V)
- CPT/MIP Location No elevated responses (>5V)
- Soil Core Location LNAPL indicated by pore fluid saturation data and/or elevated PID responses (>25 PPM)
- Soil Core Location No elevated PID responses (>25 PPM) or other indications of LNAPL
- One or more constituents exceed calculated threshold concentrations in Soil Gas
- No constituents exceed calculated threshold concentrations in Soil Gas
- One or more constituents exceed calculated threshold concentrations in groundwater
- No constituents exceed calculated threshold concentrations in groudwater
- Exceeds 10 times the cSat concentration
- Exceeds 5-10 times the cSat concentration
- Exceeds 2-5 times the cSat concentration
- Exceeds 1-2 times the cSat concentration
- Does not exceed cSat concentration

INTERPRETED EXTENT OF LNAPL

FORMER MANUFACTURING PLANT
LNAPL INVESTIGATION REPORT
THE SHERWIN-WILLIAMS COMPANY

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Figure 6-14

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Table 6-3
LNAPL Composition
The Sherwin-Williams Comany
Gibbsboro, New Jersey

Sample Location ID	H-3P		H-3P		MW-11	
Constituent	**10/5/2011**		**8/22/2017**		**8/22/2017**	
EXTRACTABLE PETROLEUM HYDROCARBONS (EPH)	**mg/kg**	**% of total**	**mg/kg**	**% of total**	**mg/kg**	**% of total**
C9-C12 Petroleum Hydrocarbons, Aliphatic	1400000	69.6%	790000	57.1%	770000	62.9%
C12-C16 Petroleum Hydrocarbons, Aliphatic	--	--	89000	6.4%	94000	7.7%
C16-C21 Petroleum Hydrocarbons, Aliphatic	--	--	38000	2.7%	39000	3.2%
Diesel Range Organics (C21-C40 Aliphatics)	360000	17.9%	63000	4.6%	62000	5.1%
C10-C12 Aromatics	130000	6.5%	25000	1.8%	30000	2.5%
C12-C16 Aromatics	6000	0.3%	5100	0.4%	6000	0.5%
C16-C21 Aromatics	14000	0.7%	1900	0.1%	1900	0.2%
C21-C36 Aromatic	67000	3.3%	3100	0.2%	5500	0.4%
Total EPH Proportion		**98.2%**		**73.4%**		**82.4%**
VOLATILE PETROLEUM HYDROCARBONS (VPH)						
C5-C8 Petroleum Hydrocarbons, Aliphatic	--	--	49000	3.5%	33000	2.7%
C9-C10 Petroleum Hydrocarbons, Aromatic	--	--	120000	8.7%	35000	2.9%
C9-C12 Petroleum Hydrocarbons, Aliphatic	--	--	250000	--	73000	--
Total VPH Proportion (Excluding C9-C12)		**--**		**12.2%**		**5.6%**
Total Aliphatic Proportion (VPH and EPH)[1]		**87.4%**		**74.4%**		**81.5%**
Total Aromatic Proportion (VPH and EPH)		**10.8%**		**11.2%**		**3.5%**
SEMIVOLATILE ORGANIC COMPOUNDS (TICs)						
1,2,4,5-Tetramethylbenzene	--	--	6100	0.4%	5300	0.4%
1,3-Diethyl Benzene	--	--	--	--	4900	0.4%
1,3-Diethyl-5-Methylbenzene	--	--	5400	0.4%	--	--
Cis-1,3-Dimethyl Cyclohexane	--	--	--	--	5800	0.5%
Cis-Decahydronaphthalene	--	--	--	--	7700	0.6%
Cyclopentane, 1,2,4-Trimethyl- (1.Alpha	--	--	--	--	4900	0.4%
Decahydro Naphthalene	--	--	4300	0.3%	--	--
M-Xylene (1,3-Dimethylbenzene)	--	--	6600	0.5%	--	--
O-Cymene (O-Isopropyltoluene)	--	--	4400	0.3%	8300	0.7%
Unknown	--	--	--	--	7000	0.6%
Unknown	--	--	3800	0.3%	6800	0.6%
Unknown	--	--	5400	0.4%	7500	0.6%
Unknown	--	--	--	--	4700	0.4%
Unknown	--	--	4200	0.3%	--	--
Unknown	--	--	--	--	6600	0.5%
Unknown	--	--	--	--	4500	0.4%
Unknown	--	--	--	--	7100	0.6%
Unknown	--	--	5800	0.4%	--	--
Unknown	--	--	11000	0.8%	9900	0.8%
Unknown	--	--	--	--	6100	0.5%
Unknown	--	--	9400	0.7%	--	--
Unknown	--	--	3300	0.2%	--	--
Unknown	--	--	3700	0.3%	--	--
Unknown	--	--	3500	0.3%	--	--
Unknown	--	--	--	--	5600	0.5%
Unknown	--	--	6800	0.5%	--	--
Unknown	--	--	3200	0.2%	--	--
Unknown	--	--	2900	0.2%	--	--
Unknown	--	--	3100	0.2%	--	--
Unknown TIC	--	--	3100	0.2%	4800	0.4%
Unknown TIC	--	--	3100	0.2%	5700	0.5%
Unknown TIC	--	--	--	--	4400	0.4%
Unknown TIC	--	--	--	--	6700	0.5%
Total SVOC TIC Mass Fraction		**--**		**7%**		**10%**

Table 6-3
LNAPL Composition
The Sherwin-Williams Comany
Gibbsboro, New Jersey

Sample Location ID	H-3P		H-3P		MW-11	
Constituent	**10/5/2011**		**8/22/2017**		**8/22/2017**	
SEMIVOLATILE ORGANIC COMPOUNDS						
1,1'-Biphenyl	--	--	--	--	--	--
2,4-Dimethylphenol	--	--	--	--	--	--
2-Methylnaphthalene	--	--	360	0.0%	130	0.0%
4-Chloroaniline	--	--	--	--	--	--
4-Methylphenol	1600	0.1%	--	--	--	--
Acenaphthene	--	--	--	--	--	--
Acenaphthylene	--	--	--	--	--	--
Anthracene	--	--	--	--	--	--
Benzo(a)anthracene	--	--	--	--	--	--
Benzo(a)pyrene	--	--	--	--	--	--
Benzo(b)fluoranthene	--	--	--	--	--	--
Benzo(g,h,i)perylene	--	--	--	--	--	--
Benzo(k)fluoranthene	--	--	--	--	--	--
Chrysene	--	--	--	--	--	--
Diethylphthalate	--	--	--	--	--	--
Fluoranthene	--	--	--	--	--	--
Fluorene	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	--
Naphthalene	1600	0.1%	1500	0.1%	50	0.0%
Phenanthrene	1600	0.2%	--	--	--	--
Phenol	--	--	--	--	--	--
Pyrene	--	--	--	--	--	--
BIS(2-Ethylhexyl) Phthalate	--	--	--	--	--	--
Total SVOC Mass Fraction		**0.1%**		**0.1%**		**0.0%**
VOLATILE ORGANIC COMPOUNDS (TICs)						
1,2,3-Trimethyl Benzene	--	--	4900	0.4%	--	--
1,2,4,5-Tetramethylbenzene	--	--	5000	0.4%	--	--
1,2,4-Trimethylbenzene	--	--	9500	0.7%	--	--
1,2-Diethylbenzene	870	0.0%	--	--	870	0.1%
1,3,5-Trimethylbenzene (Mesitylene)	--	--	7500	0.5%	--	--
1,3-Cyclopentadiene, 1,2,3,4-Tetramethyl-5-Methylene	980	0.0%	--	--	980	0.1%
1,4-Diethyl Benzene	--	--	6900	0.5%	--	--
1,4-Dimethylcyclohexane	1300	0.1%	--	--	1300	0.1%
2-Ethyl-1,4-Dimethyl Benzene	--	--	7700	0.6%	--	--
4-Ethyl-1,2-Dimethyl Benzene	990	0.0%	--	--	990	0.1%
Cis-1,3-Dimethyl Cyclohexane	9500	0.5%	5500	0.4%	9500	0.8%
Decahydro Naphthalene	1300	0.1%	--	--	1300	0.1%
Ethyl Cyclohexane	1100	0.1%	--	--	1100	0.1%
Ethylmethyl Cyclohexane	1900	0.1%	--	--	1900	0.2%
M-Cymene	--	--	12000	0.9%	--	--
Trans-1,2-Dimethylcyclohexane	990	0.0%	--	--	990	0.1%
Unknown Aromatic	1000	0.0%	6500	0.5%	1000	0.1%
Unknown Cycloalkane	--	--	6200	0.4%	--	--
Total VOC TIC Mass Fraction		**1.0%**		**5.2%**		**1.6%**
VOLATILE ORGANIC COMPOUNDS						
1,1-Dichloroethene	--	--	--	--	--	--
4-Methyl-2-Pentanone	--	--	--	--	--	--
Acetone	--	--	--	--	--	--
Benzene	91	0.0%	100	0.01%	5	0.0%
Carbon Disulfide	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	--
CIS-1,2-Dichloroethene	--	--	--	--	--	--
Cyclohexane	--	--	140	0.0%	130	0.0%
Dichloromethane	--	--	--	--	--	--
Ethylbenzene	2100	0.1%	4400	0.3%	10	0.0%
Isopropylbenzene (Cumene)	--	--	660	0.0%	260	0.0%
M,P-Xylene	--	--	19000	1.4%	3	0.0%
Methylcyclohexane	--	--	2100	0.2%	2800	0.2%

Table 6-3
LNAPL Composition
The Sherwin-Williams Comany
Gibbsboro, New Jersey

Sample Location ID	H-3P		H-3P		MW-11	
Constituent	**10/5/2011**		**8/22/2017**		**8/22/2017**	
Methyl-Tert-Butyl-Ether (MTBE)	--	--	--	--	--	--
O-Xylene (1,2-Dimethylbenzene)	--	--	50	0.0%	4	0.0%
Toluene	5	0.0%	15	0.0%	10	0.0%
Trichloroethene	--	--	--	--	--	--
Vinyl Chloride	--	--	--	--	--	--
Xylenes, Total	8800	0.9%	--	--	--	--
Total VOC Mass Fraction		**1.0%**		**1.9%**		**0.3%**
Sum of Total Detected Constituents[1]	**2012726**		**1383225**		**1224031**	

Note:

[1] C9-C12 Aliphatics by VPH methods was excluded in the sum of total detecgted constituents to avoid double counting as C9-C12 aliphatics was also quantified via EPH methods.

Table 6-9
Imbibition Testing Summary of Results
The Sherwin-Williams Company
Gibbsboro, New Jersey

Well/Sample ID	Water Bearing Zone	Specific Sample Depth (ft bgs)	Sample Orientation[1]	Moisture Content (% weight)	Density		Porosity (%Vb)[2]		Pore Fluid Saturation (% Pore Volume)[3]				Change In Saturations Via Imbibition (% Pore Volume)	
					Dry Bulk (g/cc)	Grain (g/cc)	Total	Air Filled	Prior to Imbibition Capillary Pressure		After Imbibition Capillary Pressure			
									Water (Swi) Saturation	NAPL (Soi) Saturation	Water (Srw) Saturation	NAPL (Sor) Saturation	Water	NAPL
DP-4 (13.5-14.2)	Shallow	13.9	H	15.6	1.39	2.67	47.98	9.8	41.3	4.8	74.8	4.8	33.5	0
DP-9 (8-8.8)	Shallow	8.4	H	14.4	1.46	2.66	45.19	2.8	43.5	3.5	90.3	3.5	46.8	0
DP-13 (2.2-3)	Shallow	2.7	H	9.3	1.42	2.65	46.15	6.4	27.0	2.2	84.0	2.2	57	0
DP-14 (6.8-7.5)	Shallow	6.8	H	23.7	1.52	2.70	43.51	2.3	78.5	5.7	88.9	5.7	10.4	0
DP-15 (6.8-7.4)	Shallow	7.2	H	18.2	1.33	2.67	50.23	13.3	46.1	3.0	70.5	3.0	24.4	0
DP-17 (3-3.6)	Shallow	3.0	H	17.4	1.55	2.67	41.80	7.4	61.6	4.3	78.0	4.3	16.4	0
DP-18 (3.5-4.2)	Shallow	3.5	H	13.8	1.52	2.67	43.18	11.5	47.2	5.1	68.3	5.1	21.1	0
DP-20 (6.2-6.8)	Shallow	6.7	H	14.4	1.42	2.66	46.49	1.8	39.3	6.1	90.2	6.1	50.9	0
DP-21 (11.2-11.7)	Shallow	11.5	H	20.2	1.43	2.68	46.69	8.8	60.1	1.7	79.5	1.7	19.4	0
DP-22 (13.5-14.2)	Shallow	13.5	H	22.5	1.42	2.69	47.02	1.7	61.2	8.3	88.1	8.3	26.9	0
DP-23 (14-14.7)	Shallow	14.0	H	21.5	1.39	2.67	47.89	10.8	59.1	3.6	73.8	3.6	14.7	0
DP-24 (13.5-14.2)	Shallow	13.9	H	19.2	1.55	2.68	42.14	3.2	50.2	3.6	88.8	3.6	38.6	0

Notes:
ft bgs = feet below ground surface
g = grams
cc = cubic centimeter
NAPL = Non-aqueous phase liquid
Vb = bulk volume
Swi = Initial Water Saturation as received prior to testing
Srw = Residual Water Saturation after testing
Soi = Initial NAPL Saturation as received prior to testing
Sor = Residual NAPL Saturation after testing
USCS Classifications, water bearing zones, and depth to saturated zones sourced from boring logs
(1) = Sample Orientation: H=horizontal; V - vertical; R - remold
(2) = Total Porosity = all interconnected pore channels; Air Filled = pore channels not occupied by pore fluids
(3) Fluid density used to calculate pore fluid saturation; Water = 0.9996 g/cc; NAPL = 0.7923 g/ccc

APPENDIX C

Evaluation of the Applicability of Thermal-Enhanced Recovery at the Former Manufacturing Plant

TECHNICAL MEMO

Evaluation of the Applicability of Thermal-Enhanced Recovery at the Former Manufacturing Plant

Date: January 11, 2018

Sherwin-Williams submitted the Draft *Feasibility Study, Former Manufacturing Plant Area, Sherwin-Williams Hilliards Creek Site* (FMP FS; ELM Group, 2018) to the United States Environmental Protection Agency (EPA) in May 2018. In its August 2018 comments, the EPA suggested that in situ thermal remediation (ISTR) technologies may have applicability at the FMP. In a September 6, 2018 meeting with EPA and the New Jersey Department of Environmental Protection (NJDEP), Sherwin-Williams discussed the possible outcome of evaluating ISTR as a remedial technology at the FMP based on the five balancing criteria. On September 12, 2018, the EPA requested that Sherwin-Williams provide a formal technical memorandum assessing the viability of ISTR to remove residual light non-aqueous phase liquids (LNAPL) from the subsurface at the FMP. Sherwin-Williams submitted the first version of this technical memo to EPA on October 4, 2018 and received comments electronically from EPA on November 14, 2018. Sherwin-Williams then met with EPA and NJDEP on November 19, 2018, to discuss the technical memo and EPA's comments. The technical memo incorporates both the comments and discussions with EPA.

This technical memo leverages information provided by relevant guidance from EPA (EPA, 2018, 2014, 2012, 2008, 2006, 1997,1995a), US Army Corps of Engineers (USACE, 2014), ESTCP (ESTCP, 2010a, 2010b, 2009), and academia (Munholland, 2016) (Vidonish, 2016) (Heron, 2015) (Zhao, 2014) as well as from thermal remediation patent holders like TerraTherm (TerraTherm, 2018) (Griepke, 2018), site-specific technical documents (EHS Support, 2017, 2018) (ELM Group, 2018), and other resources such as those listed in the References and Bibliography section of this technical memorandum to:

(a) Describe the site-specific factors that influence the selection and use of thermal remediation technologies at the site.
(b) Evaluate the most likely thermal remediation alternative to be utilized based on site-specific factors.
(c) Identify the implementation concerns associated with thermal remediation at the site.

In addition, as part of the process, an independent technical review of site data was completed by TerraTherm (now part of Cascade Thermal) to aid in identification of constraints and implementation recommendations for this site.

This technical memo discusses the following considerations in relation to potential utilization of thermal-enhanced LNAPL recovery:

1. What is the Conceptual Site Model (CSM) for the area(s) where ISTR would potentially be applied?

2. What is ISTR, and which technology would be used if applied at the FMP?
3. What and where are the main factors likely to limit/prevent effective thermal-enhanced LNAPL recovery at the site?

LNAPL CSM: Characteristics, Distribution, and Fate and Transport

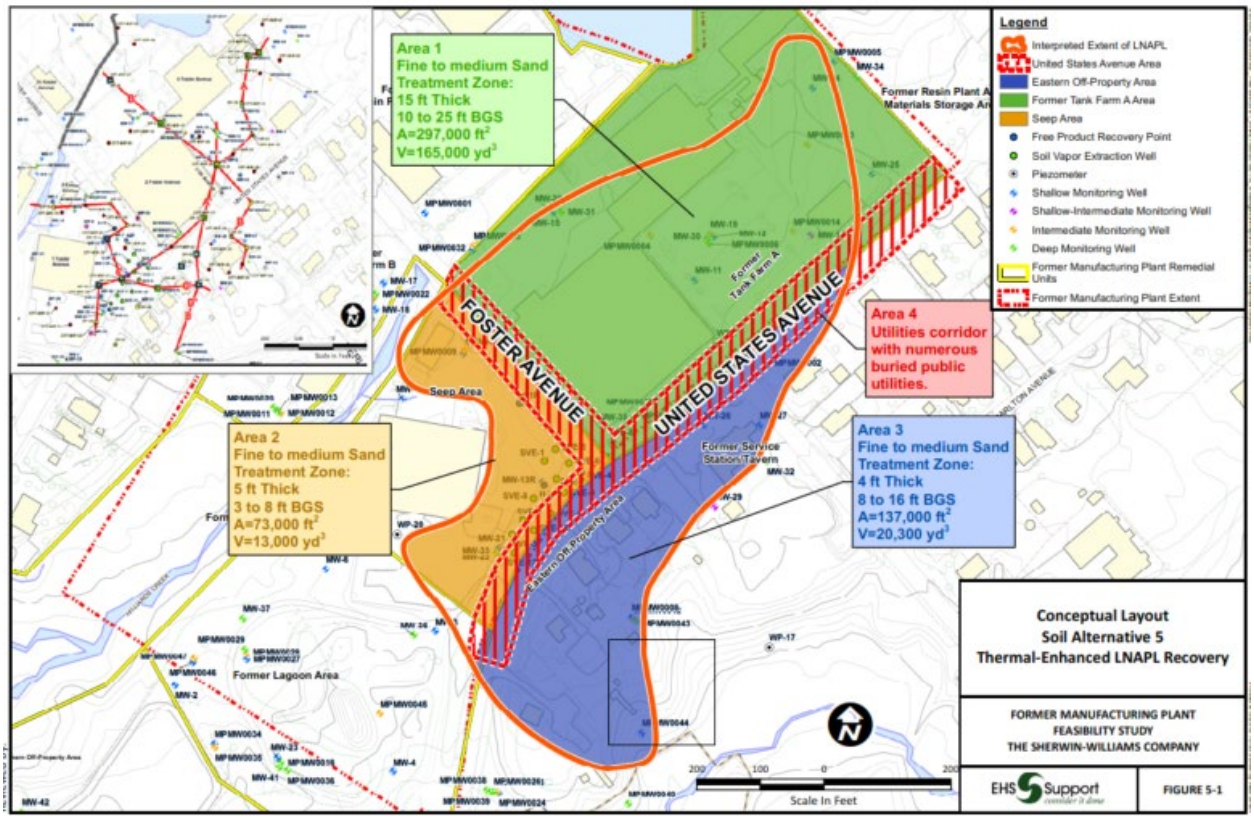
A detailed discussion of the LNAPL conditions in the subsurface is provided in the *LNAPL Investigation Report* (EHS Support, 2018) and this information is summarized in the FMP FS. LNAPL is present in portions of four contiguous areas of the FMP, as shown in the figure below:

- Area 1, the former Resin Plant and Tank Farm A Area
- Area 2, the Seep Area
- Area 3, the Eastern Off-Property Area
- Area 4, United States Avenue and Foster Avenue

Each of these areas possess unique characteristics that affect the ability to use ISTR as a remedial technology.

In the context of the September 6, 2018 discussion with EPA and in consideration of the logistical constraints at the site, the most likely area for application of thermal remediation is Area 1 (the former Resin Plant/Tank Farm A area), located west of US Avenue and north of Foster Ave. Thermal remediation is not a likely candidate for the other three areas due to the following factors:

- Area 2: As discussed in the FMP FS, the accessibility of the LNAPL supports the use of excavation as a remedial alternative.
- Area 3: This is primarily a residential area and the vertical interval of LNAPL impacts is smaller than that in Area 1, supporting the conclusion that a less intrusive technology, such as bioremediation, is most appropriate. Additionally, use of thermal remediation in these areas could lead to damage to services.
- Area 4: These are roadways with subsurface utilities. Use of thermal remediation in these areas could impact key public utilities and higher temperatures (for example from thermal conductive heating) could impact on the roadway.



(adapted from EHS Support, 2018)

The key conditions and physical attributes to consider in the assessment of thermal treatment in Area 1 are as follow:

<u>LNAPL Characteristics</u>

- The LNAPL is comprised of weathered mineral spirits with some limited mono-aromatic constituents co-eluted in the LNAPL mixture.
- Mineral spirits is predominantly comprised of aliphatic petroleum hydrocarbons in the C9 – C12 range with some heavy molecular weight petroleum hydrocarbons up to C16 comprising less than 5% of the mass.
- Testing of LNAPL samples collected from wells MW-11 and H-3P indicated initial boiling points of 240°F (115°C) and 275°F (135°C), respectively. These samples are representative of the less weathered mobile LNAPL fraction (not the residual LNAPL mass which dominates) and have light end hydrocarbon constituents coeluted in the samples. Literature values for weathered mineral spirits are as follows:
    - Initial Boiling Point: 145 to 175 ºC
    - Final Boiling Point: 220 ºC
    - Autoignition Temperature: 240 ºC
    - Vapor Pressure: 0.6 mm kPa at 20 ºC
    - Vapor Density: 4.5 to 5 (air density = 1)

The high initial and final boiling points, and the high vapor density of the mineral spirits have significant implications for the temperature and duration of any thermal-enhanced remediation that would be implemented at the Site:

- EPA has commented that in the presence of groundwater, co-boiling would likely occur at lower temperature such as 85 to 95 ºC. However, the majority of constituents in mineral spirits (even with co-boiling) will not boil at these lower temperatures (see table below), so the primary mechanism for mass loss at sub-boiling temperatures would be partitioning from liquid to vapor due to temperature elevation.

Therefore, while some proportion of the LNAPL could be recovered through volatilization, and additional mass may also be recovered as LNAPL liquid, volatilization of the LNAPL (including the Tentatively Identified Compounds which are dominated by aliphatic hydrocarbons) will be the rate-limiting step. As a result, higher temperatures and longer treatment times will be needed to facilitate effective mass removal.

The requirement for higher temperatures and longer treatment times is exacerbated by the mixture of the mineral spirits. Consistent with the US Army Corp of Engineers guidance document: In Situ Thermal Remediation (USACE, 2014), which discusses the concept of co-boiling, or the eutectic point of the azeotropic mixture, the initial boiling point is a function of the mixture. Thermal remediation of a mixed hydrocarbon product will result in preferential loss of more volatile constituents over time and resulting increases in initial boiling point increasing over time and a reduction in the associated vapor mass flux. As a result, mass losses are anticipated to decline over time and higher temperatures will be needed to continue hydrocarbon mass removal from the subsurface.

Carbon Weight	Alkane	Initial Boiling Point (ºC)
C9	Nonane	151
C10	Decane	174
C11	Undecane	193
C12	Dodecane	216

To address these key limitations on thermal treatment of this LNAPL, higher temperatures (consistent with those provided by conductive heating as described below) to accelerate remediation time frames and/or longer treatment times (prolonged periods of heating) will be required to limit the residual mass post-treatment. However, despite this and considering inefficiencies with heat transfer and potentially inaccessible areas (which cannot be treated), residual hydrocarbon mass will be present (post-treatment) which will require further remediation via natural attenuation processes.

The high temperatures and extended treatment times may also adversely affect the time needed for biodegradation to complete removal of the residual LNAPL remaining after thermal treatment. Thermally enhanced bioremediation has been observed at a number of sites where temperature increases do not increase into a range at which mesophiles cannot function (i.e. the temperature range for thermophiles) and/or major shifts in bacterial population occur. Bacteriological studies have been conducted at the site and have determined that none of the bacterial communities' present are thermophiles and that sulfate-reducing bacteria and methanogens are the dominant bacteria.

The thermal remediation temperatures required at this site would impede biological activity (due to being outside the functioning temperature range of the bacterial communities present) and these bacteria would have to recolonize/rebound before natural attenuation processes could recommence and replicate the current degradation rates observed at the site.

LNAPL Distribution

The LNAPL is typically first encountered at or slightly above the water table at depths of approximately seven to ten feet below ground surface. The LNAPL extends another ten to fifteen feet into the saturated zone. On the west side of Area 1, the LNAPL is found at a shallower depth, approximately four feet below ground surface.

The LNAPL extends over approximately seven acres. This area includes the 2 Foster Avenue/3 United States Avenue building, approximately one-half of the 4 Foster Avenue building, the adjacent paved parking areas, and portions of the lawn area north of the former Tank Farm A area.

The saturated soil where the LNAPL is located is a fine-grained silty sand unit. The impacts are contained within an unconfined groundwater system and, as such, any steam production associated with thermal remediation activities will occur at near atmospheric pressure (some localized pressure will develop but will rapidly dissipate).

LNAPL Fate and Transport

The LNAPL Report found that the LNAPL across the majority of the site is at or below residual saturation levels indicating that physical recovery would not be effective. The low saturation levels are the result of rising and falling water table levels, natural source zone depletion and manual recovery activities. Imbibition testing (application of high pore water pressures to the soil cores) found that even under high pressures, no LNAPL was displaced from the soil pore matrix. These findings supported a conclusion that the LNAPL in the majority of the area is neither recoverable nor mobile. Some small volumes of LNAPL are recovered periodically at the site but this mass removed is very small relative to the total mass of LNAPL trapped in the formation.

The LNAPL Report also concluded that the LNAPL was undergoing biodegradation. This conclusion was supported by the presence of methane beneath the floor slabs of the 2 and 4 Foster Avenue buildings and the adjacent parking areas as well as the heat signature of the groundwater in which the degradation is occurring. Literature values of several hundred to several thousand gallons per acre per year of LNAPL depletion were cited as providing a representative range of the possible natural source zone depletion occurring at the FMP. The LNAPL CSM found that the depletion rates in the former Resin Plant/Tank Farm A area were likely limited by the absence of key nutrients such as nitrogen and phosphorous.

Finally, the LNAPL Report concluded that dissolved-phase constituents originating from the LNAPL were undergoing biodegradation. This was subsequently confirmed by the results of the Phase II bio-trap assessment, which were included as an appendix to the final LNAPL report.

Thermal Remediation Technology Description and Screening

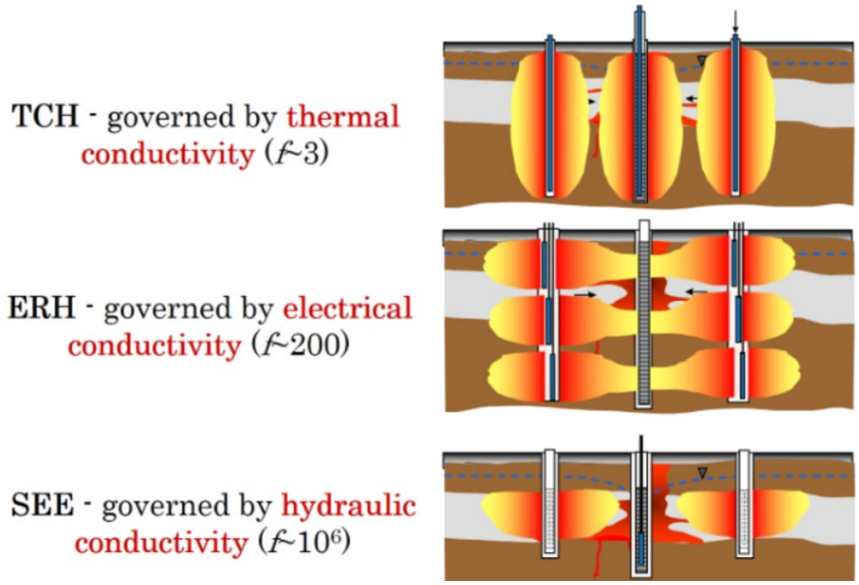
Various synonymous nomenclature for ISTR includes thermal remediation, in situ thermal treatment (ISTT), in situ thermal desorption (ISTD), thermally enhanced remediation, thermally enhanced soil vapor extraction (SVE), thermal-enhanced recovery, heat-enhanced LNAPL extraction, and other variations. The key concept function is to heat the subsurface LNAPL to boiling, which converts the LNAPL to gas or vapor that is subsequently captured by vacuum extraction and then reclaimed and/or treated at the surface.

Three primary heating methods are used in thermal remediation. These are:

- TCH – Thermal Conduction Heating (electric or gas generators)
- ERH – Electrical Resistance Heating (electric)
- SEE – Steam Enhanced Extraction (gas)

Regardless of the heating and extraction method selected, infrastructure to recover and collect the LNAPL, steam and hydrocarbon vapors must be installed. Based on the size of the area, the volumes of steam generated from heating and the volumes of air that must be moved to capture vapors, the size of this infrastructure would be significant, with hundreds of extraction wells (a thermal remediation vendor has indicated up to 500) and major treatment equipment for condensing water and hydrocarbons, and treating water and hydrocarbon vapors. The magnitude of this equipment, wells and piping will pose some significant logistical concerns at the site

The three typical heating patterns are illustrated below:



(adopted by permission from Griepke, 2018)

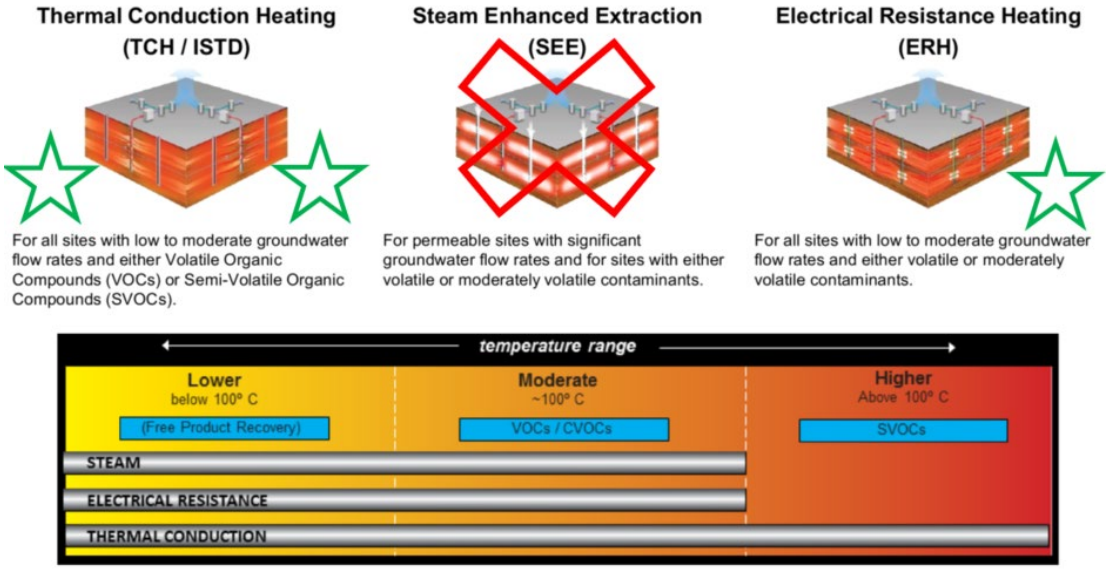
Consistent with guidance provided by EPA, USACE, ESTCP, and others, the selection of best thermal-enhanced LNAPL recovery method, and its effectiveness is governed by five key factors:

- **Target chemicals** – At the site, the target chemical(s) is mineral spirits LNAPL, which contains constituents with boiling points greater than 100° C.

- **Geology and hydrogeology** – The target treatment zones at the site are characterized as unconfined, reasonably uniform silty sand down to >25 feet below ground surface; where unsaturated vadose zone varies from 7 to 10 feet thick above the fresh (not saline) groundwater table that varies seasonally from 2 to 5 feet; presenting nominal groundwater flux (Darcy flux or Darcy velocity) of 0.02 ft/day.
- **Depth and size** – The target treatment depth at the site is the mineral spirits LNAPL smear zones down to 25 feet below ground surface. Area 1, as shown on draft Figure 5-1 above, is approximately 300,000 ft^2 (about 7 acres) and consists of a treatment volume of about 165,000 yd^3.
- **Location (proximity to above ground structures, buried utilities, buried debris, etc.)** – Adjacent to the area are Foster Avenue and United States Avenue, where subsurface utilities are present. The 2 and 4 Foster Avenue and 3 U.S. Avenue buildings are present on the site.
- **Availability of sufficient energy** – Enough energy (usually electricity) must be available directly at the site. If sufficient electricity is not available from the local electric utility, then electric generators are used to supply the electrical deficit. Alternatively, the thermal remediation can be conducted in phases (however, this will significantly extend remediation timeframes). For example, a reasonable expectation for electricity service demand for a 7-acre thermal remedy at the site is on the order of 7,500 kW and 9,000 kVA (TerraTherm, 2018). Additional evaluation is needed to assess whether this is available from the utility, if supplemental generating capacity would be needed or whether the remediation would have to be conducted in phases over a longer period of time.

Based on the physical properties of the LNAPL (as described above) and the site conditions, a technology that can maintain temperatures above 100° C is considered optimal to achieve LNAPL mass removal in a timely manner. Since there is no confining unit that would create subsurface pressures greater than atmospheric pressure, the boiling points will be consistent with those observed under atmospheric conditions. Further, TerraTherm has predicted significant reductions in pore fluid saturations (and associated hydraulic head) and, as such, limited increases in boiling point are anticipated to occur with depth. Maintaining temperatures greater than 100 ºC at the heater wells will allow for more efficient heat conduction without the number of wells becoming too excessive.

Consistent with the guidance provided by TerraTherm (as shown in the figure below), thermal conduction heating is considered the most suitable means to achieve the required temperatures in the subsurface at the site and most even treatment across the affected areas.

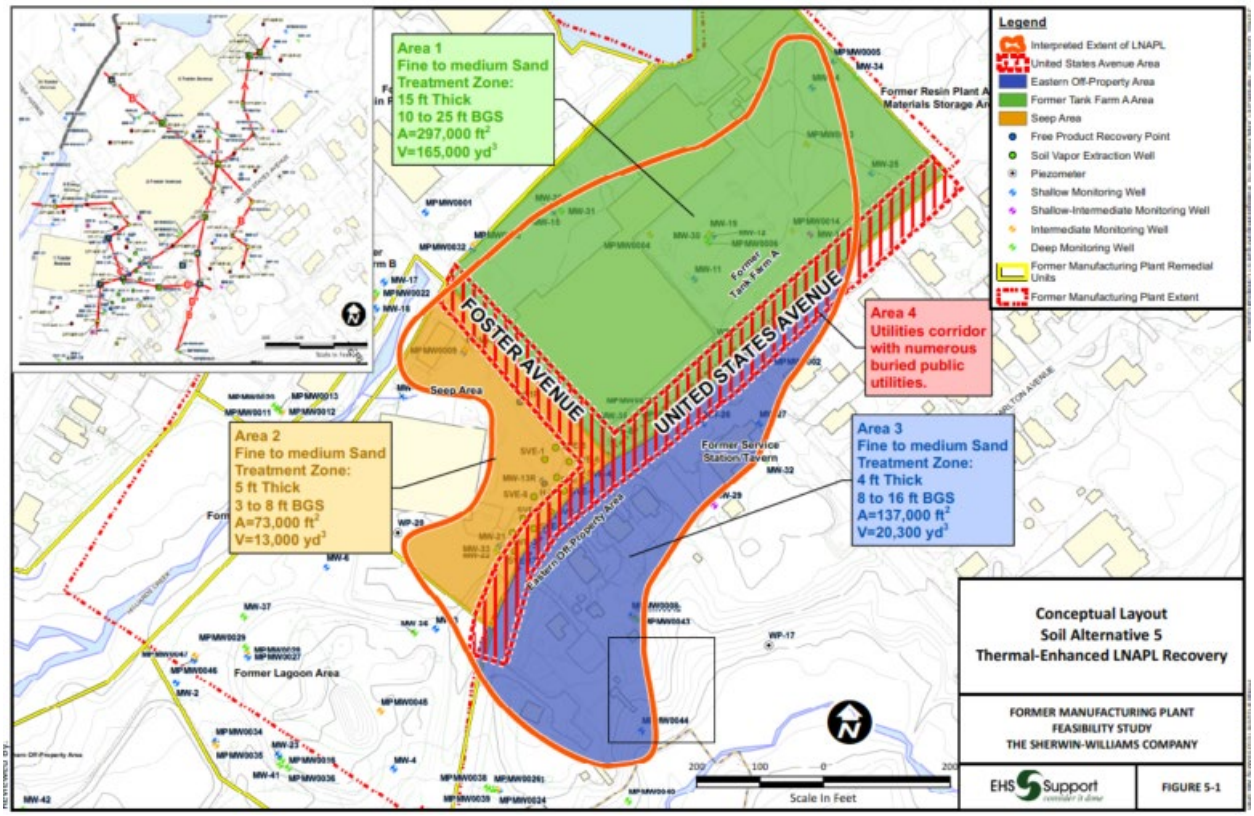


Other key considerations, consistent with the literature that supports thermal conduction heating being selected as the preferred alternative for this site are as follows:

- Steam Enhanced Extraction is not considered viable here due to a number of factors including the shallow nature of groundwater, the hydraulic properties of the soils and the presence of silt interbeds. This all will result in uneven heating and a highly variable flow of steam in the subsurface, which will cause inefficient treatment and may cause daylighting of steam, resulting in dangerous impacts to adjacent landholders.
- Electrical Resistance Heating was identified as having a number of constraints including an inability to reach desired temperatures for treatment and soil properties as well as the presence of metal debris, pipes, etc. in the subsurface which will result in uneven heating and inefficient treatment.

Implementation of Thermal in Area 1 and Preliminary Evaluation of Balancing Criteria

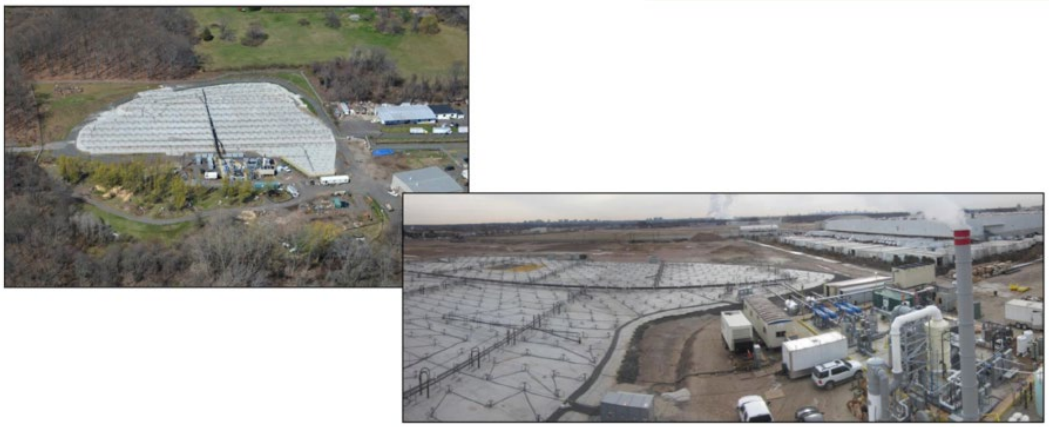
As noted above, Thermal Conductive Heating is identified as the thermal remedial technology that would likely be used in Area 1. As shown in the Figure below, Area 1 is a very large area (7 acres; 297,000 ft^2) and abuts areas of sensitive infrastructure (including public utilities in Foster Avenue and United States Avenue) as well as having proximal sensitive receptors (residents to the south-east and a police station to the south-west of the treatment area). The presence of these areas likely will require the use of major buffer zones (for example, keeping thermal heating areas 10-15 feet away from services) to ensure services and sensitive receptors are protected. As a result, an evaluation of thermal remediation as a remedial alternative in a FS will indicate that there are limitations on short-term effectiveness and implementability at this site with a high cost.



(adapted by permission from EHS Support, 2018)

It is important to note that while there is no theoretical upper limit on how much of an area can be subjected to a shallow thermal remedy, today's practical definition of a "large" TCH thermal remedy is on the order of 3 to 5 acres. In this context, treatment of this area will have major logistical constraints associated with provision of services (electricity), logistics and traffic. Again, these considerations will translate to concerns with short-term effectiveness, implementability and cost in a FS.

The potentially large size of a thermal remediation in Area 1 is supported by discussions with TerraTherm, a thermal remediation vendor, who noted that their largest TCH project to date is about 3.2 acres in Teterboro, NJ (Heron, 2015), as shown below:



TCH
Teterboro, New Jersey
3.2 Acre and 102,000 cy

(adopted by permission from Griepke, 2018)

Based on a review of the literature and discussions with thermal vendors, several location-specific impediments to TCH implementation at the FMP have been identified:

- Above ground buildings over the target treatment zone would require removal. None of these buildings are owned by Sherwin-Williams.
- The temperatures associated with thermal remediation generate vapor and steam that need to be captured. Due to potential risks associated with migration (even with operation of an extraction system) and also potential nuisance buffers have to be established which constrain the treatment area to ensure no impacts to residents.
- Buried utilities in the adjacent roadways and within the treatment area could be damaged or could act as preferential conduits for migration of steam and vapors. These utilities serve not only the commercial buildings in the treatment area but also the adjacent residential properties. It is likely that buffers will have to be established (where no treatment occurs) to ensure these utilities are protected, further limiting the extent of the area that can be effectively treated.
- Buried debris is present that could impact the efficiency of heat transfer.
- The high temperatures needed to remove the LNAPL can deform or damage roadways. While heat transfer is constrained, the shallow depth to groundwater and the optimal higher operational temperatures (needed to effect more rapid mass removal) will result in high temperatures in shallow soils.
- Silver Lake, a major recharge feature, would cause steeper gradients and facilitate an influx of cold water into the treatment areas, limiting treatment efficiency. To address these concerns the design of the remedy will require a large number of additional heater wells (upgradient of the treatment area) to mitigate the influx of cold groundwater into the treatment area.
- The temperature range of thermal remediation at this site is not optimal for hydrocarbon-degrading bacteria and will preclude the functioning and enumeration of these bacteria. This will impact the effectiveness of MNA post-treatment (as bacteria need to recolonize and enumerate before biological degradation can occur) and potentially biological remediation activities in the areas immediately abutting the thermal treatment area.

The evaluation supports a conclusion that, although thermal remediation could be performed in Area 1, the potential magnitude of impacts and risks to the community eliminate it from serious consideration when another viable alternative is available. A detailed summary of potential impacts on the remedy and risks to sensitive receptors, along with the applicable FS criteria the site-specific condition would affect, are captured in the table below, along with an assessment of significance in the context of this site. Please note that the FS evaluation criteria include consideration of both the balancing criteria that would be evaluated in the FS as well as the modifying criteria that EPA would consider following comments on the Proposed Plan.

Site Condition/Key FS Criteria	Significance and/or Risk
Potential need to remove above ground buildings and structures Balancing Criteria: • Short-term Effectiveness • Implementability • Cost	**High** – In the treatment area, all buildings and structures would have to be removed to facilitate installation of heater wells and other remediation activities. As an alternative, the buildings may be retained but this would be a major constraint to the construction activities and the density of heater wells and cables would preclude any use of these structures. It should be noted that the buildings and structures are not owned by Sherwin-Williams and it is uncertain whether the current property owner would want these structures removed or would provide access.
Damage to public roads Balancing Criteria: • Short-term Effectiveness	**High –** Proximity of roads to the thermal treatment area will result in subterranean heating of pavements and potentially deformation of surfaces. Based on the high operational temperatures recommended by the thermal remediation contractor, this could result in cracking, settlement, and establishment of pot holes and sink holes in the road structures abutting the treatment areas. As a result, it is likely that a buffer zone would be established to protect both utilities and the road (and associated pavement).
Damage to buried public utilities in roadway corridors Balancing Criteria: • Short-term Effectiveness • Implementability	**Very High** – The proximity of heating areas could have a major impact on buried utilities in US Avenue and Foster Avenue. These utilities could become inoperable or fail, leading to additional risks including explosion and fire. Key sensitive utilities identified include: Polyethylene gas lines which would be subject to deformation and loss of integrity above 65ºC (based on manufacturer specifications) Telecommunications cables which have temperature ratings below 50 ºC and critically have impedance specifications that can also be impacted by temperature Conductive metal water pipes that can conduct heat and lead to heating or worse boiling of water supplies to existing buildings and residences. To address potential risks, a buffer zone (10 to 15 feet) will have to be established in areas of utilities (where no thermal treatment can occur), limiting the area that can be treated.

Site Condition/Key FS Criteria	Significance and/or Risk
Damage to buried utilities in treatment area Balancing Criteria: • Short-term Effectiveness • Implementability	**High** – These utilities which connect to public utilities could become damaged and as a result impact on public utilities. Where practical these will have to be capped and removed, but identification of all utilities and appropriate termination will be problematic. To address potential risks to these utilities, a buffer zone (10 to 15 feet) may have to be established, limiting the area that can be treated.
Thermal desiccation of soil and potential for settlement Balancing Criteria: • Short-term Effectiveness • Implementability	**Moderate** – Assuming buildings and structures are removed from the site (and therefore cracking of on-site buildings and structures is not a concern), the heating of soils and removal of water content will result in consolidation and settlement. This is most observable in fine-grained soils such as clays, however, some fine-grained silt layers have been observed which could be affected. Any settlement could impact inflexible services such as water pipes, sewers, and stormwater pipes (especially collared fittings which may become disconnected).
Traffic and noise impacts on the community during construction. Balancing Criteria: • Short-term Effectiveness • Implementability	**High** – The scale of construction activities associated with the TCH treatment option in Area 1 will be large, requiring provisioning of a major electrical supply to the site and the drilling of nearly 1,000 wells (heater wells and extraction wells) and major construction activities associated with piping. In addition, the system would be operating 24 hours a day, 7 days a week with the potential for noise and lighting nuisance associated with these activities.
Visual impacts on the community during operation. Balancing Criteria: • Short-term Effectiveness • Implementability	**High –** In terms of thermal remediation, a large amount of electrical wiring, piping and infrastructure will be installed above grade. To support this Sherwin-Williams will have to fence the area and provide 24/7 security and lighting to preclude vandalism and theft of electrical wiring and equipment. The associated visual nuisance of such a fenced and lighted site and continuous activities will create some significant impacts on adjacent residential properties.

Site Condition/Key FS Criteria	Significance and/or Risk
Steam and vapor migration risks to adjacent residential area Balancing Criteria: • Reduction of toxicity, mobility, or volume through treatment • Short-term effectiveness • Implementability	**High** – While extraction of vapor and steam will be conducted at the site, sensitive receptors are in very close proximity to the treatment area. The presence of basements in the residential properties and utilities (water, sewer etc.) entering into the buildings, and concerns around preferential flow of vapors, biogenic gases (methane) and steam would necessitate establishment of safety buffers (limiting the area subject to treatment) and extensive monitoring. This may pose both a nuisance, a fire/explosion risk (with methane gases) and an inhalation exposure risk from hydrocarbons.
Nuisance associated with heating of water pipes. Balancing Criteria: • Short-term Effectiveness • Implementability	**Moderate** – Water service is provided to the commercial and residential areas by pipes within Foster Avenue and United States Avenue. A number of these services also have low flows (pipes only serving a single property) which increases the potential that temperature increases will occur in the water within these pipes. The proximity of the treatment area and heating dynamics could lead to the heating of these utilities which may impact appliances connected to cold water supplies and pose a nuisance. Due to these concerns, buffers would likely have to be established around water utilities, limiting the lateral extent of thermal remediation activities.
Thermal treatment may negatively impact ongoing bioremediation occurring in adjacent areas. Balancing Criteria: • Long-term Effectiveness • Short-term Effectiveness	**Moderate to High** – Soil excavation and enhanced bioremediation is proposed for adjacent areas of the site. Further natural processes may be utilized to remediate residuals within the thermal treatment areas. The high temperatures associated with TCH are not conducive to the functioning of hydrocarbon-degrading bacteria and will result in a shift in the bacterial consortia towards thermophiles. Based on the slow groundwater seepage velocities under ambient conditions, recolonization of areas will be slow.
High electricity demand could impact on local users. Balancing Criteria: • Implementability • Cost	**Moderate to High** – An assessment of electrical demands for the project indicates that around 8,000 kVA will be required to heat the area. It is unlikely that the existing electrical infrastructure can support this demand, and it is uncertain whether the Gibbsboro municipal utility(s) can provide sufficient electricity (grid power). Major upgrades to electrical infrastructure are anticipated throughout the area and this will impact schedule and potentially lead to additional interruption and disturbance for residents. Further, such large demand in a non-industrial area may result in grid stability concerns which could impact electrical supply to other users in the area. As an alternative, the thermal remediation could be conducted in phases (for example broken up into four separate treatment areas and events). However, this will significantly extend the remediation times (for example increase the remediation time frames 4-fold).

Summary

An assessment of thermal treatment technologies for Area 1 of the FMP concluded that Thermal Conductive Heating would be the likely heating technology if thermal treatment was applied at the FMP. Key considerations included application temperatures (which provided a high level of potential treatment), geology and hydrogeology and site implementability.

An evaluation of site-specific conditions, including the proximity of the residential area and Hilliards Creek, the presence of public utilities in adjacent roadways, and the presence of buildings on the site were considered to be major constraints limiting the applicability of this technology.

Based on the evaluation in this memorandum, it is concluded that if thermal treatment was to be included as a remedial alternative in the FS, it would not be ranked highly in comparison to an alternative that would consist of bioremediation/biostimulation combined with focused LNAPL removal. This conclusion is based on a preliminary evaluation of the balancing and modifying criteria:

- Long-Term Effectiveness and Permanence: Thermal treatment and the combined remedy would rank similarly for this criterion. Both technologies would remove LNAPL from Area 1. However, residual LNAPL would remain after application of thermal treatment and would need to be addressed via bioremediation. As detailed in the table below, the potential that the thermal remedy (Alternative 4) would have to be conducted in phases (due to electrical supply constraints) would result in similar or longer remediation timeframes relative to the already proposed combined remedy (Alternative 3).

ALTERNATIVE IMPLEMENTATION SCHEDULE COMPARISON

Alternative Component	Estimated Time to Complete [1]	
	Alternative 3[2]	Alternative 4[3]
Seep Area Excavation	0.5 years	0.5 years
Tank Farm A Biostimulation	7 years	
Tank Farm A Thermal		2 to 5 years
Tank Farm A Buffer Biostimulation[4]		8 years[5]
Eastern Off-Property Area Biostimulation	7 years	7 years
TOTAL TIME TO IMPLEMENT[6]	7 years	10 to 13 years[7]

NOTES

1. Schedule adapted from November 19, 2018 meeting presentation. "Time to complete" refers to estimated construction and treatment time. After completion of active remedy component, the areas will transition to monitored natural attenuation.
2. LNAPL Alternative 3 includes removal of LNAPL in Seep Area and biostimulation/soil gas recovery in former Tank Farm A Area as presented in FS, and biostimulation/soil gas recovery in Eastern Off-Property Area, as contemplated in FS under preparation.
3. LNAPL Alternative 4 includes removal of LNAPL in the Seep Area, thermal treatment of Tank Farm A, biostimulation/soil gas recovery in the former Resin Plant/Tank Farm A Area buffer area (approximately 15 feet from Foster Avenue and U.S. Avenue and the areas beneath the roadways) and the anticipated biostimulation/soil gas recovery remedy for the Eastern Off-Property Area.
4. Includes buffer north of Foster Avenue and west of U.S. Avenue as well as the Foster Avenue and U.S. Avenue roadways.
5. To be conducted after completion of thermal. One year is needed to allow cooling of groundwater, followed by seven years of construction and treatment.
6. For Alternative 3, all activities are to be conducted in parallel. For Alternative 4, thermal in Tank Farm A, excavation in Seep Area and biostimulation in Eastern Off-Property Area to be conducted in parallel, but biostimulation in the buffer area will follow thermal.
7. All active remedy components (except biostimulation in buffer area) will be completed in seven years and these areas will transition to MNA. LNAPL will remain in the buffer area three to six years longer (the time needed to complete thermal plus groundwater cooling).

- Short-Term Effectiveness: Thermal treatment would have a similar effectiveness to the combined remedy as buffer zones would have to be established to ensure that the nearby residential area, subsurface utilities, and adjacent roadways are not impacted by the thermal remedy. As a consequence of the limitations on the treatment area the restoration of groundwater quality will be determined by the effectiveness of other remedial technologies or natural attenuation processes.
- Reduction in Toxicity, Mobility or Volume Through Treatment: Although thermal treatment would reduce the volume of LNAPL within the actual treatment area, it would result in changes in the consortia of bacteria in the subsurface and or sterilization of mesophiles which would impede post thermal remediation biological degradation rates. On this basis and considering the existing robust natural degradation rates, thermal remediation is considered to rank lower than the combined remedy.
- Implementability: Thermal treatment would rank lower than the combined remedy for this criterion. The density of heating and extraction wells combined with the presence of buildings and underground utilities provides major constraints on the implementation of the thermal remedy. The large scale of the project, and the need for the very large infrastructure needed to supply electricity, heat the subsurface and manage the produced steam, vapors and LNAPL are also key implementability considerations.
- Cost: Thermal treatment is expected to rank low for this criterion. As detailed in the table below, the estimated cost for thermal treatment in Area 1 is around $35.8 million, with a total remedial cost difference between Alternative 3 (the combined remedy) and thermal remedy for of greater than $30 million.

COST COMPARISON, FMP SOIL AND LNAPL ALTERNATIVES

Alternative Component	LNAPL Alternative 3[1] ($MM)	LNAPL Alternative 4[2] ($MM)
Seep Area Excavation[3]	8.2	8.2
Tank Farm A Biostimulation[4]	5.8	
Tank Farm A Thermal[5]		35.8
Tank Farm A Buffer Biostimulation[6]		1.2
Eastern Off-Property Area Biostimulation[7]	4.5	4.5
SUBTOTAL, LNAPL REMEDY COSTS	18.5	49.7
Other FMP Areas[8]	10.8	10.8
TOTAL	29.3	60.5

NOTES

1. LNAPL Alternative 3 includes removal of LNAPL in Seep Area and biostimulation/soil gas recovery in former Tank Farm A Area as presented in FS, and biostimulation/soil gas recovery in Eastern Off-Property Area, as contemplated in FS under preparation.
2. LNAPL Alternative 4 includes removal of LNAPL in the Seep Area, thermal treatment of Tank Farm A, biostimulation/soil gas recovery in the former Resin Plant/Tank Farm A Area buffer area (approximately 15 feet from Foster Avenue and U.S. Avenue and the areas beneath the roadways) and the anticipated biostimulation/soil gas recovery remedy for the Eastern Off-Property Area.
3. Cost estimate as presented in the FS.
4. Cost estimate for LNAPL Alternative 3 is as presented in the FS.

cost.

6. Cost estimate under preparation, but current value is approximately $5 million.
7. Cost estimate for Tank Farm A thermal is based on a unit cost of $325/CY (approximate cost from SRS site cited in EPA comments) and soil volume of 110,000 CY (2/3 of Tank Farm A volume). NOTE: Actual volume and cost may be greater than estimated.
8. FS Soil Alternative 3 costs for 6 E Clementon Road, Main Plant, Upper Hilliards Creek and former Lagoon.

In summary, thermal treatment is not a technology suited to the site-specific conditions at the FMP and would not rank highly in a formal FS evaluation. Further, in the context of the current combined remedy for Tank Farm A and the Seep Area and the expanded remedy that incorporates US Avenue and the off-property area, the thermal remedy does not provide additional benefits. Therefore, it is not recommended for inclusion as a remedial alternative in the FMP FS.

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APPENDIX D

Cost Estimates

Table D-1
Soil Alternative 1 - No Action
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
	Total Costs W/O Management and Engineering				**$0**
Management and Engineering					
	Engineering/Legal Admin			16%	$0
	Subtotal				**$0**
Contingency				10%	$0
	Total Capital Cost				**$0**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance		$/Acre/Year	$0	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$60,000	$60,000
	Contingency			10%	$6,000
	Subtotal				**$66,000**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$142,416**
			Total Estimated Cost (Capital and PW O&M)		**$142,416**

Table D-2
Former Main Plant
Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$10,000	$10,000
	Subtotal				**$10,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$10,000	$10,000
	Institutional Controls	1	Each	$10,000	$10,000
	Subtotal				**$20,000**
	Total Costs W/O Management and Engineering				**$30,000**
Management and Engineering					
	Engineering/Legal Admin			16%	$4,800
	Subtotal				**$34,800**
Contingency				10%	$3,480
	Total Capital Cost				**$38,280**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspections/Maintenance	1.0	$/Year	$10,000	$10,000
	Contingency			10%	$1,000
	Total Annual O&M				$11,000
	Present Worth Annual O&M Cost for 30 years @7%				**$136,499**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$203,263**

Table D-3
Former Main Plant
Soil Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$35,000	$35,000
	Subtotal				**$35,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$50,000	$50,000
	Mobilization/Demobilization	1	LS	$75,000	$75,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$20,000	$20,000
	Field Office	5	Months	$4,000	$20,000
	Temporary access roads	0	LF	$380	$0
	Traffic Control	16	Week	$3,000	$48,000
	Temporary Fencing	0	LF	$6	$0
	Sampling - (Waste Characterization: Collection and Analysis)	10	Sample	$1,200	$12,363
	Sampling - (Post-Excavation: Collection and Analysis)	84	Sample	$400	$33,529
	Subtotal				**$258,892**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	345	CY	$70	$24,150
	Asphalt Demolition	8,650	SF	$1	$8,650
	Concrete Transportation and Recycling	518	Ton	$20	$10,350
	Asphalt Transporation and Recycling	240	Ton	$20	$4,806
	Well Abandonment	1	Well	$900	$900
	Fence Removal	0	LF	$3	$0
	Subtotal				**$48,856**
Water Management					
	Groundwater Management	1	LS	$40,000	$40,000
	Surface Water Management	1	LS	$10,000	$10,000
	Water Transportation and Disposal	50,000	Gallons	$0.56	$28,000
	Subtotal				**$78,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	20,122	SF	$27	$542,164
	Conveyance Pipe Removal	0	LS	$30,000	$0
	Soil Excavation (Upland Areas)	8,645	CY	$10	$86,450
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Soil Stabilization (Wet Soils)	2,361	Ton	$26	$61,386
	Soil T&D (Non-hazardous)	12,093	Ton	$60	$725,586
	Soil T&D (TSCA)	1,300	Ton	$240	$312,000
	Subtotal				**$1,747,586**
Capping, Backfill and Restoration					
	Geotextile Fabric	22,020	SF	$0.36	$7,881
	Structural Backfill (Furnished, placed, compacted)	12,968	Ton	$20	$259,350
	Asphalt Paving	8,650	SF	$4	$34,600
	Concrete Paving	9,320	SF	$6	$55,920
	Topsoil	83	Ton	$30	$2,500
	Landscape Restoration	0.07	Acres	$20,000	$1,377
	Conveyance Pipe Restoration (60" RCP)	0	LF	$200	$0
	Manhole Restoration	0	Each	$3,000	
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	0	Acres	$328,225	$0
	Monitoring Well Replacement	1	Well	$7,000	$7,000
	Institutional Controls	1	Each	$10,000	$10,000
	Subtotal				**$378,628**
	Total Costs W/O Management and Engineering				**$2,546,962**
Management and Engineering					
	Engineering/Legal Admin			16%	$407,514
	Subtotal				**$2,954,476**
Contingency				10%	$295,448
	Total Capital Cost				**$3,249,923**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	1.0	$/Year	$10,000	$10,000
	Contingency			10%	$1,000
	Total Annual O&M				**$11,000**
	Present Worth Annual O&M Cost for 30 years @7%				**$136,499**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$3,414,906**

Table D-4
Former Main Plant
Soil Alternative 4 - Extensive Excavation to Depth and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	**1**	**LS**	$50,000	$50,000
	Subtotal				**$50,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$240,000	$240,000
	Mobilization/Demobilization	1	LS	$200,000	$200,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$30,000	$30,000
	Field Office	24	Months	$4,000	$96,000
	Temporary access roads	0	LF	$380	$0
	Traffic Control	80	Week	$3,000	$240,000
	Temporary Fencing	0	LF	$6	$0
	Sampling - (Waste Characterization: Collection and Analysis)	55	Sample	$1,200	$66,238
	Sampling - (Post-Excavation: Collection and Analysis)	409	Sample	$400	$163,691
	Subtotal				**$1,035,928**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	885	CY	$70	$61,950
	Asphalt Demolition	146,925	SF	$1	$146,925
	Concrete Transportation and Recycling	1,328	Ton	$20	$26,550
	Asphalt Transporation and Recycling	4081	Ton	$20	$81,625
	Well Abandonment	20	Well	$900	$18,000
	Fence Removal	0	LF	$3	$0
	Subtotal				**$335,050**
Water Management					
	Groundwater Management	1	LS	$80,000	$80,000
	Surface Water Management	1	LS	$10,000	$10,000
	Water Transportation and Disposal	100,000	Gallons	$0.56	$56,000
	Subtotal				**$146,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	80,590	SF	$27	$2,171,404
	Conveyance Pipe Removal	1	LS	$30,000	$30,000
	Soil Excavation (Upland Areas)	46,658	CY	$10	$466,580
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Soil Stabilization (Wet Soils)	4,713	Ton	$26	$122,538
	Soil T&D (Non-hazardous)	70,457	Ton	$60	$4,227,438
	Soil T&D (TSCA)	1,300	Ton	$240	$312,000
	Subtotal				**$7,349,960**
Capping, Backfill and Restoration					
	Geotextile Fabric	205,220	SF	$0.36	$73,446
	Structural Backfill (Furnished, placed, compacted)	69,987	Ton	$20	$1,399,740
	Asphalt Paving	146,925	SF	$4	$587,700
	Concrete Paving	23,900	SF	$6	$143,400
	Topsoil	764	Ton	$30	$22,917
	Manhole Restoration	5	Each	$3,000	$15,000
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	0.00	Acres	$328,225	$0
	Monitoring Well Replacement	20	Well	$7,000	$140,000
	Institutional Controls	0	Each	$10,000	$0
	Subtotal				**$2,382,203**
	Total Costs W/O Management and Engineering				**$11,299,141**
Management and Engineering					
	Engineering/Legal Admin			16%	$1,807,863
	Subtotal				**$13,107,004**
Contingency				10%	$1,310,700
	Total Capital Cost				**$14,417,704**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	0.0	$/Year	$20,000	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$14,446,188**

Table D-5
Former Resin Plant and Tank Farm A Area
Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$10,000	$10,000
	Subtotal				**$10,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$10,000	$10,000
	Institutional Controls	3	Each	$10,000	$30,000
	Subtotal				**$40,000**
	Total Costs W/O Management and Engineering				**$50,000**
Management and Engineering					
	Engineering/Legal Admin			16%	$8,000
	Subtotal				**$58,000**
Contingency				10%	$5,800
	Total Capital Cost				**$63,800**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspections/Maintenance	1.0	$/Year	$10,000	$10,000
	Contingency			10%	$1,000
	Total Annual O&M				$11,000
	Present Worth Annual O&M Cost for 30 years @7%				**$136,499**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$228,783**

Table D-6
Former Resin Plant and Tank Farm A Area
Soil Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Pre-Design Bail-Down Testing	1	LS	$25,000	$25,000
	Delineation of Sensitive Areas	0	LS	$25,000	$0
	Buried Utility Locations	1	LS	$12,000	$12,000
	Soil Gas Extraction and Fertigant Pilot Tests	1	LS	$50,000	$50,000
	Aqueous Amendment Capacity Test	1	LS	$50,000	$50,000
	Anaerobic Biotreatability Bench Test	1	LS	$200,000	$200,000
	Delineation of Sensitive Areas	0	LS	$25,000	$0
	Assessment of Air Emissions and Potential Permit Requirements	1	LS	$10,000	$10,000
	NJDEP Discharge To Groundwater Permit-By-Rule	1	LS	$10,000	$10,000
	Subtotal				**$357,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$50,000	$50,000
	Mobilization/Demobilization	1	LS	$20,000	$20,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$18,000	$18,000
	Field Office	6	Months	$4,000	$24,000
	Subtotal				**$112,000**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	0	CY	$70	$0
	Asphalt Demolition	0	SF	$1	$0
	Concrete Transportation and Recycling	0	Ton	$20	$0
	Asphalt Transporation and Recycling	0	Ton	$20	$0
	Well Abandonment	0	Well	$900	$0
	Fence Removal	0	LF	$3	$0
	Subtotal				**$0**
Waste Management					
	Drill Cuttings From Vertical Wells	50	Cubic Yards	$80	$4,000
	Drill Cuttings From Horizontal Wells	15	Cubic Yards	$80	$1,200
	Captured Bail-down Testing Liquids	8	Weeks	$1,000	$8,000
	Waste Soil From Trenching	2,000	Cubic Yards	$80	$160,000
	Subtotal				**$173,200**
Well Drilling					
	LNAPL Extraction Wells	8	Wells	$7,500	$60,000
	Vertical Fertigant Emplacement Wells (low-pressure outdoor)	100	Wells	$2,100	$210,000
	Vertical Fertigant Emplacement Wells (high-pressure indoor)	7	Wells	$3,500	$24,500
	Horizontal Fertigant Emplacement Wells	600	Lineal Feet	$150	$90,000
	Vertical Soil Gas Extraction Wells	20	Wells	$3,500	$70,000
	Horizontal Soil Gas Extraction Wells	1200	Lineal Feet	$200	$240,000
	Soil Gas Monitoring Probes	6	Probes	$1,500	$9,000
	Sub-Slab Soil Gas Monitoring Probes	6	Probes	$1,000	$6,000
	Subtotal				**$709,500**
Trenching and Piping					
	Buried Piping and Trenching Contractor (Outdoor)	4,250	LF	$250	$1,062,500
	Buried Piping and Trenching Oversight Labor (Outdoor)	4,250	LF	$10	$42,500
	Buried Piping and Trenching Contractor (Indoor)	350	LF	$500	$175,000
	Buried Piping and Trenching Oversight Labor (Indoor)	350	LF	$20	$7,000
	Indoor Overhead and Down-Coming Piping and Labor	1,000	LF	$6	$6,000
	Indoor Overhead and Down-Coming Piping Oversight	1,000	LF	$6	$6,000
	Subtotal				**$1,299,000**
Remediation Equipment and Compound					
	Fertigant Mixing and Pumping Equipment	1	Each	$130,000	$130,000
	Soil Gas Extraction and Treatment Equipment	1	Each	$57,500	$57,500
	Remediation Equipment Compound	1,000	SF	$75	$75,000
	Field Soil Gas Analyzers	1	LS	$17,500	$17,500
	Electrical Service	1	LS	$18,000	$18,000
	Municipal Water Service	1	LS	$10,000	$10,000
	Subtotal				**$308,000**

Table D-6
Former Resin Plant and Tank Farm A Area
Soil Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Portable LNAPL Skimmer Assemblies					
	Standard Magnum Spill Buster (LNAPL skimmer pumps)	4	Each	$8,950	$35,800
	24-Volt Solar Power Module	0	Each	$3,401	$0
	Tax and Freight	4	Each	$1,149	$4,596
	55-gallon Recovered Product Tank	4	Each	$100	$400
	Spill/Leak Containment Pallet	4	Each	$400	$1,600
	Flat-bed Utility Trailer	4	Each	$1,500	$6,000
	Steel Carport-Like Rain Shelter	0	Each	$3,500	$0
	Electricity	4	Each	$1,500	$6,000
	Assemble LNAPL Skimmer Assemblies on Trailer	4	Each	$1,000	$4,000
	Subtotal				**$58,396**
	Institutional Controls	1	Each	$10,000	$10,000
	Subtotal				**$10,000**
	Total Costs W/O Management and Engineering				**$3,027,096**
Management and Engineering					
	Engineering/Legal Admin			16%	$484,335
	Subtotal				**$3,511,431**
Contingency				10%	$351,143
	Total Capital Cost				**$3,862,574**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	0.0	$/Year	$10,000	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	Labor for Monthly O&M. activities will be conducted 1 day per month and will involve the checking of skimmer pump operations, product levels in tanks and removal of accumulated product.	72	Man Days	$750	$54,000
	Sample and analyze groundwater.	0	Samples	$250	$0
	Replace 5 LNAPL skimmer pump assemblies every six months for three years.	30	Replacements	$500	$15,000
	Replace 1 Magnum Spill Buster LNAPL skimmer assembly every six months for three years.	6	Replacements	$10,000	$60,000
	Transportation and recycling of captured LNAPL.	10,800	Gallons	$2.5	$27,000
	Annual Performance Report for 5 years	5	Each	$25,000	$125,000
	Labor for Weekly O&M.	1,120	Man Days	$750	$840,000
	Sample and Analyze Groundwater	168	Samples	$500	$84,000
	Sample and Soil Gas	174	Samples	$100	$17,400
	Service Soil Gas Analyzers	9	Events	$3,000	$27,000
	Repair or Replace Pumps and Blowers	9	Events	$5,000	$45,000
	Electricity	2,190,000	kWh	$0.12	$262,800
	Water	50,000,000	Gallons	$0.002	$100,000
	Powdered Potassium Sulfate Material	100,000	Pounds (dw)	$1	$100,000
	Powdered Diammonium Phosphate (DAP) Material	20,000	Pounds (dw)	$2	$40,000
	Annual Performance Report for 5 years (bio)	5	Each	$35,000	$175,000
	Management/Consulting	324	Man Days	$1,500	$486,000
	CERCLA Five Year Review (30 yrs)	6	Each	$12,000	$72,000
	Subtotal				**$2,530,200**
	Subtotal Present Worth Periodic O&M Cost for 30 years @7%			7%	**$1,717,261**
	Contingency			10%	$171,726
	Total Present Worth Periodic O&M Cost for 30 years @7%				**$1,888,987**
			Total Estimated Cost (Capital and PW O&M)		**$5,751,561**

Table D-7
Former Resin Plant and Tank Farm A Area
Soil Alternative 4 - Extensive Excavation to Depth and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	**1**	**LS**	$100,000	$100,000
	Subtotal				**$100,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$360,000	$360,000
	Mobilization/Demobilization	1	LS	$200,000	$200,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$30,000	$30,000
	Field Office	60	Months	$4,000	$240,000
	Temporary access roads	0	LF	$380	$0
	Traffic Control	200	Week	$3,000	$600,000
	Temporary Fencing	0	LF	$6	$0
	Sampling - (Waste Characterization: Collection and Analysis)	209	Sample	$1,200	$250,795
	Sampling - (Post-Excavation: Collection and Analysis)	403	Sample	$400	$161,315
	Subtotal				**$1,842,110**
Demolition Activities					
	Building Demolition	2	LS	$50,000	$100,000
	Concrete Demolition and Crushing	3,075	CY	$70	$215,250
	Asphalt Demolition	65,560	SF	$1	$65,560
	Concrete Transportation and Recycling	4,612	Ton	$20	$92,240
	Asphalt Transporation and Recycling	1821	Ton	$20	$36,422
	Well Abandonment	17	Well	$900	$15,300
	Fence Removal	0	LF	$3	$0
	Subtotal				**$524,772**
Water Management					
	Groundwater Management	1	LS	$500,000	$500,000
	Surface Water Management	1	LS	$50,000	$50,000
	Water Transportation and Disposal	1,000,000	Gallons	$0.56	$560,000
	Subtotal				**$1,110,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	79,500	SF	$27	$2,142,035
	Soil Excavation (Upland Areas)	171,444	CY	$10	$1,714,440
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Soil Stabilization (Wet Soils)	145,278	Ton	$26	$3,777,228
	Soil T&D (Non-hazardous)	271,695	Ton	$60	$16,301,688
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$23,955,391**
Capping, Backfill and Restoration					
	Geotextile Fabric	0	SF	$0.36	$0
	Structural Backfill (Furnished, placed, compacted)	257,166	Ton	$20	$5,143,320
	Asphalt Paving	65,560	SF	$4	$262,240
	Concrete Paving	83,012	SF	$6	$498,072
	Topsoil	1,458	Ton	$30	$43,750
	Landscape Restoration	1.21	Acres	$20,000	$24,105
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	0.00	Acres	$328,225	$0
	Monitoring Well Replacement	17	Well	$7,000	$119,000
	Institutional Controls	0	Each	$10,000	$0
	Subtotal				**$6,090,487**
	Total Costs W/O Management and Engineering				**$33,622,761**
Management and Engineering					
	Engineering/Legal Admin			16%	$5,379,642
	Subtotal				**$39,002,402**
Contingency				10%	$3,900,240
	Total Capital Cost				**$42,902,643**
Operation/Maintenance					

Table D-7
Former Resin Plant and Tank Farm A Area
Soil Alternative 4 - Extensive Excavation to Depth and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Annual O&M					
	Quarterly Inspection/Maintenance	0.0	$/Year	$10,000	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$42,931,126**

Table D-8
Former Lagoon Area
Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$7,500	$7,500
	Subtotal				**$7,500**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$30,000	$30,000
	Mobilization/Demobilization	1	LS	$50,000	$50,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$10,000	$10,000
	Field Office	3	Months	$4,000	$12,000
	Temporary access roads	0	LF	$380	$0
	Traffic Control	8	Week	$3,000	$24,000
	Temporary Fencing	1400	LF	$6	$8,400
	Sampling - (Waste Characterization: Collection and Analysis)	4	Sample	$1,200	$4,800
	Sampling - (Post-Excavation: Collection and Analysis)	113	Sample	$400	$45,201
	Subtotal				**$184,401**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	0	CY	$70	$0
	Asphalt Demolition	0	SF	$1	$0
	Concrete Transportation and Recycling	0	Ton	$20	$0
	Asphalt Transporation and Recycling	0	Ton	$20	$0
	Well Abandonment	7	Well	$900	$6,300
	Fence Removal	0	LF	$3	$0
	Subtotal				**$6,300**
Water Management					
	Groundwater Management	0	LS	$10,000	$0
	Surface Water Management	1	LS	$10,000	$10,000
	Water Transportation and Disposal	0	Gallons	$0.56	$0
	Subtotal				**$10,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	0	SF	$27	$0
	Soil Excavation (Upland Areas)	2,195	CY	$10	$21,950
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Soil Stabilization (Wet Soils)	0	Ton	$26	$0
	Soil T&D (Non-hazardous)	3,292	Ton	$60	$197,520
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$239,470**
Capping, Backfill and Restoration					
	Geotextile Fabric	31,020	SF	$0.36	$11,102
	Structural Backfill (Furnished, placed, compacted)	3,292	Ton	$20	$65,840
	Topsoil	862	Ton	$30	$25,850
	Landscape Restoration	0.71	Acres	$20,000	$14,242
	Fence Restoration	1,400	LF	$40	$56,000
	Wetlands Restoration	0.02	Acres	$328,225	$6,564
	Monitoring Well Replacement	7	Well	$7,000	$49,000
	Institutional Controls	2	Each	$10,000	$20,000
	Subtotal				**$248,599**
	Total Costs W/O Management and Engineering				**$696,270**
Management and Engineering					
	Engineering/Legal Admin			16%	$111,403
	Subtotal				**$807,673**
Contingency				10%	$80,767
	Total Capital Cost				**$888,440**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	1.0	$/Year	$10,000	$10,000
	Contingency			10%	$1,000
	Total Annual O&M				**$11,000**
	Present Worth Annual O&M Cost for 30 years @7%				**$136,499**

Table D-8
Former Lagoon Area
Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$1,053,423**

Table D-9
Former Lagoon Area
Soil Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$7,500	$7,500
	Subtotal				**$7,500**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$30,000	$30,000
	Mobilization/Demobilization	1	LS	$50,000	$50,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$20,000	$20,000
	Field Office	4	Months	$4,000	$16,000
	Temporary access roads	0	LF	$380	$0
	Traffic Control	12	Week	$3,000	$36,000
	Temporary Fencing	1400	LF	$6	$8,400
	Sampling - (Waste Characterization: Collection and Analysis)	5	Sample	$1,200	$5,677
	Sampling - (Post-Excavation: Collection and Analysis)	128	Sample	$400	$51,056
	Subtotal				**$217,133**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	0	CY	$70	$0
	Asphalt Demolition	0	SF	$1	$0
	Concrete Transportation and Recycling	0	Ton	$20	$0
	Asphalt Transporation and Recycling	0	Ton	$20	$0
	Well Abandonment	7	Well	$900	$6,300
	Fence Removal	0	LF	$3	$0
	Subtotal				**$6,300**
Water Management					
	Groundwater Management	0	LS	$10,000	$0
	Surface Water Management	1	LS	$10,000	$10,000
	Water Transportation and Disposal	0	Gallons	$0.56	$0
	Subtotal				**$10,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	0	SF	$27	$0
	Soil Excavation (Upland Areas)	4,100	CY	$10	$41,000
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Soil Stabilization (Wet Soils)	0	Ton	$26	$0
	Soil T&D (Non-hazardous)	6,150	Ton	$60	$369,000
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$430,000**
Capping, Backfill and Restoration					
	Geotextile Fabric	41,520	SF	$0.36	$14,860
	Structural Backfill (Furnished, placed, compacted)	6,150	Ton	$20	$123,000
	Asphalt Paving	0	SF	$4	$0
	Concrete Paving	0	SF	$6	$0
	Topsoil	1,153	Ton	$30	$34,600
	Landscape Restoration	0.95	Acres	$20,000	$19,063
	Fence Restoration	1,400	LF	$40	$56,000
	Wetlands Restoration	0.02	Acres	$328,225	$6,564
	Monitoring Well Replacement	7	Well	$7,000	$49,000
	Institutional Controls	2	Each	$10,000	$20,000
	Subtotal				**$323,087**
	Total Costs W/O Management and Engineering				**$994,020**
Management and Engineering					
	Engineering/Legal Admin			16%	$159,043
	Subtotal				**$1,153,063**
Contingency				10%	$115,306
	Total Capital Cost				**$1,268,370**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	1.0	$/Year	$10,000	$10,000
	Contingency			10%	$1,000
	Total Annual O&M				**$11,000**
	Present Worth Annual O&M Cost for 30 years @7%				**$136,499**

Table D-9
Former Lagoon Area
Soil Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$1,433,352**

Table D-10
Former Lagoon Area
Soil Alternative 4 - Extensive Excavation to Depth and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$35,000	$35,000
	Subtotal				**$35,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$225,000	$225,000
	Mobilization/Demobilization	1	LS	$100,000	$100,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$30,000	$30,000
	Field Office	30	Months	$4,000	$120,000
	Temporary access roads	0	LF	$380	$0
	Traffic Control	112	Week	$3,000	$336,000
	Temporary Fencing	1400	LF	$6	$8,400
	Sampling - (Waste Characterization: Collection and Analysis)	77	Sample	$1,200	$91,972
	Sampling - (Post-Excavation: Collection and Analysis)	214	Sample	$400	$85,753
	Subtotal				**$997,125**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	0	CY	$70	$0
	Asphalt Demolition	0	SF	$1	$0
	Concrete Transportation and Recycling	0	Ton	$20	$0
	Asphalt Transporation and Recycling	0	Ton	$20	$0
	Well Abandonment	9	Well	$900	$8,100
	Fence Removal	0	LF	$3	$0
	Subtotal				**$8,100**
Water Management					
	Groundwater Management	1	LS	$30,000	$30,000
	Surface Water Management	1	LS	$20,000	$20,000
	Water Transportation and Disposal	750,000	Gallons	$0.56	$420,000
	Subtotal				**$470,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	36,000	SF	$27	$969,978
	Soil Excavation (Upland Areas)	62,377	CY	$10	$623,770
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Soil Stabilization (Wet Soils)	60,717	Ton	$26	$1,578,642
	Soil T&D (Non-hazardous)	99,637	Ton	$60	$5,978,202
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$9,170,592**
Capping, Backfill and Restoration					
	Geotextile Fabric	0	SF	$0.36	$0
	Structural Backfill (Furnished, placed, compacted)	93,566	Ton	$20	$1,871,320
	Asphalt Paving	0	SF	$4	$0
	Concrete Paving	0	SF	$6	$0
	Topsoil	2,413	Ton	$30	$72,375
	Landscape Restoration	1.99	Acres	$20,000	$39,876
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	0.07	Acres	$328,225	$22,976
	Monitoring Well Replacement	9	Well	$7,000	$63,000
	Institutional Controls	0	Each	$10,000	$0
	Subtotal				**$2,069,547**
	Total Costs W/O Management and Engineering				**$12,750,364**
Management and Engineering					
	Engineering/Legal Admin			16%	$2,040,058
	Subtotal				**$14,790,422**
Contingency				10%	$1,479,042
	Total Capital Cost				**$16,269,464**
Operation/Maintenance					
Annual O&M					

Table D-10
Former Lagoon Area
Soil Alternative 4 - Extensive Excavation to Depth and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

	Quarterly Inspection/Maintenance	0.0	$/Year	$10,000	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$16,297,947**

Table D-11
Seep Area
Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$10,000	$10,000
	Subtotal				**$10,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$10,000	$10,000
	Institutional Controls	1	Each	$10,000	$10,000
	Subtotal				**$20,000**
	Total Costs W/O Management and Engineering				**$30,000**
Management and Engineering					
	Engineering/Legal Admin			16%	$4,800
	Subtotal				**$34,800**
Contingency				10%	$3,480
	Total Capital Cost				**$38,280**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspections/Maintenance	1.0	$/Year	$10,000	$10,000
	Contingency			10%	$1,000
	Total Annual O&M				$11,000
	Present Worth Annual O&M Cost for 30 years @7%				**$136,499**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$203,263**

Table D-12
Seep Area
Soil Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$35,000	$35,000
	Subtotal				**$35,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$60,000	$60,000
	Mobilization/Demobilization	1	LS	$75,000	$75,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$20,000	$20,000
	Field Office	12	Months	$4,000	$48,000
	Temporary access roads	0	LF	$380	$0
	Traffic Control	16	Week	$3,000	$48,000
	Temporary Fencing	1600	LF	$6	$9,600
	Sampling - (Waste Characterization: Collection and Analysis)	19	Sample	$1,200	$22,802
	Sampling - (Post-Excavation: Collection and Analysis)	182	Sample	$400	$72,695
	Subtotal				**$356,097**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	74	CY	$70	$5,180
	Asphalt Demolition	24,463	SF	$1	$24,463
	Concrete Transportation and Recycling	111	Ton	$20	$2,220
	Asphalt Transporation and Recycling	680	Ton	$20	$13,591
	Well Abandonment	7	Well	$900	$6,300
	Fence Removal	0	LF	$3	$0
	Subtotal				**$51,754**
Liquids Management					
	Dewatering	16	Weeks	$6,250	$100,000
	Treatment (Oil-water Separation, Filtration, Activated Carbon); Dis	16	Weeks	$5,000	$80,000
	Treated Water Disposal	5,644,800	Gallons	$0.03	$141,120
	Subtotal				**$321,120**
Water Management					
	Groundwater Management	1	LS	$150,000	$150,000
	Surface Water Management	1	LS	$20,000	$20,000
	Water Transportation and Disposal	1,000,000	Gallons	$0.56	$560,000
	Subtotal				**$730,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	31,000	SF	$27	$835,259
	Soil Excavation (Upland Areas)	15,204	CY	$10	$152,040
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Soil Stabilization (Wet Soils)	18,972	Ton	$26	$493,272
	Soil T&D (Non-hazardous)	24,702	Ton	$60	$1,482,132
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$2,982,703**
Capping, Backfill and Restoration					
	Geotextile Fabric	0	SF	$0.36	$0
	Structural Backfill (Furnished, placed, compacted)	22,806	Ton	$20	$456,120
	Asphalt Paving	24,463	SF	$4	$97,852
	Concrete Paving	2,000	SF	$6	$12,000
	Topsoil	1,050	Ton	$30	$31,512
	Landscape Restoration	0.69	Acres	$20,000	$13,728
	Construct LNAPL Recovery Trench with 5 Sumps	400	LF	$500	$200,000
	Fence Around Each of 5 LNAPL Recovery Trench Sumps	200	LF	$40	$8,000
	LNAPL Skimmar Assemblies (Magnum Spill Buster)	5	Each	$9,750	$48,750
	Install LNAPL Skimmar Assemblies (Magnum Spill Buster)	5	Each	$1,000	$5,000
	Electric Service to LNAPL Recovery Trench Sumps	6	Each	$5,000	$30,000
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	0	Acres	$328,225	$0
	Monitoring Well Replacement	7	Well	$7,000	$49,000
	Institutional Controls	1	Each	$10,000	$10,000

Table D-12
Seep Area
Soil Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

	Subtotal				**$961,962**
	Total Costs W/O Management and Engineering				**$5,438,636**
Management and Engineering					
	Engineering/Legal Admin			16%	$870,182
	Subtotal				**$6,308,817**
Contingency				10%	$630,882
	Total Capital Cost				**$6,939,699**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	0.0	$/Year	$10,000	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	Gauged for occurrence of LNAPL in 4 new post-excavation monitoring wells monthly for the first year of their life, quarterly for the next two years, and annually thereafter for seven years.	27	Events	$250	$6,750
	Gauged for occurrence of LNAPL in 5 LNAPL Recovery Sumps monthly for the first year of their life, quarterly for the next two years, and annually thereafter for seven years.	27	Events	$250	$6,750
	Sample groundwaterfrom 4 new post-excavation monitoring wells and analyze for VOCs quarterly for three years and annually thereafter for seven years.	76	Samples	$250	$19,000
	Replace 5 LNAPL skimmer pump assemblies every six months for three years.	30	Replacements	$500	$15,000
	Replace 1 Magnum Spill Buster LNAPL skimmer assembly every six months for three years .	6	Replacements	$10,000	$60,000
	Transportation and recycling of captured LNAPL.	10,950	Gallons	$2.5	$27,375
	LNAPL Recovery Trench General Operating Labor	72	Man Days	$750	$54,000
	Electricity for 5-Watt LNAPL Skimmers	220.0	kWh	$0.12	$26
	Annual Performance Report for 10 years	8	Each	$25,000	$200,000
	Management/Consulting	156	Man Days	$1,500	$234,000
	CERCLA Five Year Review	6	Each	$12,000	$72,000
	Subtotal				**$694,901**
	Subtotal Present Worth Periodic O&M Cost for 30 years @7%			7%	**$476,923**
	Contingency			10%	$47,692
	Total Present Worth Periodic O&M Cost for 30 years @7%				**$524,616**
			Total Estimated Cost (Capital and PW O&M)		**$7,464,315**

Table D-13
Seep Area
Soil Alternative 4 -Extensive Excavation to Depth and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$35,000	$35,000
	Subtotal				**$35,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$60,000	$60,000
	Mobilization/Demobilization	1	LS	$75,000	$75,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$20,000	$20,000
	Field Office	12	Months	$4,000	$48,000
	Temporary access roads	0	LF	$380	$0
	Traffic Control	16	Week	$3,000	$48,000
	Temporary Fencing	1600	LF	$6	$9,600
	Sampling - (Waste Characterization: Collection and Analysis)	19	Sample	$1,200	$22,802
	Sampling - (Post-Excavation: Collection and Analysis)	182	Sample	$400	$72,695
	Subtotal				**$356,097**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	74	CY	$70	$5,180
	Asphalt Demolition	24,463	SF	$1	$24,463
	Concrete Transportation and Recycling	111	Ton	$20	$2,220
	Asphalt Transporation and Recycling	680	Ton	$20	$13,591
	Well Abandonment	7	Well	$900	$6,300
	Fence Removal	0	LF	$3	$0
	Subtotal				**$51,754**
Liquids Management					
	Dewatering	16	Weeks	$6,250	$100,000
	Treatment (Oil-water Separation, Filtration, Activated Carbon); Dis	16	Weeks	$5,000	$80,000
	Treated Water Disposal	5,644,800	Gallons	$0.03	$141,120
	Subtotal				**$321,120**
Water Management					
	Groundwater Management	1	LS	$150,000	$150,000
	Surface Water Management	1	LS	$20,000	$20,000
	Water Transportation and Disposal	1,000,000	Gallons	$0.56	$560,000
	Subtotal				**$730,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	31,000	SF	$27	$835,259
	Soil Excavation (Upland Areas)	15,204	CY	$10	$152,040
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Soil Stabilization (Wet Soils)	18,972	Ton	$26	$493,272
	Soil T&D (Non-hazardous)	24,702	Ton	$60	$1,482,132
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$2,982,703**
Capping, Backfill and Restoration					
	Geotextile Fabric	0	SF	$0.36	$0
	Structural Backfill (Furnished, placed, compacted)	22,806	Ton	$20	$456,120
	Asphalt Paving	24,463	SF	$4	$97,852
	Concrete Paving	2,000	SF	$6	$12,000
	Topsoil	1,050	Ton	$30	$31,512
	Landscape Restoration	0.69	Acres	$20,000	$13,728
	Construct LNAPL Recovery Trench with 5 Sumps	400	LF	$500	$200,000
	Fence Around Each of 5 LNAPL Recovery Trench Sumps	200	LF	$40	$8,000
	LNAPL Skimmar Assemblies (Magnum Spill Buster)	5	Each	$9,750	$48,750
	Install LNAPL Skimmar Assemblies (Magnum Spill Buster)	5	Each	$1,000	$5,000
	Electric Service to LNAPL Recovery Trench Sumps	6	Each	$5,000	$30,000
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	0	Acres	$328,225	$0
	Monitoring Well Replacement	7	Well	$7,000	$49,000
	Institutional Controls	1	Each	$10,000	$10,000

Table D-13
Seep Area
Soil Alternative 4 -Extensive Excavation to Depth and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

	Subtotal				**$961,962**
	Total Costs W/O Management and Engineering				**$5,438,636**
Management and Engineering					
	Engineering/Legal Admin			16%	$870,182
	Subtotal				**$6,308,817**
Contingency				10%	$630,882
	Total Capital Cost				**$6,939,699**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	0.0	$/Year	$10,000	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	Gauged for occurrence of LNAPL in 4 new post-excavation monitoring wells monthly for the first year of their life, quarterly for the next two years, and annually thereafter for seven years.	27	Events	$250	$6,750
	Gauged for occurrence of LNAPL in 5 LNAPL Recovery Sumps monthly for the first year of their life, quarterly for the next two years, and annually thereafter for seven years.	27	Events	$250	$6,750
	Sample groundwaterfrom 4 new post-excavation monitoring wells and analyze for VOCs quarterly for three years and annually thereafter for seven years.	76	Samples	$250	$19,000
	Replace 5 LNAPL skimmer pump assemblies every six months for three years.	30	Replacements	$500	$15,000
	Replace 1 Magnum Spill Buster LNAPL skimmer assembly every six months for three years .	6	Replacements	$10,000	$60,000
	Transportation and recycling of captured LNAPL.	10,950	Gallons	$2.5	$27,375
	LNAPL Recovery Trench General Operating Labor	72	Man Days	$750	$54,000
	Electricity for 5-Watt LNAPL Skimmers	220.0	kWh	$0.12	$26
	Annual Performance Report for 10 years	8	Each	$25,000	$200,000
	Management/Consulting	156	Man Days	$1,500	$234,000
	CERCLA Five Year Review	6	Each	$12,000	$72,000
	Subtotal				**$694,901**
	Subtotal Present Worth Periodic O&M Cost for 30 years @7%			7%	**$476,923**
	Contingency			10%	$47,692
	Total Present Worth Periodic O&M Cost for 30 years @7%				**$524,616**
			Total Estimated Cost (Capital and PW O&M)		**$7,464,315**

Table D-14
Hilliards Creek
Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$35,000	$35,000
	Subtotal				**$35,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$50,000	$50,000
	Mobilization/Demobilization	1	LS	$75,000	$75,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$20,000	$20,000
	Field Office	7	Months	$4,000	$28,000
	Temporary access roads	900	LF	$380	$341,631
	Traffic Control	20	Week	$3,000	$60,000
	Temporary Fencing	0	LF	$6	$0
	Sampling - (Waste Characterization: Collection and Analysis)	8	Sample	$1,200	$9,065
	Sampling - (Post-Excavation: Collection and Analysis)	217	Sample	$400	$86,905
	Subtotal				**$670,601**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	0	CY	$70	$0
	Asphalt Demolition	0	SF	$1	$0
	Concrete Transportation and Recycling	0	Ton	$20	$0
	Asphalt Transporation and Recycling	0	Ton	$20	$0
	Well Abandonment	1	Well	$900	$900
	Fence Removal	0	LF	$3	$0
	Subtotal				**$900**
Water Management					
	Groundwater Management	1	LS	$150,000	$150,000
	Surface Water Management	1	LS	$100,000	$100,000
	Water Transportation and Disposal	250,000	Gallons	$0.56	$140,000
	Subtotal				**$390,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	0	SF	$27	$0
	Soil Excavation (Upland Areas)	0	CY	$10	$0
	Soil Excavation (Wetland/Riparian Areas)	5,952	CY	$20	$119,040
	Soil Stabilization (Wet Soils)	8,928	Ton	$26	$232,128
	Soil T&D (Non-hazardous)	9,821	Ton	$60	$589,248
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$960,416**
Capping, Backfill and Restoration					
	Geotextile Fabric	88,463	SF	$0.36	$31,660
	Structural Backfill (Furnished, placed, compacted)	8,928	Ton	$20	$178,560
	Topsoil	2,457	Ton	$30	$73,719
	Landscape Restoration	2.03	Acres	$20,000	$40,617
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	2.03	Acres	$328,225	$666,569
	Monitoring Well Replacement	1	Well	$7,000	$7,000
	Institutional Controls	2	Each	$10,000	$20,000
	Subtotal				**$1,018,125**
	Total Costs W/O Management and Engineering				**$3,075,043**
Management and Engineering					
	Engineering/Legal Admin			16%	$492,007
	Subtotal				**$3,567,049**
Contingency				10%	$356,705
	Total Capital Cost				**$3,923,754**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	1.0	$/Year	$10,000	$10,000
	Contingency			10%	$1,000

Table D-14
Hilliards Creek
Soil Alternative 2 - Targeted Surface Soil Removal, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

	Total Annual O&M				**$11,000**
	Present Worth Annual O&M Cost for 30 years @7%				**$136,499**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$4,088,737**

Table D-15
Hilliards Creek
Soil Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$50,000	$50,000
	Subtotal				**$50,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$75,000	$75,000
	Mobilization/Demobilization	1	LS	$100,000	$100,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$30,000	$30,000
	Field Office	14	Months	$4,000	$56,000
	Temporary access roads	900	LF	$380	$341,631
	Traffic Control	48	Week	$3,000	$144,000
	Temporary Fencing	0	LF	$6	$0
	Sampling - (Waste Characterization: Collection and Analysis)	13	Sample	$1,200	$15,592
	Sampling - (Post-Excavation: Collection and Analysis)	217	Sample	$400	$86,905
	Subtotal				**$849,128**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	0	CY	$70	$0
	Asphalt Demolition	0	SF	$1	$0
	Concrete Transportation and Recycling	0	Ton	$20	$0
	Asphalt Transporation and Recycling	0	Ton	$20	$0
	Well Abandonment	1	Well	$900	$900
	Fence Removal	0	LF	$3	$0
	Subtotal				**$900**
Water Management					
	Groundwater Management	1	LS	$300,000	$300,000
	Surface Water Management	1	LS	$200,000	$200,000
	Water Transportation and Disposal	1,000,000	Gallons	$0.56	$560,000
	Subtotal				**$1,060,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	0	SF	$27	$0
	Soil Excavation (Upland Areas)	0	CY	$10	$0
	Soil Excavation (Wetland/Riparian Areas)	10,238	CY	$20	$204,760
	Soil Stabilization (Wet Soils)	15,356	Ton	$26	$399,256
	Soil T&D (Non-hazardous)	16,892	Ton	$60	$1,013,496
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$1,637,512**
Capping, Backfill and Restoration					
	Geotextile Fabric	0	SF	$0.36	$0
	Structural Backfill (Furnished, placed, compacted)	15,356	Ton	$20	$307,120
	Topsoil	2,457	Ton	$30	$73,719
	Landscape Restoration	2.03	Acres	$20,000	$40,617
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	2.03	Acres	$328,225	$666,569
	Monitoring Well Replacement	1	Well	$7,000	$7,000
	Institutional Controls	0	Each	$10,000	$0
	Subtotal				**$1,095,025**
	Total Costs W/O Management and Engineering				**$4,692,565**
Management and Engineering					
	Engineering/Legal Admin			16%	$750,810
	Subtotal				**$5,443,376**
Contingency				10%	$544,338
	Total Capital Cost				**$5,987,714**
Operation/Maintenance					
Annual O&M					
	Inspection/Maintenance	1.0	$/Year	$1,000	$1,000
	Contingency			10%	$100

Table D-15
Hilliards Creek
Soil Alternative 3 - Soil and LNAPL Removal/Treatment, Capping and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

	Total Annual O&M				**$1,100**
	Present Worth Annual O&M Cost for 30 years @7%				**$13,650**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$6,029,847**

Table D-16
Hilliards Creek
Soil Alternative 4 - Extensive Excavation to Depth and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$50,000	$50,000
	Subtotal				**$50,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$75,000	$75,000
	Mobilization/Demobilization	1	LS	$100,000	$100,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$30,000	$30,000
	Field Office	14	Months	$4,000	$56,000
	Temporary access roads	900	LF	$380	$341,631
	Traffic Control	48	Week	$3,000	$144,000
	Temporary Fencing	0	LF	$6	$0
	Sampling - (Waste Characterization: Collection and Analysis)	13	Sample	$1,200	$15,592
	Sampling - (Post-Excavation: Collection and Analysis)	217	Sample	$400	$86,905
	Subtotal				**$849,128**
Demolition Activities					
	Building Demolition	0	LS	$50,000	$0
	Concrete Demolition and Crushing	0	CY	$70	$0
	Asphalt Demolition	0	SF	$1	$0
	Concrete Transportation and Recycling	0	Ton	$20	$0
	Asphalt Transporation and Recycling	0	Ton	$20	$0
	Well Abandonment	1	Well	$900	$900
	Fence Removal	0	LF	$3	$0
	Subtotal				**$900**
Water Management					
	Groundwater Management	1	LS	$300,000	$300,000
	Surface Water Management	1	LS	$200,000	$200,000
	Water Transportation and Disposal	1,000,000	Gallons	$0.56	$560,000
	Subtotal				**$1,060,000**
Soil Excavation and Disposal					
	Utility Protection/Management	1	LS	$20,000	$20,000
	Structural Support/Shoring	0	SF	$27	$0
	Soil Excavation (Upland Areas)	0	CY	$10	$0
	Soil Excavation (Wetland/Riparian Areas)	10,238	CY	$20	$204,760
	Soil Stabilization (Wet Soils)	15,356	Ton	$26	$399,256
	Soil T&D (Non-hazardous)	16,892	Ton	$60	$1,013,496
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$1,637,512**
Capping, Backfill and Restoration					
	Geotextile Fabric	0	SF	$0.36	$0
	Structural Backfill (Furnished, placed, compacted)	15,356	Ton	$20	$307,120
	Topsoil	2,457	Ton	$30	$73,719
	Landscape Restoration	2.03	Acres	$20,000	$40,617
	Fence Restoration	0	LF	$40	$0
	Wetlands Restoration	2.03	Acres	$328,225	$666,569
	Monitoring Well Replacement	1	Well	$7,000	$7,000
	Institutional Controls	0	Each	$10,000	$0
	Subtotal				**$1,095,025**
	Total Costs W/O Management and Engineering				**$4,692,565**
Management and Engineering					
	Engineering/Legal Admin			16%	$750,810
	Subtotal				**$5,443,376**
Contingency				10%	$544,338
	Total Capital Cost				**$5,987,714**
Operation/Maintenance					
Annual O&M					
	Inspection/Maintenance	1.0	$/Year	$1,000	$1,000
	Contingency			10%	$100

Table D-16
Hilliards Creek
Soil Alternative 4 - Extensive Excavation to Depth and Institutional Controls
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

	Total Annual O&M				**$1,100**
	Present Worth Annual O&M Cost for 30 years @7%				**$13,650**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$6,029,847**

Table D-17
Hilliards Creek
Sediment Alternative 1 - No Action
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
	Total Costs W/O Management and Engineering				**$0**
Management and Engineering					
	Engineering/Legal Admin			16%	$0
	Subtotal				**$0**
Contingency				10%	$0
	Total Capital Cost				**$0**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance		$/Acre/Year	$0	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$28,483**

Table D-18
Hilliards Creek
Sediment Alternative 2 - Capping and Monitored Natural Recovery
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$20,000	$20,000
	Subtotal				**$20,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$20,000	$20,000
	Mobilization/Demobilization	1	LS	$50,000	$50,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$15,000	$15,000
	Field Office	4	Months	$4,000	$16,000
	Temporary access roads	1500	LF	$380	$569,385
	Traffic Control	8	Week	$3,000	$24,000
	Sampling - (Waste Characterization: Collection and Analysis)	2	Sample	$1,200	$2,400
	Subtotal				**$696,785**
Water Management					
	Groundwater Management	0	LS	$20,000	$0
	Surface Water Management (e.g. stream diversion)	1	LS	$200,000	$200,000
	Water Transportation and Disposal	40,000	Gallons	$0.56	$22,400
	Subtotal				**$222,400**
Sediment Excavation and Disposal					
	Excavation	310	CY	$30	$9,300
	Soil Stabilization (Wet Soils)	465	Ton	$26	$12,090
	Soil T&D (Non-hazardous)	512	Ton	$60	$30,690
	Subtotal				**$52,080**
Capping, Backfill and Restoration					
	Sand Backfill (Furnished, placed, compacted)	232.5	Ton	$27	$6,278
	Gravel Cap Material	117	Ton	$27	$3,159
	Institutional Controls	2	Each	$10,000	$20,000
	Subtotal				**$29,437**
Silver Lake Conveyance Cleaning					
	Cleaning of Conveyance System	1	LS	$20,000	$20,000
	Soil Stabilization (Wet Soils)	420	Ton	$26	$10,920
	Soil T&D (Non-hazardous)	462	Ton	$60	$27,720
	Subtotal				**$58,640**
	Total Costs W/O Management and Engineering				**$1,079,341**
Management and Engineering					
	Engineering/Legal Admin			16%	$172,695
	Subtotal				**$1,252,036**
Contingency				10%	$125,204
	Total Capital Cost				**$1,377,239**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	1.0	$/Year	$10,000	$10,000
	Annual Monitoring	1.0	$/Year	$5,000	$5,000
	Subtotal				**$15,000**
	Contingency			10%	$1,500
	Total Annual O&M				**$16,500**
	Present Worth Annual O&M Cost for 30 years @7%				**$204,749**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
		Total Estimated Cost (Capital and PW O&M)			**$1,610,472**

Table D-19
Hilliards Creek
Sediment Alternative 3 - Removal of Surface Sediment with Contaminants Greater than PRGs, Capping and Natural Recovery
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$20,000	$20,000
	Subtotal				**$20,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$30,000	$30,000
	Mobilization/Demobilization	1	LS	$50,000	$50,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$15,000	$15,000
	Field Office	5	Months	$4,000	$20,000
	Temporary access roads	1500	LF	$380	$569,385
	Traffic Control	12	Week	$3,000	$36,000
	Sampling - (Waste Characterization: Collection and Analysis)	3	Sample	$1,200	$3,600
	Subtotal				**$723,985**
Water Management					
	Groundwater Management	1	LS	$20,000	$20,000
	Surface Water Management (e.g. stream diversion)	1	LS	$200,000	$200,000
	Water Transportation and Disposal	100,000	Gallons	$0.56	$56,000
	Subtotal				**$276,000**
Sediment Excavation and Disposal					
	Structural Support/Shoring	0	SF	$22	$0
	Excavation	1,411	CY	$30	$42,330
	Soil Stabilization (Wet Soils)	2,117	Ton	$26	$55,029
	Soil T&D (Non-hazardous)	2,328	Ton	$60	$139,689
	Subtotal				**$237,048**
Capping, Backfill and Restoration					
	Sand Backfill (Furnished, placed, compacted)	1491	Ton	$27	$40,257
	Gravel Cap Material	0	Ton	$27	$0
	Institutional Controls	0	Each	$10,000	$0
	Subtotal				**$40,257**
Silver Lake Conveyance Cleaning					
	Cleaning of Conveyance System	1	LS	$20,000	$20,000
	Soil Stabilization (Wet Soils)	420	Ton	$26	$10,920
	Soil T&D (Non-hazardous)	462	Ton	$60	$27,720
	Subtotal				**$58,640**
	Total Costs W/O Management and Engineering				**$1,355,930**
Management and Engineering					
	Engineering/Legal Admin			16%	$216,949
	Subtotal				**$1,572,878**
Contingency				10%	$157,288
	Total Capital Cost				**$1,730,166**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	0.0	$/Year	$15,000	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
		Total Estimated Cost (Capital and PW O&M)			**$1,758,649**

Table D-20
Surface Water Alternative 1 - No Action
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
	Total Costs W/O Management and Engineering				**$0**
Management and Engineering					
	Engineering/Legal Admin			16%	$0
	Subtotal				**$0**
Contingency				10%	$0
	Total Capital Cost				**$0**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance		$/Acre/Year	$0	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$28,483**

Table D-21
Surface Water Alternative 2 - Institutional Controls with Monitoring
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	0	LS	$0	$0
	Subtotal				**$0**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$1,000	$1,000
	Institutional Controls	2	Each	$10,000	$20,000
	Subtotal				**$21,000**
	Total Costs W/O Management and Engineering				**$21,000**
Management and Engineering					
	Engineering/Legal Admin			16%	$3,360
	Subtotal				**$24,360**
Contingency				10%	$2,436
	Total Capital Cost				**$26,796**
Operation/Maintenance					
Annual O&M					
	Annual Sampling	1.0	$Year	$5,000	$5,000
	Contingency			10%	$500
	Total Annual O&M				**$5,500**
	Present Worth Annual O&M Cost for 30 years @7%				**$68,250**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$123,529**

Table D-22
Eastern Off-Property Area
Alternative 1 - No Action
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
	Total Costs W/O Management and Engineering				**$0**
Management and Engineering					
	Engineering/Legal Admin			16%	$0
	Subtotal				**$0**
Contingency				10%	$0
	Total Capital Cost				**$0**
Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance		$/Acre/Year	$0	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	CERCLA Five Year Review (6 Reporting Events)	6	Each	$10,000	$60,000
	Contingency			10%	$6,000
	Subtotal				**$66,000**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$142,416**
			Total Estimated Cost (Capital and PW O&M)		**$142,416**

Table D-23
Eastern Off-Property Area
Alternative 2 - Enhanced LNAPL Biodegradation and Soil Gas Recovery
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Biogeochemical Assessment of Groundwater and Soil Gas	1	LS	$200,000	$200,000
	Soil Gas Extraction Pilot Test	1	LS	$50,000	$50,000
	Aqueous Amendment Capacity Test	1	LS	$50,000	$50,000
	Anaerobic Biotreatability Bench Test	1	LS	$200,000	$200,000
	Delineation of Sensitive Areas	0	LS	$25,000	$0
	Buried Utility Locations	1	LS	$8,000	$8,000
	Assessment of Air Emissions and Potential Permit Requirements	1	LS	$10,000	$10,000
	NJDEP Discharge to Groundwater Permit-By-Rule	1	LS	$10,000	$10,000
	Subtotal				**$528,000**
Project Management and Mobilization					
	Project Management, Contracting and Coordination	1	LS	$50,000	$50,000
	Well Driller Mobilization/Demobilization	1	LS	$1,000	$1,000
	Piping and Trenching Contractor Mobilization/Demobilization	1	LS	$5,000	$5,000
	Surveying, Site Preparation	1	LS	$5,500	$5,500
	Field Office	2	Months	$4,000	$8,000
	Temporary Access Road(s)	0	LF	$380	$0
	Traffic Control	0	Weeks	$3,000	$0
	Subtotal				**$69,500**
Demolition Activities					
	Assume No Demolition Activities Required	0	LS	$0	$0
	Subtotal				**$0**
Waste Management					
	Drill Cuttings	53	Well	$1,000	$53,000
	Treated Water Disposal	0	Gallons	$0.03	$0
	Subtotal				**$53,000**
Well Drilling					
	Pressurized Amendment Emplacement Wells	30	Well	$3,500	$105,000
	Vertical Soil Gas Extraction Wells	23	Well	$4,000	$92,000
	Direct-Push Amendment Emplacement Points	25	Day	$12,500	$312,500
	Contingency Direct_Push Injeciton Sites for Road	18	Day	$7,500	$135,000
	Soil Gas Monitoring Probes	6	Probe	$1,250	$7,500
	Subtotal				**$652,000**
Trenching and Piping					
	Buried Piping and Trenching Contractor - SVE	1,500	LF	$250.00	$375,000
	Buried Piping and Trenching Contractor - Amendment Convey	2,000	LF	$100	$200,000
	Buried Piping and Trenching Oversight Labor	3,500	LF	$10	$35,000
	Contingency - Buried Piping and Trenching Oversight Labor				$0
	Subtotal				**$610,000**
Remediation Equipment and Compound					
	Amendment Mixing and Pumping Equipment	1	Each	$100,000	$100,000
	Soil Gas Extraction and Treatment Equipment	1	Each	$77,500	$77,500
	Remediation Equipment Compound	1,000	SF	$75	$75,000
	Field Soil Gas Analyzers	1	LS	$17,500	$17,500
	Electrical Service	1	LS	$10,000	$10,000
	Municipal Water Service	1	LS	$10,000	$10,000
	Internet Service	1	LS	$0	$0
	Subtotal				**$290,000**
	Total Costs W/O Management and Engineering				**$2,202,500**
Management/Engineering/Legal Admin					
	Engineering/Legal Admin			16%	$352,400
	Subtotal				**$2,554,900**
Contingency				10%	$255,490
	Total Capital Cost				**$2,810,390**

Table D-23
Eastern Off-Property Area
Alternative 2 - Enhanced LNAPL Biodegradation and Soil Gas Recovery
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Operation/Maintenance					
Annual O&M					
	Labor for Weekly O&M	500	Man Days	$750	$375,000
	Sample and Analyze Groundwater	168	Samples	$500	$84,000
	Sample and Analyze Soil Gas	174	Samples	$100	$17,400
	Service Soil Gas Analyzers	9	Events	$3,000	$27,000
	Repair or Replace Pumps and Blowers	9	Events	$5,000	$45,000
	Electricity	1,666,666	kWh	$0.12	$200,000
	Water	40,000,000	Gallons	$0.002	$80,000
	Reagent for Continuous Emplacement - Potassium Sulfate	73,000	Pounds (dw)	$1	$73,000
	Reagent for Continuous Emplacement - DAP	18,250	Pounds (dw)	$2	$36,500
	Reagent for Direct-Push Injection	100	Points	$150	$15,000
	Reagent for Contingency Direct-Push Injection	36	Points	$150	$5,400
	Annual Performance Report for 10 Years	8	Each	$35,000.0	$280,000
	Subtotal				$1,238,300
Contingency				10%	$123,830
	Total Annual O&M				**$1,362,130**
Periodic O&M					
	CERCLA Five Year Review	2	Each	$50,000	$100,000
	Management/Consulting	120	Man Days	$1,500	$180,000
	Subtotal				**$280,000**
Contingency				10%	$28,000
				Total Periodic O&M	**$308,000**
				Total Annual & Periodic O&M	**$1,670,130**
			Total Estimated Cost (Capital and PW O&M)		**$4,480,520**

Table D-24
Eastern Off-Property Area
Alternative 3 - Extensive Excavation to Depth
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

		Quantity	Unit	Unit Rate	Total Cost
Predesign					
	Supplemental Investigation	1	LS	$75,000	$150,000
	Subtotal				**$150,000**
Project Management and Mobilization					
	Project Management and Coordination	1	LS	$300,000	$300,000
	Mobilization/Demobilization	1	LS	$300,000	$300,000
	Site Preparation, Clearing, Erosion Controls	1	LS	$60,000	$60,000
	Field Office	30	Months	$4,000	$120,000
	Temporary access roads	1,000	LF	$380	$379,590
	Traffic Control	112	Week	$3,000	$336,000
	Temporary Fencing	2000	LF	$6	$12,000
	Sampling - (Waste Characterization: Collection and Analysis)	26	Sample	$1,200	$30,913
	Sampling - (Post-Excavation: Collection and Analysis)	322	Sample	$400	$128,889
	Subtotal				**$1,667,391**
Demolition Activities					
	Outbuilding/Minor Structure Demolition	10	LS	$10,000	$100,000
	House/Structure Move/Temporary Relocation	23,052	SF	$16	$368,832
	Temporary Housing	6	Each	$48,000	$288,000
	Moving and Storage Property Owner Belongings	6	Each	$10,000	$60,000
	Concrete Demolition and Crushing	320	CY	$70	$22,412
	Asphalt Demolition	27,511	SF	$1	$27,511
	Concrete Transportation and Recycling	480	Ton	$20	$9,605
	Asphalt Transporation and Recycling	1146	Ton	$20	$22,926
	Well Abandonment	7	Well	$900	$6,300
	Fence Removal	695	LF	$3	$2,085
	Subtotal				**$907,671**
Water Management					
	Groundwater Management	1	LS	$250,000	$250,000
	Surface Water Management	6	Property	$5,000	$30,000
	Water Transportation and Disposal	2,000,000	Gallons	$0.56	$1,120,000
	Subtotal				**$1,400,000**
Soil Excavation, Soil Management and Disposal					
	Utility Protection/Management	6	Property	$10,000	$60,000
	Odor and Vapor Control/Management	81,185	CY	$3	$202,963
	Structural Support/Shoring	115,500	SF	$27	$3,112,014
	Soil Excavation (Upland Areas)	81,185	CY	$10	$811,852
	Soil Excavation (Wetland/Riparian Areas)	0	CY	$20	$0
	Temporary Stockpiling of Clean Overburden for Reuse	60,889	CY	$10	$608,889
	Soil Stabilization (Wet Soils)	30,444	Ton	$26	$791,556
	Soil T&D (Non-hazardous)	33,489	Ton	$60	$2,009,333
	Soil T&D (TSCA)	0	Ton	$240	$0
	Subtotal				**$7,596,606**
Capping, Backfill and Restoration					
	Geotextile Fabric	0	SF	$0.36	$0
	Placement of Clean Overburden for Reuse	60,889	CY	$10	$608,889
	Structural Backfill (Furnished, placed, compacted)	31,967	Ton	$20	$639,333
	House/Structure New Foundation	13	Each	$30,000	$390,000
	House/Structure Move/Installation on New Foundation	23,052	SF	$16	$368,832
	Return Moving Property Owner Belongings	6	Each	$10,000	$60,000
	Asphalt Paving	27,511	SF	$4	$110,044
	Concrete Paving	0	SF	$6	$0
	Topsoil	3,235	Ton	$30	$97,042
	Landscape Restoration	3.15	Acres	$20,000	$62,902
	Outbuilding/Minor Structure Restoration	10	Each	$20,000	$200,000
	Fence Restoration	695	LF	$40	$27,800
	Wetlands Restoration	0.20	Acres	$328,225	$65,645
	Monitoring Well Replacement	7	Well	$7,000	$49,000
	Institutional Controls	0	Each	$10,000	$0
	Subtotal				**$2,679,487**
	Total Costs W/O Management and Engineering				**$14,401,155**
Management and Engineering					
	Engineering/Legal Admin			16%	$2,304,185
	Subtotal				**$16,705,339**
Contingency				10%	$1,670,534
	Total Capital Cost				**$18,375,873**

Table D-24
Eastern Off-Property Area
Alternative 3 - Extensive Excavation to Depth
Former Manufacturing Plant Area, Hilliards Creek Site
Gibbsboro, New Jersey

Operation/Maintenance					
Annual O&M					
	Quarterly Inspection/Maintenance	0.0	$/Year	$10,000	$0
	Contingency			10%	$0
	Total Annual O&M				**$0**
	Present Worth Annual O&M Cost for 30 years @7%				**$0**
Periodic O&M					
	CERCLA Five Year Review	1	Each	$12,000	$12,000
	Contingency			10%	$1,200
	Subtotal				**$13,200**
	Present Worth Periodic O&M Cost for 30 years @7%			7%	**$28,483**
			Total Estimated Cost (Capital and PW O&M)		**$18,404,357**

APPENDIX E

Detailed LNAPL Treatment Conceptual Design Documents

Sherwin-Williams Gibbsboro
Conceptual Soil Feasibility Study Alternative 3B - Former Resin Plant & Tank Farm A Area
Enhanced Bioremediation of LNAPL Impacts
Component B of Two Component Soil FS Alternative 3

Soil Feasibility Study Alternative 3 intends to couple A) focused LNAPL recovery with B) enhanced bioremediation of LNAPL impacts. The following is conceptual approach and assumptions used to craft the vision and cost estimate for Alternative 3B Enhanced Bioremediation of LNAPL Impacts component of Soil FS Alternative 3. Conceptual approach and assumptions used to craft the vision and cost estimate for Alternative 3A Focused LNAPL Recovery component of Soil FS Alternative 3 is provided separately.

Conceptual Approach

This LNAPL Alternative 3B intends to enhance existing biological processes in the subsurface that are degrading both mobile and residual LNAPL by fertigation of the subsurface with water-soluble fertilizer-like ingredients sulfate, nitrogen, and phosphorous. Provision of these nutrients are intended to enhance anaerobic biodegradation of dissolved hydrocarbons through sulfate reduction and methanogenesis occurring in close proximity to the LNAPL body, which will result in increased rate of LNAPL depletion.

Due to the production of biogenic gases (methane and carbon dioxide) from degradation hydrocarbons in the saturated zone, a soil gas extraction system will be installed in the unsaturated zone to prevent upward migration of gases into buildings and structures on-site (if present), and prevent lateral migration of gases towards sensitive receptors (for example utilities in the street). A combination of vertical soil gas extraction wells and horizontal soil gas extraction wells (either directionally-drilled or placed in near-surface trenches will be used because of varying depths to groundwater in the treatment area and because buildings overlay some portions of the treatment area.

A soil gas extraction blower located within a remediation compound will be used to extract gases from the subsurface. Entry of oxygen into the unsaturated zone from operation of the soil gas extraction system will facilitate the aerobic degradation of methane. Based on the LNAPL character and chemistry, it is assumed that extracted soil gas will not require pre-treatment before discharging to atmosphere under a readily-obtainable permit.

The addition of amendments to the subsurface will be achieved through infiltration/injection of city water containing water-soluble fertilizer. These amendments will be delivered to the subsurface through:

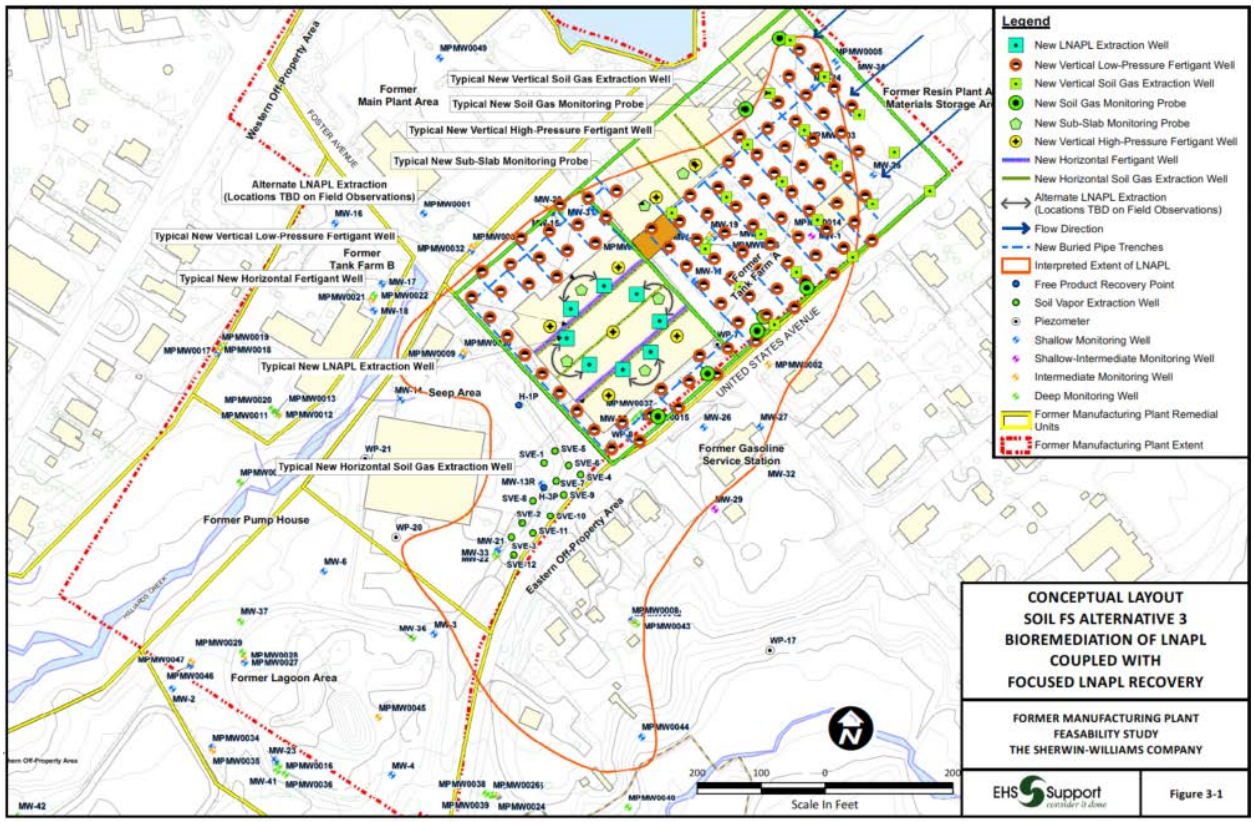
1) A network of shallow low pressure PVC fertigation wells which will be constructed to a maximum depth of 15 feet and spaced at 40-foot centers across the treatment area.
2) High pressure fertigation injection wells which will be constructed in the buildings at a lower density to facilitate treatment in these areas.
3) Drip irrigation piping placed in the piping trenches.

A centralized equipment compound will be constructed with a building to house fertigation system inclusive of amendment feedstock storage, amendment mixing equipment, and fertigant delivery pumps, and soil gas extraction blower and its activated carbon treatment units.

Key work tasks be completed prior to design and commissioning of the system include:

1. Obtaining a discharge to groundwater permit-by-rule from NJDEP for the proposed activities.
2. Completing pilot testing to determine the number and geometry of soil gas extraction wells or trenches, and optimal dosing rates for fertigation of the subsurface.

Figure 3-1 – Conceptual Layout of Enhanced Bioremediation of LNAPL Impacts is shown below. It includes a typical trench section that shows the conceptual arrangement of 1) aqueous fertigant conveyance pipes, 2) drip irrigation pipe, and 3) horizontal soil gas extraction pipe or extracted soil gas conveyance pipe.



Major Elements

Pricing of this alternative assumes the following major elements apply:

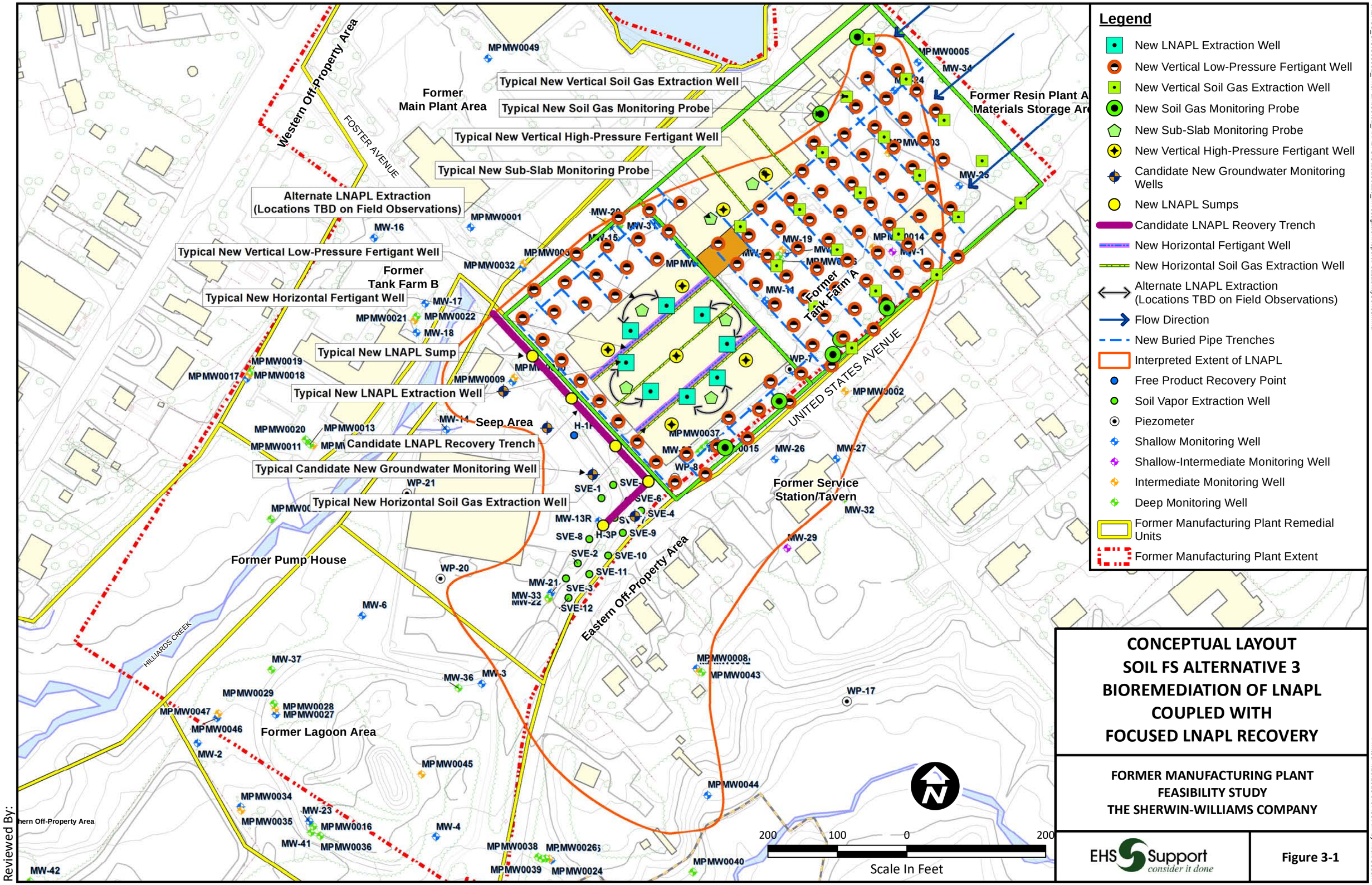
- Existing structures remain.
- Completion of a pilot test for soil gas extraction and fertigant injection.

- Aqueous fertigant application rate is one (1) treatment zone pore volume per year (5,000,000 gallons/year), given treatment zone dimensions LxWxH of 700'x350'x10' (2,450,000 ft^3) and a porosity of 0.27, which comes to a continuous application rate of 9.5 gpm.
- Preparation and submission of permit applications to NJDEP for chemical injection and potential air emissions.
- Installation of approximately 100 new 2-inch diameter 15-foot deep PVC low-pressure fertigation wells at nominal 40-foot centers where practicable outside of building footprints. The spacing of the wells reflects the groundwater seepage velocities of 10 to 30 feet per year and the anticipated head of injection that will allow reagents to migrate 30 to 50 feet in a year.
- Installation of approximately 7 new 2-inch diameter 15-foot deep PVC high-pressure fertigation wells at nominal 80-foot centers where practicable inside of existing readily-accessible empty warehouse building(s).
- Installation of approximately 600 lineal feet of new directionally-drilled 2-inch diameter single-ended horizontal fertigant emplacement wells beneath warehouse building.
- Construction of approximately 4,250 lineal feet of outdoor buried pipe trenches and placement of individual 1-inch diameter LDPE aqueous fertigant conveyance pipe to each fertigation well.
- Construction of approximately 350 lineal feet of indoor 1-inch diameter HDPE aqueous fertigant conveyance pipe placed in concrete floor-cut trenches inside buildings.
- Construction of approximately 1,000 lineal feet of indoor 1-inch diameter HDPE aqueous fertigant conveyance pipe placed aboveground inside buildings.
- Placement of 1,000 nominal feet of 1-inch diameter LDPE drip irrigation pipe (with 4-gph emitters at 1-foot centers) in every other buried pipe trench.
- Installation of approximately 20 vertical soil gas extraction wells and approximately 1,000 lineal feet of horizontal 4-inch diameter slotted PVC soil vapor extraction pipe placed in every other trench.
- Installation of approximately 1,200 lineal feet of new directionally-drilled 4-inch diameter single ended horizontal soil gas extraction wells beneath buildings.
- Installation of six soil gas monitoring probes where practicable outside of building footprints; 1-inch diameter 5-foot deep PVC wells; flush-mounted in 9-inch diameter vault-box.
- Installation of six sub-slab soil gas monitoring probes where practicable inside of buildings; 1-inch diameter 3-foot deep PVC wells; flush-mounted in 9-inch diameter vault-box set in concrete floor.
- Actual number and length of vertical and horizontal wells and trenches wells to be determined during pilot tests.
- Construction of a 1,000 ft^2 heated equipment building/enclosure and fenced compound for housing of fertigant storage, mixing, and delivery equipment, and soil gas extraction and treatment equipment.
- A 115/230-volt electrical service (100-amp minimum) to the treatment building.
- A Municipal water service capable of providing 20 gpm supply.
- Internet service to support the PLC and enable automated monitoring and control of equipment.
- Provision of a 500-scfm soil gas extraction blower (captured water to be recycled for makeup of fertigant), which will apply a minimum of 20 inches of water vacuum at wellheads.
- A PLC and fertigation controller system for automated delivery of water and reagents to the fertigant emplacement wells and drip irrigation systems.
- Fertigant mixing and pumping assembly.

Operation and Maintenance

It is assumed for the purposes of costing that:

- Operating period will be ten (10) years from construction and commissioning of Bioremediation of LNAPL Impacts system. A seven-year operating period is anticipated but costs are conservatively based on ten years.
- O&M activities on the fertigation systems will comprise weekly system inspections and automated monitoring of system functions include water flow rates and injected pressures, volumes injected into individual wells and fertigation lines, amounts of fertigants used and available.
- O&M activities on the soil gas extraction system will comprise weekly maintenance on the extraction blower, and field measurement of extracted vapor concentrations with organic vapor analyzer (for VOCs and landfill gas monitor (for methane and CO_2).
- Field monitoring will be conducted in soil gas probes to assess concentrations of VOCs, methane and carbon dioxide to determine presence of biological activity and effectiveness of soil gas extraction systems. Soil gas monitoring will be conducted monthly for the first year, quarterly for the next 2 years, semiannually for the next 2 years, and annually thereafter for 5 years.
- Seven (7) existing groundwater monitoring well samples will be analyzed for VOCs, field measured analytes (dissolved oxygen, ORP, pH, and temperature), geochemical analytes (nitrate/nitrite, dissolved iron, sulfate), non-toxic biogenic analytes (dissolved methane and CO_2), and nutrients (TKN and P) quarterly for two years and semi-annual thereafter until the termination of remediation activities.
- Electricity costs $0.12/kWh.
- Water costs $2/1,000 gallons ($10,000/year at 5,000,000 gallons per year).
- Operation, maintenance, and performance sample collection labor costs $65/hour.
- Operation and maintenance labor utilization is 1 man-day per week.
- Performance monitoring labor utilization is 1 man-hour per sample.
- Non-hazardous activated carbon exchange rate is four (4) 200-lb drums per year.
- Fertigant material utilization rate is 10 pounds (dw) commodity potassium sulfate per day and 2.5 pounds (dw) of commodity diammonium phosphate per day.
- Let potassium sulfate cost = $1/pound (dw), delivered.
- Let diammonium phosphate and ammonium nitrate cost = $2/pound (dw), delivered.
- There is no salvage value of equipment at end of operating period.


Legend
New LNAPL Extraction Well
New Vertical Low-Pressure Fertigant Well
New Vertical Soil Gas Extraction Well
New Soil Gas Monitoring Probe
New Sub-Slab Monitoring Probe
New Vertical High-Pressure Fertigant Well
Candidate New Groundwater Monitoring Wells
New LNAPL Sumps
Candidate LNAPL Reovery Trench
New Horizontal Fertigant Well
New Horizontal Soil Gas Extraction Well
Alternate LNAPL Extraction (Locations TBD on Field Observations)
Flow Direction
New Buried Pipe Trenches
Interpreted Extent of LNAPL
Free Product Recovery Point
Soil Vapor Extraction Well
Piezometer
Shallow Monitoring Well
Shallow-Intermediate Monitoring Well
Intermediate Monitoring Well
Deep Monitoring Well
Former Manufacturing Plant Remedial Units
Former Manufacturing Plant Extent
Typical New Vertical Soil Gas Extraction Well
Typical New Soil Gas Monitoring Probe
Typical New Vertical High-Pressure Fertigant Well
Typical New Sub-Slab Monitoring Probe
Alternate LNAPL Extraction (Locations TBD on Field Observations)
Typical New Vertical Low-Pressure Fertigant Well
Typical New Horizontal Fertigant Well
Typical New LNAPL Sump
Typical New LNAPL Extraction Well
Candidate LNAPL Recovery Trench
Typical Candidate New Groundwater Monitoring Well
Typical New Horizontal Soil Gas Extraction Well
Former Main Plant Area
Western Off-Property Area
FOSTER AVENUE
Former Tank Farm B
Former Tank Farm A
Former Resin Plant A Materials Storage Ar
UNITED STATES AVENUE
Seep Area
Former Service Station/Tavern
Former Pump House
Eastern Off-Property Area
HILLIARDS CREEK
Former Lagoon Area
Scale In Feet
200 100 0 200
CONCEPTUAL LAYOUT
SOIL FS ALTERNATIVE 3
BIOREMEDIATION OF LNAPL
COUPLED WITH
FOCUSED LNAPL RECOVERY
FORMER MANUFACTURING PLANT
FEASIBILITY STUDY
THE SHERWIN-WILLIAMS COMPANY
EHS Support consider it done
Figure 3-1
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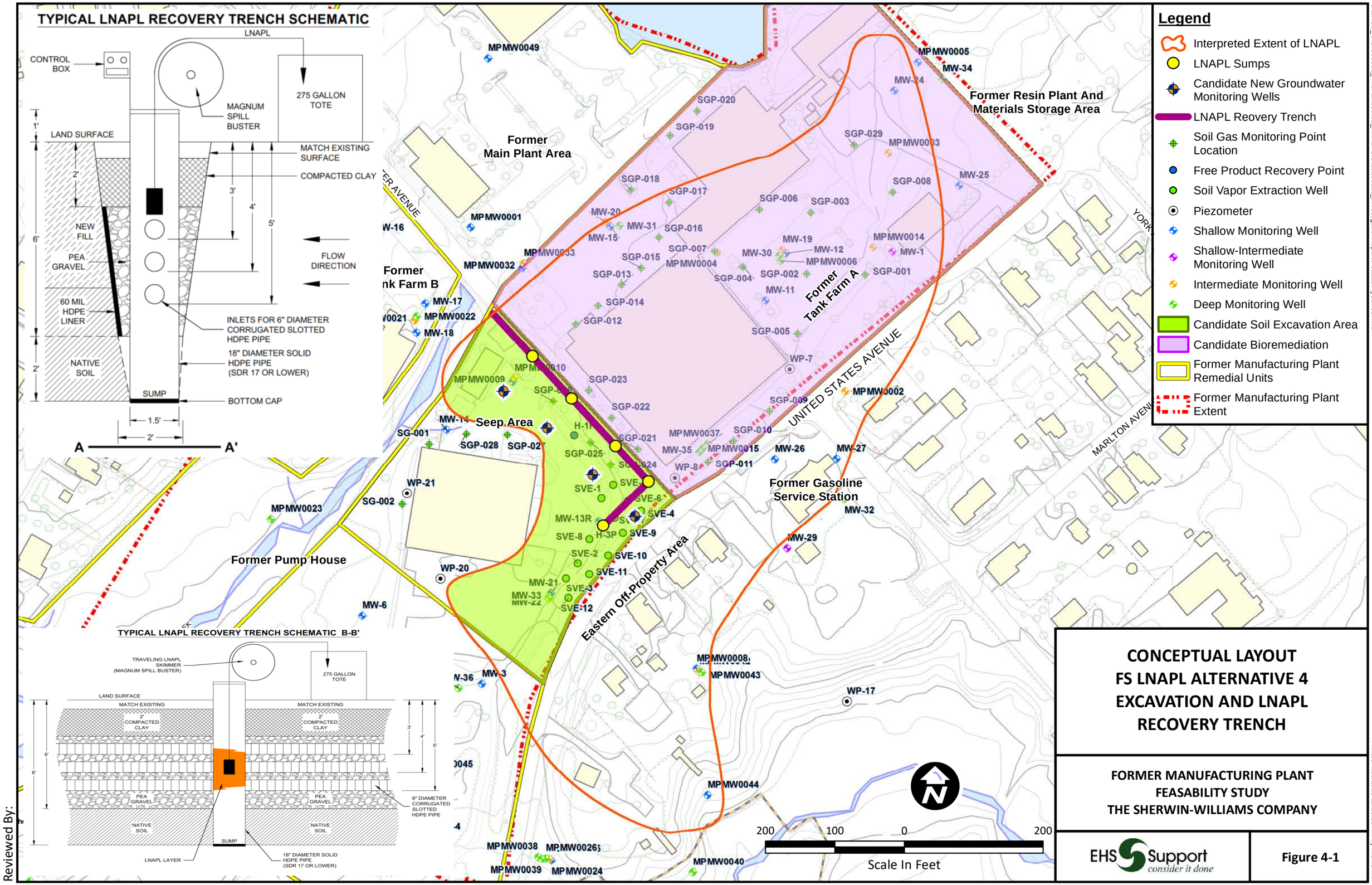

CONCEPTUAL LAYOUT FS LNAPL ALTERNATIVE 4 EXCAVATION AND LNAPL RECOVERY TRENCH

FORMER MANUFACTURING PLANT
FEASABILITY STUDY
THE SHERWIN-WILLIAMS COMPANY

EHS Support consider it done

Figure 4-1

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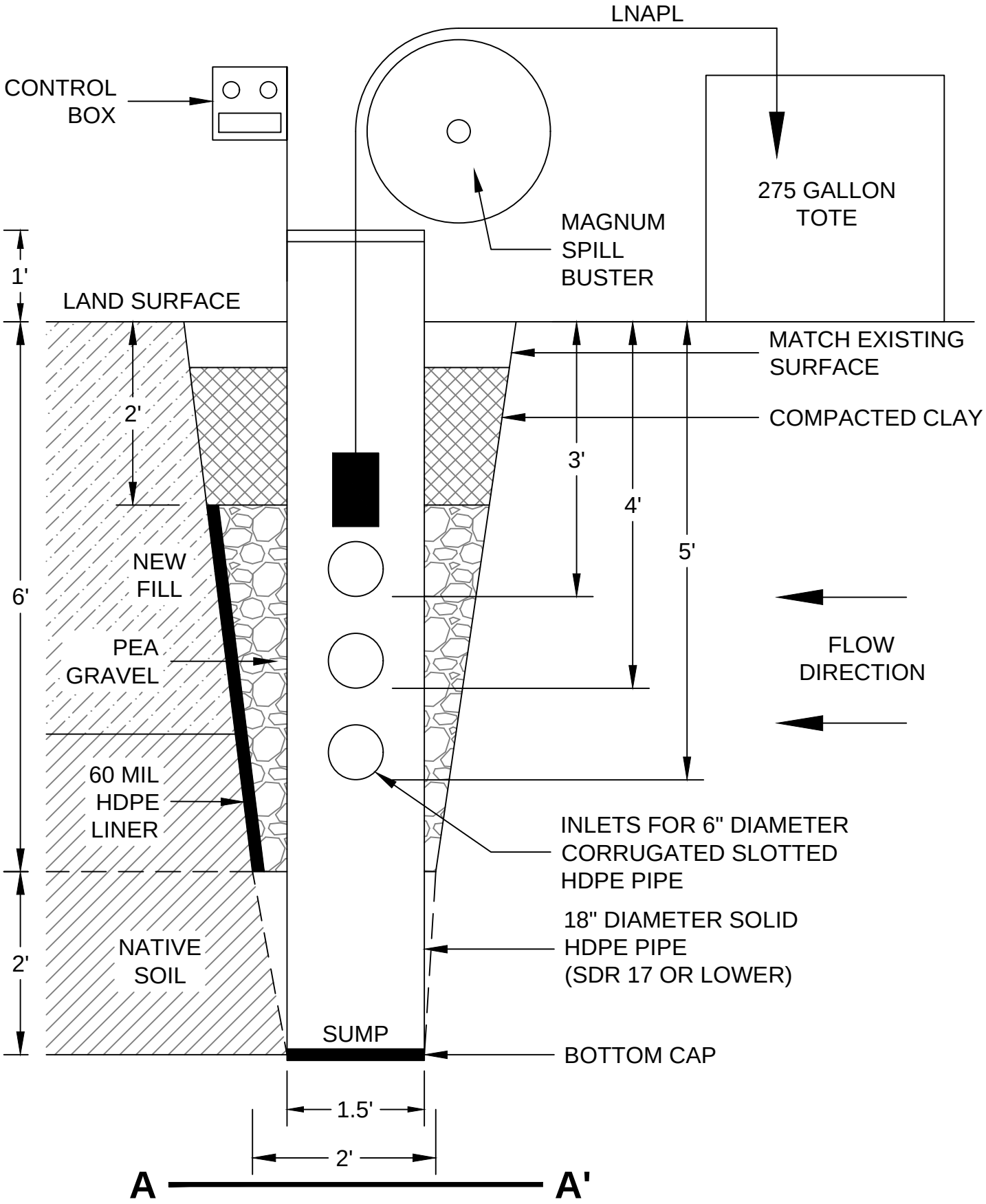
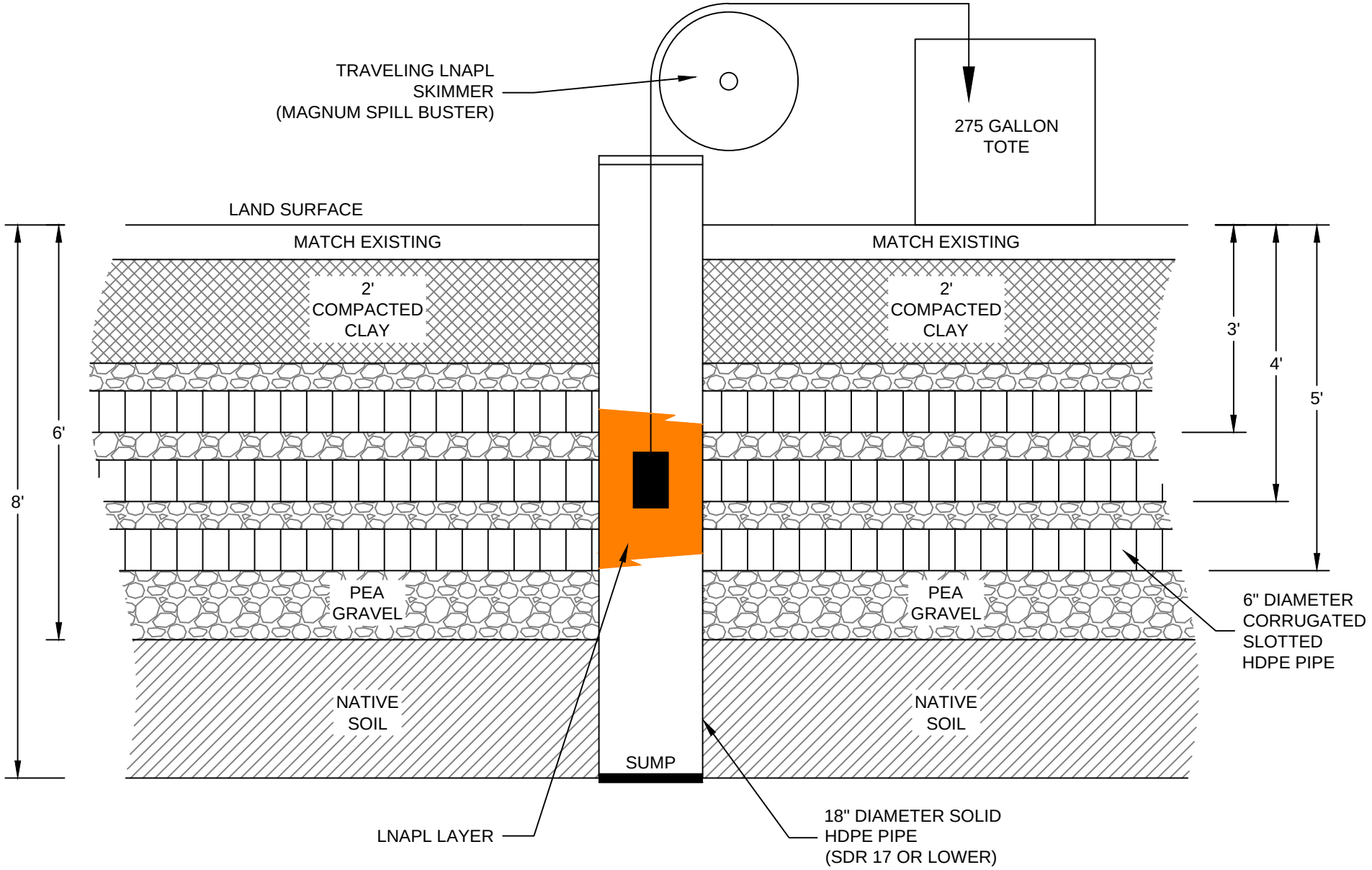
TYPICAL LNAPL RECOVERY TRENCH SCHEMATIC



EHS Support consider it done	FORMER MANUFACTURING PLANT FEASABILITY STUDY THE SHERWIN-WILLIAMS COMPANY	**FIGURE 4-2** CONCEPTUAL TRENCH SECTION 1-A - A' FS LNAPL ALTERNATIVE 4 EXCAVATION AND INSTITUTIONAL CONTROLS	Drawn By: MDO	Date Drawn: 04/2018
			Reviewed By: WH	Date Reviewed: 04/2018
			Scale: - NTS -	Plot Date: 04/2018
			Project Number.:	

TYPICAL LNAPL RECOVERY TRENCH SCHEMATIC B-B'



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Rev.		By:	Date:

FORMER MANUFACTURING PLANT
FEASABILITY STUDY
THE SHERWIN-WILLIAMS COMPANY

FIGURE 4-3
CONCEPTUAL TRENCH SECTION B - B'
FS LNAPL ALTERNATIVE 4
EXCAVATION AND INSTITUTIONAL CONTROLS

Drawn By:	MDO	Date Drawn:	04/2018
Reviewed By:	WH	Date Reviewed:	04/2018
Scale:	- NTS -	Plot Date:	04/2018
Project Number.:			

Sherwin-Williams Gibbsboro
Conceptual Off-Property Remedy
Feasibility Study LNAPL Alternative EOP 2

Conceptual Approach

Sherwin Williams has assessed the biogeochemical conditions within the Former Manufacturing Plant (FMP) and Eastern Off-Property Area, and has determined that the LNAPL is undergoing Natural Source Zone Depletion (NSZD) via several mechanisms, including anaerobic biodegradation. It was also concluded that the biodegradation processes were limited by the depletion of key nutrients. A combination of sulfate reduction and methanogenesis was identified as the predominant processes that could be augmented through the addition of electron acceptors (sulfate), nutrients.

Peripheral to the main area of study (Area 1 – former Resin Plant/Tank Farm A and the Seep Area south of Foster Ave), are three other areas where LNAPL is present:

- Foster Avenue – immediately south and downgradient of the former resin Plant/Tank Farm A Area
- US Avenue – located east and side gradient of the former Tank Farm A Area
- The Eastern Off-Property Area, consisting of the former tavern/service station and six residential properties.

The biogeochemical conditions in these areas will be the subject of supplemental investigations. However, it is reasonable to assume, given the proximity of these areas the former Resin Plant/Tank Farm A Area, conditions will the similar. Based on the interpreted extent of residual LNAPL in the Eastern Off-Property Area, it is reasonable to assume that reducing conditions are present and the LNAPL is undergoing similar NSZD processes to those documented for the former Resin Plant/Tank Farm A Area.

However, the LNAPL thicknesses in the Eastern Off-Property Area are generally less than those in the former Resin Lant/Tanl Farm A Area (supported by historical investigations) and there are extensive unpaved areas across the Eastern Off-Property Area. This supports a conclusion, supported by the available soil gas data, that the accumulation of methane observed in the former Resin Plant/Tank Farm A Area will not be observed in the Eastern Off-Property Area. The absence of impermeable surfaces supports an oxygenated unsaturated zone, and methane rapidly biodegrades in the presence of oxygen.

Also uncertain is the state of biogeochemical conditions in the areas where methanogeneic hydrocarbon degradation is identified to occur and the limitations on biological activity. Based on the age of the release and the reatively slow groundwater velocities in shallow groundwater, it is predicted that the site is in long-term stationary phase where the hydrocarbon degradation rate is limited by lack of fertilizer-like essential nutrients and/or electron acceptors.

In the context of the uncertainties identified above, Alternative EOP 2 will be conducted in a phased manner:

1. Phase 1 – A Pre-Design Investigation (PDI) to better refine conditions at the Eastern Off-Property Area. The PDI will evaluate:
    a. Depth and vertical interval of LNAPL impacts in all treatment areas.
    b. Biogeochemical conditions and associated controls/limitations on biological activity.
    c. Amendment chemistry required to stimulate biological activity.
    d. The radius of influence of injection wells and the need to implement contingency direct push locations.
2. Phase 2 – Review of the PDI information to determine the nature of amendments required, the delivery mechanics, and the need for, and configuration of, any soil vapor extraction activities.
3. Phase 3 – Detailed design of the remedy incorporating the information from Phases 1 and 2.
4. Phase 4 – Construction and operation of the biological treatment system and, if needed, the soil gas removal system.

For the purposes of developing a conceptual alternative for the purposes of the Feasibility Study, Alternative EOP 2 will:

- Enhance physical removal of LNAPL, and prevent vapor intrusion of soil gas into indoor air, by physical extraction of soil gas in the areas of higher LNAPL saturation (along US Avenue and the former tavern/service station).
- Enhance existing biological LNAPL depletion processes in the subsurface by extracting soil gas and injecting nutrients and/or electron acceptors, such as fertilizer-like ingredients sulfate, nitrogen, and phosphorous, into the subsurface.

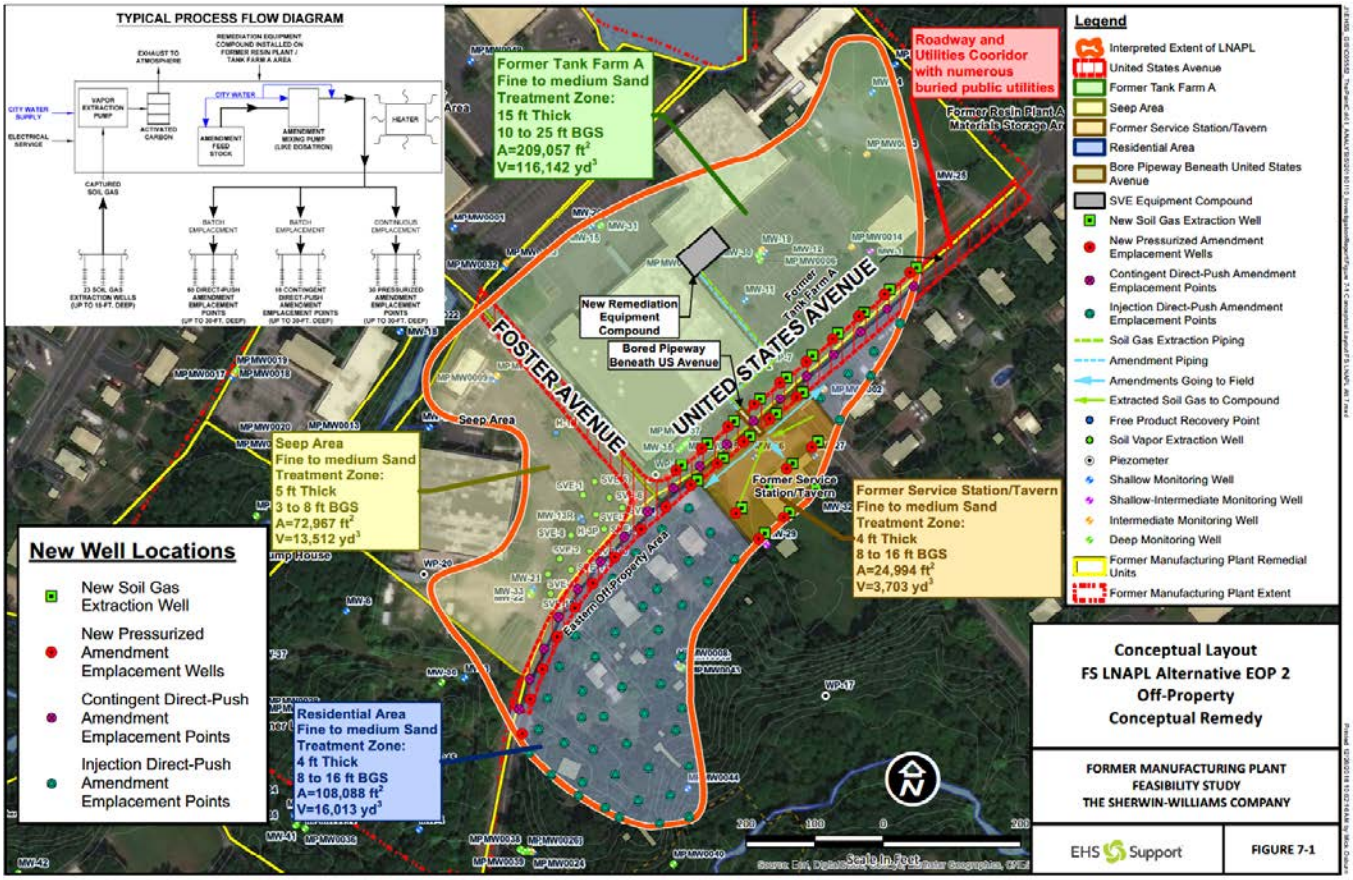
The basic concepts of the remedial approach for Alternative EOP 2 includes:

- Injecting nutrients and amendments on the west side of U.S. Avenue under high pressure to facilitate lateral transport of reagents under United States Avenue.
- Physical injection of bioremediation reagents on the eastern side of US Avenue and the former Service Station/Tavern site using pressurized injection wells, which will maximize the lateral spread of reagents to facilitate transport of reagents under US Avenue and downgradient to the residential area.
- Use of direct injection approaches (without establishing underground piping with associated trenching) to deliver reagents in the residential area with minimal disturbance to landholders.
- Inclusion of contingency direct-push injection locations in US Avenue in the event that pressurized amendment emplacement wells on either side of US Avenue are insufficient to support effective transfer of reagents and treatment of hydrocarbon mass.
- Continuous or periodic extraction of soil gas in areas where soil gas or biogenic methane gas production is observed. For purposes of this FS, extraction wells will be installed on the western side of US Avenue, eastern side of US Avenue, and on the former Service

Station/Tavern property. These are the areas where LNAPL saturations are highest and methane generation is most likely to occur.

On the basis of these key components of the remedy**, Figure 7-1** provides a Conceptual Layout of the remedial alternative. This figure shows the concept type, number, and placement of remediation wells, which include:

- Twenty three new soil gas extraction wells (serving also as bioremediation amendment emplacement wells):
  - On the former tavern/service station
  - In the easement along United States Avenue
- Thirty new pressurized injection wells:
  - In the former tavern/service station
  - In the easement along United States Avenue
- Fifty direct-push injection points in the area south of the former tavern/service station
  - At least two rounds of injections
- Eighteen contingent direct-push injection points within United States Avenue
  - Need for will be evaluated based on monitoring results



Further discussion on the individual components is provided in the section below.

Soil Gas Extraction Component of Remedy

Soil gas extraction along U.S. Avenue and on the former tavern/service station is included as a component of Alternative EOP 2 to mitigate potential risks associated with the potential accumulation of hydrocarbons and methane as a result of the enhancement of the biodegradation of the LNAPL. As stated previously, the combination of lower LNAPL saturations, the depth to groundwater, and oxic conditions in the vadose zone (the majority of the area is unpaved allow the entry of oxygen into the subsurface) on the Eastern Off-Property Area limits the potential for biogenic gas buildup and the need for soil vapor extraction.

However, the rate of methane generation or formation of other soil gas will not be known until the biostimulation occurs, so a soil gas extraction system will be installed in the unsaturated zone to prevent migration of hydrocarbon gases into buildings and prevent lateral migration of soil gases towards sensitive receptors by way of buried utilities corridor along United States Avenue.

A soil gas extraction blower located on the former Resin PlantTank Farm A Area will be used to extract gases from the subsurface. This location is chosen to remove the noise source (the blower) away from residents to minimize nusance. As discussed for the biostimulation component, piping would be run beneath U.S. Avenue to connect the extraction wells on the east side of U.S. Avenue to the blower. For purposes of the FS cost estimate, it is assumed that vapor phase activated carbon will be used to treat the off-gas from the soil gas extraction system. This will be evaluated in the design.

The design will also evaluate continuous or periodic soil gas extraction. One advantage of continuous soil gas extraction compared to periodic soil gas extraction is that it may promote aerobic biodegradation of some hydrocarbons in the capillary fringe above the water table. The likely end product is biogenic carbon dioxide gas.

However, continuous soil gas extraction will result in noise throughout the night and may disturb adjacent residents. Periodic soil gas extraction is considered as equally protective, preventing the excess accumulation of methane that may pose a risk to sensitive receptors, but by not operating at night it avoids the main concern (noise) associated with continuous operations.

Additionally, continuous operation could convert the current methanogenic hydrocarbon biodegradation regime to an aerobic degradation regime. The old paradigm that aerobic hydrocarbon biodegradation rates are much-much higher than their anaerobic counterparts, including methanogenesis, is increasingly changing to a paradigm that recognizes that each individual hydrocarbon has its own set of preferential microbial degraders; some aerobic, some anaerobic, and even some synergistic aerobic/anaerobic cooperation. Thus, alternating site conditions in and above the LNAPL smear zone between aerobic and anaerobic states in order to inspire natural or enhanced cycling through all of major hydrocarbon degradation pathways, may be most effective.

Bioremediation Amendment Component of Remedy

The addition of amendments to the subsurface will be achieved through injection of city water containing nutrients and amendments. Selection of amendment type will be based on results of the Phase 1 pilot testing and post-implementation monitoring. These amendments will be delivered to the subsurface through:

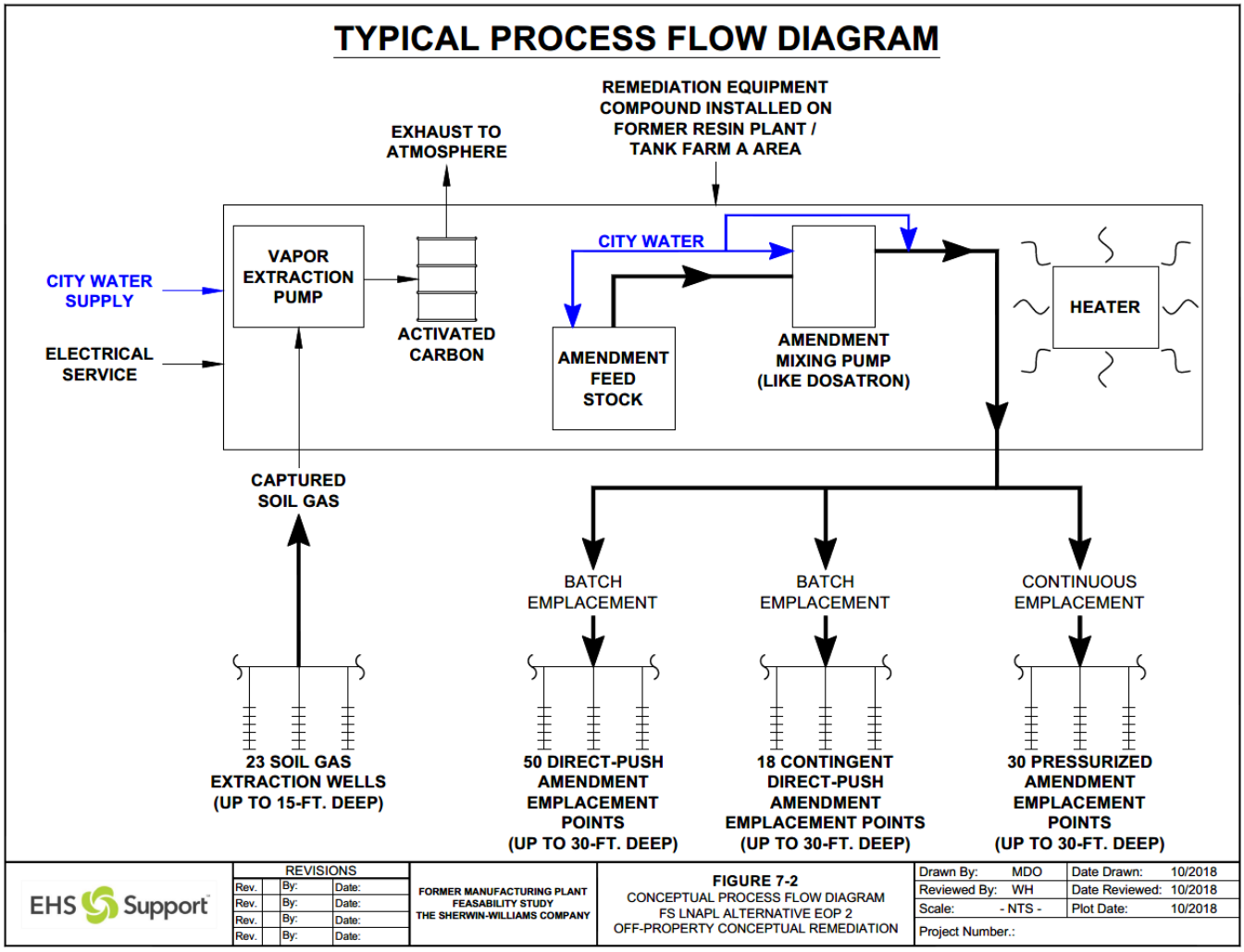
1) A network of shallow (up to 15 feet deep) soil gas extraction wells along US Avenue and on the former Service Station/Tavern property, which will be temporarily repurposed from soil gas extraction to amendment emplacement wells.
2) A network of shallow pressurized amendment injection wells (up to 30 feet deep but in most cases less than 20 feet), which will be used to inject amendments and maximize the radius of influence
3) Direct-push injection points in the off-property residential areas (designed to minimize disturbance to residents) and contingency locations within US Avenue.

To support the remedy, it is anticipated that piping will be installed under US Avenue from the treatment syst em located on the former Resin Plant/Service Station Area to the former tavern/service station property. Additional injection wells will be installed on the west side of US Avenue to improve reagent delivery and treatment under US Avenue.

Key work tasks be completed prior to design and installation of the system include:

1. Complete the PDI.
2. Complete bench and/or pilot testing to determine the actual optimum number and type of wells or direct-push points, and optimal type and dosing for bioremediation amendments.
3. Obtain a discharge to groundwater permit-by-rule equivalency from NJDEP for the proposed activities (in combination with work planned for Area 1).
4. Assess air emissions and potential permit requirements.

The simplified process flow diagram is shown below as **Figure 7-2 –** Typical Conceptual Process Flow Diagram.



Major Elements

Pricing of this alternative assumes the following major elements apply:

- Completion of a pilot test for soil gas extraction and bioremediation amendment injection.
- Preparation and submission of permit applications to NJDEP for chemical injection and potential air emissions.
- Construction of a treatment system on the former Resin Plant/Tank Farm A Area. It is assumed that electricity is readily available in this area.
- Installing piping beneath U.S. Avenue to connect the treatment system with the former tavern/service station.
- Construction of wells and conveyance piping in the former tavern/service station.
- Nutrient/amendment injection at the former tavern/service station of one (1) treatment zone pore volume per year (27,000 ft^3/year = 200,000 gallons/year), given bulk treatment zone volume of 100,000 ft^3 and a porosity of 0.27, which comes to a continuous application rate of 0.4 gpm.
- Two aqueous bioremediation amendment emplacement events in the residential area through 50 individual direct-push anmendment emplacement points is one-tenth (0.1) treatment zone pore

volume per injection event, given bulk treatment zone volume of 2,000 ft^3/injection point and a porosity of 0.27 (pore volume 540 ft^3/injection point), which comes to a direct-push emplacement rate of 400 gallons/point/event or 20,000 gallons/event.

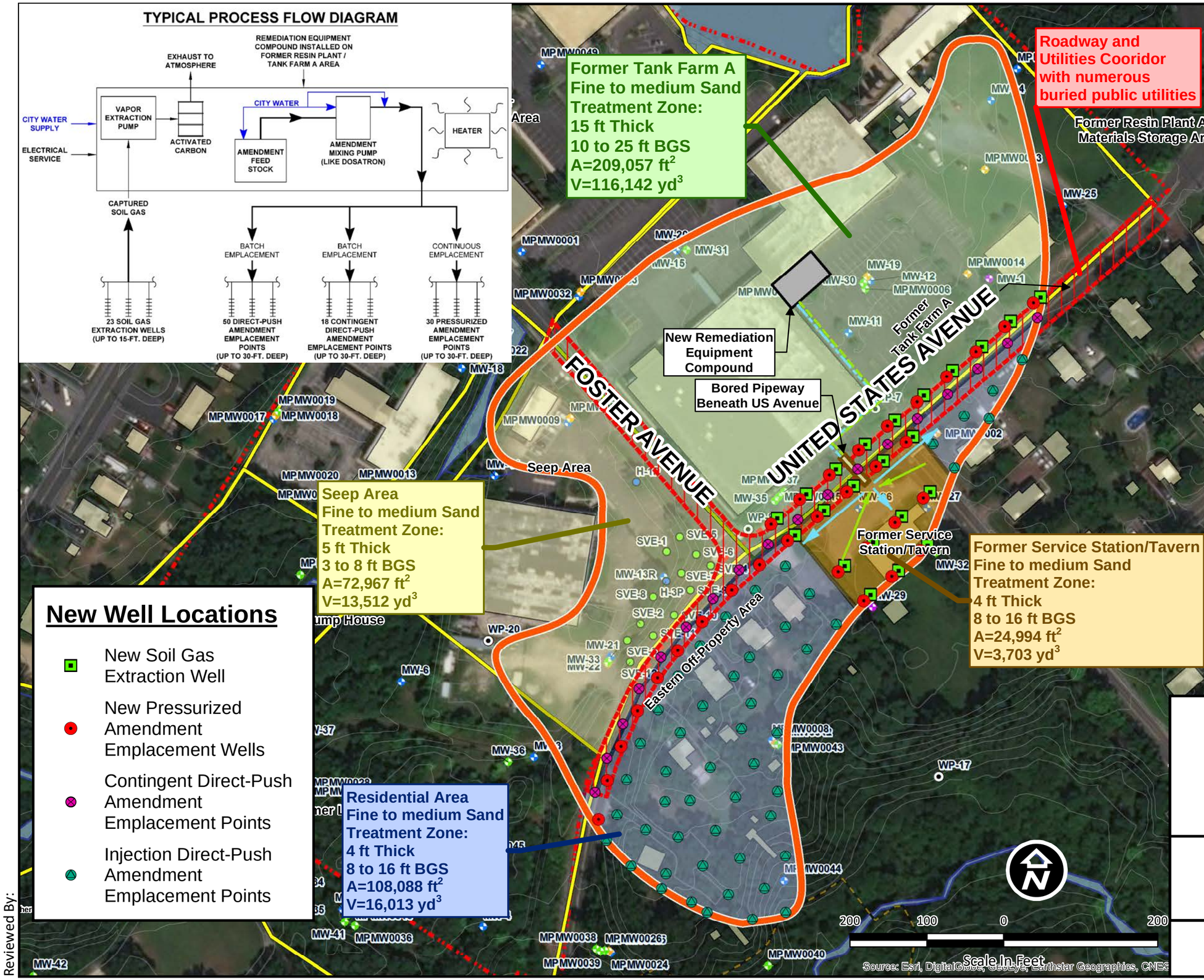
- Installation of approximately 23 new 4-inch diameter (maximum depth 15-foot deep) PVC soil gas extraction wells.
- Installation of approximately 30 new 2-inch diameter (maximum depth 30-foot deep) PVC pressurized amendment emplacement wells.
- Pressure for the injection of reagents into the pressurized emplacement wells will be provided by mains water pressure with injections pulsed into individual wells.
- Two (2) contingent direct-push bioremediation amendment emplacement events involving 18 direct-push points in US Avenue.
- The nominal 50-foot spacing of the wells and direct-push points reflects the groundwater seepage velocities of 10 to 30 feet per year and the anticipated head of injection that will allow reagents to migrate 30 to 50 feet in a year.
- Excavation of approximately 2,000 lineal feet of buried pipe trenches and:
    - 1,500 lineal feet of 4-inch diameter LDPE soil gas conveyance pipe.
    - 2,000 lineal feet of 1-inch diameter LDPE bioremediation amendment conveyance pipe.
- Installation of direct-push amendment emplacement points assume:
    - The two (2) direct-push injection events in the residential area will be separated by 5 years.
    - Evaluation of groundwater data in and around US Avenue to determine if contingency direct push amendments need to be completed
    - Assume production rate 5 points per day (a two-week duration of work for Area 4B)
- A 115/230-volt electrical service (200-amp minimum) to the treatment building.
- A municipal water service capable of providing 10 gpm supply.
- Internet service to support the PLC and enable automated monitoring and control of equipment.
- Provision of a 500-scfm soil gas extraction blower (captured water to be recycled for makeup of bioremediation amendments), which will apply a minimum of 20 inches of water vacuum at wellheads.
- A PLC and controller system for automated delivery of water and reagents to the bioremediation amendment emplacement wells.
- Bioremediation amendment mixing and pumping assembly.
- Twin 200-lb vapor phase activated carbon systems for treatment of extracted soil gas prior to discharge to atmosphere. Biogenic methane and carbon dioxide will be vented to atmosphere.
- Six (6) new (up to 15-foot deep) multi-level soil gas monitoring probes; four (4) contiguous to United States Avenue, one in the former tavern/service station, and one in the residential area.

Operation and Maintenance

It is assumed for the purposes of costing that:

- Operating period will be ten (10) years from construction and commissioning of systems. It is expected that the system will only need to operate for seven years, but an additional three years have been added to the cost estimate as a contingency.
- O&M activities of the bioremediation amendment emplacement system will comprise weekly system inspections and automated monitoring of system functions, including water flow rates and injected pressures, volumes injected into individual wells and nutrient lines, and amounts of nutrients used and available.

- O&M activities on the soil gas extraction system will comprise weekly maintenance on the extraction blower, and field measurement of vapor phase carbon influent and effluent gas concentrations with organic vapor analyzer (for VOCs and landfill gas monitor (for methane and CO_2).
- Field monitoring will be conducted in soil gas probes to assess concentrations of VOCs, methane and carbon dioxide to determine presence of biological activity and effectiveness of soil gas extraction systems. Soil gas monitoring will be conducted monthly for the first year, quarterly for the next 2 years, semiannually for the next 2 years, and annually thereafter for 5 years.
- Samples will be collected from seven (7) existing groundwater monitoring wells and analyzed for VOCs, field measured analytes (dissolved oxygen, ORP, pH, and temperature), geochemical analytes (nitrate/nitrite, dissolved iron, sulfate), non-toxic biogenic analytes (dissolved methane and CO_2), and nutrients (TKN and P) quarterly for two years and semi-annual thereafter until the termination of remediation activities.
- Electricity costs $0.12/kWh.
- Water costs $2/1,000 gallons ($1,000/year at 4,000,000 gallons per year).
- Operation, maintenance, and performance sample collection labor costs $65/hour.
- Operation and maintenance labor utilization is 1 man-day per week.
- Performance monitoring labor utilization is 1 man-hour per sample.
- Non-hazardous activated carbon exchange rate is four (4) 200-lb drums per year.
- Assume that bioremediation amendments will be fertilizer-like nutrients, and that the fertigant material utilization rate is 4 pounds (dw) commodity potassium sulfate per day and 1 pound (dw) of commodity diammonium phosphate per day.
- Let potassium sulfate cost $1/pound (dw), delivered.
- Let diammonium phosphate cost $2/pound (dw), delivered.
- There is no salvage value of equipment at end of operating period.



Conceptual Layout
FS LNAPL Alternative EOP 2
Off-Property
Conceptual Remedy

FORMER MANUFACTURING PLANT
FEASIBILITY STUDY
THE SHERWIN-WILLIAMS COMPANY

EHS Support

FIGURE 7-1

Reviewed By:

J:\EHSS_GIS\C05552_ThePaintCo\01_ANALYSIS\20180110_InvestigationReport\Figure 7-1 Conceptual Layout FS LNAPL Alt 7.mxd

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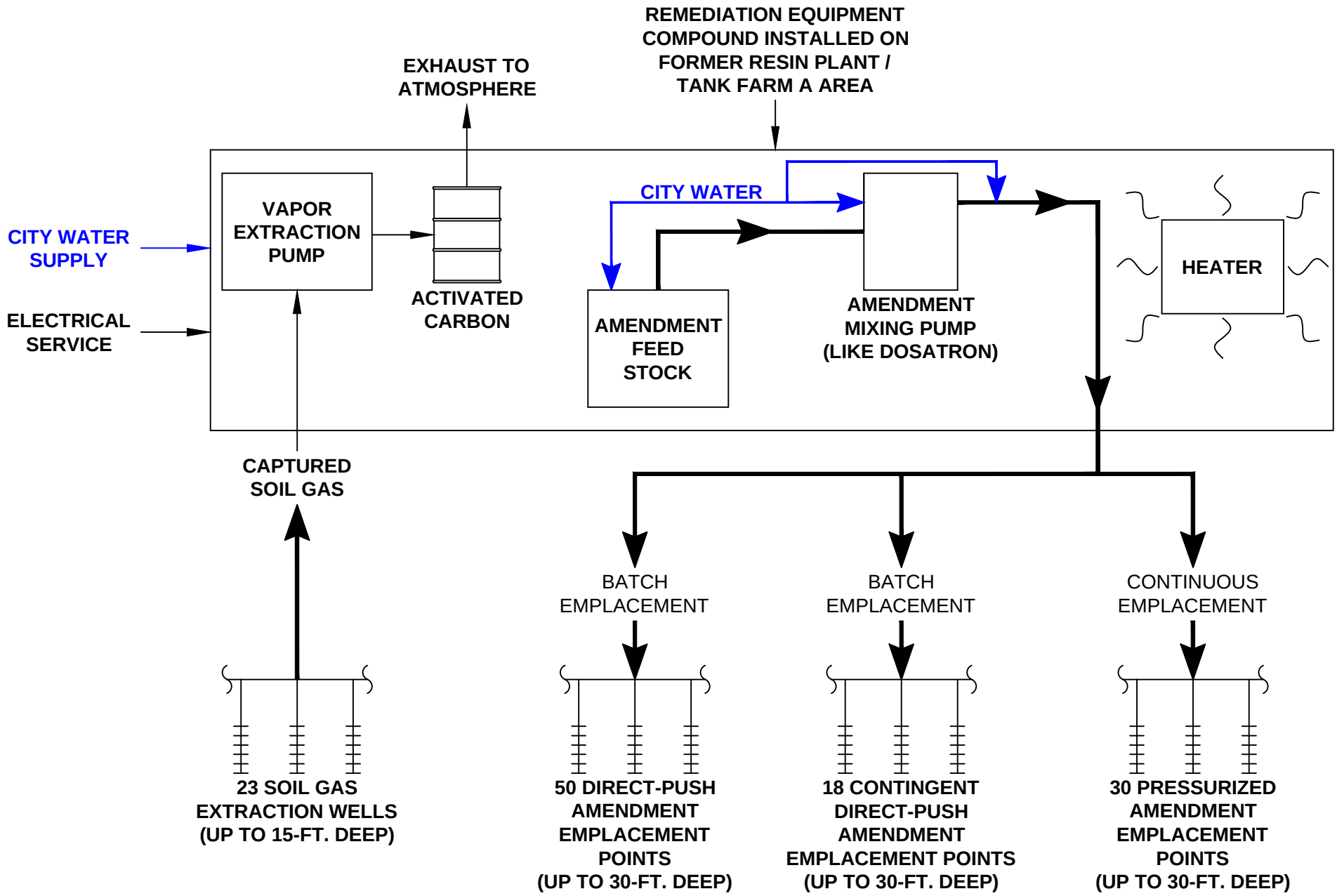
TYPICAL PROCESS FLOW DIAGRAM



EHS Support

REVISIONS			
Rev.		By:	Date:
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Rev.		By:	Date:

FORMER MANUFACTURING PLANT
FEASABILITY STUDY
THE SHERWIN-WILLIAMS COMPANY

FIGURE 7-2
CONCEPTUAL PROCESS FLOW DIAGRAM
FS LNAPL ALTERNATIVE EOP 2
OFF-PROPERTY CONCEPTUAL REMEDIATION

Drawn By:	MDO	Date Drawn:	10/2018
Reviewed By:	WH	Date Reviewed:	10/2018
Scale:	- NTS -	Plot Date:	10/2018
Project Number.:			