Alcoa

Alcoa Corporation

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December 16, 2020

962944

Mr. Dion Novak
Remedial Project Manager
United States Environmental Protection Agency, Region V
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Re: Transmittal
Pre-Design Investigation Work Plan (Revised)
Operable Unit No. 2
North Alcoa Site, East St. Louis, Illinois

Dear Mr. Novak:

Please find a revised version of the Pre-Design Investigation Work Plan for the OU2 residential properties along Louisiana Blvd. The document submitted in November has been revised per recent email correspondence that included Agency conditional approval dated December 14, 2020. We will keep you apprised of progress to gain access.

Sincerely,

Ronald M. Morosky
Director, Corp. Remediation

Enc.

cc w/ enc.:

Michael Wagner, Clayborne and Wagner
Charlene Falco, Illinois EPA
Tom Miller, Illinois EPA (Collinsville)
Dan Forlastro, Tetra Tech, Inc.

TETRA TECH

Pre-Design Investigation Work Plan

Operable Unit No. 2
North Alcoa Site
East St. Louis, Illinois

December 2020

Pre-Design Investigation Work Plan

Operable Unit No. 2
North Alcoa Site
East St. Louis, Illinois

Submitted By:

Alcoa Corporation

and

City of East St. Louis

Prepared by:

TETRA TECH

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Tetra Tech Project No. 212IC-AU-00038

December 2020

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1.0 INTRODUCTION

This Pre-Design Investigation Work Plan (PDIWP) has been prepared on behalf of the Respondents Alcoa Corporation (Alcoa) and the City of East St. Louis (City) for Operable Unit 2 (OU-2) of the North Alcoa Site located in East St. Louis, Illinois (Figure 1-1). Alcoa and the City will enter into a Consent Decree (CD) with the U.S. EPA for OU-2 remedial design (RD) and remedial action (RA). Prior to entering into the CD for RD/RA, Alcoa and the City conducted remedial investigation activities and prepared a Focused Feasibility Study (FFS) Report (Alcoa, 2019) for OU-2 that summarized the investigation results and presented remedy options. U.S. EPA used information in the FFS Report to develop a Record of Decision (ROD) for OU-2 that detailed the selected OU-2 remedy. After review of the ROD remedy, it was determined that data gaps remain for residential properties along Louisiana Boulevard (Investigative Block 5a) that will be addressed via this PDIWP.

2.0 REMEDY DESCRIPTION AND PREVIOUS INVESTIGATION SUMMARY

The OU-2 ROD remedy description includes the following components:

- Site clearing and preparation;
- Excavation of no less than 2 feet of bauxite waste material/soil from designated OU-2 parcels with consolidation on the OU-1 parcel designated as Investigative Block 4a (IB-4a);
- Construction of a minimum 2-foot soil cover that complies with solid waste landfill requirements over the OU-2 parcel excavation areas and the IB-4a bauxite waste material consolidation area;
- Maintain and reassess existing surface stormwater run-off controls on OU1 and construct on OU-1 and OU-2 additional stormwater run-off engineering controls as necessary to contain and control on Site the volume of on-Site precipitation from a 100-year stormwater event;
- Site restoration and revegetation;
- Recording of appropriate institutional controls (ICs) on the Site parcels; and
- Monitoring of previously sampled IB-5a residences to determine if EPA action levels for indoor radon are exceeded; construction and operation of a radon mitigation system to reduce the levels of radon below EPA action standards in residences where radon standard is exceeded.

In addition, the remedy description includes, “The OU-2 remedy also selects excavating and removing the full volume (referred to as “to depth”) of bauxite waste and contaminated soil from OU-2 residential parcels in IB-5a, depending on accessibility, constructability, and risk to the structural integrity of improvements at the OU2 residential parcels.”

Figure 2-1 shows the OU-2 parcels with investigative block designations that are subject to the ROD remedy.

Based on the remedy review, the following data gaps have been identified:

- Extent of bauxite residue on IB-5a residential properties has not been fully characterized.
- Radon testing of the IB-5a residences to confirm the results of the previous testing.

2.1 Previous Investigation Summary

Previous investigation activities focused on delineating the areal extent of bauxite residue on OU-2 parcels with the understanding that the remedy would only require removal of a minimum of two feet of bauxite residue/soil. Figure 2-2 provides the investigation summary, showing the affected parcels, investigation boring locations and extent of residue. The selected remedy now includes, to the extent possible, removing bauxite residue to depth on the IB-5a residential properties. Previous investigations did not fully characterize the depth of the bauxite residue on the residential properties; therefore, the PDI includes additional borings that will be advanced to further delineate the depth of bauxite residue. Complete delineation will be dependent upon gaining access and the ability to conduct the investigation without adversely affecting the structures and improvements on the properties.

PDI activities will further define the full nature and extent (lateral and vertical) of residue on the affected residential properties. Step-in or step-out borings are not likely but may be included in the scope as needed with the exception that boring locations will not be located in the vicinity of structures if it is believed that damage to the structure could result. The PDI data will be used during the Remedial Design and discussed with the property owner to develop the final residue removal methodology for the OU2 remedy.

2.2 Radon Investigation

Radon gas testing was conducted at the IB-5a residential properties in 2016. Radon concentrations were measured at four residences within the IB-5a area in accordance with the requirements of Illinois Administrative Code (IAC) Title 32 Part 422 Regulations for Radon Service Providers. Measurements were conducted and supervised by an Illinois Radon Professional and locations were tested according to 32 IAC 422.130, which requires measurements be made in the lowest structural area suitable for occupancy.

The four residences tested showed radon concentrations in living spaces less than the EPA action level of 4 pCi/L. The test results at one of the locations in an unfinished basement was 5.2 pCi/L. This is the average concentration measured by the Continuous Radon Monitor (CRM) and the average of the 2 E-Perms deployed in the basement, which is not currently being used as a living space. The homeowner where the radon level was measured at 5.2 pCi/L was offered a radon mitigation unit and declined. Assuming access, the PDI includes a second monitoring event to confirm the results of the initial investigation conducted in 2016.

3.0 PDI SCOPE OF WORK

The description of field work and methods of documentation are described for each PDI activity in the sections below.

Adjustments may be made to the PDI activities, e.g., boring locations, as warranted by the field engineer/geologist to accommodate conditions encountered during the work. The five properties and their current condition are:

- [redacted] [redacted] vacant home
- [redacted] [redacted] vacant property
- [redacted] [redacted] occupied home
- [redacted] [redacted] occupied home
- [redacted] [redacted] vacant home

The PDI field activities will be conducted in accordance with established SOPs within the effective Field Sampling Plan (FSP) for the site. Appendix B contains the SOPs from the FSP for reference.

3.1 Soil Borings

Borings will be advanced to the base of bauxite residue and will continue for up to two additional feet to confirm the residue depth; total depths will likely range from 10 to 20 feet bgs.

Soil borings will be advanced using direct push drilling techniques to minimize the generation of investigation derived waste (IDW) soil. A minimum 1.5-inch inside diameter continuous boring will be advanced from the ground surface to the total depth as determined by field conditions. Soil cores will be logged continuously. The field geologist will log the soil characteristics of each core along with any other pertinent information, e.g., the presence of water.

Figures 3-1 through 3-5 provide proposed boring locations for each individual residential property. Property boundaries shown on Figures 3-1 through 3-5 were obtained from the online St. Clair County Assessor GIS Parcel Map.

After the investigation on each property is completed, equipment will be cleaned to remove loose soil debris. Soil cores, debris, and any cleaning fluids (IDW) will be appropriately containerized in sealed containers to prevent access to the materials and relocated to inside the OU-1 security fence for proper handling and disposal during the RA. All soil borings will be plugged with a cement/bentonite grout mixture. Figure 3-6 shows the location on OU1 where the IDW will be staged.

Disposable equipment including acetate liners from the direct push methods will be gathered in heavy duty garbage bags and disposed in a designated solid waste disposal container. General trash including personal protective equipment (PPE), e.g., disposal gloves and coveralls, and plastic ground and equipment covers will be gathered in heavy duty garbage bags and disposed in a designated solid waste disposal container.

A final cleaning of equipment will occur upon project completion as follows:

- Potable water rinse;
- Phosphate-free detergent wash;
- De-ionized (DI) or distilled water rinse; and

- Air dry.

The final cleaning will be conducted at a decontamination area established at OU1. The decontamination area will be constructed from materials, e.g., plastic sheeting, tubs, etc., that will allow collection and containerization of the decontamination fluids and removed materials. The decontamination fluids and materials will be placed in sealed containers and located at the staging area for disposition during the RA. Figure 3-6 shows the decontamination area location.

At a minimum, disturbance to a property will be restored to the condition that existed prior to the work. This includes replacement in kind; therefore, vegetation will be replaced by like vegetation, gravel with gravel, etc. Should a fence, gate, tree, etc. be disturbed, it will be repaired or replaced.

3.2 Field Documentation

Field data will be recorded on standard forms. Field data primarily will be direct observations and measurements. The data will be tabulated and included in the PDI Report.

Soil boring logs will be documented for all borings. Borings will be continuously sampled for lithologic purposes and logged for the entire depth of the boring. The lithologic description of the log will include soil type, color, grain size, texture, hardness, degree of induration, calcareous content, indications of contamination, and other pertinent information. Soil type will be described using the Unified Soil Classification System (ASTM D 2488-00).

3.3 Photographic Documentation

The field engineer/geologist will take photographs that are representative of field sampling activities and locations. Digital images will be retained electronically with the project files. Photographs of the residential properties and associated structures and improvements will be obtained prior to initiating the work and following work completion and any required restoration.

3.4 Radon Monitoring

A radon monitoring event will be conducted at occupied residential properties with owners who have agreed to allow the testing to occur and at properties which have access agreements in place. Radon sampling will be performed in accordance with the requirements of Illinois Title 32 Part 22 Regulations for Radon Service Providers. Structural foundation information will be documented and/or confirmed in the report.

Appendix A presents the Residential Radon Sampling Plan.

4.0 DELIVERABLES

A PDI Report will be prepared that summarizes the results from the investigation activities. Revised drawings for the IB-5a residential properties will be developed that show the areal extent and depth of residue for each property. Boring logs and photographs documenting the work will be included in the Report.

Radon monitoring results will be presented similar to the report provided after the 2016 monitoring event.

Limitations will be identified where applicable should structures or other improvements on the residential properties prevent complete extent and depth of residue delineation. Data from the PDI will be incorporated into the OU-2 RD.

5.0 PRE-DESIGN INVESTIGATION SCHEDULE

The PDI will be implemented in accordance with the overall schedule for RD/RA submitted to U.S. EPA. It is expected that a draft of the PDI Report will be submitted 60 days from initiation of the field activities for Agency review. This expectation assumes that access agreements for all affected properties are in place at the start of the work, one mobilization is required, and the homeowners grant access to the interior of the residences for radon monitoring. Schedule revisions will be communicated to USEPA and IEPA as necessary.

6.0 REFERENCES

Alcoa Inc. and the City of East St. Louis, 2003. Remedial Investigation and Feasibility Study Work Plan, Field Sampling Plan, North Alcoa Site, East St. Louis, Illinois. July 24.

———, 2005. Draft Remedial Investigation Report. Alcoa Former East St. Louis Operations, East St. Louis, Illinois. February 22.

———, 2019. Revised Focused Feasibility Study, Operable Unit No.2, North Alcoa Site, East St. Louis, Illinois. October 14.

United States Environmental Protection Agency (USEPA), 2020. Record of Decision, Operable Unit 2, North Alcoa (Alcoa Properties) Superfund Alternative Site. June 26.

FIGURES

Figures 2-2 through 3-4 redacted for privacy

Explanation

- ☐ Operable Unit No. 1 (OU-1)
- ▨ Operable Unit No. 2 Boundary
- 🟥 Site Boundary

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NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

SITE MAP

Project No.: 212IC-AU-00038
Date: OCTOBER 28, 2020
Designed By: CML

Figure No.
1-1

Document Path: D:\ESL\PDIWP\Figure 1-1 Site Map.mxd

Investigative Block	Remedial Investigation Description (See Text)
1a	RDA1
1b	RDA2
1c	RDA3
2	Gypsum Dike Areas
3a	Brick Works/Childs Property
3b	Redevelopment Area
3c	SPL Stockpile Area
4a	North Wet Area
4b	Triangle Wet Area
4c	Balls Fields
4d	Berm Wet Area
4e	Active Commercial Area
5a	Residential Properties
6a	Former US Steel Drum Site

Explanation

☐ Operable Unit No. 1 (OU-1)
▨ Operable Unit No. 2 Boundary
☐ Investigative Blocks
🟥 Site Boundary

Note:
Boundary of Investigative Blocks were originally set forth in the Remedial Investigation Work Plan (2003).
Several properties outside the proposed limits of Operable Unit No. 1 have changed ownership since that time.

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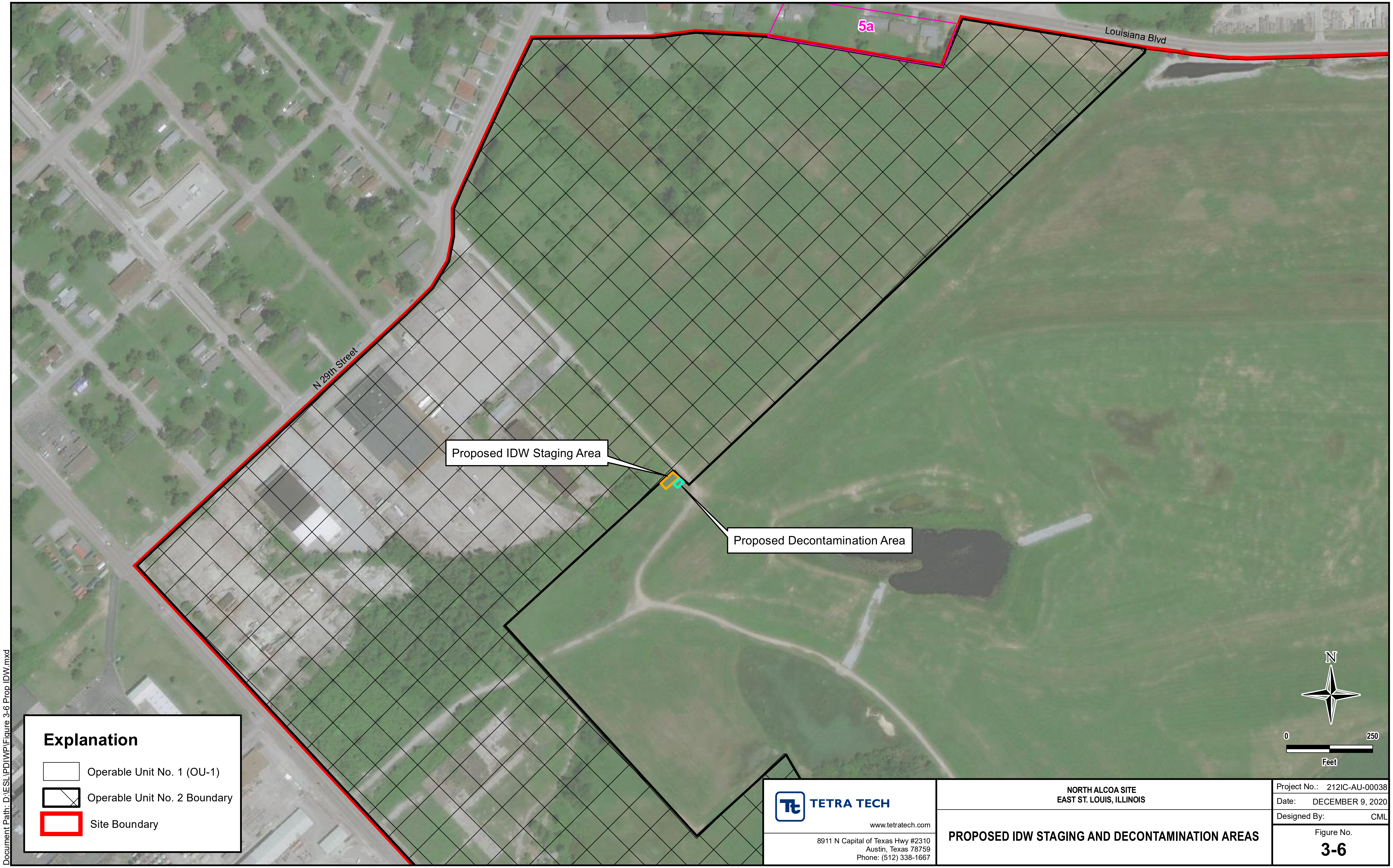
NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

INVESTIGATIVE BLOCKS

Project No.: 212IC-AU-00038
Date: NOVEMBER 3, 2020
Designed By: CML
Figure No.
2-1

Path: D:\ESL\PDIWP\Figure 2-1 Investigative Block.mxd



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NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

PROPOSED IDW STAGING AND DECONTAMINATION AREAS

Project No.: 212IC-AU-00038
Date: DECEMBER 9, 2020
Designed By: CML

Figure No.
3-6

Document Path: D:\ESL\PDIWP\Figure 3-6 Prop IDW.mxd

APPENDIX A
RESIDENTIAL RADON SAMPLING PLAN

Residential Radon Sampling Plan for Residential Properties in the Vicinity of the North Alcoa Site, East St. Louis, IL

Introduction

Subsurface bauxite residue is known to be present on the properties of some of the residences along the south side of Louisiana Boulevard adjoining the North Alcoa Site in East St. Louis, IL. Previous off-site borings indicated that the bauxite residue does not extend as far north as Louisiana Boulevard. Whether the extent of the residue continues underneath the foundations of the homes is not known. This residential radon sampling plan is designed to measure the radon concentrations in these homes and determine whether there are radon concentrations attributable to the bauxite residue present on the properties.

The purpose of this radon sampling plan is to update the data previously collected in 2016 on 4 selected properties. The selected properties are:

- [redacted]
- [redacted]
- [redacted]
- [redacted]

Background

Radon is naturally present in widely varying concentrations throughout the State of Illinois. Therefore, detection of radon in any particular residence in the Illinois is not unusual. The bauxite residue at the North Alcoa Site contains concentrations of radium-226 and radium-228 that are above background concentrations. These radium isotopes decay to form radon-222 and radon-220 (after intermediate decays) which can diffuse out of the ground. Due to its short half-life (55 seconds) radon-220 is not a significant contributor to indoor radon concentrations. This work plan is designed to:

1. Determine the residential radon concentrations in the homes along Louisiana Blvd adjacent to the North Alcoa Site.
2. Determine whether the measured residential radon concentrations are impacted by the North Alcoa Site, i.e., are greater than background.

The US EPA has a recommended maximum indoor air concentration for radon of 4 picocuries per liter (pCi)/L.

The North Alcoa Site is within zip code 62205. No other radon measurements have been collected and reported to the State of Illinois within this zip code or within 62203 or 62204. Zip code 62207 to the south has only a single measurement of 1.0 pCi/L. Zip code 62223 to the west has had 139 measurements collected with an average of 3.7 pCi/L and 35% of the measurements were in excess of 4 pCi/L. Zip code 62208 is similar with 228 measurements also with an average of 3.7 pCi/L and 34% of the measurements above 4 pCi/L.[1]

Field Sampling Plan

Radon sampling of the selected houses will be performed in accordance with the requirements of Illinois Title 32 Part 22 Regulations for Radon Service Providers. A State of Illinois licensed radon measurement professional will perform the measurements using a continuous radon monitor to collect hourly data. Measurements will be taken for a minimum of 48 hours. In addition, backup measurements and alternate locations may be sampled using passive monitors that provide only a single integrated measurement.

Illinois regulations require that the radon sampling be conducted in each of the lowest structural areas suitable for occupancy. In addition to this requirement, radon sampling shall be conducted on the most-commonly occupied level of the house, i.e., the floor containing the living room, den, and/or master bedroom even if this level is not on the lowest structural level. Houses with a single level and a single foundation type may be sampled in only one location while houses with a basement or multiple foundation types will be sampled in two locations.

Quality Assurance

The surveys will be conducted in accordance with the State of Illinois-approved Quality Assurance for the selected radon measurement professional to ensure the integrity of the data.

Data Analysis

The collected residential data will be compared to the available background data from zip codes 62208 and 62223. If available, detailed background data will be used to do a statistical comparison.

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[1] https://maps.iema.state.il.us/RADON31a/PGS/county.cfm?cnty=St.%20Clair&FIPS=17163

APPENDIX B
JULY 24, 2003 FIELD SAMPLING PLAN STANDARD OPERATING PROCEDURES

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 1

FIELD DOCUMENTATION

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol for documenting field activities. MFG field personnel shall document field activities on formatted field records and other appropriate data sheets. These formatted record and data sheets will be part of the MFG project file; all forms must be filled out carefully and completely by one of the personnel actually performing the field activities.

2.0 PROCEDURES

2.1 Daily Field Record

The MFG field representative will prepare a Daily Field Record form (Figure SOP-1-1) for each day of field work. Documentation on the multiple-page form will include:

A. Project identification;
B. Date;
C. Time on job (beginning and ending time);
D. Weather conditions;
E. Activity description;
F. List of personnel and visitors on site;
G. Safety equipment used and monitoring performed;
H. Waste storage inventory (if any);

I. Chronological record of activities and events;

J. Comments and variances from project work plan;

K. Content of telephone conversations; and

L. Signature of the MFG field representative.

The MFG field representative will document all details that would be necessary to recreate the day's activities and events at a later time, using as many additional sheets as necessary. The Daily Field Record also will be used to document field activities that may not be specified on other field record forms. Other activity-specific documentation requirements to be recorded on the Daily Field Record are discussed in the MFG Standard Operating Procedure for each activity.

3.0 DOCUMENTATION

3.1 Field Record Forms

In addition to the Daily Field Record, MFG field personnel will complete specific MFG field record forms applicable to the field activities being conducted. The procedures for completion of activity-specific field record forms are presented in the applicable MFG Standard Operating Procedures. MFG field record forms include:

- Daily Field Record (SOP No. 1);
- Chain-of-Custody Record and Request for Analysis (SOP No. 2);
- Field Log of Borehole by Cuttings (SOP No. 4);
- Field Log of Borehole by Coring (SOP No. 4);
- UST Closure Field Record (SOP No. 3);
- Well Construction Summary (SOP No. 6);
- Well Development Record (SOP No. 7);

- Geophysical Log (SOP No. 5);
- Water Level Monitoring Record (SOP No. 11);
- Pumping Test Record (SOP No. 14);
- Eh Data Sheet (SOP No. 13);
- Groundwater Sampling Record (SOP No. 12); and
- Surface Water Sampling Record (SOP No. 12).

Additional field record forms and applicable procedures may be created for project-specific activities, as necessary.

3.2 Records Management

All original field forms will be filed with the appropriate project's records.

4.0 QUALITY ASSURANCE

4.1 Form Review and Filing

All completed field forms will be reviewed by the Project Manager or project designated QA/QC reviewer. Any necessary corrections will be made in pen with a single-line strike out that is initialed and dated.

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 2

SAMPLE CUSTODY, PACKAGING AND SHIPMENT

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed for sample custody, packaging and shipment. The procedures presented herein are intended to be general in nature. If warranted, appropriate revisions may be made when approved in writing by the MFG Project Manager.

This SOP applies to any liquid or solid sample that is being transported by the sampler, a courier or an overnight delivery service.

2.0 PROCEDURES

The objectives of this packaging and shipping SOP are: to minimize the potential for sample breakage, leakage or cross contamination; to provide for preservation at the proper temperature; and to provide a clear record of sample custody from collection to analysis.

2.1 Packaging Materials

The following is a list of materials that will be needed to facilitate proper sample packaging:

X Chain-of-Custody Record forms (see Figure SOP-2-1);

X Coolers (insulated ice chests) or other shipping containers as appropriate to sample type;

X Transparent packaging tape;

X Zip-lock type bags (note: this is used as a generic bag type, not a specific brand name);

- X Protective wrapping and packaging material;
- X Contained ice (packaged and sealed to prevent leakage when melted) or “Blue Ice”; and
- X Chain-of-Custody seals.

2.2 Sample Custody from Field Collection to Laboratory

After samples have been collected, they will be maintained under chain-of-custody procedures. These procedures are used to document the transfer of custody of the samples from the field to the designated analytical laboratory. The same chain-of-custody procedures will be used for the transfer of samples from one laboratory to another, if required.

The field sampling personnel will complete a Chain-of-Custody Record and Request for Analysis form (CC/RA form, Figure SOP-2-1) for each separate container of samples to be shipped or delivered to the laboratory for chemical or physical (geotechnical) analysis. Information contained on the triplicate, carbonless form will include:

1. Project identification;
2. Date and time of sampling;
3. Sample identification;
4. Sample matrix type;
5. Sample preservation method(s);
6. Number and types of sample containers;
7. Sample hazards (if any);
8. Requested analysis(es);
9. Requested sample turnaround time;
10. Method of shipment;
11. Carrier/waybill number (if any);

12. Signature of sampling personnel;
13. Name of MFG Project Manager;
14. Signature, name and company of the person relinquishing and the person receiving the samples when custody is being transferred;
15. Date and time of sample custody transfer; and
16. Condition of samples upon receipt by laboratory.

The sample collector will cross out any blank space on the CC/RA form below the last sample number listed on the part of the form where samples are listed. The samples will be carefully packaged into shipping containers/ice chests.

The sampling personnel whose signature appears on the CC/RA form is responsible for the custody of a sample from time of sample collection until the custody of the sample is transferred to a designated laboratory, a courier, or to another MFG employee for the purpose of transporting a sample to the designated laboratory. A sample is considered to be in their custody when the custodian: (1) has direct possession of it; (2) has plain view of it; or (3) has securely locked it in a restricted access area.

Custody is transferred when both parties to the transfer complete the portion of the CC/RA form under "Relinquished by" and "Received by." Signatures, printed names, company names, and date and time of custody transfer are required. Upon transfer of custody, the MFG sampling personnel who relinquished the samples will retain the third sheet (pink copy) of the CC/RA form. When the samples are shipped by a common carrier, a Bill of Lading supplied by the carrier will be used to document the sample custody, and its identification number will be entered on the CC/RA form. Receipts of Bills of Lading will be retained as part of the permanent documentation in the MFG project file.

2.3 Sample Custody Within Laboratory

The designated laboratory will assume sample custody upon receipt of the samples and CC/RA form. Sample custody within the analytical laboratory will be the responsibility of designated laboratory personnel. The laboratory will document the transfer of sample custody and receipt by the laboratory by signing the correct portion of the CC/RA form. Upon receipt, the laboratory sample custodian will note the condition of the samples, by checking the following items:

1. Agreement of the number, identification and description of samples received by comparison with the information on the CC/RA form; and
2. Condition of samples (no air bubbles in VOA containers; any bottle breakage; leakage, cooler temperature, etc.).

If any problems are discovered, the laboratory sample custodian will note this information on the "Laboratory Comments/Condition of Samples" section of the CC/RA form, and will notify the MFG sampling personnel or Project Manager immediately. The MFG Project Manager will decide on the final disposition of the problem samples.

The laboratory will retain the second sheet (yellow copy) of the CC/RA form and return the first sheet (white original) to MFG with the final laboratory report of analytical results. The original of the CC/RA form will be retained as part of the permanent documentation in the MFG project file.

A record of the history of the sample within the laboratory containing sample status and storage location information will be maintained in a logbook, or a computer sample tracking system, at the laboratory. The following information will be recorded for every sample access event:

1. Sample identification;
2. Place of storage;
3. Date(s) and time(s) of sample removal and return to storage;
4. Accessor's name and title;
5. Reason for access; and

6. Comments/observations (if any).

The laboratory will provide MFG with a copy of the logbook or computer file information pertaining to a sample upon request.

2.4 Sample Custody During Inter-Laboratory Transfer

If samples must be transferred from one laboratory to another, the same sample custody procedures discussed above will be followed. The designated laboratory person (sample custodian) will complete a CC/RA Record (MFG form or similar) and sign as the originator. The laboratory relinquishing the sample custody will retain a copy of the completed form. The laboratory receiving sample custody will sign the form, indicating transfer of custody, retain a copy, and return the original record to MFG with the final laboratory report of analytical results. The CC/RA Record will be retained as part of the permanent documentation in the MFG project file.

2.5 Packaging and Shipping Procedure

Be sure that all sample containers are properly labeled and all samples have been logged on the Chain-of-Custody Request for Analysis form (CC/RA, SOP-2-1) in accordance with the procedures explained above and in the MFG SOPs entitled WATER QUALITY SAMPLING and SOIL/SEDIMENT SAMPLING FOR CHEMICAL ANALYSIS.

All samples should be packed in the cooler so as to minimize the possibility of breakage, cross-contamination and leakage. Before placing the sample containers into the cooler, be sure to check all sample bottle caps and tighten if necessary. Bottles made of breakable material (e.g., glass) should also be wrapped in protective material (e.g., bubble wrap, plastic gridding, or foam) prior to placement in the cooler. Place each bottle or soil liner into two zip-lock bags to protect from cross-contamination and to keep the sample labels dry. Place the sample containers upright in the cooler. Avoid stacking glass sample bottles directly on top of each other.

If required by the method, samples should be preserved to 4°C prior to the analysis. Water ice or "blue ice" will be used to keep the sample temperatures at 4°C. The ice will be placed in two zip-lock bags if the samples are to be transported by someone other than the MFG sampler (e.g., a courier or overnight delivery service). Place the zip-lock bags of ice in between and on top of the sample containers so as to maximize the contact between the containers and the bagged ice. If the MFG sampler is transporting the samples to the laboratory shortly after sample collection, the water ice may be poured over and between the sample bottles in the cooler.

If there is any remaining space at the top of the cooler, packing material (e.g., styrofoam pellets or bubble wrap) should be placed to fill the balance of the cooler. After filling the cooler, close the top and shake the cooler to verify that the contents are secure. Add additional packaging material if necessary.

When transport to the laboratory by the MFG sampler is not feasible, sample shipment should occur via courier or overnight express shipping service that guarantees shipment tracking and next morning delivery (e.g., Federal Express Priority Overnight). In this case, place the chain-of-custody records in a zip-lock bag and place the bag on top of the contents within the cooler. Tape the cooler shut with packaging tape. Packaging tape should completely encircle the cooler, and a chain-of-custody seal should be signed and placed across the packaging tape, and across at least one of the opening points of the container.

Retain copies of all shipment records provided by the courier or overnight delivery service and maintain in the project's file.

2.6 Documentation and Records Management

Daily Field Records or a field notebook with field notes will be kept describing the packaging procedures and the method of shipments. Copies of all shipping records and chain-of-custody records will be retained in the project files.

3.0 QUALITY ASSURANCE

The Project Manager or designated QA reviewer will check and verify that documentation has been completed and filed per this procedure.

Analysis Request/Environmental Services Chain of Custody

Lancaster Laboratories
Where quality is a science.

For Lancaster Laboratories use only
Acct. # ______________ Group# ______________ Sample # ______________

COC #

Please print. Instructions on reverse side correspond with circled numbers.

①
Client: ______________________ Acct. #: ______________
Project Name/#: ______________________ PWSID #: ______________
Project Manager: ______________________ P.O.#: ______________
Sampler: ______________________ Quote #: ______________
Name of state where samples were collected: ______________

Matrix ④ — Check if Applicable: ☐ Potable ☐ NPDES

⑤ Analyses Requested

For Lab Use Only
FSC: ______________
SCR #: ______________

② Sample Identification	Date Collected	Time Collected	③ Grab	Composite	Soil	Water	Other	Total # of Containers										Remarks	⑥ Temperature of samples upon receipt (if requested)

⑦ Turnaround Time Requested (TAT) (please circle): Normal Rush
(Rush TAT is subject to Lancaster Laboratories approval and surcharge.)
Date results are needed: ______________
Rush results requested by (please circle): Phone Fax E-mail
Phone #: ______________ Fax #: ______________
E-mail address: ______________

⑧ Data Package Options (please circle if required)
QC Summary
Type I (Tier I)
Type II (Tier II)
Type III (NJ Red. Del.)
Type IV (CLP)
Type VI (Raw Data)
GLP
Other

SDG Complete? Yes No

Site-specific QC required? Yes No
(If yes, indicate QC sample and submit triplicate volume.)
Internal Chain of Custody required? Yes No

⑨

Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time

FIGURE SOP-2-1

Lancaster Laboratories, Inc., 2425 New Holland Pike, PO Box 12425, Lancaster, PA 17605-2425 (717) 656-2300
Copies: White and yellow should accompany samples to Lancaster Laboratories. The pink copy should be retained by the client.

2102 Rev. 1/2/03

Directions For Completing This Form

(1) **Client:** Your company's name

Acct. #: Your account number with Lancaster Laboratories

Project Name/#: The way your company refers to the work involved with these samples. You may want to include project location as part of the description.

PWSID: Potable Water Source ID#

Project Manager: The person at your company responsible for overseeing the project

P.O.#: Your company's purchase order number

Sampler: The name of the person who collected the samples

Quote #: The reference number that appears on your quote (if Lancaster Laboratories gave you a number)

State where sample was collected: Please indicate where the sample was taken, e.g., PA, NJ, etc.

(2) **Sample Identification:** The unique sample description you want to appear on the analytical report

Date Collected/Time Collected: When the sample was collected

(3) **Grab:** Check here if sample was taken at one time from a single spot.

Composite: Check here if samples were taken from more than one spot, or periodically, and combined to make one sample.

(4) **Matrix:** Check the type of sample you are submitting. If it is a water sample, please indicate if it is a potable water or if it is an NPDES sample.

Number of Containers: Indicate the total number of containers for each sampling point.

(5) **Analyses Requested:** Write the name of each analysis (or an abbreviation of it) here, and use the **catalog number** that appears at the beginning of each line in the *Schedule of Services*. Be sure to indicate which analyses are to be performed on which samples.

(6) **Remarks:** List special instructions about the sample here (e.g., hazardous elements, high levels of analyte, etc.). The space can also be used (if needed) for listing additional analyses.

(7) **Turnaround Time Requested:** Circle **Normal** if you want routine TAT, which is usually within 10-15 days. If you need your results faster, call ahead to schedule **Rush** work.

Rush Results Requested by: Circle **Fax** or **Phone** and include the number.

(8) **Data Package Options:** Call our Client Services Group (717-656-2300) if you have questions about these choices.

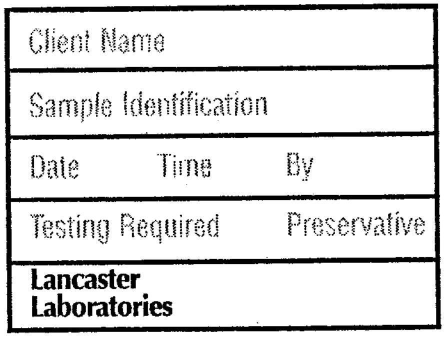
SDG Complete? Indicate **Yes** if this is a complete sample delivery group or **No** if you will be submitting additional samples to be included in the same data package.

Note: We need to have one quality control (QC) sample for every 20 samples you send, if you are requesting site-specific QC. Please give us this sample in triplicate volume and identify it by writing "QC" in the **Remarks** column.

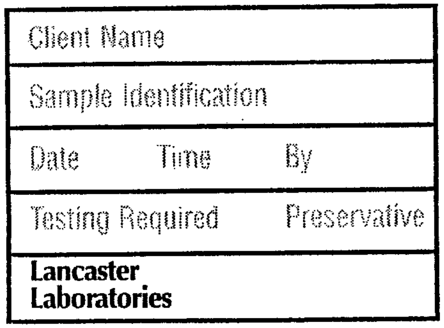
The internal chain of custody is a hand-to-hand documentation recording a sample's movement throughout the company. We routinely start a chain of custody for data package samples unless we are told otherwise. There is a $25 **per sample** charge for the chain-of-custody documentation.

(9) **Relinquished by/Received by:** The form must be signed each time the sample changes hands. We can supply chain-of-custody seals for the outside of your packages if you require them.

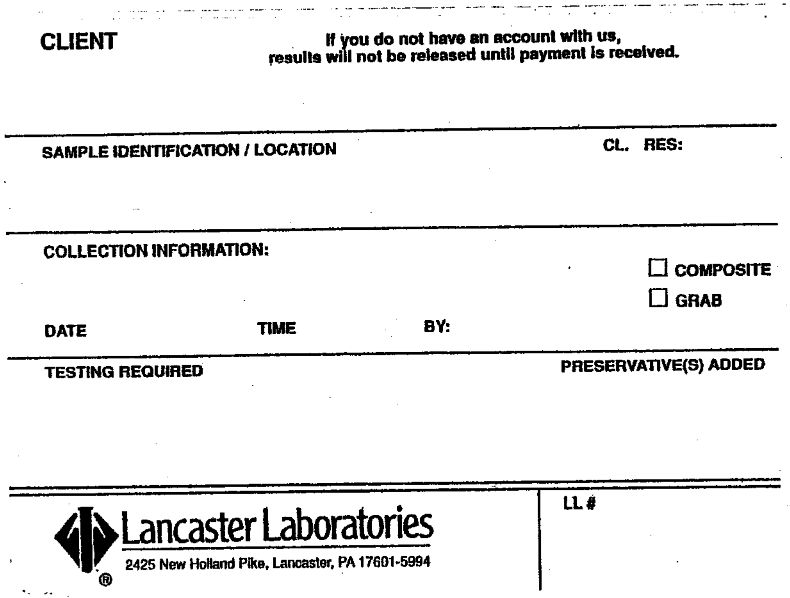
Thank you for using Lancaster Laboratories.
Please call our Client Services Group (717-656-2300) if you have any questions about completing this form.



Client Name
Sample Identification
Date Time By
Testing Required Preservative
Lancaster Laboratories



Client Name
Sample Identification
Date Time By
Testing Required Preservative
Lancaster Laboratories



CLIENT

If you do not have an account with us, results will not be released until payment is received.

SAMPLE IDENTIFICATION / LOCATION **CL. RES:**

COLLECTION INFORMATION:

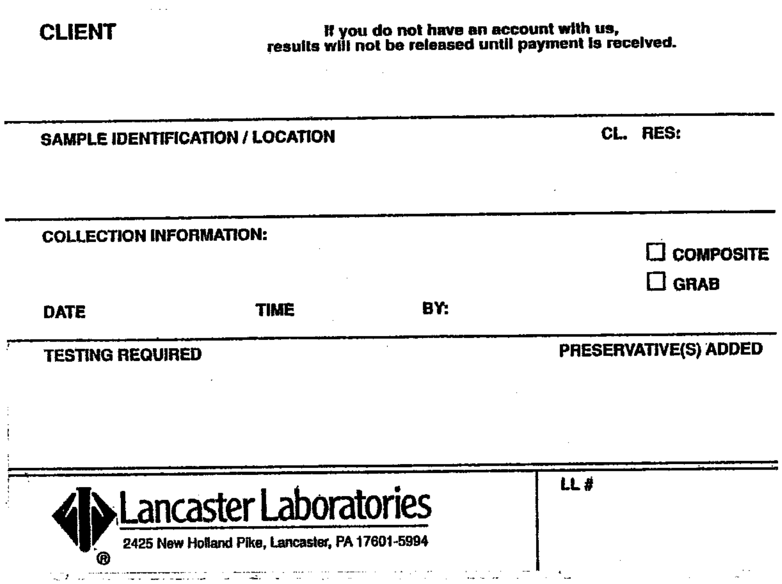
☐ **COMPOSITE**
☐ **GRAB**

DATE **TIME** **BY:**

TESTING REQUIRED **PRESERVATIVE(S) ADDED**

Lancaster Laboratories
2425 New Holland Pike, Lancaster, PA 17601-5994

LL #



CLIENT

If you do not have an account with us, results will not be released until payment is received.

SAMPLE IDENTIFICATION / LOCATION **CL. RES:**

COLLECTION INFORMATION:

☐ **COMPOSITE**
☐ **GRAB**

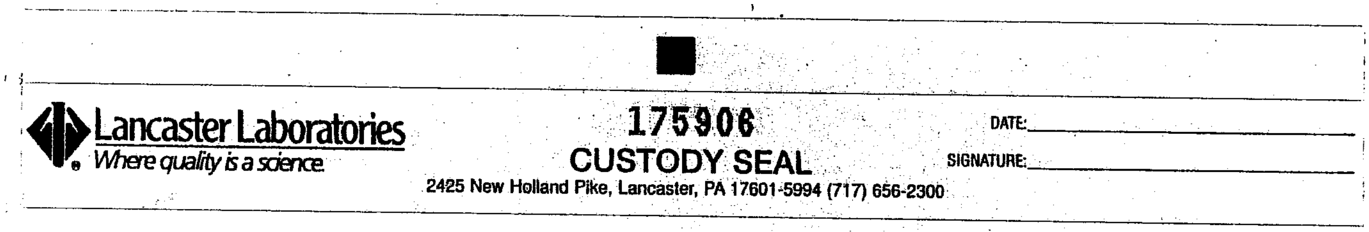
DATE **TIME** **BY:**

TESTING REQUIRED **PRESERVATIVE(S) ADDED**

Lancaster Laboratories
2425 New Holland Pike, Lancaster, PA 17601-5994

LL #

SAMPLE LABELS

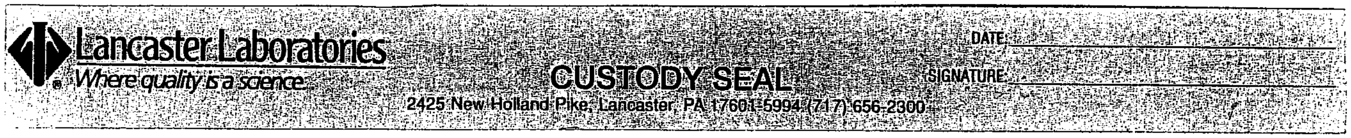


Lancaster Laboratories
Where quality is a science.

175906
CUSTODY SEAL
2425 New Holland Pike, Lancaster, PA 17601-5994 (717) 656-2300

DATE:

SIGNATURE:



Lancaster Laboratories
Where quality is a science.

CUSTODY SEAL
2425 New Holland Pike, Lancaster, PA 17601-5994 (717) 656-2300

DATE:

SIGNATURE:

CUSTODY SEALS

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 4

SUPERVISION OF EXPLORATORY BORINGS

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed during the drilling and logging of exploratory borings by MFG. Exploratory borings (pilot holes) may be drilled to obtain samples of the subsurface strata or to run borehole geophysical logs. Borings will be either backfilled with grout or completed as monitoring wells or piezometers.

The procedures presented herein are intended to be general in nature. As site-specific conditions become known, appropriate modifications to the procedures may be made when approved in writing by the MFG Project Manager.

2.0 PROCEDURES

2.1 Drilling

For any site or drilling location, the selection of drilling methods will be based on: (1) availability and cost of the method; (2) suitability for the type of geologic materials at the site (e.g., consolidated, unconsolidated); and (3) potential effects on sample integrity (influence by drilling fluids and potential for cross contamination between aquifers). Some commonly used drilling methods include hollow-stem auger method, cone penetrometer testing (CPT) method, direct-push geoprobe method, hydraulic rotary method, cable tool method, or casing-hammer air rotary method. Synthetic polymer drilling fluid additive should be used only if a boring: (1) will not be sampled for chemical analysis; (2) will not be completed as a monitoring well; or (3) if cuttings return and/or borehole integrity cannot be achieved by any other method.

Exploratory borings for monitoring wells and piezometers will be drilled in a manner that will minimize the potential for cross contamination between aquifers. The actual depth of each exploratory boring will be specified by the MFG field geologist assigned to the drill rig and will be based on the intended use of the boring. No solvents or petroleum-based products will be used for lubricating any drilling equipment (rods, bit, augers, mud pit, etc.) which will contact the borehole or the drilling fluid. For air rotary drilling, an air filter will be installed between the air compressor and the drill pipe to intercept oil droplets.

The drilling equipment in which fluid (including air) circulates, including drive samplers and bits, will be thoroughly steam cleaned before and after drilling of each exploratory boring. Only clean, potable water from a municipal supply will be used as makeup water for drilling fluid and for decontamination of drilling equipment. An acid rinse (e.g., 0.1 N HCl) or solvent rinse (e.g., methanol or hexane) may be used to supplement these procedures if tarry or oily deposits are encountered during drilling. Drilling equipment cleaned in this manner will be thoroughly steam cleaned prior to reuse or leaving the site.

To ensure that the specified equipment has been provided by the drilling contractor, prior to drilling the MFG field geologist will measure and record the outside diameter of the drill bit or augers and, when using the hollow stem auger method, the inside diameter of the augers.

During drilling, the MFG field geologist may choose to periodically measure and record the depth to water within the drill casing. The position of the lead drill casing will be recorded each time a water level measurement is taken. When the total depth of a boring is reached, the water level within the drill casing will be measured.

If the boring is to be completed as a monitoring well or a piezometer, the final borehole diameter will be sufficiently large to allow placement of a specified type and size of well casing, screen and filter pack. The MFG field geologist will measure and record the total depth of the final borehole at the completion of drilling.

The MFG field geologist shall specify to the driller the penetration rate, depth of soil sample collection, method of sample retrieval, and any other matters which pertain to the satisfactory completion of the exploratory borings.

Soil cuttings and drilling fluid generated during drilling should be temporarily stored in steel drums or other approved containers. Final disposal of the soil cuttings and drilling fluid will be conducted in accordance with all legal requirements and with procedures discussed in the MFG SOP entitled STORAGE AND DISPOSAL OF SOIL, DRILLING FLUIDS, AND WATER GENERATED DURING FIELD WORK.

2.2 Sampling and Logging

Representative samples of cores and/or drill cuttings may be obtained and evaluated. A detailed lithologic log of these samples should be made.

Selected samples may be retained for further physical analysis. Soil samples may also be obtained for chemical analysis. Sample collection and preservation for chemical analysis will be in accordance with the MFG SOP entitled SOIL/SEDIMENT SAMPLING FOR CHEMICAL ANALYSIS. Selected samples that illustrate specific geologic features may be retained and shall be labeled with boring number and appropriate sample interval.

2.2.1 Obtaining Samples

When samples are collected, they should be obtained by one or both of the following methods described below.

A. Coring -- Cores will be collected from selected intervals of the exploratory borings. Core barrels, Pitcher tubes, modified California drive samplers or other split-spoon drive samplers will be used to obtain the soil cores. The MFG field geologist will carefully record on a boring log information which applies to the coring, such as rate of penetration, coring smoothness, core recovery, intervals of core loss, zones of lost circulation of drilling fluid, hammer weight, drop length and blow counts, as appropriate to the drilling method.

Cores may be retained for future examination and/or preserved for chemical or geotechnical analysis. If they are retained, the cores will be stored and labeled to show project, boring number, date, and cored interval.

B. Collecting Cuttings -- The MFG field geologist may collect cuttings from the drilling return fluid, air return from a cyclone separator, or the auger blade for every five-foot (or more frequent) increment of the exploratory boreholes. Sampling and logging should be performed in accordance with the following procedures (Note: Items 2 through 6 do not apply to drilling methods that do not use a drilling fluid, e.g., hollow stem auger, push point sampler, etc.):

1. The height of the drilling table above ground surface, lengths of the drill bit, sub and drill collars, and length of drill rods or augers should be taken into account in calculating the depth of penetration.

2. A small-diameter, fine-mesh hand screen or a shovel may be used to obtain a sample of the cuttings from the boring by holding the sampling device directly in the flow of the drilling return fluid or cyclone separator.

3. A sample will be obtained from the drilling return fluid or cyclone separator by leaving the sampling device in place only for the brief period required to collect an adequate sampling volume.

4. The most representative cuttings samples are usually obtained whenever the driller stops advancing the hole and circulates drilling fluid or air prior to adding another joint of drill rod.

5. Keep in mind that the deeper the hole, the longer cuttings at the drill bit take to reach the surface. The travel time for cuttings to reach the surface may be estimated each time the driller adds a new length of drill rod by timing the first arrival of cuttings after fluid or air circulation is resumed. This travel time should be used along with the depth of penetration to estimate the start and finish of each sampling interval.

6. In hydraulic rotary drilling, carefully wash the cutting sample in a bucket of fresh water by slowly shaking the screen while the sample is submerged, to wash away the drilling fluid.

7. For all drilling methods, place the cutting samples on a sampling table, labeled in consecutive order. If the sample is to be retained, place the sample in a plastic or cloth sample bag labeled with the boring number and sample interval. The retained samples will later be used during preparation of a detailed lithologic log.

2.3 Logging of Boreholes

The drill-rig operator and the MFG field geologist should discuss significant changes in material penetrated by the drill bit, changes in drilling conditions, hydraulic pressure, drilling action, and drilling fluid circulation rate. The MFG field geologist will be present during drilling of exploratory borings and will observe and record such changes by time and depth. When using a drilling method that does not involve the use of a wet drilling fluid, the MFG field geologist will evaluate the relative moisture content of the samples and note zones that produce water. The MFG field geologist will record such field notes to use later in preparing a detailed lithologic log.

Core samples and selected cuttings that are collected and retained during the drilling of the exploratory borings shall be examined to evaluate the lithologic properties. A detailed lithologic log for the exploratory borings shall be completed using MFG's Log of Boring by Cuttings (Figure SOP-4-1) or Field Log of Borehole by Coring (Figure SOP-4-2). The lithologic description of the log should include soil or rock type, color, grain size, texture, hardness, degree of induration, calcareous content, indications of contamination, and other pertinent information. Color should be described using the Munsell Color Chart. Soil type should be described using the Unified Soil Classification System. When the Field Log of Borehole by Coring form is used, it shall include the method of sample collection (coring, cuttings) and the sample collection interval (Figure SOP-4-2), if any samples are collected.

2.4 Geophysical Logs

The MFG SOP entitled GEOPHYSICAL LOGGING discusses in detail the steps to be followed when performing geophysical logs of exploratory borings. Geophysical logging will be performed generally in uncased, fluid-filled boreholes. Following completion of the drilling, spontaneous potential, single-point resistance, lateral resistivity, natural gamma or other logs may be made for each exploratory boring immediately after the drilling fluid has been circulated to remove all of the cuttings. When performed, geophysical logging shall be done as quickly and efficiently as possible, while the wall of the borehole is in good condition, to minimize the possibility of trapping or entangling the downhole probes. Instruments on the logging unit should be adjusted to give the maximum definition of strata boundaries.

2.5 Sealing and Abandonment

For borings (pilot holes) not used to install a monitoring well and/or piezometer, the exploratory borings will be abandoned by sealing the hole with cement grout or other approved sealing agents. The MFG field geologist shall inspect the grout for adequate mixing prior to placement in the borehole.

If the borehole is dry and is less than 10-feet deep, the grout or other approved sealant may be poured slowly from the ground surface into the borehole. The grout should be added in one continuous pour before its initial set. If the borehole is greater than 10-feet deep, or if more than 2-feet of water is present in the borehole, the grout should be placed in one continuous pour by pumping through a tremie hose or pipe. The tremie hose or pipe initially shall be placed near the bottom of the bore hole and shall remain submerged in the grout during the entire grouting operation. Grout will continue to be pumped until return of fresh grout (uncontaminated by drilling fluid) is witnessed at the ground surface.

The preferred grout mix is one (1) sack of Type I-II Portland cement, five (5) percent by weight of powdered bentonite, per 8.5 gallons of water. If a high-yield bentonite grout (trade names Quik-Gel, Super Gel X, etc.) is used, the powdered bentonite percentage should be reduced to two (2) percent. The grout mixture may be modified to meet local regulations or site-specific conditions or specifications.

2.6 Documentation and Records Management

Field notes recorded by the MFG field geologist during the drilling of each exploratory boring shall be transferred to the log forms (Figures SOP-4-1 and SOP-4-2). The original logs shall be sent to the MFG office and placed in the MFG project file. A copy of the logs will be retained in the field file for the project. For preparation of the report, data from the field boring logs may also be transferred to another format.

3.0 QUALITY ASSURANCE

Field notes and field forms completed by the field geologist shall be reviewed by the field supervisor and the MFG Project Manager or other designated QA officer before they are placed into project files. Deviation from this SOP or a project-specific work plan shall be identified and described in field notes. The QA review will be recorded on the reviewed originals by initials of reviewer and date.

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 5

GEOPHYSICAL LOGGING

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed for borehole geophysical logging. Borehole geophysical logs of exploratory borings may be run to aid in the interpretation and correlation of geologic units. The procedures include calibration, production, filing, and interpretation of the geophysical logs. The procedures presented herein are intended to be general in nature; when warranted, appropriate revisions may be made when approved in writing by the MFG Project Manager.

2.0 PROCEDURES

2.1 Geophysical Well-Logging Equipment Operating Procedures

The geophysical well-logging equipment (GWLE) shall be capable of performing single-point resistance, lateral resistivity, spontaneous potential, and natural gamma-ray logging.

2.1.1 GWLE Setup

The GWLE shall be arranged as follows at the borehole to be logged:

A. Place tripod over well or use pulley (sheave) suspended from drill rig.

B. Set cable reel and chart recorder sections near the borehole.

C. Attach power source (vehicle battery, generator, or line current) to GWLE.

D. Attach probe (spontaneous potential/resistance - resistivity, or gamma) to cable head.

E. Run probe and cable over tripod pulley or sheave suspended from drill rig and into the borehole.

F. Place electrical ground in mud pit or other suitable location (for spontaneous potential/resistance - resistivity logging only).

The probe shall be referenced to the ground surface elevation of the borehole by placing the probe reference mark at ground level and setting the depth counter on the cable reel section to zero.

The chart recorder section of the GWLE shall be checked to determine the following:

A. Pens have sufficient ink to log the entire borehole;

B. Pen drives are working properly;

C. Chart paper is of sufficient quantity to log the entire borehole; and

D. Vertical scale is set at 1 inch = 10 feet or other suitable scale.

2.1.2 GWLE Calibration

The GWLE shall be calibrated before starting both spontaneous potential/resistance - resistivity (SP/RES) and natural gamma ray (gamma) logging by following the detailed procedures in the GWLE operators manual.

2.1.3 Setting Scales

After calibration, the probe will be lowered to the bottom of the borehole. While lowering the probe, the proper SP/RES or gamma scales will be selected as follows:

A. SP/RES Logging:

As the probe is lowered to the bottom of the borehole, the SP and RES scales and zero adjust controls should be adjusted so that the pen has maximum deflection without going off the chart paper.

B. Gamma Logging:

1. Set time constant switch on chart recorder to 3 seconds or other suitable setting.

2. Lower the probe to bottom of borehole and observe pen deflection. Select a "recorder output" setting (gamma scale) that gives maximum pen deflection without the pen going off the chart paper (to the right).

3. The time constant switch should be adjusted to give good definition of relatively thin geologic features without showing too much "background noise".

4. Selection of a time constant and gamma scale is generally possible only while logging the borehole. After the first borehole in the drilling program has been logged, a gamma scale and time constant may be selected for gamma logging of subsequent holes.

The scale settings and the depth at which logging will start shall be recorded on the chart paper.

2.1.4 Logging Procedure

Log the boring in accordance with the following procedure:

A. For SP/RES and gamma logging, reel the probe(s) up at an even steady rate at the speed recommended in the detailed equipment procedures. Monitor the speed by observing the instrument's rate meter.

B. Reel probe to the ground surface (which should correspond to zero on the depth counter) and record on the chart paper the actual pen position at zero depth (as indicated by the depth counter). Also record the depth of fluid in the hole, as indicated by the SP and RES curves.

The spontaneous potential/resistance - resistivity and natural gamma traces on the chart paper shall be checked in the field by the MFG field geologist for completeness of record, and rechecked to determine if the traces are representative of assumed subsurface conditions. If the traces on the chart paper appear to be non-representative or peculiar, the instrument shall be checked for a possible malfunction and the borehole re-logged.

2.2 Documentation and Records Management

The MFG Geophysical Log form (Figure SOP-5-1) shall be attached to all original geophysical well logs. The log heading form furnished by a geophysical logging subcontractor may be substituted for the MFG form, provided the items below (A through R) are recorded on the subcontractor's logging form. The following data shall be recorded on the logging form soon after the logs have been run:

A. Project number;

B. Date;

C. Boring description/location;

D. Log type (e.g., single-point resistance, spontaneous potential, natural gamma);

E. Scale settings;

F. Starting and completion depths of geophysical logs;

G. Datum (measuring point, MP) of logs;

H. Borehole depth and diameter;

I. Casing depth(s) and diameter(s);

J. Ground surface elevation of well (if available);

K. Type of borehole fluid;

L. Temperature of borehole fluid;

M. Level of borehole fluid (datum is measuring point);

N. Resistivity or specific conductance of borehole fluid;

O. Logging speed;

P. Vertical scale of log;

Q. Name of operator of GWLE and name of witness (if any); and

R. Pertinent remarks.

The Geophysical Log form (Figure SOP-5-1) may be filled out after completing logging on any day, provided that the MFG field geologist records the required information directly on the geophysical log chart paper and/or on the Daily Field Record. The Daily Field Record is described in the MFG SOP entitled FIELD DOCUMENTATION.

The original Geophysical Log form and attached logs (or a reproducible copy) shall be sent to the MFG office. All original geophysical logs will be filed in the MFG project files. Copies of the logs will be retained in the field. Upon receipt of the original geophysical logs at the MFG office, they shall be checked for accuracy and completeness by the MFG Project Manager. If not accurate or complete, they shall be returned to the MFG field geologist for revision.

2.3 Interpretive Procedure

The geophysical logs will be compared to and correlated with the lithologic log of the same exploratory boring in order to evaluate the accuracy and precision of the interpretation, refine the interpretive technique, evaluate the interpretive limits of the geophysical logging procedure, and aid in identifying the hydrostratigraphic units. Geophysical logs and lithologic logs of the cored intervals of borings will be compared in order to formulate a control group to be used for correlation of uncored borings.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

3.1 Cleaning of Equipment

The logging probes, electrical cable and all accessories that have been in contact with the drilling fluid or have entered the borehole will be thoroughly cleaned after each trip in and out of the borehole. See MFG SOP entitled Equipment Decontamination for additional decontamination procedures.

3.2 Technical Review

Geophysical logs, lithologic logs and interpretive reports based on those logs shall be thoroughly reviewed by a geologist with experience and training in geophysics. The technical review must be performed before interpretive results are reported and record of that review should be included in the project's files along with other documentation of geophysical logging.

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 6

INSTALLATION OF MONITORING WELLS AND PIEZOMETERS

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed during installation of monitoring wells and piezometers by MFG, Inc. The procedures presented herein are intended to be general in nature. As site-specific conditions become known, appropriate modifications of the procedures may be made when approved in writing by the MFG Project Manager.

2.0 PROCEDURES

2.1 Monitoring Well Installation

Each monitoring well will be designed to register the potentiometric surface and to permit water sampling of a specific depth zone encountered beneath the drill site. Separate monitoring wells may be completed, as necessary, in the different water-yielding zones underlying the site. The MFG field geologist, in consultation with the MFG Project Manager, will specify the exact depths of screened intervals using the lithologic log and geophysical log (if performed) for control. Drilling and logging of the exploratory borings for the monitoring wells will be conducted in accordance with the MFG SOP entitled SUPERVISION OF EXPLORATORY BORINGS. Construction and completion of all monitoring wells will be in general conformance with the following procedures. Specific monitoring well completion requirements may vary in accordance with project-specific work plans and/or local regulatory agency guidance.

2.1.1 Screens and Riser Casing

The monitoring well assembly shall consist of flush joint, threaded casing composed of mild steel, stainless steel or polyvinyl chloride (PVC) Schedule 40 (minimum). The threaded joints will have O-ring seals. Steel casing joints may be welded rather than threaded. The inside diameter of both the perforated and unperforated casing will be sufficiently large to permit easy passage of an appropriate water-level probe, equipment for development and purging of wells, and for collection of groundwater samples.

The perforated casing (well screen) will be factory slotted. The perforations will be compatible in size with the selected filter material. These perforated casing sections are generally not intended to provide optimum flow but only to provide hydraulic connection between the pervious material in the water-yielding zone and the monitoring well.

Prior to well construction, the MFG field geologist will inspect the blank and perforated casing delivered to the job site to verify that it meets the project specifications.

When the total depth of a boring has been reached, and prior to installation of the well casing, the MFG field geologist will measure and record the depth to water in the borehole.

Upon completion of drilling and/or geophysical logging, the monitoring well casing and screen will be assembled and lowered to the bottom of the boring. The monitoring well assembly will be designed so that the well screen is approximately adjacent to the water-yielding zone that is to be monitored. The bottom of the screen will be approximately flush with the bottom of the well and will be closed with a threaded PVC cap or plug, or a slip cap secured with stainless steel screws. No PVC cement or other solvents are permitted to be used to fasten the joints of the casing or screen. Centralizers spaced at the top and bottom of the screened interval and not more than 40 feet apart along the casing may be used to center the well assembly in the borehole, unless the boring is drilled by a low annular space method and the well is installed with the drill casing in place. Wells installed prior to pulling low annular space drill casing will be centered by the inside walls of the drill casing.

If well casing assembly is being performed by a drilling subcontractor, the MFG field geologist will observe and inspect the assembly, insuring that the bottom cap is threaded or secured with stainless steel screws, O-rings are properly placed in the joints, the joints are completely tightened, and the blank and perforated intervals are constructed as specified. The MFG field geologist will measure the location of the top and bottom of the perforated interval by measuring the distances from the joint above the perforated interval to the top slot and from the base of the bottom cap to the bottom slot.

When using the mud rotary drilling technique, after the monitoring well assembly has been lowered to the specified depth, clean water may be circulated downward through the well casing and upward through the annular space between the borehole wall and the monitoring well casing. Circulation will continue until the suspended sediment in the return fluid has been thinned.

If the well is greater than 50 feet deep, the casing assembly will be held under tension prior to and during emplacement of the filter pack and seal.

2.1.2 Filter Material

Filter material will be a well-graded, clean sand with less than 2 percent by weight passing a No. 200 sieve and less than 5 percent by weight of calcareous material.

Filter sand will be tremied into the annular space using a one-inch diameter (or larger) pipe, in a calculated quantity sufficient to fill the annular space to a level of about two feet above the top of the perforated casing. The required height of the filter pack above the top of the perforated casing may vary by jurisdiction. The depth to the top of the filter pack must be verified by measuring, using the tremie pipe or a weighted steel tape. When use of a tremie pipe is not feasible, the filter sand may be poured slowly between the well casing and the inside walls of the auger, and the drill casing may be removed in stages.

2.1.3 Seal

Once the depth to the top of the filter pack has been verified, a layer of bentonite pellets will be emplaced by pouring the pellets into the annular space in a calculated quantity sufficient to fill the annular space to a level at least one foot above the top of the filter pack. The depth to the top of the bentonite pellets layer must be verified by measuring, using the tremie pipe or a weighted steel tape. When the bentonite pellets are placed above the zone of saturation, they will be hydrated, after they have been emplaced, by adding clean, potable municipal water. Approximately 3 gallons of water should be added for every foot of bentonite pellets. More water may be required when completing a well in relatively permeable material. The bentonite pellets will be hydrated in lifts no greater than 3 feet.

A bentonite/cement grout seal or other approved sealant will be emplaced above the bentonite pellet layer after it has been allowed to hydrate for a minimum of ½ hour. If the depth to the top of the bentonite pellet layer is dry and is less than 10 feet deep, the grout may be poured slowly from the ground surface into the annular space. The grout should be added in one continuous pour before its initial set. If the depth is greater than 10 feet deep, or if more than two feet of water is present in the annular space, the grout should be placed in one continuous pour by pumping through a tremie hose or pipe. The tremie hose or pipe initially shall be placed near the top of the bentonite seal and shall remain submerged in the grout during the entire grouting operation. When constructing a well or piezometer inside a low annular space drill casing, the drill casing may be used as a tremie pipe by pouring the grout down the annular space between the well casing and the inner wall of the drill casing. Grout will continue to be pumped until return of fresh grout is witnessed at the ground surface.

The bentonite/cement grout mix should be one (1) sack of Type I-II Portland cement, five (5) percent by weight (of cement) of powdered bentonite, per 8.5 gallons of water. If a high-yield bentonite (trade names Quik-Gel, Super Gel X, etc.) is used, the powdered bentonite percentage should be reduced to two (2) percent. An alternative grout mixture may be used if approved by the applicable regulatory agency and the MFG Project Manager. Only clean water from a municipal supply will be used to prepare the grout. The grout seal will extend from the top of the bentonite pellet layer to near the ground surface. After grouting, no work will be done on the monitoring well until the grout has set for a minimum of 24 hours.

When the casing hammer air rotary or similar method is used to complete the borehole for a monitoring well, the protective casing will be jacked out of the borehole gradually as the filter pack, bentonite pellets, and cementing operations are in progress.

2.1.4 Capping Monitoring Well

Upon completion of the work, a suitable watertight, cap or plug will be fitted on the top of the well casing to prevent the entry of surface runoff or foreign matter. The well will be completed either: (1) above the ground surface using a locking, steel protective well cover set in concrete; or (2) below the ground surface using a watertight, traffic-rated valve-box with a bolt-down cover. The cover of the valve box will be stamped or cast with "Monitoring Well."

2.2 Piezometer Installation

The piezometer will be designed to register the potentiometric surface of a specific depth zone encountered beneath the drill site. The MFG field geologist, in consultation with the MFG Project Manager, will specify the exact depths of the piezometers using the lithologic log and geophysical log (if performed) for control. Drilling and logging of the boreholes for the piezometers will be in conformance with the MFG SOP entitled SUPERVISION OF EXPLORATORY BORINGS. Construction, completion and development of the piezometers will generally follow the same procedures as those for monitoring wells (see Section 2.0 above), except that a piezometer may be completed with casing material of less than two inches in diameter and may use a porous tip (ceramic or other material) in place of perforated casing.

2.3 Documentation and Records Management

The MFG field geologist will complete a Well Construction Summary form for each monitoring well (Figure SOP-6-1). The completed form will be submitted to the MFG Project Manager and included in the project files. In addition to the information requested on the Well Construction Summary form, the MFG field geologist will record the volumes and types of well construction materials (filter material, bentonite, cement, etc.) used for each well in their field notes. Also, the daily events and other items not covered in the Well Construction Summary form will be entered on a Daily Field Record form in accordance with the procedures contained in the MFG SOP entitled FIELD DOCUMENTATION.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

3.1 Cleaning of Equipment Used in Drilling, Well Construction

The drilling equipment will be thoroughly steam cleaned before and after installation of each monitoring well or piezometer. Only clean, potable water from a municipal supply will be used as makeup water for drilling fluid and for decontamination of drilling equipment. An acid rinse (0.1 N HCl) or solvent rinse (i.e., hexane or methanol) may be used to supplement the steam cleaning if tarry or oily deposits are encountered. Equipment cleaned in this manner will be thoroughly steam cleaned prior to reuse or leaving the site.

Well casing that is not factory cleaned and in a sealed container will be steam cleaned thoroughly before it is installed. This cleaning is particularly critical to prevent cross contamination in a multi-aquifer environment. After cleaning, the casing will be covered with plastic to protect it from contact with dust or other contaminants.

Equipment will be cleaned by scrubbing with a stiff brush using a laboratory-grade detergent/water solution, followed by rinsing with clean, potable, municipal water, then rinsing with distilled or deionized water. Alternatively, the equipment may be steam cleaned followed by rinsing with distilled or deionized water. An acid rinse (0.1 N HCl) or solvent rinse (i.e., hexane or methanol) may be used to supplement these cleaning steps if tarry or oily deposits are encountered. The acid or solvent rinse will be followed by thoroughly rinsing with municipal water and then with distilled or deionized water. After cleaning, equipment will be packaged and sealed in plastic bags or other appropriate containers to minimize contact with dust or other contaminants.

3.2 Records Review

The Project Manager or designated QA reviewer will check and verify that documentation has been completed and filed per this procedure.

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 7

MONITORING WELL DEVELOPMENT

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed during the development of groundwater monitoring wells. Monitoring wells must be developed before they are used to collect groundwater samples. The procedures presented are intended to be general in nature. As site-specific conditions become known, appropriate modifications of the procedures may be made when approved in writing by the MFG Project Manager.

2.0 PROCEDURES

2.1 Development Procedure

After construction of the monitoring well is complete, the well will be developed by surging, bailing and/or pumping (e.g., positive displacement hand pump, electric pump or pneumatic pump). At least 24 hours must pass between completion of grouting of the monitoring well and development to allow sufficient curing of the grout.

The total depth of the well will be measured in accordance with the procedures described in the MFG SOP entitled WATER LEVEL, IMMISCIBLE LAYER AND WELL DEPTH MEASUREMENT. The presence of sediment at the bottom of the well will be checked using a stainless steel bailer or positive displacement hand pump. Water and sediment will first be removed from the bottom of the well to ensure that the entire screened interval is open for water to flow into the well. The well should be bailed or pumped until the water removed from the bottom of the well is relatively free of sediment. If a bailer is used, care must be taken to avoid breaking the bottom cap on the well casing.

After most of the sediment has been removed from the bottom of the well, a well development pump (positive displacement hand pump, electric pump or pneumatic pump) should be used to remove water from the well. Initially, the intake of the pump should be at the bottom of the well. The pump intake should be raised in two- to three-foot increments to the top of the water column after approximately one-half of a casing volume of water has been removed from each interval.

Next, a surge block constructed of non-reactive material (usually stainless steel or PVC) should be used to develop the well screen by forcing water in and out of the screened area. The surge block should be moved up and down in one-to two-foot increments creating a suction action on the upstroke and a pressure action on the downstroke. Development should begin at the top of the water column and move progressively downward to prevent the surge block from becoming sand locked. After surging to the bottom of the well, the surge block should be moved progressively upward to the top of the water column.

If necessary, water may be added to the well to facilitate surging. This water should be distilled deionized or “clean” potable municipal water. The volume of de-ionized water added to the well should be noted on the Well Development Record form (Figure SOP-7-1).

After surging, the surge block should be removed and replaced with the pump or bailer. The intake of the pump or bailer should be at the bottom of the well to remove any sediment that may have collected in the bottom of the well. The pump intake should again be raised in two- to three-foot increments to the top of the water column after approximately one-half of a casing volume of water has been removed from each interval.

During development, the pH, specific conductance and temperature of the purge water should be periodically measured and documented on a Well Development Record form. Parameter readings should be collected and noted for every casing volume of water removed from the well.

The well should be alternately surged and pumped until the field water quality parameters have stabilized to within 10% for specific conductance, 0.05 pH units for pH, and 1EC for temperature, and the water is relatively clear and free of sediment.

Water removed during well development should be temporarily stored in steel drums, a portable storage tank or other approved storage container. Final disposal of all water generated during development procedures will be conducted in accordance with all legal requirements and with procedures discussed in the MFG SOP entitled STORAGE AND DISPOSAL OF SOIL, DRILLING FLUIDS, AND WATER GENERATED DURING FIELD WORK.

2.2 Documentation and Records Management

A Well Development Record will be filled out by the MFG Field Geologist for each well developed. The Well Development Record will be submitted to the MFG Project Manager. Also, the daily events and other items not covered in the Well Development Record will be entered on a Daily Field Record form in accordance with the procedures contained in the MFG SOP entitled FIELD DOCUMENTATION.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

3.1 Equipment Cleaning

All reusable equipment used in developing the monitoring well should be cleaned prior to and following use. Cleaning shall be accomplished by either (1) washing with a laboratory-grade detergent/water solution, rinsing with clean, potable, municipal water, then rinsing with distilled or deionized water; or (2) steam cleaning followed by rinsing with distilled or deionized water. An acid rinse (0.1 N HCl) or solvent rinse (i.e., hexane or methanol) may be used to supplement these cleaning steps if tarry or oily deposits are encountered. The acid or solvent rinse will be followed by thoroughly rinsing with water. After final cleaning, equipment will be packaged and sealed in plastic bags or other appropriate containers to minimize contact with dust or other contaminant when not in use.

3.2 Records Review

The Project Manager or designated QA reviewer will check and verify that documentation has been completed and filed per this procedure.

WELL DEVELOPMENT RECORD

WELL NUMBER:

Project No:________________ Project Name:___________________________________ PAGE ____ of: ____

Date(s): ___________________________________

Developed by: ______________________________

Measuring Point (MP) of Well: _________________

Screened Interval (ft. BGL): ___________________

Filter Pack Interval (ft. BGL): _________________

Casing Stick-Up/Down (ft.): ___________________

Starting Water Level (ft. BMP): ___________________________

Total Depth (ft. BMP): _______Water Column Height (ft.): _____

Casing Diameter (in. ID): ____ Multiplication Factor: _________

Casing Volume (gal.): ___________________________________

Water Level (ft. BMP) at End of Development: ______________

Total Depth (ft. BMP) at End of Development: ______________

QUALITY ASSURANCE

METHODS (describe):

Cleaning Equipment:

____

Development:

____

Disposal of Discharged Water:

____

INSTRUMENTS (indicate make, model, i.d.):

Water Level: ___________________________________

Thermometer: ___________________________________

pH Meter: ___________________________________

Field Calibration: ___________________________________

Conductivity Meter: ________________________________

Field Calibration: ___________________________________

Other:

Field Calibration:

DEVELOPMENT MEASUREMENTS

	Purge Characteristics		Water Quality Data				Appearance			
					Specific Conductance (µmhos/cm)					
Date/ Time	Cumul.Vol. (gal)	Water Level (ft. BGL)	Temp. (°C)	pH	@ Field Temp.	@ 25° C	Color	Turbidity & Sediment	Intake Depth (ft. BMP)	Remarks

Total Discharge (gallons): ___________________________

Casing Volumes Removed: ______________________________

Observations/Comments:

ABBREVIATIONS:

BMP - below measuring point	C - Celsius
BGL - below ground level	gal. - gallons
Cumul. Vol. - Cumulative volume removed	gpm - gallons per minutes
ID - Inside Diameter	in. – inches

Well Development Form Revision 8/00

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FIGURE SOP-7-1. WELL DEVELOPMENT RECORD

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 9

SOIL AND SEDIMENT SAMPLING FOR CHEMICAL ANALYSIS

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocols to be followed when soil and sediment samples are collected for physical or chemical analysis. The procedures presented herein apply to: soil sampling from the surface, soil sampling when drilling boreholes, and sediment sampling from surface waters, wetlands, drainage structures, etc. These procedures are intended to be general in nature. Appropriate revisions may be made when approved in writing by the MFG Project Manager to address site-specific conditions or project-specific protocols.

2.0 PROCEDURES

2.1 Surface Soil and Sediment Sample Collection

This section describes sampling of soils and sediment from near the land surface, including the bottom or sides of an excavation and the bottom of a surface water drainage course. The collected samples will be placed in appropriate sample containers, as designated by the laboratory, for the parameters to be analyzed.

2.1.1 Surface Soil Sampling

Soil will be removed using a spade and, if necessary, a post-hole digger to the top of the targeted sampling interval.

A. Direct Sampling Method -- A stainless-steel or, as appropriate, plastic instrument (trowel, scoop) will be used to recover the sample directly into appropriate containers provided by the analytical laboratory.

B. Manual Core Sampler Method -- A slide-hammer core sampler with brass or stainless steel liners may be used to recover a relatively undisturbed core sample. Extension sections may be added to reach deeper sampling intervals. This method is recommended for samples that will be analyzed for volatile organic compounds.

C. Hand Auger Method -- A hand auger with stainless-steel auger and sampler sections may be used to advance and sample the boring. Extension sections may be added to reach deeper sample intervals.

2.1.2 Sampling Sediment in a Surface Water Course

Sediment in a surface water course with little or no free water may be sampled by directly scooping the sample with a stainless steel or, as appropriate, plastic instrument (trowel, scoop). All sediments, including sediment submerged under water, may be sampled by the following methods:

A. Direct Sampling Method -- Fluid sediment may be collected directly using the sample container. If sampled under water, the container will be capped in place to avoid disturbance while surfacing.

B. Manual Core Sampler Method -- A slide-hammer core sampler with brass or stainless steel liners may be used to recover a relatively undisturbed core sample of the sediment. An extension section may be added to reach sediment intervals in deeper waters.

C. Remote Scoop Method -- A sampling cup or container attached to a pole may be used to collect a sediment sample in deeper water or where a longer reach is needed.

D. Bottom Sampling Dredge Method -- A sampling dredge attached to a cable also may be used to recover sediment samples in deeper waters.

2.2 Sample Collection During the Drilling of Borings

During borehole drilling, core samples may be collected for chemical analysis by lining the core barrel or drive sampler with clean brass or stainless steel liners. The procedures for obtaining soil cores are discussed in the MFG SOP entitled SUPERVISION OF EXPLORATORY BORINGS. The drive sampler or core barrel will be steam cleaned or washed with a laboratory-grade detergent and water solution to remove dirt, rinsed with tap water, and then rinsed with distilled or deionized water prior to and between sampling. Upon disassembly of the soil sampler by the drilling contractor, the MFG field geologist will take possession of the core. The core will be parted at the joints between the liners using a clean, sharp, stainless steel knife or spatula or similar implement. The most representative liner(s) in the drive sampler will be preserved for chemical analysis.

2.3 Sample Preservation

The soil or sediment sample will be quickly inspected for color, appearance, and composition, then capped immediately. If brass or stainless steel liners are used, the ends of the tube will be covered with Teflon® sheeting and then capped with clean polyethylene slip caps. The capped ends will be sealed with duct tape. The sample will be placed in a plastic, ziplock bag and stored (in an ice-cooled, insulated chest, if necessary) until delivery to the laboratory.

2.4 Sample Labeling

The sample container will be labeled with self-adhesive tags. Each sample will be labeled with the following information in waterproof ink:

A. Project identification;

B. Sample identification;

C. Date and time sample was obtained;

D. Sample Depth Interval (feet below ground level); and

E. First initial and last name of sample collector(s).

2.5 Documentation and Record Management

2.5.1 Daily Field Record

An MFG field representative will document the activities of each day of field work chronologically in accordance with the procedures contained in the MFG SOP entitled FIELD DOCUMENTATION. For soil sampling, the Daily Field Record (included in the MFG SOP entitled FIELD DOCUMENTATION) or field notebook entries should include the following items:

A. Decontamination Record: Decontamination method, source of tap water or deionized water, type of detergent or other cleaning agent;

B. Sample Inventory Record: Sample identification, location, date and time of sampling, sample depth interval, analyses requested and analysis methods;

C. Sampling Location Map: Surface soil sampling only, include scale, orientation, sample locations tied into a permanent reference point and sample identifications; and

D. Sampling Equipment Record: Description of sampling methodology and equipment including unique equipment identification, if available.

Copies of these records will be placed in the project files. Sample location and depth information should also be included in any electronic database maintained for the project.

2.5.2 Log of Boring Activity

The depth intervals of the soil samples collected for chemical analysis, the sampling date and times, and the sample identifications will be documented by the MFG field geologist on the Log of Boring forms (included in the MFG SOP entitled SUPERVISION OF EXPLORATORY BORINGS) in the portion of the boring log corresponding to the sample interval. The original Log of Boring will be submitted to the MFG Project Manager upon completion of the borehole for placement in the MFG project file.

2.5.3 Sample Custody

A Chain-of-Custody and Request for Analysis (CC/RA) form will be filled out for every sampling event or shipment, whichever is more frequent. Sample custody procedures and CC/RA form are discussed in the MFG SOP entitled SAMPLE CUSTODY, PACKAGING AND SHIPMENT.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

3.1 Equipment Cleaning

The sampler, liners, polyethylene end caps, parting knife, and any tools used in the assembly and disassembly of the sampler will be cleaned before and after each use. Equipment will be cleaned by scrubbing with a stiff brush using a laboratory-grade detergent/water solution, followed by rinsing with clean, potable, municipal water, then rinsing with distilled or deionized water. Alternatively, the equipment may be steam cleaned followed by rinsing with distilled or deionized water. An acid rinse (0.1 N HCl) or solvent rinse (i.e., hexane or methanol) may be used to supplement these cleaning steps if tarry or oily deposits are encountered. The acid or solvent rinse will be followed by thoroughly rinsing with municipal water and then with distilled or deionized water. After cleaning, equipment will be packaged and sealed in plastic bags or other appropriate containers to minimize contact with dust or other contaminants.

3.2 Record Review

The project manager or designated QA reviewer will check and verify that documentation has been completed and filed per this procedure and the other procedures referenced herein.

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 10

STORAGE AND DISPOSAL OF SOIL, DRILLING FLUIDS, AND WATER GENERATED DURING FIELD WORK

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed for the storage, testing, and disposal of soil, drilling fluids, and water generated during any field operations performed by MFG. The procedures presented herein are intended to be of a general nature. Appropriate modifications to the procedures may be made when approved in writing by the MFG Project Manager.

2.0 PROCEDURES

2.1 Material Storage and Labeling

Potentially-contaminated materials will be collected and stored in water-tight, secured containers pending determination of their hazards. The containers will be stored temporarily at the site of origin. All steel drums used for storage will be Department of Transportation (DOT)-approved, so that hazardous materials may be transported in these drums if necessary. A daily inventory of the materials generated and the containers in which they are stored will be recorded on the Daily Field Record form. The Daily Field Record is presented in the MFG SOP entitled FIELD DOCUMENTATION.

2.2 Well Purging and Development Water

Water extracted from potentially-contaminated wells or piezometers for the purpose of development, sampling, or hydraulic testing will be stored in sealed, 55-gallon, steel drums or in portable, watertight storage tanks. The containers will be labeled with an indelible marking including the: date; well or piezometer number(s); and "development water" if the water was extracted for development or "purge water" if the water was extracted for sampling or hydraulic testing, in addition to the other labeling requirements included Section 3.0 of this SOP.

2.3 Drilling Fluid

Drilling fluid generated by hydraulic rotary drilling operations will be stored in sealed, 55-gallon, steel drums or in portable, watertight storage tanks. The containers will be labeled with an indelible marking including the: date; boring, well, or piezometer number(s); and "drilling fluid," in addition to the other labeling requirements included in Section 3.0 of this SOP.

2.4 Soil Cuttings

Soil cuttings generated by drilling operations will be stored in sealed, 55-gallon, steel drums or in soil boxes with roll-top, lockable covers. The containers will be labeled with an indelible marking including the: date; boring, well or piezometer number(s); and "cuttings," in addition to the other labeling requirements included in Section 3.0 of this SOP.

2.5 Wash Water

Water used to decontaminate equipment, by steam cleaning or other methods, that was used in potentially contaminated borings, wells or piezometers will be stored in sealed, 55-gallon steel drums or in portable, watertight storage tanks. The containers will be labeled with an indelible marking including the: date; boring, well or piezometer number(s); and "wash water," in addition to the other labeling requirements included Section 3.0 of this SOP.

2.6 Criteria for Hazard Determination

Analyses for hazard determination will be conducted by a laboratory certified by the applicable agency in the state in which the project site is located. Determination of whether the waste is hazardous waste will be based on the criteria in the applicable state and federal regulations.

2.6.1 Drilling Fluid and Cuttings from Exploratory Soil Borings and Well or Piezometer Installation

Evaluation of the hazard status for drilling fluid and cuttings from each boring, well or piezometer may be based upon the results of chemical analyses of the soil and groundwater samples collected from each boring, well or piezometer. Alternatively, representative samples of the drilling fluid and cuttings may be collected and analyzed.

2.6.2 Well Purging and Development Water

Evaluation of the hazard status for well purging and development water from each well or piezometer may be based upon the results of chemical analysis of the groundwater sample subsequently collected from each well or piezometer. Alternatively, representative samples of the purging and development water may be collected and analyzed.

2.7 Labeling

All drums containing waste will be labeled using self-adhesive labels placed on the side of the drums. The labels will be placed in a location on the drum such that the label can be easily read. At a minimum, the following information will be placed on the label using an indelible pen:

- Generator (client) name;
- Drum identification number (when more than one drum present);
- Description of contents, including boring, well or piezometer number(s), as appropriate;
- Date of generation;

- Technical contact (generally the name and phone number of MFG Project Manager); and
- MFG project number.

Local hazardous material storage regulations will also be reviewed for labeling requirements in addition to those listed above.

Appropriate hazardous waste labels will be used when analytical results indicate that the contents are hazardous waste.

2.8 Documentation

All of the information recorded on the drum labels will also be recorded in field notes completed at the work site. This information will be copied to the project file.

3.0 QUALITY CONTROL

3.1 Treatment and Disposal of Contaminated Materials

Soil, drilling fluid and water containing hazardous constituents will be treated and/or disposed of in accordance with all local, state and federal regulations. The appropriateness of on-site treatment versus off-site treatment and/or disposal will be evaluated by the MFG Project Manager based on the hazard determination.

3.2 On-Site Treatment of Contaminated Materials

Soil, drilling fluid, and water of known hazardous composition may be treated on-site provided: (1) such treatment is conducted in accordance with all local, state, and federal regulations based upon location, level of contamination, and volume of material; and (2) permission has been obtained as part of a site access agreement. On-site treatment may be feasible and economical if an on-site soil and/or groundwater treatment system is planned.

3.3 Transport and Disposal of Contaminated Materials

Hazardous waste that requires off-site disposal will be transported by certified hazardous material haulers to approved disposal sites in accordance with state and federal transportation regulations. Soil, drilling fluid, and water which has been classified as hazardous waste based upon the criteria in Section 2.6 of this SOP will be disposed of within 90 days of generation.

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 12

WATER QUALITY SAMPLING

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed during sampling of surface water, groundwater, stormwater or waste water. Note that the protocol for collection of non-aqueous phase liquid (NAPL) samples from monitoring wells is provided in the MFG, Inc. (MFG) SOP entitled WATER LEVEL, IMMISCIBLE LAYER AND WELL DEPTH MEASUREMENT. The procedures presented herein are intended to be general in nature. Appropriate revisions may be made to accommodate site-specific conditions or project-specific protocols when they are approved in writing by the MFG Project Manager or detailed in a project work plan, sampling plan or quality assurance project plan.

2.0 PROCEDURES

2.1 Groundwater Sample Collection

Individual samples from wells will be collected as follows:

A. The depth to water, the thickness or presence of a Non-Aqueous Phase Liquid (NAPL) in a well and the total depth will be measured using the procedures discussed in the MFG SOP entitled WATER LEVEL, IMMISCIBLE LAYER AND WELL DEPTH MEASUREMENT.

B. A positive displacement pump, submersible pump, and/or bailer will be used for removing the groundwater in the monitoring wells (purging). Equipment used for purging and sampling may be permanently installed (dedicated) in the monitoring wells. Care must be taken that bailers and/or tubing are constructed from materials that will not affect the sample analyses.

C. Wells will be pumped or bailed at least until the volume of water removed is equal to three casing volumes (volume of standing water in the well based upon total depth of well, the depth to water, and the well casing diameter). The purge rate must not reach a point where the recharge water is entering the well in an agitated manner. To assure that the water samples are representative of the water-yielding zone, periodic measurements of the temperature, pH, and specific conductance will be made. The sample will be collected only when the temperature, pH and specific conductance reach a relatively constant value (see Section 2.8) or after five well volumes have been removed. If the yield of the well is low such that it can be bailed or pumped dry, then the recharged groundwater in the well will be considered representative regardless of the number of casing volumes of groundwater removed, since all standing water in the well has been replaced by recharge from the water-yielding zone. If a well is purged dry, the well can be sampled upon 90% recovery or after two hours, whichever occurs first.

D. For specific projects, a low-flow purge method or “micopurge” method may be used for sample collection. Wells will be purged at a low pumping rate to minimize agitation of water in the well and minimize drawdown. The goal is to limit drawdown in the well to less than 10 percent of the length of the saturated well screen. If the initial water level is above the top of the screen, then the goal is to limit drawdown due to purging so that the water level in the well does not drop below the top of the screened interval. Wells will be purged by pumping water at a rate less than 250 mL per minute. Bailers will not be used for purging of sampling wells.

E. A sample drawn from plumbing on municipal or domestic wells will be taken at the access valve closest to the well and upstream of any water softening or chlorination input.

F. Prior to collecting samples from a well, a clean plastic apron will be placed adjacent to or around the well to prevent equipment and sample containers from coming into contact with surface materials. Alternatively, a clean field table may be set up near the well. If used, the table will be cleaned (Section 6.0) before and after use at each well.

G. Sample containers prepared specifically for the required analyses by the analytical laboratory or their supplier will be used for sample collection. Samples for volatile organic compound analyses will be collected first. To collect a sample in a volatile organic analysis (VOA) vial, remove the cap with Teflon-lined septum, then fill slowly (avoiding agitation) until a miniscus of sample water (held by surface tension) extends above the top of the vial. Carefully replace the cap, then turn the vial upside down and tap gently while checking to ensure that no headspace (air bubbles) is present in the vial.

Other glass sample bottles for semi- and non-volatile analyses should be filled to near the top. To account for slight expansion due to temperature changes, leave headspace approximately equivalent to the volume of liquid which would fill the bottle's cap. Plastic sample bottles should be filled completely. Splashing of the water in the sample container and exposure to the atmosphere shall be minimized during sampling. The container cap will be screwed on tightly immediately after filling the sample container. Sample filtration, if necessary, is discussed in Section 2.4 of this SOP.

Sample bottles that do not contain preservative should be rinsed with the sample water prior to filling.

H. Where more than one well within a specific field or site is to be sampled, the sampling sequence should begin with the well having the lowest suspected level of contamination. Successive samples should be obtained from wells with increasing suspected contamination. If the relative degree of suspected contamination at each well cannot be reasonably assumed, sampling should proceed from the perimeter of the site towards the center of the site. The sampling sequence should be arranged such that wells are sampled in order of increasing proximity to the suspected source of contamination, starting from the wells up-gradient of the suspected source.

I. Sampling activity for each monitoring well will be recorded on a Groundwater Sampling Record (example attached).

2.2 Surface Water Sample Collection

Individual samples from surface water sampling stations will be collected as follows:

A. Where multiple sampling stations exist along a moving water source (i.e., a creek or drainage channel), the downstream station will be sampled first. A moving water sample will be taken from the portion of the water with maximum flow at any given sampling station unless otherwise specified. If the sampling point is inaccessible from shore, the sampling personnel will enter the water from a point downstream of the sampling point, taking care not to disturb the water.

B. A standing water sample will be taken at a point in the body of water at least three feet from the shore, if possible, or unless otherwise specified.

C. A surface water sample will be collected according to one of the following, or similar, techniques.

   1. Direct Method -- Sample bottle is inverted, submerged to the specified depth, turned upright, removed from the water, and then capped. Add preservative, if any, after sample collection.

   2. Dipper Method -- Sample bottle or container attached to a pole is dipped in the water, raised above the water, and then capped (if actual sample bottle used).

3. Bailer Method -- A appropriate sampling bailer with a ball check valve is submerged to the desired sample depth, either directly or by suspending the bailer on a rope from a pole.

4. Syringe Method (for very shallow water) -- A disposable plastic filtering syringe may be used to collect very shallow surface water without disturbing the sediment. The syringe will be disposed of after each use.

5. Peristaltic Pump Method -- The sample is collected through a section of new, clean, flexible Tygon (polyvinylchloride) tubing. The tubing intake will be secured manually or by attaching weights. This procedure may be modified to collect the sample through a Teflon tube into a sample flask by running the pump on a vacuum.

D. The first collected water will be used to rinse the sampling equipment. Sample bottles that do not contain preservative should be rinsed with the sample water prior to filling. Subsequent water collected will be used to fill the analytical sample bottles until all bottles are filled. Field measurement of parameters will be taken once for each sampling station. Field parameters (pH, specific conductance, temperature, odor, turbidity, and/or sediment) will be measured from a separate container (instruments will not contact the analytical samples).

E. A stake or pole identifying the sampling station should be placed at or near the sampling station for future identification of the location. MFG personnel will record a brief description of the stake or pole location in relation to permanent landmarks, and the sampling location in relation to the stake or pole (example: stake is approximately 100 feet west along Markley Creek from Somersville Road, on north-side shore. Sampling point is 25 feet south of stake, in middle of Markley Creek). MFG personnel will include a sketch map of the sampling station in the Surface Water Sampling Record (example attached).

2.3 Sample Filtration

When required, a field-filtered water sample will be collected using a disposable, in-line 0.45 μm filter. The water sample will be pumped through the filter using a peristaltic pump and a section of Tygon (polyvinylchloride) tubing or other appropriate method. An aliquot of approximately 100 ml of sample will be run through the tubing and filter prior to collection into the sampling containers. Both the filter and tubing will be disposed of between samples.

2.4 Sample Containers and Volumes

The sample containers will be appropriate to the analytical method and will be obtained from the water analysis laboratory or other approved source. Different containers will be required for specific groups of analytes in accordance with U.S. EPA Methods, project-specific requirements, and/or other local jurisdictional guidance. The MFG sampler will confirm with the laboratory performing the analyses that appropriate bottleware and preservatives are used and ensure that a sufficient volume of sample is collected.

2.5 Sample Labeling

Sample containers will be labeled with self-adhesive tags. Each sample will be labeled with the following information using waterproof ink.

A. Project identification;

B. Sample identification;

C. Date and time samples were obtained;

D. Requested analyses and method;

E. Treatment (preservative added, filtered, etc.); and

F. Initials of sample collector(s).

2.6 Sample Preservation and Storage

If required by the project or analytical method, water samples submitted for chemical analysis will be stored at 4°C in ice-cooled, insulated containers immediately after collection. Preservation and storage methods depend on the chemical constituents to be analyzed and should be discussed with the water analysis laboratory prior to sample collection. EPA and/or other local jurisdictional requirements and/or the requirements of a project-specific plan (e.g., sampling and analysis plan, work plan, quality assurance project plan, etc.) shall be adhered to in preservation and storage of water samples.

2.7 Sample Custody

Samples shall be handled and transported according to the sample custody procedures discussed in the MFG SOP entitled SAMPLE CUSTODY. The sample collector shall document each sample on the Chain-of-Custody and Request for Analysis form (Figure SOP-2-1).

2.8 Field Measurements

Specific conductance, pH, and temperature measurements may be performed on water samples at the time of sample collection. Data obtained from these (or other) field water quality measurements will be recorded on the appropriate sampling records. Separate aliquots of water shall be used to make field measurements (i.e., sample containers for laboratory analysis shall not be reopened).

For groundwater samples, field measurement intervals will be calculated based upon the casing volume of the monitoring well so that at least four readings will be taken during the course of purging the target volume from the well (at least three casing volumes). Note that the target volume criteria does not apply if the well is purged dry. If the parameters have not stabilized after the target volume is removed from the well, field measurements and purging will continue until two consecutive readings have stabilized to within the following limits or until five casing volumes have been removed:

- Specific conductance+/-10%
- pH +/-0.05 pH units
- temperature+/-1EC

For surface water sampling, the parameters will be measured once and recorded.

2.8.1 Temperature Measurement

Temperature will be measured directly from the water source or from a separate sample aliquot. Temperature measurements will be made with a mercury-filled thermometer, bimetallic-element thermometer, or electronic thermistor. All measurements will be recorded in degrees Celsius (°C).

2.8.2 pH Measurement

A pH measurement will be made by dipping the probe directly into the water source or into a separate sample aliquot. Prior to measurement, the container in which the field parameter sample will be collected will be acclimated to the approximate temperature of the sample. This can be accomplished by immersing the container in water removed from a well during the purging process. The pH measurement will be made as soon as possible after collection of the field parameter sample, preferably within a few minutes, using a pH electrode. The value displayed on the calibrated instrument will be recorded after the reading has stabilized. If the value falls outside of the calibrated range, then the pH meter will be recalibrated using the appropriate buffer solutions.

2.8.3 Specific Conductance Measurement

Specific conductance will be measured by dipping the probe directly into the water source or into a separate sample aliquot. The probe must be immersed to the manufacturer's recommended depth. Specific conductance will be reported in micromhos/cm at 25°C. If the meter is not equipped with an automatic temperature compensation function, then the field value will be adjusted at a later time using the temperature data and the following formula:

$$SC_{25} = SC_T / [1 + \{(T - 25) \times 0.025\}]$$

where: SC_{25} = specific conductance at 25°C
SC_T = specific conductance measured at temperature T (°C)
T = sample temperature (°C)

The value displayed on the calibrated instrument will be recorded after the reading has stabilized. If the value falls outside of the calibrated "range" set by the range dial on the instrument, then the range setting will be changed to a position which gives maximum definition. If the specific conductance value falls outside of the calibrated range of the conductivity standard solution, then the instrument will be recalibrated using the appropriate standard prior to measurement.

2.8.4 Equipment Calibration

Equipment used to measure field parameters will be calibrated by MFG personnel according to manufacturer's instructions. Calibration checks will be performed at least once prior to and at least once following each day of instrument use in the field and the results will be documented on the Sampling Record for each sampling station.

2.9 DOCUMENTATION

2.9.1 Groundwater Sampling Record

Each sampling event for each monitoring well will be recorded on a separate Groundwater Sampling Record form. The documentation should include the following:

A. Project identification;

B. Location identification;

C. Sample identification(s) (including quality control samples);

D. Date and time of sampling;

E. Purging and sampling methods;

F. Sampling depth;

G. Name(s) of sample collector(s);

H. Inventory of sample bottles collected including sample preservation (if any), number, and types of sample bottles;

I. Total volume of water purged;

J. Results of field measurements and observations (time and cumulative purge volume, temperature, pH, specific conductance, turbidity, sediment, color, purge rate);

K. Equipment cleaning record;

L. Description and identification of field instruments and equipment; and

M. Equipment calibration record.

When the sampling activity is completed, the Groundwater Sampling Record will be checked by the MFG Project Manager or his/her designee, and the original record will be placed in the MFG project file.

2.9.2 Surface Water Sampling Record

Each sampling event for each surface water sampling station will be recorded on a separate Surface Water Sampling Record form (Figure SOP-12-2). The documentation should include the following:

A. Project identification;

B. Location identification (sampling station);

C. Sample identification(s) (including quality control samples);

D. Date and time of sampling;

E. Description of sampling location;

F. Sampling depth below water surface;

G. Sampling method;

H. Condition of water (standing or moving);

I. Description of flow measurement method, if applicable, and any flow data;

J. Instrument calibration and cleaning record;

K. Results of field measurements and observations (time, temperature, pH, specific conductance, turbidity, sediment, color);

L. Name(s) of sample collector(s); and

M. Sketch map showing location of sampling station and permanent landmarks.

When the sampling activity is completed, the Surface Water Sampling Record will be checked by the MFG Project Manager or his/her designee, and the original record will be placed in the MFG project file.

3.0 QUALITY CONTROL

3.1 Chain-of-Custody and Request for Analysis Form

A Chain-of-Custody and Request for Analysis form (CC/RA form) will be filled out as described in the MFG SOP entitled SAMPLE CUSTODY. Sample custody procedures are discussed and the CC/RA form presented in the MFG SOP entitled SAMPLE CUSTODY, PACKAGING AND SHIPMENT.

3.2 Equipment Cleaning

Sample bottles and bottle caps will be cleaned and prepared by the analytical laboratory or their supplier using standard EPA-approved protocols. Sample bottles and bottle caps will be protected from dust or other contamination between time of receipt by MFG and time of actual usage at the sampling site.

Groundwater sampling equipment may be dedicated to a particular well at a project site. Prior to installation of this equipment, all equipment surfaces that will be placed in the well or may come in contact with groundwater will be cleaned to prevent the introduction of contaminants (refer to the MFG SOP entitled EQUIPMENT DECONTAMINATION).

Sampling equipment that will be used at multiple wells or sampling locations will be cleaned after sampling at each location is completed in accordance with the MFG SOP entitled EQUIPMENT DECONTAMINATION.

Equipment such as submersible electric pumps, which cannot be disassembled for cleaning, will be cleaned by circulating a laboratory-grade, detergent and potable water solution through the assembly, followed by clean potable water from a municipal supply, and then by distilled or deionized water. Equipment cleaning methods will be recorded on the Groundwater Sampling Record and Surface Water Sampling Record.

3.3 Records Review

The MFG Project Manager or designated QA reviewer will check and verify that documentation has been completed and filed per this procedure.

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 13

FIELD MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL (ORP)

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed for the field measurement of oxidation-reduction potential in water samples. If necessary to accommodate specific field conditions, modifications of these procedures may be made when approved in writing by the MFG Project Manager.

2.0 PROCEDURES

2.1 Explanation of Method

The potential difference measured between an indicator electrode and a reference electrode in a water sample is the oxidation-reduction potential (ORP) of the water. Indicator electrodes are typically made of platinum and reference electrodes are commonly either calomel or Ag/AgCl electrodes with a KCl electrolyte solution. The reference electrode provides a constant electrode potential for comparison to the potential at the platinum electrode.

The oxidation-reduction potential of water samples is most commonly reported relative to the standard hydrogen electrode, as Eh. Therefore, the oxidation-reduction potential of a water sample measured using a platinum indicator electrode and reference electrode must be corrected for the half-cell potential of the reference electrode in order to provide an Eh estimate for the water.

2.2 Instrumentation and Equipment

Measurement of ORP requires the following equipment:

1. pH meter reading millivolts **OR** ORP meter such as Orion Model 98-75
2. Combination ORP electrode (Pt electrode with reference electrode) **OR** Reference electrode[1] (calomel or Ag/AgCl) and platinum electrode
3. Reference electrode filling solution, as required for some combination ORP electrodes[2]
4. Calibration standard (Zobell or Light's solution)
5. Clean (e.g., deionized) water for probe cleaning
6. Squeeze bottle for clean water
7. Clean container for sample water during measurement
8. Electrode cleaning solution

2.3 Instrument Checks

It is not possible to calibrate ORP electrodes over a range of conditions. Instead, standard solutions of known redox potential for specific indicator electrodes (i.e., Pt electrode) are used to check the electrode response at the temperature of measurement. Calibration checks should be performed and recorded on the Eh Data Sheet prior to each sample measurement as follows:

1. Assemble meter with either combination ORP electrode or set of platinum and reference electrodes.
2. If needed, select appropriate filling solution and fill reference electrode with fresh solution.

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[1] The reference electrode and the filling solution must be recorded with ORP measurements.

[2] If a combination ORP electrode is used, it may be possible to select the appropriate electrolyte filling solution for the reference electrode. For sample waters of low ionic strength (< 10,000 mg/L TDS), use the filling solution that matches the potential of a calomel electrode. For higher ionic strength waters (> 10,000 mg/L TDS), use 4N KCl saturated with Ag/AgCl.

3. Place standard solution in clean container.

4. Measure and record temperature of standard solution (T_1) in EC.

5. For Zobell's solution, calculate the theoretical potential at the measured temperature using the following equation:

$$Eh_{(Zobell)} = 428 + 2.2*(25 - T) = \_\_\_\_\_ \text{ mV}$$

6. For Light's solution, the theoretical potential at 25EC is **675 mV**. *(note: no temperature correction data available for Light's solution)*

7. Measure and record the potential of the standard solution in mV.

8. Correct the measured potential of Zobell's solution for the half-cell potential of the reference electrode using the potential of the reference electrode for the temperature of measurement (T_1) given in Table 1 below.

$$Eh_{(Standard)} = E_{(Standard)}\text{, observed} + E_{(ref.\ electrode)}\text{, at } T_1 = \_\_\_\_\_ \text{ mV}$$

Table 1. Half-Cell Potential of Reference Electrode at T

Temperature (EC)	Calomel	4N KCl saturated Ag/AgCl
10	251 mV	214 mV
20	244 mV	204 mV
25	241 mV	199 mV
30	238 mV	194 mV

9. Compare the corrected, measured potential of the standard solution (step 8) to the theoretical potential at the measured temperature (calculated in step 5 or 6). If the values are more than ±10 mV different, the meter and electrode functions should be checked as follows:

   (a) recheck temperature of standard solution
   (b) replace electrode filling solution
   (c) clean electrodes (refer to Section 4.1)
   (d) replace standard with new mix of solution

   Note: If the temperature of the standard solution is much higher or lower than 25EC (i.e., ± 15EC), then the half-cell potential of the reference electrode may deviate significantly from the values given in Table 1. In this case, the proper function of the ORP measurement system cannot be verified.

   Alternate procedures are available to check the function of the ORP measurement system but require two reference electrodes, one that is known to be functioning properly. Refer to APHA Method 4500-H, section 5.b. for a description of the alternate procedures.

10. Check initial measurement of standard solution. Measurements should agree within 10 mV. If the measurements do not agree, the meter and electrode functions should be checked as described in step 9.

2.4 Sample Measurement

After measurement of the standard solution confirms the electrode function, measure the redox potential of the water sample as follows:

1. Thoroughly clean the outside of the electrode(s) with deionized water prior to introducing to the sample water.

2. Measure and record sample temperature (T_2) in EC.

   Note: If the sample temperature is more than approximately 10EC higher or lower than the temperature of the standard solution previously measured, the sample measurement may require additional time to stabilize due to drift in the reference electrode potential. Efforts should be made to maintain the standard solution at approximately the same temperature as the sample waters to be measured.

3. Immerse the ORP electrode(s) in the sample water.

4. Wait 2 minutes and then record the measured potential in mV.

5. Correct the measured potential of the sample solution for the half-cell potential of the reference electrode at the temperature of measurement (T_2) (refer to Table 1):

$$Eh_{(Sample)} = E_{(Sample)}\text{, observed} + Eh_{(ref.\ electrode)}\text{, at } T_2 = \underline{\qquad}\ \text{mV}$$

These steps must be documented on the attached Eh Data Sheet for each sample measurement.

2.5 Documentation and Record Management

Calibration information will be recorded on the Eh Data Sheet. ORP measurements will also be recorded on the Eh Data Sheet (Data Record, page 2 of 2) with associated calculations to compute Eh from ORP measurements. ORP measurements will not be reported as Eh data without first performing the correction calculations.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

3.1 Electrode Maintenance and Storage

Contamination of the electrode surface, salt bridge, or internal electrolyte solution in the case of reference electrodes can lead to excessive drift, poor electrode response, and artifact potentials (electrode "poisoning").

3.1.1 Routine Maintenance for Intermittent Use

The reference electrode should be cleaned for storage following each series of measurements or daily, as follows:

> Empty reference electrode of filling solution and rinse thoroughly with distilled water. The electrode should be stored filled with distilled water and should be labeled as so. If salt deposits have formed on the outside of the electrode casing, clean with a dilute acid or detergent solution and rinse thoroughly with distilled water.

The Pt indicator electrode should be cleaned daily by rinsing with distilled water and should be stored in distilled water between uses.

3.1.2 Long-term Maintenance

Follow manufacturer's instructions for long-term maintenance, cleaning and rejuvenation of electrodes. If excessive drift occurs or erratic performance of electrodes is observed in a standard solution after appropriate cleaning, refilling or regeneration procedures, discard the faulty electrode and use a new one.

3.2 Records Review

Calculations will be checked before any ORP or Eh data are reported for use on a project. The calculation check will be documented by the reviewers initials and date of review on the Eh Data Sheet.

4.0 REFERENCES

American Public Health Association (APHA), 1995. *Standard Methods for the Examination of Water and Wastewater, 19th Edition*. Published by APHA, American Water Works Association, and Water Environment Association.

American Society for Testing and Materials (ASTM), 1993. *Standard Practice for Oxidation-Reduction Potential of Water, D-1498-93*.

Orion Research, Inc., 1983. *Instruction Manual for Platinum Redox Electrodes*.

USGS, 1976. *Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents.* Techniques of Water-Resources Investigations, Book 1, Chapter D2.Eh DATA SHEET.

Eh DATA SHEET

DATE:
LOCATION:

Project Number:

Project Name:

Sample No.

Sampler(s):

Meter (Model No.):

Reference Electrode:

Filling Solution:

Standard: Zobell ________ Date Mixed: (Discard after 6 months)
Light's _______

MEASUREMENTS/CALCUATIONS

A) Temperature of Standard Solution, T_1 (°C)

B) $Eh_{Standard;}$ theoretical
For Zobell: $Eh_{Zobell;}$ theoretical = 428 + 2.2 (25 – T) (mV)
For Light's: $Eh_{Lights;}$ theoretical = 675 mV

C) $E_{(Standard);}$ measured (mV)

D) $Eh_{(ref.\ electrode)}$ at T_1 (mV) for the appropriate reference electrode

Temperature (°C)	Calomel	4N KCI saturated Ag/AgCl
10	251	214
20	244	204
25	241	199
30	238	194

E) $Eh_{(Standard)} = E_{(standard);}$ measured + $E_{(ref.\ electrode)}$ (mV) E = C + D

F) Difference between theoretical and measured Eh of standard

$Eh_{(standard);}$ theoretical – $Eh_{(standard)}$ > ± 10 mV? B – E > ± 10 mV?

If yes, then:
1) check temperature
2) replace electrode filling solution
3) replace standard

G) Temperature of sample, T_2 (°C)

H) $E_{(Sample);}$ measured (mV)

I) $Eh_{(ref.\ electrode)}$ at T_2 for the appropriate reference electrode

Temperature (°C)	Calomel	4N KCI saturated Ag/AgCl
10	251	214
20	244	204
25	241	199
30	238	194

J) $Eh_{(Sample)} = E_{(Sample)} + Eh_{(ref.\ electrode)}$ (mV) J = H + I

REFERENCES:
1. American Society for Testing and Materials (ASTM), 1981. Standard Practice for Oxidation-Reduction Potential of Water, D1498.
2. Orion Research, Inc, 1982. Instruction Manual for Platinum Redox Electrodes.
3. USGS, 1976. Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents. Techniques of Water-Resources Investigations, Book 1, Chapter D2.

DATA RECORD

Date	Time	Location or Sample	T_1 (°C)	$\text{Eh}_{\text{(standard)}}$ (mV)	$\text{E}_{\text{(standard)}}$ (mV)	$\text{Eh}_{\text{(ref. electrode)}}$ (mV)	$\text{Eh}_{\text{(standard)}}$ (mV)	Check value (mV)	T_2 (°C)	$\text{E}_{\text{(sample)}}$ (mV	$\text{Eh}_{\text{(ref. electrode)}}$ (mV)	$\text{Eh}_{\text{(sample)}}$ (mV)
			A	B	C	D	E (=C+D)	F (=B-E)	G	H	I	J (=H+I)
8/14/00	1500	Example 1	10°C	461	240	214	454	7	12°C	150	214	+364mV

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 14

HYDRAULIC TESTING

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed during performance of a constant-discharge pumping test or a "slug test." The procedures presented herein are intended to be general in nature; as the work progresses and when warranted, appropriate revisions may be made when approved in writing by the MFG Project Manager.

2.0 PROCEDURES

2.1 Constant-Discharge Test

The performance of a constant-discharge pumping test involves three phases: 1) pre-test measurements; 2) pumping portion of the test; and 3) recovery portion of the test. Pre-test measurements include water level measurements which indicate water level trends in the test area. These effects must be accounted for when test data are analyzed. The pumping portion of the test involves monitoring water levels in the pumping well and observation wells while the discharge in the pumping well is kept fairly constant. Groundwater samples may be collected during this phase. The recovery portion of the test occurs after pumping is stopped and involves the measurement of recovery water levels in the pumped well and observation wells.

2.1.1 Pre-Test Measurements

2.1.1.1 Water Level Measurements

Prior to conducting a pumping test, water level measurements should be taken in the pumped well and all observation wells (other monitoring wells and piezometers) to be monitored during the test to describe the pre-test potentiometric surface and its natural variability (refer to MFG SOP entitled WATER LEVEL, IMMISCIBLE LAYER AND WELL DEPTH MEASUREMENT). Measurements in both the pumped well and observation wells should be taken at least every 4 hours for a minimum of three days before the pumping test begins. More frequent water level measurements in one or more wells using a continuous recording device may be used to substitute for the 4-hour measurement requirement in the pumped well and all observation wells.

Prior to beginning the pumping test, watches, the datalogger and other timing devices to be used in the test should be synchronized.

The water level measurements will be made with an electric water level probe, steel surveyors' tape or continuous recording device (Stevens recorder or pressure transducer/recorder). Accuracy of water level measurements prior to and during the aquifer test will be to within plus or minus 0.02-foot in the observation wells.

An observation well may be monitored continuously with a Stevens Type F water level recorder or a pressure transducer/recorder.

If water levels are measured by hand, all pre-test water level measurements for the pumping well and observation wells will be recorded on a Pumping Test Record form (Figure SOP-14-1). The same form will be used during the pumping portion of the pumping test.

2.1.1.2 Barometric Measurements

A record of barometric changes in the vicinity of the pumping test site shall be obtained for the pre-test and test period. This record will be used to monitor changes in water levels caused by barometric effects. A recording barograph or record from a nearby weather station is acceptable.

2.1.2 Pumping Portion of Test

2.1.2.1 Measurements to be Taken

During the pumping portion of the pumping test, the following measurements will be made: 1) water levels in both the pumped well and the observation wells; 2) instantaneous and cumulative discharge from the pumped well; and 3) time at which these measurements are made. Samples of the discharge water may also be collected periodically during the test for chemical analysis or field testing. All data will be recorded on the Pumping Test Record form (Figure SOP-14-1) for the appropriate well.

2.1.2.2 Water Levels

Pumped Well:

The water level measurements in the pumped well should be taken according to the time schedule outlined below. More frequent measurements may be used.

Time Since Pumping Started	Time Intervals
0 - 10 minutes	0.5 - 1 minute
10 - 15 minutes	1 minutes
15 - 60 minutes	5 minutes
60 - 300minutes	30 minutes
300 - 1440 minutes	60 minutes
1440 - shut down of pump	480 minutes (8 hours)

Observation Wells:

Stevens Type F continuous recorders or pressure transducer/datalogger may be installed in the observation wells. Water level measurements may be taken in these wells using an electric water level probe or steel surveyors' tape for calibration when the Stevens recorder or transducer/recorder is installed, and whenever the recorder chart paper is changed or the recorder is adjusted in any way. If a continuous recorder or pressure transducer/datalogger is not used, then water level measurements may be taken using an electric water level probe or steel surveyor's tape according to the following schedule:

Time Since Pumping Started			Time Intervals
0	-	60 minutes	1 minute
60	-	120 minutes	5 minutes
120	-	240 minutes	10 minutes
240	-	360 minutes	30 minutes
360	-	1440 minutes	60 minutes
1440	-	shut down of pump	480 minutes (8 hours)

The time of measurements and water level measurement will be entered in the appropriate columns of the Pumping Test Record form (Figure SOP-14-1) for the pumped well and observation wells. If a Stevens recorder or pressure transducer/recorder is used, water level calibration and pertinent notes will be entered on the Pumping Test Record form.

2.1.2.3 Discharge Rate

Discharge from the pumped well will be measured using either of the following methods: 1) totalizing flow meter and stopwatch; 2) circular orifice meter; 3) Venturi meter; 4) Parshall flume; or 5) calibrated container and stopwatch. The discharge reading and time of reading will be entered on the Pumping Test Record form for the pumped well.

Discharge should be maintained within plus or minus 5 percent of the designated rate by means of a globe valve or other throttling device. Discharge will be checked and adjusted, if necessary, every 10 minutes during the first hour of pumping, at 30-minute intervals for the following 5 hours, and at one-hour intervals thereafter. Time of measurement and rate of discharge will be entered on the Pumping Test Record form for the pumped well (Figure SOP-14-1). If the pump is driven directly by an engine, the engine speed (in RPM) should be checked and noted every hour during the test. If the pump is run by an engine or a generator, the fuel level and the oil level in the engine or generator will have to be checked periodically, and fuel and/or lubricating oil added when necessary.

2.1.3 Sampling of Discharge Water

Samples of discharge water from the pumped well may be collected at time intervals specified by the MFG Project Manager, provided such sampling does not interfere with water level measurements. The temperature, pH, and specific conductance of the samples will be measured in the field when the samples are collected. The samples will be preserved for subsequent chemical analysis by an authorized laboratory in accordance with the MFG SOP entitled WATER QUALITY SAMPLING. The time the samples were collected and field measurements of water quality parameters will be recorded on the Pumping Test Record form (Figure SOP-14-1) for the pumped well.

2.1.4 Duration of Pumping

The target duration of the pumping portion of each pumping test will be established prior to beginning the test. During the test, time-drawdown and/or distance-drawdown curves for the observation wells may be plotted on semi-logarithmic paper to assist in evaluating if the test is running well and deciding on the time that the pump should be shut off. If the plots indicate steady-state conditions (e.g., the interception of a recharge source), the test may be ended before its target duration. The pumping portion of the test may be extended, at the discretion of the MFG Project Manager, to evaluate hydrologic boundaries or other transient conditions.

2.1.5 Aborted Test

Failure of pumping operations for a period greater than one (1) percent of the elapsed pumping time will require suspension of the test until the water level measured in the pumped well has recovered to within two (2) percent of the total drawdown in the pumped well during pumping. Recovery in the pumped well will also be considered complete after the well has not been stressed for a period at least equal to the elapsed pumping time of the aborted test, or if any three successive water level measurements, at least 30 minutes apart, show no further rise in the water level in the pumped well. When recovery is complete, the pumping portion of the test may be resumed.

2.1.6 Recovery Portion of Test

After the pumping portion of the test has been completed, the pump will be shut off. Water level measurements will then be taken in the pumped well and observation wells in accordance with the schedule presented below:

Time Since Pumping Stopped			Time Intervals	
0	-	15 minutes	1	minute
15	-	60 minutes	5	minutes
60	-	300 minutes	30	minutes
300	-	1440minutes	60	minutes
1440	-	End of test	480	minutes (8 hours)

Water level measurements will continue in the pumped well and observation wells until the water level in the pumped well has recovered to its pre-pumping level, or until a length of time equal to the pumping period has elapsed.

The water level data (water level below MP) and time at which measurement is made for each well will be entered on a Pumping Test Record form (Figure SOP-14-1), using the columns for the recovery portion of the test.

2.1.7 Pump Discharge

The water discharged from the pumped well should be prevented from entering the water-yielding zone being tested. If concentrations of chemicals in the discharged water are suspected to be above regulatory limits for discharge to natural water courses, the water from the pumped well shall be collected for appropriate treatment and/or disposal.

2.2 Slug Tests

Falling-head or rising-head permeameter tests ("slug tests") may be performed on piezometers and monitoring wells to estimate the lateral hydraulic conductivity of the water-bearing strata. Although the radius of influence (i.e., portion of the water-yielding zone tested) is smaller for a slug test than for long-term pumping tests, this testing method is often selected due to the low productivity and/or small available drawdown in wells. Another important consideration is that many locations can be evaluated with the slug test method for the same level of effort and cost of one pumping test.

2.2.1 Testing Equipment

A slug test consists of instantaneously raising or lowering the water level in a well and then monitoring the change of the water level through time. The slug tests will be performed by rapidly submerging (slug-in test) or retracting (slug-out test) a slug of known volume. A typical slug used in 2-inch wells is constructed of a sealed, 1-inch diameter, stainless steel pipe. The displacement volume of the slug will be measured prior to the test program.

A pressure transducer with an appropriate operating range will be used to measure the water levels during the slug tests. The pressure readings will be recorded and converted to feet of water above the transducer using a datalogger. The datalogger is programmed to record the water levels at one-second intervals at the beginning of a test and to logarithmically increase the sampling interval to several minutes toward the end of the test.

2.2.2 Testing Procedure

Upon arrival at a test well site, the static water level and total depth of the well will be measured with an electric water level probe or steel surveyors' tape (see the MFG SOP entitled WATER LEVEL, IMMISCIBLE LAYER AND WELL DEPTH MEASUREMENT). The pressure transducer is then secured in the well to a depth below the lowest point to which the slug will be lowered. Before starting the test, sufficient time will be allowed for the water level in the well to adjust to the displacement caused by the transducer and cable, and for the transducer to equilibrate to the water temperature. During this period, the water level in the well will be monitored electronically using the datalogger and measured periodically with the electric water level probe or steel surveyors' tape to confirm that static water level conditions exist. Next, the slug will be lowered to a point just above the water level in the well and then rapidly submerged to begin the test.

As data are collected, the water levels displayed by the datalogger will be examined to monitor trends and the progress of the test. Manual water level measurements also will be taken during the test to confirm the transducer readings. Each test will proceed until the water level attains at least 95 percent recovery from the slug displacement. Following completion of the slug-in test, a slug-out test will be performed by rapidly pulling the slug out of the water and monitoring the recovery of water level in the same manner as for the slug-in test. In some cases, more than one slug-in and/or slug-out test may be performed to provide additional confirmation of the results.

2.2.3 Equipment Decontamination

Prior to the first slug test and between each test, the slugs, transducer, cable and water level probe (or steel tape) will be decontaminated in accordance with MFG SOP entitled EQUIPMENT DECONTAMINATION.

2.3 Data Analysis

2.3.1 Data Processing

The data collected by the datalogger are stored in the memory of the datalogger and then transferred to a cassette tape or to a computer in the field. If not transferred directly to a computer, these data are subsequently transferred to a computer for field data quality checks and data analysis. When transferred to computer, the data sets are transferred to files in comma-delineated ASCII format. The contents of each data file are imported to a spreadsheet program which allows the data manipulation and graphical presentation needed to calculate the hydraulic parameters of the water-yielding zone.

2.3.2 Slug Test Data Analysis

Slug tests in confined zones will be analyzed primarily by the method described by Cooper, Bredehoeft and Papadopulos (1967), whereas slug tests in semi-confined to unconfined water-yielding zones will be analyzed by the method discussed by Bouwer and Rice (1976). The Bouwer and Rice (1976) method is also applicable to confined aquifers and may be used to compare the results of the Cooper et al. (1967) method for confined aquifers.

Summary of Cooper, Bredehoeft and Papadopulos Method

Cooper et al. (1967) derived a solution using a partial differential equation for radial flow for the response of a finite-diameter well to an instantaneous "slug" of water. The method of analysis involves plotting the results of the slug test as H/H_o versus log t (time), where:

H = head inside the well above or below the initial head at time t after injection or removal of the slug.

H_o = head inside the well above or below the initial head at the instant of injection or removal of the slug.

The slug test plot is then compared against a set of "Type Curves" derived and published by Cooper et al. (1967) and Papadopulos, Bredehoeft and Cooper (1973), using a curve matching method, such that curves are moved parallel to H/H_o to match each other. When the best match between the data plot and type curves is obtained, a value of t is selected at the $Tt/r_c^2 = 1$ match point. The transmissivity (T) is then calculated using the following equation:

$$T = \frac{r_c^2}{t}$$

where: r_c = radius of the well casing.

The hydraulic conductivity (K) is obtained from the T value by:

$$K = \frac{T}{b}$$

where: b = thickness of water-yielding zone.

This method assumes that the water-yielding zone is homogeneous, isotropic, and of uniform thickness, and that the tested well is screened throughout the thickness of the water-yielding zone.

Summary of Bouwer and Rice Method

Bouwer and Rice (1976) presented a procedure for analysis of slug test data from an unconfined aquifer. Based on an electrical analog, Bouwer and Rice provided a convenient set of curves relating the effective radius (R_e) to the other well dimensions. This procedure is based on a modification of the Theim equation for steady state groundwater flow.

$$K = \frac{r_c^2 \ln(R_e / r_w)}{2L} \frac{1}{t} \frac{\ln^{Y_0}}{Y_t}$$

where:
K = Hydraulic conductivity
L = Screen length
Y_o = Head of water at time (o)
Y_t = Head of water at time (t)
t = Time
r_c = Inside radius of casing
r_w = Radius of casing plus thickness of filter pack
R_e = Effective radius (value of R_e obtained from the set of curves given by Bouwer and Rice)

This method estimates the hydraulic conductivity without calculating transmissivity. The results of the slug tests are plotted as a semi-logarithmic graph of Y_t versus t. The values of Y_t, Y_o, and t are obtained from the straight-line portion of the graph, and the value of K is calculated.

If the water level fluctuates within the screened interval or below the base of the bentonite seal in the well, the following correction will be made to include the porosity of the filter pack in the cross-sectional area of the well (Bouwer and Rice (1976)):

$$r_c = \left\{r^2 + n\left(R^2 - r^2\right)\right\}^{0.5}$$

where:

r_c = radius of the well including estimated filter pack porosity
r = radius of the well screen
n = estimated porosity of the filter pack
R = radius of the bore hole

3.0 QUALITY ASSURANCE

3.1 Calculation Check

All data and calculations recorded on the Pumping Test Record will be reviewed prior to use. The reviewer will be a technically qualified hydrologist or hydrogeologist, as designated by the MFG Project Manager. Record of the calculation review will be made by the reviewers initials and date of review on the original Pumping Test Record form.

3.2 Records Review

The project manager or designated QA reviewer will check and verify that documentation has been completed and filed per this procedure.

4.0 REFERENCES

Bouwer, Herman and R. C. Rice, 1976. *A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells*. Water Resource Research, Vol. 12, No. 3, pp. 423-428, June.

Bouwer, Herman, 1989 *The Bouwer and Rice Slug Test - An Update*: Ground Water, Vol. 27, No. 3, pp. 304-309, May-June.

Bouwer, Herman, 1989. *Discussion of "The Bouwer and Rice Slug Test - An Update*: Ground Water, Vol. 27, No. 5, pp. 715, September - October.

Cooper, Hilton H. (Jr.), John D. Bredehoeft, and Istavros S. Papadopulos, 1967. *Response of a Finite-diameter Well to an Instantaneous Charge of Water*. Water Resources Research, Vol. 3, No. 1, pp. 263-269.

Papadopulos, Istavros S., John D. Bredehoeft, and Hilton H. Cooper (Jr.), 1973, *On the Analysis of `Slug Test' Data*. Water Resources Research, Vol. 9, No. 4, pp. 1087-1089, August.

PUMPING TEST RECORD

☐ OBSERVATION WELL _____
☐ PUMPING WELL __________

PAGE _____ OF _______

PROJECT AND LOCATION				PROJECT NO.	ELEVATION AND DATUM
PUMPING WELL		OBSERVATION WELL		TIME STARTED	TIME FINISHED
RADIUS	DEPTH	DEPTH	DISTANCE (OBS TO PUMP)	MEASURING POINT (MP)	CASING HEIGHT
PUMP SETTING	ORIFICE SIZE	RECORDER		CONTRACTOR	
PUMP				FOREMAN	
ELECTRICAL EQUIPMENT				INSPECTOR	

					WATER LEVEL DATA			PUMPING DATA				WATER QUALITY			
DATE AND TIME	TIME SINCE START OF PUMPING, t (MIN)	t/R^2 (DAY/FEET^2)	TIME SINCE PUMPING STOPPED, t' (MIN)	RATIO t/t'	WATER LEVEL BELOW MP (FEET)	DRAWDOWN, s (FEET)	RESIDUAL DRAWDOWN, s' (FEET)	ORIFICE MANOMETER READING (INCHES)	INSTANT DISCHARGE (BY) (GPM)	CUMULATIVE DISCHARGE (BY) (GAL)	ENGINE SPEED (RPM)	TEMPERATURE (°C)	pH	SPECIFIC CONDUCTANCE	REMARKS

WELL:

MFG, INC.
4900 Pearl East Circle, Suite 300W
Boulder, Colorado 80301-6118
(303) 447-1823
FAX: (303) 447-1836

FIGURE SOP-14-1. PUMPING TEST RECORD (Page 1 of 2)

PUMPING TEST RECORD

☐ OBSERVATION WELL _____
☐ PUMPING WELL __________

PAGE 2 OF _______

PROJECT:	PROJECT NO.	PUMPING WELL	OBSERVATION WELL

					WATER LEVEL DATA			PUMPING DATA				WATER QUALITY			
DATE AND TIME	TIME SINCE START OF PUMPING, t (MIN)	t/R^2 (DAY/FEET^2)	TIME SINCE PUMPING STOPPED, t' (MIN)	RATIO t/t'	WATER LEVEL BELOW MP (FEET)	DRAWDOWN, s (FEET)	RESIDUAL DRAWDOWN, s' (FEET)	ORIFICE MANOMETER READING (INCHES)	INSTANT DISCHARGE (BY) (GPM)	CUMULATIVE DISCHARGE (BY) (GAL)	ENGINE SPEED (RPM)	TEMPERATURE (°C)	pH	SPECIFIC CONDUCTANCE	REMARKS

WELL:

MFG, INC.
4900 Pearl East Circle, Suite 300W
Boulder, Colorado 80301-6118
(303) 447-1823
FAX: (303) 447-1836

Pumping Test Record Revision 8/00

FIGURE SOP-14-1. PUMPING TEST RECORD (Page 2 of 2)

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 16

EQUIPMENT DECONTAMINATION

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the methods to be used for the decontamination of all reusable field equipment which could become contaminated during use or during sampling. The equipment may include split spoons, bailers, trowels, shovels, hand augers or any other type of equipment used during field activities.

Decontamination is performed as a quality assurance measure and a safety precaution. It prevents cross contamination between samples and also helps to maintain a clean working environment.

Decontamination is achieved mainly by rinsing with liquids which may include: soap and/or detergent solutions, tap water, distilled weak acid solution, and/or methanol or other solvent. Equipment may be allowed to air dry after being cleaned or may be wiped dry with chemical-free towels or paper towels if immediate re-use is necessary.

At most project sites, decontamination of equipment that is re-used between sampling locations will be accomplished between each sample collection point. Waste produced by decontamination procedures, including waste liquids, solids, rags, gloves, etc., should be collected and disposed of properly, based upon the nature of contamination. Specific details for the handling of decontamination wastes are addressed in the MFG SOP entitled STORAGE AND DISPOSAL OF SOIL, DRILLING FLUIDS AND WATER GENERATED DURING FIELD WORK or may be specified by a project plan.

2.0 PROCEDURES

2.1 Responsibilities

It is the responsibility of the field sampling coordinator to ensure that proper decontamination procedures are followed and that all waste materials produced by decontamination are properly managed. It is the responsibility of the project safety officer to draft and enforce safety measures which provide the best protection for all persons involved directly with sampling and/or decontamination.

It is the responsibility of any subcontractors (i.e., drilling contractors) to follow the proper, designated decontamination procedures that are stated in their contracts and outlined in the Site-Specific Health and Safety Plan. It is the responsibility of all personnel involved with sample collection or decontamination to maintain a clean working environment and ensure that any contaminants are not negligently introduced to the environment.

2.2 Supporting Materials

1. Cleaning liquids: soap and/or detergent solutions (Alconox, etc.), tap water, distilled water, methanol, weak nitric acid solution, etc.
2. Personal protective safety gear as defined in the Site-Specific Health and Safety Plan.
3. Chemical-free towels or paper towels.
4. Disposable, nitrile gloves.
5. Waste storage containers: drums, boxes, plastic bags, etc.
6. Cleaning containers: plastic and/or stainless steel pans and buckets.
7. Cleaning brushes.
8. Aluminum foil.

2.3 Methods

The extent of known contamination will determine the degree of decontamination required. If the extent of contamination cannot be readily determined, cleaning should be done according to the assumption that the equipment is highly contaminated. Decontamination procedures should account for the types of contaminants known or suspected to be present. In general, high levels of organic contaminants should include an organic solvent wash step, and high levels of metals contamination should include a weak acid rinse step.

The procedures listed below constitute the full field decontamination procedure. If different or more elaborate procedures are required for a specific project, they may be specified in sampling and analysis or work plan. Such variations in decontamination protocols may include all, part or an expanded scope of the decontamination procedure stated herein.

1. Remove gross contamination from the equipment by dry brushing, and rinse with tap water.
2. Wash with soap or laboratory-grade detergent solution.
3. Rinse with tap water.
4. Rinse with methanol (optional, for equipment potentially contaminated by organic compounds).
5. Rinse with acid solution (optional, for equipment potentially contaminated by metals).
6. Rinse with distilled or deionized water.
7. Repeat entire procedure or any parts of the procedure as necessary.
8. Air dry.

Decontaminated equipment should be stored in sealable containers, such as Ziplock-type plastic bags or cases or boxes with lids.

2.4 DOCUMENTATION

Field notes will be kept describing the decontamination procedures followed. The field notes will be recorded according to procedures described in the MFG SOP entitled FIELD DOCUMENTATION.

3.0 QUALITY CONTROL

To assess the adequacy of decontamination procedures, field rinsate blanks may be collected. The specific number of rinsate blanks will be defined in a sampling and analysis or work plan or by the MFG project manager. In general, at least one field rinsate blank should be collected per sampling event or per day.

Rinsate blanks with elevated or detected contaminants will be evaluated by the Project Manager, who will relay the results to the site workers. Such results may be indicative of inadequate decontamination procedures that require corrective actions (e.g., retraining).

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 17

FIELD MEASUREMENT OF DISSOLVED OXYGEN (DO)

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed for the field measurement of dissolved oxygen in water samples. If necessary to accommodate specific field conditions, modifications to the procedure may be made when approved in writing by the MFG Project Manager.

2.0 PROCEDURES

2.1 Explanation of Dissolved Oxygen and Methodology

Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water. Oxygen enters the water by photosynthesis of aquatic biota and by the transfer of oxygen across the air-water interface. The amount of oxygen that can be held by the water depends on the water temperature, salinity, and pressure. Gas solubility increases with decreasing temperature (i.e., colder water holds more oxygen). Gas solubility increases with decreasing salinity (i.e., freshwater holds more oxygen than does saltwater). Both the partial pressure and the degree of saturation of oxygen will change with altitude. Finally, gas solubility decreases as pressure decreases. Thus, the amount of oxygen in water decreases as altitude increases because of the decrease in relative pressure.

Flowing water is more likely to have high dissolved oxygen levels than stagnant water because of the water movement at the air-water interface. In flowing water, oxygen-rich water at the surface is constantly being replaced by water containing less oxygen as a result of turbulence, creating a greater potential for exchange of oxygen across the air-water interface. Because stagnant water undergoes less internal mixing, the upper layer of oxygen-rich water tends to stay at the surface, resulting in lower dissolved oxygen levels throughout the water column. Oxygen losses readily occur when water temperatures rise, when plants and animals respire, and when microbes aerobically decompose organic matter.

The Membrane Electrode Method (such as that used on the YSI Model 55) is ideal for field dissolved oxygen (DO) testing. Polarographic or galvanic oxygen-sensitive membrane electrodes are composed of two metal electrodes in contact with a supporting electrolyte that is separated from the test solution by a selective membrane. Indicator electrodes are typically made of platinum and reference electrodes are commonly either calomel or Ag/AgCl electrodes with a KCl electrolyte solution. The reference electrode provides a constant electrode potential for comparison to the potential at the platinum electrode. A thin permeable membrane, stretched over the sensor, isolates the electrodes from the environment while allowing gases to enter. When a polarizing voltage is applied to the sensor electrodes oxygen, which has passed through the membrane, reacts at the cathode causing a current flow. The membrane passes oxygen at a rate proportional to the pressure difference across it. Since oxygen is rapidly consumed at the cathode, it can be assumed that the oxygen pressure inside the membrane is zero. Hence, the force causing the oxygen to diffuse through the membrane is proportional to the partial pressure of oxygen outside the membrane. As oxygen partial pressure varies, so does the oxygen diffusion through the membrane. This causes the probe current to change proportionally.

2.2 Instrumentation and Equipment

Typically, obtaining a field DO measurement requires the following equipment:

1. Membrane Electrode-type Dissolved Oxygen meter
2. Platinum indicator electrode and reference electrodes of either calomel or Ag/AgCl
3. KCl reference electrode filling solution
4. Clean (e.g., deionized) water for probe cleaning
5. Squeeze bottle of clean water
6. Membrane/O-ring & KCl kit for probe cleaning and replacement

2.3 Instrument Checks and Calibration

2.3.1 Probe Operation and Precautions

Membrane life depends on usage. Membranes will last a long time if installed properly and treated with care. Erratic readings are a result of loose, wrinkled, damaged, or fouled membranes, or from large (more than ½ inch dia.) bubbles in the electrolyte reservoir. If erratic readings or evidence of membrane damage occurs, replace the membrane and the KCl solution. The average replacement interval is two to four weeks.

1. If the membrane is coated with oxygen consuming material (e.g., bacteria) or oxygen evolving organisms (e.g., algae), erroneous readings may occur.

2. Chlorine, sulfur dioxide, nitric oxide, and nitrous oxide can affect readings by behaving like oxygen at the probe. If you suspect erroneous readings, it may be necessary to determine if these gases are present.

3. Avoid any environment which contains substances that may attack the probe materials. Examples of some of these substances are concentrated acids, caustics, and strong solvents. Probe materials that come in contact with the sample include FEP Teflon, acrylic plastic, EPR rubber, stainless steel, epoxy, polyetherimide and the polyurethane cable covering.

4. For correct probe operation, the gold cathode must always be bright. If it is tarnished, which can result from contact with certain gases, or plated with silver, which can result from extended use with a loose or wrinkled membrane, the gold surface must be restored. To restore the cathode you may either return the instrument to the factory, or clean it using a meter-specific reconditioning kit. Never use chemicals or abrasives not supplied with the kits.

5. It is also possible for the silver anode to become contaminated, which will prevent successful calibration. To clean the anode, remove the O-ring and membrane and soak the probe overnight in a 3% ammonium hydroxide solution. Next, rinse the sensor tip and KCl reservoir with deionized water, add new KCl solution, and install a new membrane and O-ring. Turn the instrument on and allow the system to stabilize for at least 30 minutes. If, after several hours, you are unable to calibrate, return the instrument to the manufacturer for service.

6. If the sensor O-ring is worn or loose, replace it with an appropriate O-ring.

7. To keep the electrode from drying out, store the probe in the instrument

calibration chamber with a small piece of moist towel or sponge.

8. Consult the operations manual of the electrode instrument for the correct, instrument-specific calibration procedure.

2.4 Sample Measurement Procedures

2.4.1 Surface Water Measurements

Dissolved oxygen measurements taken from surface water locations should be representative of the conditions being monitored. For example, if a sample is to be collected from the middle of a stream cross-section, that is also where the DO measurement should be taken.

The dissolved oxygen probe should be fully immersed in the water body being monitored. If the DO measurement is taken from a stream, the probe should be elevated above the stream bed to minimize disturbance of channel sediments. If DO measurements are taken from a water body that is not flowing, the probe should be slowly raised and lowered so that water is moving past the DO probe membrane.

Dissolved oxygen readings should be recorded after allowing sufficient time for the probe to equilibrate and the readings to stabilize. For surface water measurements, the DO reading will typically stabilize as soon as the probe has equilibrated.

2.4.2 Groundwater Measurements

Dissolved oxygen measurements should be taken during well purging and immediately before and after sample acquisition using a direct-reading meter. Because most well purging techniques allow aeration of collected groundwater samples, it is important to minimize potential aeration by taking the following precautions.

1) Use a pump to purge the well when possible (a peristaltic pump can be used for groundwater depths of less than approximately 25 feet) to prevent downhole aeration of the sample in wells screened across the water table. Well drawdown should not exceed 5 percent of the height of the standing water column in the well. This drawdown amount may vary with each site. The pump tubing should be immersed alongside the dissolved oxygen probe beneath the water level in the sampling container (i.e., a flow-through cell). This will minimize aeration and keep water flowing past the dissolved oxygen probe's sampling membrane. A maximum low purge flow rate of 200 - 500 mL/minute is typically suggested to minimize aeration, however, this is dependent on site-specific hydrogeology. If bubbles are observed in the tubing during purging, the flow rate of the pump must be slowed.

2) Although not recommended, a bailer can be used to collect a sample for dissolved oxygen measurements. The problem with this method is that it is very unlikely to provide an undisturbed sample. When using a bailer, the bailer should be slowly immersed in the standing column of water in the well to minimize aeration. After sample collection, the water should be drained from the bottom of the bailer through tubing into the sample container. The tubing used for this operation should be immersed alongside the dissolved oxygen probe beneath the water level in the sampling container. This will minimize aeration and keep water flowing past the DO probe's sampling membrane.

3) Downhole dissolved oxygen probes can be used for dissolved oxygen analysis, but such probes must be thoroughly decontaminated between wells. In some cases, decontamination procedures can be harmful to the dissolved oxygen probe. When taking a downhole DO measurement, the probe should be lowered to the midpoint of the water column and slowly raised and lowered so that water is moving past the probe's sampling membrane.

4) Dissolved oxygen measurements can be used as a stabilizing parameter in conjunction with other indicator parameters (i.e., pH, temperature, conductivity, etc.) to distinguish between formation water and stagnant casing water. Once these parameters have stabilized (typically ± 10% for DO) and a minimum of three well casing volumes have been removed, a representative DO measurement can be recorded either from an in-line flow cell or a downhole DO probe. Of the stabilization indicator parameters used above, DO usually requires the longest time for stabilization.

2.5 Documentation

All measurement results should be recorded according to procedures outlined in the MFG SOP titled FIELD DOCUMENTATION. The instrument manufacturer, model number and unique identification number should also be recorded with the measurement data.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

Field measurements will be reviewed prior to their use on a project. The project manager or designated reviewer will verify the DO data and also confirm that documentation has been completed per this procedure.

4.0 REFERENCES

EPA, 1995. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures.

YSI Inc., 1994. Operations Manual for YSI Model 55 Handheld Dissolved Oxygen System (Membrane Electrode Instrument).

MFG, Inc.

STANDARD OPERATING PROCEDURE No. 18A

CORE SAMPLE SCREENING BY FIELD PORTABLE XRF

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol for performing screening-level analyses of cores to assess sample compositing intervals using a field-portable, Niton Corporation X-Ray Fluorescence (XRF) Spectrometer. The XRF spectrometer may be used to determine the elemental concentrations of metals and metalloids. For the purposes of this program only lead will be evaluated.

The procedures presented herein are intended to be general in nature. Appropriate modifications to this SOP may be made when approved in writing by the MFG Project Manager.

These procedures provide screening-level data, and are recommended for use when screening-level data are sufficient to meet the project's objectives. Decisions regarding a project's data uses and data quality objectives will be made by the MFG Project Manager or will be detailed in project planning documents such as work plans or sampling and analysis plans.

This SOP should be used in conjunction with the Niton Corporation operation manual for the XRF instrument model used. Niton Corporation reports that the method detection limit for an unprepared soil sample is approximately 100 ppm, which will also be the reporting limit for purposes of this program. The upper range of measurement on an undiluted, unprepared sample is 10,000 ppm.

1.1 Principles of Operation

XRF spectrometry uses up to three radiation/radioisotope sources for the analysis of inorganic analytes in soil. Typical radiation sources include cadmium (Cd)-109, iron (Fe)-55, americium (Am)-241, and curium (Cm)-244. Depending on the radiation source(s), an XRF spectrometer may be used to analyze up to 26 different analytes. These include: antimony, arsenic, barium, cadmium, calcium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, potassium, rubidium, selenium, silver, strontium, thallium, thorium, tin, titanium, vanadium, zinc and zirconium. As stated earlier, only lead will be evaluated for this program.

1.2 Health and Safety Issues

Proper training for safe use of the instrument and radiation training should be completed by the analyst prior to use of the instrument. This may include a more formal training session with a manufacturer representative. Information and procedures contained herein are specific to the operation of Niton Corporation XRF 700 series instruments. The analyst is referred to operation manuals of the specific XRF instrument in use for proper operation of that instrument. The instrument user should also be aware of local, state and national regulations that pertain to the use of radiation producing equipment and radioactive materials. Compliance with all applicable regulations is required.

Safety precautions, as specified by Niton Corporation, for use of the XRF instrument are as follows:

- Never point the XRF at yourself or anybody else with the shutter open when they or you are within a distance to be exposed.
- Stand to the rear or side of the XRF when the shutter is open. Do not operate the instrument in a seated position, this may expose your lower body to radiation.
- Do not fix the shutter in an open position (except to provide test stands).
- Do not leave the XRF unattended.
- Store the XRF in a safe place. Do not drop the machine (or put the instrument in a position where it will be likely to be dropped).
- Wear a dosimeter ring (if required by regulations).
- Perform wipe tests, per manufacturer’s instructions.
- Women of child bearing age should be aware of the potential damage to a developing fetus from radiation exposure.
- Transport XRF in a shock-proof case.

- Follow all manufacturer's training and instructions.

OSHA exposure limits, as presented by Niton Corporation, are presented below.

Whole body exposure:	5,000 mREM/yr	1,250 mREM/quarter
Extremities:	75,000 mREM/yr	17,500 mREM/quarter

Some states have specified lower limits for public exposure. The lowest exposure limits were found to be 100 mREM/yr and 1 mREM/day.

More detailed information and procedures are contained in EPA Method 6200, Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment, Revision 0, January 1998.

2.0 PROCEDURES

The following method outlines procedures that shall be taken during XRF analysis for the purpose of screening subsurface cores to guide sample compositing intervals.

2.1 Supplies

General Sample Supplies:
Measuring tape

XRF Equipment and Supplies
(obtained from the XRF manufacturer):
XRF source and detector
X-ray window film (Mylar, or similar)

2.2 Sample Collection and Preparation

The core sample shall be placed on a stable work surface. Place a measuring tape adjacent to the core sample. Turn the XRF detector on and allow to warm up for the manufacturer recommended time (ranges from 10 to 30 minutes, depending on instrument). Perform a calibration check each time the instrument is activated using a 1100 ppm NIST (National Institute of Standards and

Technology) standard (i.e., instrument performance check of the XRF detector according to manufacturer specifications).

1. Sample preparation: Place a piece of Mylar XRF film over the core at 1 foot intervals. The sample is ready for XRF analysis.

2. XRF Analysis: Place the XRF detector on the core sample to be measured. When ready for analysis, release the XRF lock, opening the shutter, and press down on the sample. Keep the XRF shutter open for 60 seconds then remove/release the XRF from the sample to stop the analysis. Count times are the seconds the sample is analyzed. The same count time should be used for calibration standards and samples for the same matrix. Record the results for the analytes of interest, including the +/- variance value.

3. Decontamination: Equipment shall be decontaminated prior to reuse. The XRF detector and soil test platform may be wiped with a clean paper towel. The work area should be kept clean and clear of unnecessary equipment at all times.

2.3 DOCUMENTATION

The following information will be recorded on the boring log:

- Site-specific calibration standards used, if any, and standard reference materials used to confirm instrument performance.
- Instrument make and model number; supplier of instrument; radioactive source used.
- Date of analyses.
- Name of analyst.
- Core sample number and depth interval.
- Documentation of instrument performance checks.
- QC samples, their origin and type.
- Results of XRF analyses for every sample, QC sample and any standards.
- Any problems encountered in instrument set up and operation or sample preparation and analysis.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

Proper warm up times and calibration of the XRF detector shall always be followed as recommended and specified by the manufacturer.

Calibration checks will be performed each time the instrument is activated standard according to manufacturer specifications, using a 1100 ppm NIST (National Institute of Standards and Technology). Calibration readings should be within 20 % of the reference value, and recorded in the field log. If calibration readings are outside of the acceptable range, perform an additional calibration. If the calibration remains unacceptable, use an alternative standard or perform maintenance on the instrument according to manufacturer's specifications.