Memorandum

CH2M HILL, Inc.
9191 S. Jamaica Street
Englewood, CO 80112-5946

Subject:	**Supplemental Upgradient Slurry Wall Investigation Work Plan**
Project Name:	Velsicol Chemical Corporation/Pine River Superfund Site
Attention:	U.S. Environmental Protection Agency (EPA) Region 5
From:	CH2M HILL, Inc. (CH2M)
Date:	February 16, 2022
DCN:	GLAES-R5-21F0106-02002

CH2M has prepared this Investigation Work Plan Technical Memorandum for EPA to describe the methods, procedures, and rationale for the completion of a supplemental upgradient slurry wall (UGSW) investigation at the Velsicol Chemical Corporation/Pine River Superfund Site (site) located in St. Louis, Michigan. This work is being performed to supplement field activities presented in the *Data Evaluation Report – Velsicol Former Plant Site Upgradient Slurry Wall Investigation, St. Louis, Michigan* (CH2M, 2020). The work is being performed under Great Lakes Architect and Engineering Services II Contract Number 68HE0519D0007, Task Order Number 68HE0521F0106.

1. Site Description

The site (National Superfund Database Identification Number MID00722439) is approximately 100 acres and includes the Former Plant Site (FPS) and a residential area that is referred to as the adjacent or nearby properties (ANP). The Michigan Department of Environment, Great Lakes, and Energy was the lead agency for the remedial investigation (RI)/feasibility study. EPA is the lead agency for the remedial design (RD) and remedial action (RA).

A chemical manufacturing plant formerly occupied the FPS from the mid-1930s until it was demolished in 1978. Industrial operations at the plant, which included manufacturing of pesticides and fire retardants, resulted in widespread contamination on the FPS. In 1982, the Velsicol Chemical Corporation entered into an Administrative Order on Consent with the United States and the State of Michigan. Pursuant to the Administrative Order on Consent, the Velsicol Chemical Corporation constructed a containment system for the FPS, which included the installation of a low-permeability cap and a 2-foot-thick low-permeability slurry wall around the entire 52-acre FPS.

The FPS is fenced and is bordered on the south and east by the ANP, with Washington Avenue (M-46) along the southern edge. Watson and North streets mark the eastern edge, and the Pine River and Mill Pond form the western and northern boundaries. The ANP spans approximately 12 blocks and is primarily composed of residential properties that lie south and east of the former plant boundary. A small number of commercial properties are also located south of the FPS, along M-46 and East Washington Avenue.

The site consists of four operable units (OUs), as shown in Figure 1. The OUs are described as follows:

- OU1—FPS and ANP, for which RD and RA activities are in progress.
- OU2—Pine River and Mill Pond sediment adjacent and upstream from the St. Louis hydroelectric dam, for which RA activities were completed in 2006.
- OU3—Pine River sediments stretching from the St. Louis hydroelectric dam to approximately 1.25 miles downstream of the dam, for which RI activities are ongoing.
- OU4—Pine River sediments stretching from approximately 1.25 miles downstream of the St. Louis hydroelectric dam to the confluence of the Pine, Chippewa, and Tittabawassee rivers, for which RI activities are ongoing.

The UGSW investigation activities described in this memorandum will occur in OU1 within the FPS.

2. Velsicol Former Plant Site Upgradient Slurry Wall Investigation Results Summary

Between September 2019 and May 2020, a remedial design investigation (RDI) was conducted to evaluate the condition of approximately 3,100 linear feet of UGSW bordering M-46 and the ANP (CH2M, 2020). The information was obtained to support future work associated with the design, installation, and operation of site remedy components specified in the 2012 Record of Decision (EPA, 2012). The RDI involved the installation of 42 shallow-unit groundwater piezometers along the UGSW, short- and long-term groundwater elevation monitoring interior and exterior to the UGSW, collection of slurry wall material for permeability testing, and the completion of a dye tracer study.

Field observations and data collected during the RDI indicate that the UGSW is performing as a barrier to groundwater flow over the majority of its installation length. Specifically, groundwater elevation measurements and dye testing results suggested that the UGSW acts as a hydraulic barrier to shallow groundwater flow in the areas defined by piezometer clusters CPZ-1 through CPZ-27 and CPZ-29 through CPZ-42 (see Figure 2). During the investigation, anomalies consistent with UGSW leakage were observed between piezometer clusters CPZ-27 and CPZ-29. The potential for UGSW leakage at this location is supported by the following lines of evidence:

- The materials encountered in UGSW boring "CPZ-28 Slurry Wall" includes a 3.25-foot-thick sand/gravel lens between the bottom of the slurry wall and the top of the till unit. The presence of this granular material under the UGSW indicates that the slurry wall is not keyed into the till at this location.
- Groundwater elevations between interior (I) piezometers CPZ-24I to CPZ-28I and CPZ-30I to CXPZ-28I confirm shallow groundwater flow south and north, respectively. In these piezometer groupings groundwater flow is parallel to the UGSW and toward piezometer CPZ-28I, where the presence of a sand/gravel lens (beneath the UGSW) was confirmed by a soil boring.
- Between September 2019 and February 2020, the groundwater elevation differences calculated for the CPZ-28 interior and exterior (X) piezometers were negligible (flat), indicating that the piezometer pair may be in direct hydraulic connection despite their locations relative to the UGSW alignment.
- Automated groundwater level measurements collected between March 13 and May 21, 2020, during a 10-week transient groundwater elevation monitoring investigation at CPZ-28I and CPZ-28X returned nearly identical results to the static level measurements previously described, further supporting the conclusion that these locations are hydraulically connected.

- The presence of D&C red 28 dye in piezometer CPZ-26X confirmed that the UGSW is leaking and does not serve as a hydraulic barrier to groundwater flow near piezometer cluster CPZ-28. These piezometers are adjacent to the soil boring location where the presence of a sand/gravel lens was directly observed below the UGSW. Collectively, these data support the conclusion that D&C red 28 dye injected in injection point piezometers (IPs) CPZ-26IP or CPZ-29IP resulted in the positive dye test observation at piezometer CPZ-26X.

The initial UGSW RDI concluded that supplemental investigation of the area surrounding CPZ-28 was warranted to further characterize UGSW performance.

3. UGSW Supplemental Evaluation Objectives and Methodology

CH2M will perform a supplemental UGSW RDI to provide additional data and information needed to support further RD work. The supplemental UGSW RDI will be conducted to achieve the following:

- Define the potential pathway(s) of the D&C red 28 dye identified in piezometer CPZ-26X.
- Define the lateral extent of the UGSW leakage area identified between piezometer clusters CPZ-27 and CPZ-29.
- Collect seasonal groundwater elevation data and identify groundwater flow trends near the UGSW, especially near the UGSW leakage area.
- Collect additional slurry wall samples for hydraulic conductivity analysis.

To accomplish those objectives, the work will generally consist of the following tasks:

- Perform up to 20 soil borings within the slurry wall to visually inspect the UGSW lithology, thereby defining the lateral extent of UGSW leakage.
- Survey the lateral extent of UGSW leakage.
- Conduct additional slurry wall hydraulic conductivity tests at six soil boring locations.
- Install six additional UGSW piezometer clusters – five clusters near the UGSW leakage area and one cluster to replace existing piezometers WPZ-03I and WPZ-03S.
- Collect manual and automated groundwater elevation data.
- Collect groundwater samples from select piezometers for volatile organic compound (VOC) analysis.
- Complete a supplemental dye tracer study.

The following subsections outline the approach.

3.1 Slurry Wall Borings

Up to 20 borings will be completed within the slurry wall between piezometers CPZ-27 and CPZ-29 (see Figure 2) using a direct-push technology (DPT) drill rig. Each soil boring will be characterized and logged continuously from ground surface to the boring terminus by a CH2M geologist in accordance with the Field Standard Operating Procedure-12, *Soil Boring Logging* (Attachment 1). Soil and groundwater analytical samples, however, will not be collected. Initial soil borings will be placed 10 feet north and 10 feet south of piezometer location CPZ-28 (moving away from this location). If a sand/gravel lens is encountered above the till, additional borings will be placed 10 feet farther north and south of the initial borings. This procedure will continue until the slurry wall is confirmed to be keyed within the till. At this point, one additional boring will be placed 5 feet toward CPZ-28 to provide verification of delineation of the leakage area. Upon meeting these objectives, no additional borings will be conducted.

3.2 Hydraulic Conductivity Testing

CH2M will collect up to six samples of slurry wall material for hydraulic conductivity testing at select locations along the UGSW (see Figure 2). Samples will be collected using a DPT drill rig equipped with hollow-stem auger capabilities and 3-inch-diameter Shelby Tube samplers. The borehole at each sampling location will initially be advanced to a minimum of 10 feet below ground surface (bgs) using standard DPT core samplers. Once the slurry wall is encountered (expected between 6 to 8 feet bgs), the borehole will be overdrilled with 4.25-inch-diameter hollow-stem augers to a minimum of 2 feet below the identified top of the slurry wall. A Shelby Tube sampler will then be deployed through the augers (below the depth of the exploratory boring) to collect a section of slurry wall material. Once collected, Shelby Tube samples will be capped with wax and end caps, stored vertically, and protected from disturbance.

Shelby Tube samples will be transported by the drilling subcontractor to the geotechnical and materials testing laboratory for hydraulic conductivity analysis. Analyses will be performed using the flexible wall permeameter method in accordance with ASTM International D5084.

3.3 Piezometer Installation

CH2M will use a DPT drill rig to install six piezometer clusters, with five placed near the UGSW leakage area and one set to replace the Weston Solutions-installed WPZ-03 piezometer cluster (Figure 2). Four of the six proposed piezometer clusters will consist of one interior and one exterior piezometer. Two of the six proposed piezometer clusters will consist of three piezometers: one interior and one exterior piezometer and an additional interior piezometer that will serve as a dye injection point. All six piezometer clusters will be incorporated into the groundwater elevation data collection. The five piezometer clusters near the UGSW leakage area will also be used for the completion of a supplemental dye tracer study, as discussed further in this memo.

Piezometer clusters will be installed to bisect the UGSW such that one piezometer will be located on the exterior side of the wall (exterior piezometer), and one (or two piezometers where applicable) will be located on the interior side of the wall (interior piezometer and injection point piezometer). Piezometers will be installed, at a minimum, 2 to 7 feet from the interior/exterior edges of the slurry wall and to a depth just above the underlying till unit (approximately 15 to 25 feet bgs). For dye tracer study piezometer clusters, the interior-most piezometer (injection point piezometer) will be installed approximately 5 feet from the first interior piezometer. Each piezometer boring will be characterized and logged continuously from ground surface to the boring terminus by a CH2M geologist in accordance with Field Standard Operating Procedure-12, *Soil Boring Logging* (Attachment 1). Soil cores will also be visually inspected for soil contamination. Soil and groundwater analytical samples, however, will not be collected during piezometer installations.

Piezometers will be constructed with 1-inch-diameter polyvinyl chloride (PVC) riser pipe, and 1-inch-diameter 0.010-slot PVC screens. The screened interval for each piezometer will be determined in the field and will be selected to approximately match the shallow-unit saturated thickness observed at each location. Construction of the annulus will conclude with a medium silica sand filter pack placed to 1 foot above the top of screen, and hydrated bentonite chips placed from the top of the filter pack to 1 foot bgs. The surface completion for each piezometer will be composed of a concrete pad and a lockable metal protective cover.

Once a piezometer cluster is installed, development of that cluster may commence concurrently with installation of the remaining piezometer clusters to gain efficiency. Development will be performed by a second member of the CH2M field team in accordance with the Field Standard Operating Procedure-25, *Monitoring Well Development* (Attachment 1). The piezometers will be purged using a peristaltic pump with clean disposable down-hole tubing; surging will be accomplished using clean disposable pencil bailers. Development will be considered complete once groundwater turbidity is below 50 nephelometric turbidity units or when 10 boring volumes have been purged, whichever occurs first.

3.4 Survey

Once all the soil borings and piezometers have been installed, a survey will be conducted to obtain horizontal locations, ground elevations, and top-of-casing elevations. Horizontal coordinates will be obtained using the North American Datum of 1988 with an accuracy of within 0.01 foot. The vertical component of the survey locations will be expressed in feet above National Geodetic Vertical Datum of 1988 to an accuracy and resolution of within 0.01 foot. Surveying will be completed by a subcontracted professional surveyor licensed in the state of Michigan and 40-hour hazardous waste operations-trained.

3.5 Groundwater Elevation Measurement Events

Once the six UGSW piezometer clusters have been installed and developed, an initial groundwater elevation measurement event will be conducted. Following the initial event, successive events will be conducted monthly for up to 3 months, and quarterly for 1 year thereafter, to assess seasonal variation in the water table and to determine hydraulic gradients across the UGSW. For the initial event, groundwater levels will be measured in all UGSW piezometer clusters. For subsequent events, measurements will only be collected from the 2-piezometer clusters. The 3-piezometer clusters will be used for conducting the dye tracer study and will therefore be omitted from subsequent events to prevent dye cross-contamination.

Groundwater elevation measurements will be conducted in accordance with the Field Standard Operating Procedure-18, *Groundwater Level and Total Depth Measurements* (Attachment 1). Each event will consist of collecting static water level measurements from each of the interior and exterior slurry wall piezometers using an electronic water level indicator. Static water level measurements for the 3-piezometer clusters will be collected during the initial round only, and prior to dye injection.

Continuous groundwater elevation data will also be collected along the UGSW section between piezometer clusters CPZ-23 and CPZ-36 using electronic data loggers (UGSW section can be referenced in Figure 2). The purpose will be to accumulate long-term groundwater elevation data of sufficient density to further evaluate groundwater flow conditions near the leakage area. The data loggers will be deployed in 10 select interior and 10 select exterior piezometer locations between CPZ-23 and CPZ-36 (exact locations to be determined following completion of the additional slurry wall piezometers) and configured to log groundwater elevation measurements continuously once per hour over a 12-month period. Data files will be downloaded and processed monthly, and data loggers will be recalibrated as needed during each monthly data download based on comparison with manual water level measurements.

Local precipitation will be continuously monitored and recorded during the groundwater elevation monitoring period, and the data will be used to identify precipitation-driven groundwater elevation fluctuations. Precipitation will be recorded by an onsite weather station capable of data logging and storage.

3.6 Groundwater Sampling Event

CH2M will collect groundwater samples from the five new piezometer clusters along the UGSW leakage area and from existing piezometers CPZ-27X, CPZ-28X, and CPZ29X. Samples will be collected using a peristaltic pump following low-flow methods (Field Standard Operating Procedure-18, *Groundwater Sampling Procedures*; Attachment 1). Additionally, four shallow groundwater samples will be collected from within the residential yard area immediately east of the UGSW near CPZ-28X, as shown in Figure 2, to evaluate offsite groundwater conditions in the leakage area. Three samples spaced approximately 35 feet apart will be collected along a north-south line offset approximately 25 feet from the UGSW and centered about CPZ-28X. The fourth sample will be collected 50 feet east of CPZ-28X. The parcel ID for the residential yard area is 53-450-020-00 located at 609 W Center Street. Prior to performing any work in the area, a signed agreement granting access to the property must be obtained from the property owner. If access to the property is granted, CH2M and the drilling subcontractor will access the area with a DPT drill rig via the easement west of the intersection of Watson St. and Saginaw St.

The offsite groundwater samples will be collected using temporary 1-inch diameter PVC monitoring wells installed at each location. The temporary wells will be installed using a DPT drill rig and will be constructed with 5-foot long .010 slot screens installed so that the well screen bisects the water table. The wells will not be completed with a filter pack or seal with the expectation that sampling will occur immediately following installation. Upon completion of groundwater sampling at each location, the temporary wells will be removed, and the borehole will be sealed with hydrated bentonite chips.

In total, up to 16 groundwater samples, two duplicates, and one MS/MSD will be collected for the groundwater sampling event. Samples will be packaged and shipped on ice to the analytical laboratory for VOC analysis using EPA Method 8260.

3.7 Dye Tracer Study Work Approach

Based on the results of the initial UGSW RDI (CH2M, 2020), CH2M has designed a supplemental investigation that will aid in defining the origin and pathway(s) of the D&C red 28 dye identified in piezometer CPZ-26X. This investigation will provide a better understanding of the groundwater flow patterns near the UGSW leakage area. The work approach is described in the following paragraphs.

One round of background dye samples will be collected from the 3-piezometer clusters, except the injection point piezometers (total of 30 background sample locations). Background samples will be obtained by deploying one charcoal dye receptor in each of the interior and exterior dye-study piezometers. The receptors will be deployed on nylon line (secured to the piezometer casing cap) to below the water table and within the screened interval of each piezometer. Marble weight packs may be used, if necessary, to ensure the dye receptors remain submerged at the intended depth. The receptors will be retrieved after the recommended background collection period and submitted to Crawford Hydrology Laboratory for analysis. If a receptor is unable to be collected from a given piezometer, a grab groundwater sample will be collected in its place. The receptors, or grab groundwater samples (if necessary), will be analyzed for six industry standard dyes to establish background concentrations due to previous dye studies conducted at the site.

CH2M recommends completing the supplemental dye study using two unique dyes at two individual injection points located north and south of the UGSW leakage area. The injection points will be two newly installed piezometer clusters located approximately 35 feet south of CPZ-29 and 35 feet north of CPZ-26. The use of two dyes will allow for an evaluation of groundwater flow both north, south, and through the UGSW leakage area. Charcoal dye receptors will be placed in all five new piezometer clusters along the UGSW leakage area and will also include CPZ piezometer clusters 26 through 29, for a total of 18 receptors.

The specific dye(s) and quantities for the injections will be selected based on recommendations from Crawford Hydrology Laboratory. After dye injection has occurred, charcoal dye receptors deployed in the interior and exterior slurry wall piezometers will be initially retrieved after 4 days and then once per week for an initial period of 1 month, followed by a 2-week interval for 1 month (7 total submittals). Retrieved dye receptors will be packaged and shipped to Crawford Hydrology Laboratory where they will be analyzed for the presence of the specific injection dye(s). Based on the preliminary results from the first 2 months, the sampling schedule may be extended for an additional 1 to 2 months and may be modified to reduce the number of piezometers sampled.

4. Evaluation of the Supplemental Results

CH2M will evaluate the supplemental UGSW RDI results as follows:

- Groundwater elevation differences measured between interior and exterior slurry wall piezometers over the course of the investigation will be used to determine hydraulic gradients present across the slurry wall and the extent to which they are affected by seasonal variability. The persistence of downward gradients from the interior to exterior side of the slurry wall will be considered as evidence that the slurry wall is functioning in some capacity to contain shallow groundwater inside the FPS. Interior and exterior groundwater levels will also be compared to historical levels measured in previously existing piezometers to determine whether conditions have changed over time.
- Dye receptor analytical results will be evaluated for the presence or absence (positive or negative result) of the injection dye(s) used during the dye tracer study. Using this information, groundwater flow pathways and travel time will be evaluated along the interior of the UGSW, through the leakage area, and along the exterior of the UGSW.
- The data evaluation will also include an evaluation of technology alternatives for containment on the upgradient portion of the site. The evaluation will consist of a preliminary assessment of up to three technology alternatives and will include a technical description of the identified alternatives sufficient to support a cost estimate.

CH2M will review the results of the supplemental UGSW RDI and present the findings and recommendations in a technical memorandum. A future design phase will take further consideration of these findings and recommendations to determine the appropriate technical approach for FPS containment and fulfillment of site remediation requirements defined within the Record of Decision.

5. Field Documentation

The Field Team Leader or designee(s) will record information pertinent to field activities in a field logbook. The following information will be included:

- Heading including date, project name, specific task, client, and physical location
- Site conditions, health and safety tailgate topics, and quality tailgate topics
- Names, titles, and organization of personnel onsite, names and titles of visitors, and times of visits
- Field observations such as time of specific activities; details on sampling activities, including type of sampling, time of sampling, and sample numbers; references to field forms used or type of document generated; and lists and descriptions of photographs taken to document field activities

- Specific problems, including equipment malfunctions and their resolutions
- Unexpected or adverse field conditions that may inhibit the field team's ability to perform the day's activity or that may affect the accuracy of the data collected
- Decontamination
- Soil boring log documenting percent recovery, soil type, standard penetration test results, color, moisture content, texture, grain size and shape, density, visible evidence of staining, and any other observations
- Equipment calibration records
- Air monitoring field forms

Additional information may be recorded at the discretion of the Field Team Leader.

Field personnel will complete, sign, and date forms in the field and submit them daily to the Field Quality Manager, who will review the data sheets to ensure that all necessary information has been recorded. Dates and times will be compared across field documentation to ensure consistency (for example, sample labels and chain-of-custody forms will be compared to field data sheets and the field notebook). Completed and reviewed field forms will be filed onsite in a project-specific file.

At the conclusion of the event, scanned copies of all field records, chain-of-custody forms, and photos will also be uploaded to a specified network location.

5.1.1 Health and Safety

CH2M and its subcontractors will abide by U.S. Occupational Safety and Health Administration regulations and the site-specific Health and Safety Plan (HASP) (CH2M, 2021). The HASP will be kept onsite during all field activities, and a copy will be maintained in the project files. Prior to onsite field activities, CH2M field personnel and subcontractor personnel will conduct a field chartering meeting in which the scope of work and site- and task-specific hazards (such as dye hazards and Safety Data Sheets) are reviewed.

5.2 Personal Protective Equipment

Personal protective equipment (PPE) must be worn by field personnel at all times when actual or potential hazards exist. All field personnel will refer to and follow procedures outlined in the HASP (CH2M, 2021). Fieldwork for this investigation will be performed in Modified Level D:

- Work clothes or cotton overalls
- Safety-toe, chemical-resistant boots, or safety-toe leather work boots with outer rubber boot covers
- Surgical-style nitrile gloves
- Hardhat
- Safety glasses with side shield protection
- Hearing protection

5.3 Air Monitoring

Air monitoring procedures will be completed in accordance with the HASP (CH2M, 2021). The potential presence of VOCs within the FPS requires air monitoring using a photoionization detector to monitor the breathing zone near the drill rig, near the soil sample processing and sample collection table, and at the exclusion zone boundary. Air monitoring activities will be documented in the field logbook or field data sheets. Documented information will include the following:

- Calibration information
- Weather conditions
- Boring location
- Drilling location
- Instrument reading
- Date and time of the reading

The photoionization detector (MiniRAE unit, MultiRAE unit, or equivalent) will be calibrated daily using compressed gas cylinders per manufacturer's instructions. Calibration results will be recorded in the field logbook or on equipment calibration forms as a record of equipment accuracy and consistency.
If equipment calibration does not meet manufacturer specifications or if equipment is not operating correctly, it will not be used.

6. Investigation-Derived Waste

Solid investigation-derived waste (IDW) (soil and PPE) generated during soil boring activities will be placed in Department of Transportation-approved 55-gallon drums and transported to the IDW staging area. Upon filling, the drums will be labeled with the site name, media (for example, soil or PPE), date generated, generator contact information, and drum number. Drums will be inspected weekly until removed from the site and the information documented on the Waste Inventory Log. CH2M will be responsible for waste characterization sampling, analysis, and subcontracting IDW transport and disposal.

Liquid IDW (decontamination water and development water) generated during field activities is expected to be minimal and will be placed in the existing waste water tanks onsite and disposed during routine waste water removal operations.

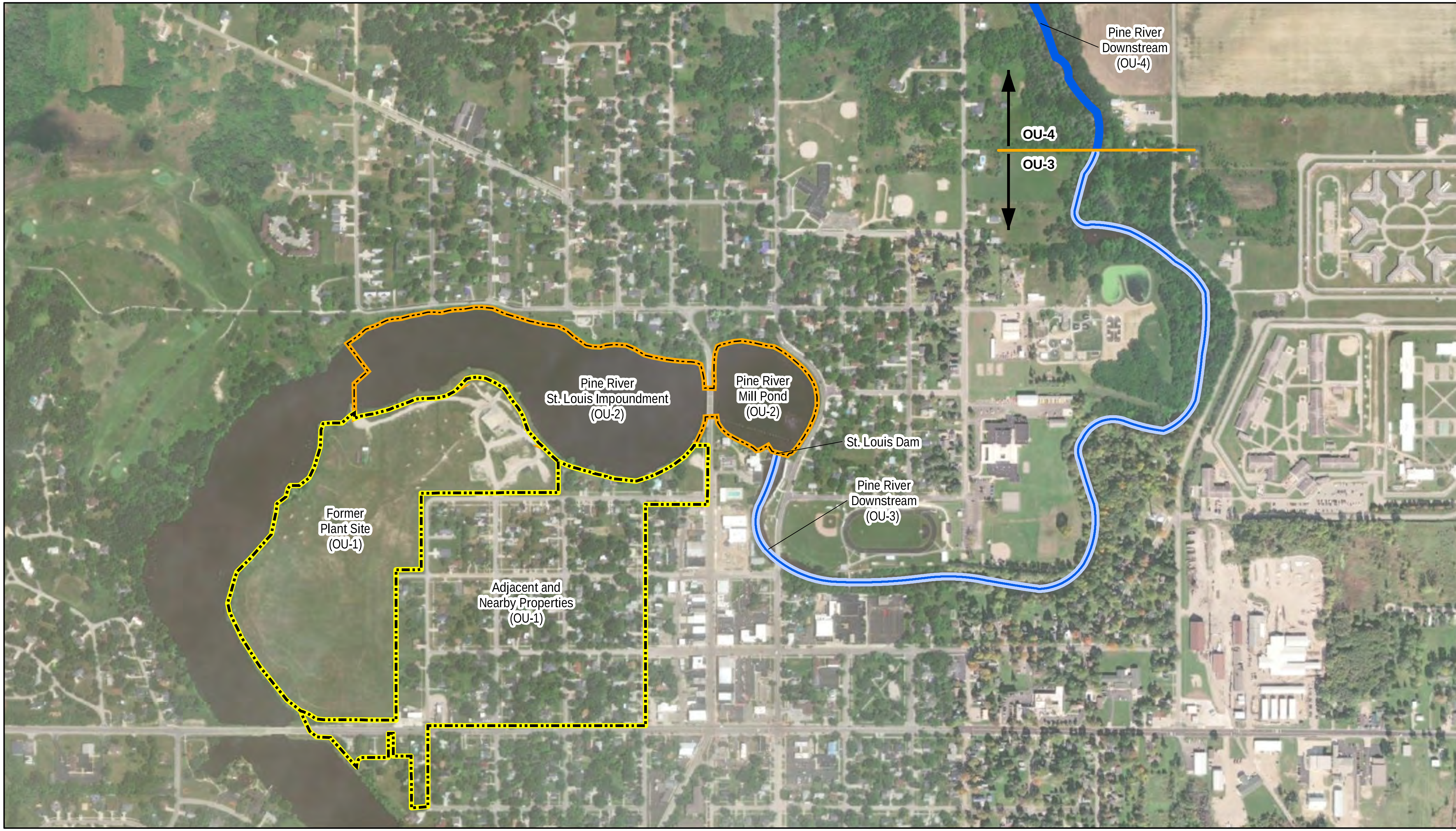
7. References

CH2M HILL, Inc. (CH2M). 2020. *Data Evaluation Report – Velsicol Former Plant Site Upgradient Slurry Wall Investigation, Velsicol Chemical Superfund Site, St. Louis, Michigan.* August.

CH2M HILL, Inc. (CH2M). 2021. *Health and Safety Plan, Velsicol Chemical Superfund Site Former Plant Site Remedial Design, St. Louis, Michigan.* September.

U.S. Environmental Protection Agency (EPA). 2012. *Record of Decision – Velsicol Chemical Corporation/Pine River Superfund Site, Former Plant Site – Operable Unit 1, St. Louis, Michigan.* June 19.

Figures



Legend

- FORMER PLANT SITE AND ADJACENT AND NEARBY PROPERTIES (OU1)
- PINE RIVER - ST LOUIS IMPOUNDMENT (OU2)
- PINE RIVER (OU3)
- PINE RIVER (OU4)

N

0 600 1,200
Feet

FIGURE 1
Study Areas and Operable Units
Velsicol Chemical Corporation Superfund Site
St. Louis, Michigan

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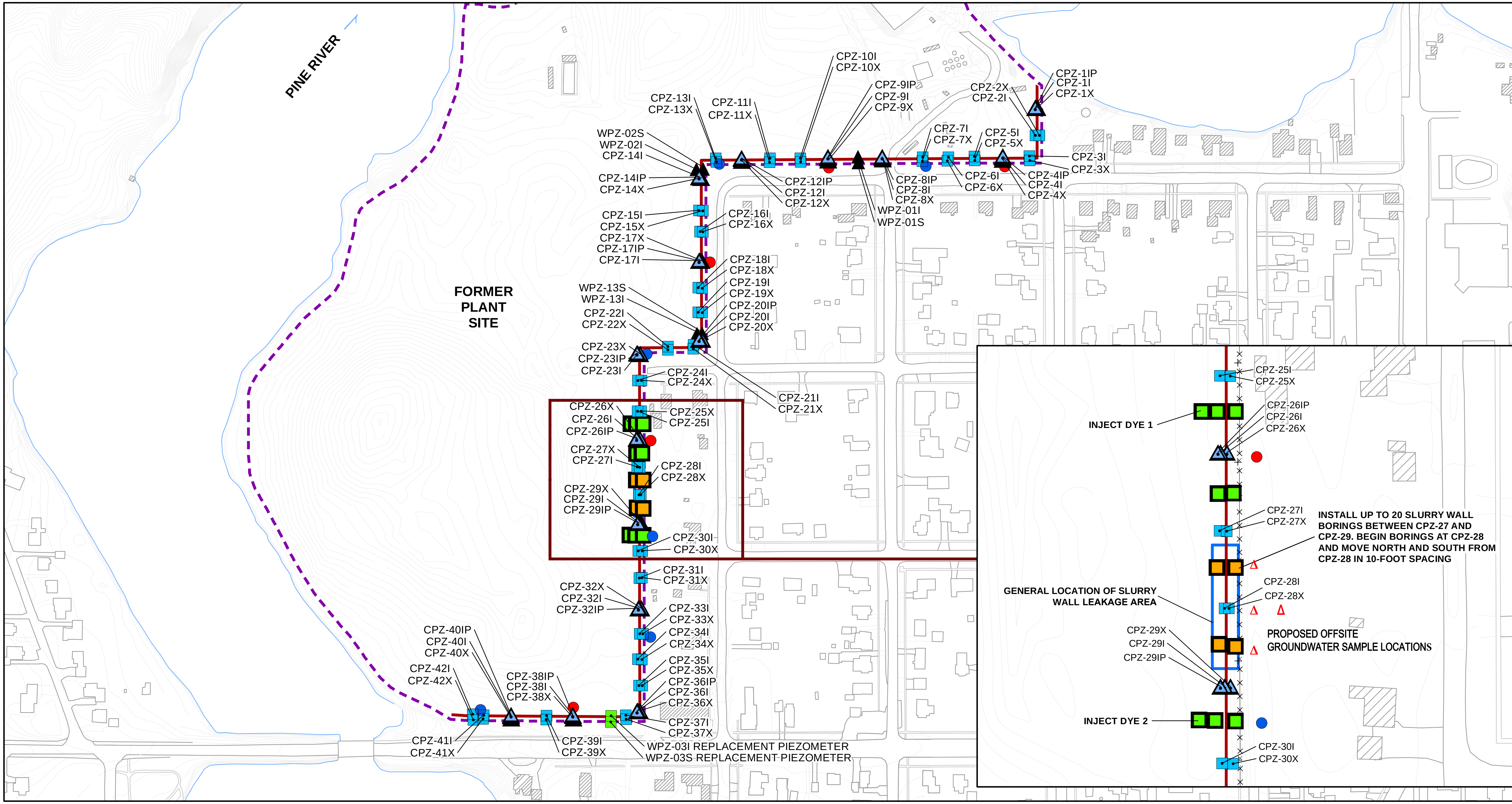

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- NEW TWO/THREE PIEZOMETER CLUSTER WITHIN POTENTIAL SLURRY WALL LEAKAGE AREA
- NEW TWO/THREE PIEZOMETER CLUSTER
- EXISTING TWO PIEZOMETER CLUSTER
- PROPOSED OFFSITE GROUNDWATER SAMPLE
- WPZ-03 PIEZOMETER REPLACEMENT
- EXISTING THREE PIEZOMETER CLUSTER
- PROPOSED SHELBY TUBE SAMPLE
- EXISTING SHELBY TUBE SAMPLE
- WPZ PIEZOMETER
- GENERAL LOCATION OF SLURRY WALL LEAKAGE AREA
- APPROXIMATE OU1 BOUNDARY
- UPGRADIENT SLURRY WALL

N

0 250 500

Feet

FIGURE 2

Supplemental Upgradient Slurry Wall Investigation

Velsicol Chemical Corporation Superfund Site

St. Louis, Michigan

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Attachment 1
Field Standard Operating Procedures

Field Standard Operating Procedure-12
Soil Boring Logging

Author: Steve Chumney 8/27/2021

Approver: Theresa Himmer 08/31/2021

Quality Assurance Manager

Field Standard Operating Procedure-12
Soil Boring Logging

1. Purpose

This field operating procedure (FOP) document provides guidance for obtaining accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

2. Scope

The logging of soil samples will be conducted in general accordance with current ASTM International (ASTM) Designation D 2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). The ASTM procedure is available for internal use only on the Jacobs Technical Information Library. Neither the ASTM electronic file nor the hard copy print may be reproduced in any way.

3. Equipment and Materials

- Indelible Soil boring log forms
- Soil logging guide
- Field logbook
- Write-in-the-rain pen (for extreme weather conditions—cold/rain)
- Clean plastic sheeting
- Clean 55-gallon steel drum approved by the U.S. Department of Transportation and label
- Tape measure
- Pocket penetrometer (optional)
- Clean latex or nitrile gloves
- 12-inch ruler
- Hand lens
- Color Chart for Soil and Rock

4. Procedures and Guidelines

This section covers several aspects of the soil characterization: instructions for completing the soil boring log, field classification of soil, and standard penetration test procedures.

4.1 Instructions for Completing Soil Boring Logs

Soil boring logs will be completed on the soil boring log. The information collected in the field to perform the soil characterization is described below. Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Analytical samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets. Print all information on the field log form—do not write in cursive.

4.1.1 Heading Information

- **Boring Number**. Enter the boring number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each location.
- **Location**. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as “approximate” or “estimated” as appropriate.
- **Elevation**. Elevation will be determined at the conclusion of field activities.
- **Contractor**. Enter name of the company and the city and state where it is based.
- **Drilling/Excavation Method and Equipment**. Identify the bit size and type and method of drilling (e.g., rotary, rotosonic, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted. For excavations enter type of equipment used (e.g., make/model of equipment).
- **Water Level and Date**. Enter the depth below ground surface to the apparent water level in the borehole/excavation. If free water is not encountered during drilling/excavation or cannot be detected because of the drilling method, this information should be noted. Record date and time of day of each water level measurement.
- **Date of Start and Finish**. Enter the date(s) and time(s) the boring/excavation was begun and completed.
- **Logger**. Enter the first initial and full last name of the person completing the form and describing the materials from the borehole.

4.1.2 Technical Data

- **Depth below Ground Surface**. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.
- **Sample Interval**. Note the depth at the top and bottom of the sample interval.

4.1.3 For Soil Borings:

- **Sample Type and Number.** Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.
- **Sample Recovery.** Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material (e.g., slough) in the measurement. Record recovery in feet.
- **Soil Description**. The soil classification should follow the format described in the Field Classification of Soil subsection below.

- **Comments**. Include all pertinent observations (e.g., rod drops, rod bounce as in driving on a cobble, and equipment malfunctions). In addition, note if casing was used, the sizes, and depths installed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders). Such information should be attributed to the driller and recorded in this column.

4.2 Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils.

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1) Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example “Sandy CLAY”
2) Group symbol, in parentheses—for example, “(CL)”
3) Color, using Munsell color designation if appropriate
4) Moisture content
5) Relative density or consistency
6) Soil structure, mineralogy, or other descriptors

This order generally follows the format described in ASTM D 2488.

4.2.1 Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is Silty SAND with gravel, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is Sandy SILT. The gravel portion is not included in the soil name because the gravel

portion was estimated as less than 15 percent. The Group Symbol is (ML). However, the description of this sample should include the phrase "with some gravel" after the descriptive terminology of the primary soil group.

- The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as “Interlayered Sand and Silt,” should be used. In addition, the relative proportion of each soil type should be indicated.

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

4.2.2 Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group.

Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

4.2.3 Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

4.2.4 Moisture Content

The relative degree of moisture present in a soil sample should be defined as dry, moist, or wet.

4.2.5 Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586). If an auto-hammer is not used to collect samples, this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly determined using a pocket penetrometer. For purposes of environmental sampling, the ‘rule of thumb’ can be used, for example, very soft means the soil can be easily penetrated several inches by fist, soft is easily penetrated several inches by thumb, firm can be penetrated several inches by thumb with moderate effort, stiff is readily indented by thumb, but penetrated only with great effort, very stiff is readily indented by thumbnail, and hard is indented with difficulty by thumbnail.

4.2.6 Soil Structure, Mineralogy, and Other Descriptions

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described. Man-made debris encountered in drilling (such as slag from mineral smelting activities) should be identified as such on the log and otherwise described similar to soils, considering aspects such as grain size, angularity, and moisture content.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product (for example, nonaqeous phase liquid, or NAPL).

4.2.7 Equipment and Calibration

No equipment needs to be calibrated if not sampling with the auto hammer.

5. Records Management

Project records will be managed in accordance with the Quality Management Plan Great Lakes Architect-Engineer Services II Contract (Jacobs, 2021). Project documents and records will be retained for10 years after the closing date of the prime contract. All information generated under this program is considered confidential and shall not be released to others without the written consent of the Contract Officer.

6. Quality Control and Quality Assurance

The field notes and utility-locate drawings will be reviewed by the Field Quality Manager at the end of each work day performed.

7. Attachments

Soil boring log.

8. References

ASTM D2488. Standard Practice for Description and Identification of Soils (Visual-Manual Procedures. July 2017.

Jacobs Engineering Group, Inc. 2021. *Quality Management Plan Great Lakes Architect-Engineer Services II (GLAES II) Contract (Jacobs, 2021)*. March.

PROJECT NUMBER	BORING NUMBER SHEET 1 OF 2

SOIL BORING LOG

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	#/TYPE	PID READING (ppm)	CORE DESCRIPTION SOIL TYPE, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF SURFACE CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND START/STOP TIMES OF DAILY DRILLING RUNS.
5						
10						
15						
20						
25						
30						
35						
40						
45						

PROJECT NUMBER	BORING NUMBER SHEET 2 OF 2

SOIL BORING LOG

PROJECT : LOCATION :
ELEVATION : DRILLING CONTRACTOR :
DRILLING METHOD AND EQUIPMENT USED :
WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	#/TYPE	PID READING (ppm)	CORE DESCRIPTION SOIL TYPE, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF SURFACE CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND START/STOP TIMES OF DAILY DRILLING RUNS.
50						
55						
60						
65						
70						
75						
80						
85						
90						

Field Standard Operating Procedure-14
Water Level and Total Depth Measurements

Author: Kaitlin Ma 8/27/2021

Approver: Theresa Himmer 08/31/2021

Quality Assurance Manager

Field Standard Operating Procedure-14
Water Level and Total Depth Measurements

1. Purpose

This field operating procedure (FOP) provides guidelines for measuring depths to groundwater and total depth in soil borings, piezometers, and monitoring wells.

2. Scope

This FOP also covers the topic of measuring light nonaqueous phase liquid (LNAPL) that may be present. It includes only guidelines for discrete measurements of static water levels.

3. Equipment and Materials

- Field logbook and water proof pen
- Equipment/instrument decontamination materials (see *Field Equipment Cleaning and Decontamination Procedures*)
- Well keys and wrenches/T-bar
- Clean latex or nitrile gloves
- Electronic water level meter or oil/water interface probe (Solinst® or equivalent) with a minimum 100-foot tape with graduations in increments of 0.01 foot or less

4. Procedures and Guidelines

- Decontaminate equipment/instruments in accordance with the *Field Equipment Cleaning and Decontamination Procedures*.
- Open the protective cover on well.
- Unlock and remove all monitoring well caps. The well caps will be removed from all monitoring wells prior to beginning depth to groundwater measurements. A minimum time of 30 minutes shall be allotted between the removal of a well cap and measuring the depth to groundwater in the same monitoring well unless the well casing has a hole in it to allow barometric pressures to constantly equilibrate. This will allow the groundwater surface within the riser to stabilize with atmospheric pressure prior to taking a depth to water measurement.
- Lower the probe slowly into the monitoring well or soil boring until the probe just contacts the groundwater surface; the unit will respond with a tone or light signal. Make sure that the top of the riser pipe does not have a sharp edge that may damage the protective coating around the wires in the tape.

- Note the depth to groundwater relative to a reference point indicated on the monitoring well riser pipe. If no reference is clearly visible, reference the northern edge of the riser pipe or soil boring. Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the field logbook.
- Measure water levels to the nearest 0.01 foot.
- Record the condition of the concrete pad, padlock, well cap, protective cover, and bollards (if present) in the field logbook, along with the depth to the groundwater surface.
- Compare the newly measured depth to water in each well to the historical depth to water in that and adjacent wells and re-measure if the new data are outside the historic range for an individual well or if the new data are inconsistent with general patterns of water table rise and fall, considering all wells being monitored. [For example, if most wells measured are generally a few feet higher than the past monitoring event but one well is measured as being several feet lower than past data indicate, re-measure and verify the depth.]
- The total depth of the monitoring well or soil boring should be measured and recorded in the field logbook every time the well is monitored. The total well depth shall be measured in the same general manner as the depth to groundwater except that no indication [light or buzzer] will be produced by the instrument when bottom is reached. Instead, the field personnel will have to monitor the relative weight of the tape and probe as it is lowered into the well and use feel to determine when bottom is reached. The feel of the bottom of the well should also be recorded, this would be soft if the bottom appears to be covered in silt, or firm if the bottom feels clean.
- Decontaminate the probe and tape as it is removed from the well or boring in accordance with the *Personnel and Equipment Decontamination Procedures*.

5. Records Management

Project records will be managed in accordance with the Quality Management Plan Great Lakes Architect-Engineer Services II Contract (Jacobs, 2021). Project documents and records will be retained for10 years after the closing date of the prime contract. All information generated under this program is considered confidential and shall not be released to others without the written consent of the Contract Officer.

6. Quality Control and Quality Assurance

Verify that the battery of the water level meter or oil/water interface probe is charged before each use by pressing the test button on the side of the unit.

- Verify that the unit is operating correctly by testing the probe in tap water (not distilled or deionized water) and verifying that the light and buzzer are activated at the same depth. If one measures higher or lower than the other, continue testing in tap water and determine which indicator is more accurate, and use that indicator for the field measurements.
- Inspect the tape for abrasions that may have been exposed to the wires. The unit will not function properly if there is a short in the wiring.
- It is recommended that a map of all wells to be monitored be carried into the field when monitoring occurs.

- Prior to mobilizing to the site, use historical data to determine which wells to be monitored are cleanest and which are dirtiest/most contaminated and start monitoring with the clean wells first and moving to more contaminated wells last.

7. Attachments

None.

8. References

Jacobs Engineering Group, Inc. 2021. *Quality Management Plan Great Lakes Architect-Engineer Services II (GLAES II) Contract (Jacobs, 2021)*. March.

Field Standard Operating Procedure-18
Groundwater Sampling Procedures

Author: Kaitlin Ma 8/30/2021

Approver: Theresa Himmer 08/31/2021

Quality Assurance Manager

Field Standard Operating Procedure-18 Groundwater Sampling Procedures

1. Purpose

This field operating procedure (FOP) presents general guidelines for collecting groundwater or groundwater grab samples from monitoring wells using low-flow sampling techniques. *FOP-14 Water Level and Total Depth Measurements* should be consulted in conjunction with this FOP.

2. Scope

This FOP is applicable to low-flow sampling techniques. This FOP does not cover purging and sampling of monitoring wells by bailing or other high-flow methods.

3. Equipment and Materials

- Nitrile gloves
- Field Notebook
- Water Level Meter
- YSI 600XLM Water Quality Meter, or similar device
- Groundwater pump
    - Adjustable rate, submersibile pumps are preferred (centrifugal or bladder pump)
    - Peristaltic pump with portable battery may be used with caution. EPA guidance states that "suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds."
- Calibration standard solution for pH (4, 7, and 10), conductivity, and ORP
- HACH turbidity meter, or similar device
- Distilled or deionized water in spray bottle
- Alconox, of equivalent, in spray bottle
- Environmental Manager-approved container such as United Nations drum
- T connector
- Disposable Teflon tubing
- Disposable silicon tubing (for peristaltic)
- Measuring cup to assess flow rate

- 1-micron filter for dissolved phase target analyte list (TAL) metals sample collection
- Stopwatch
- Laboratory-supplied analytical sample containers

4. Water Quality Indicator Parameters Defined

The six field indicator parameters to be monitored include dissolved oxygen, turbidity, ORP, specific conductance, pH, and temperature. Of the parameters, dissolved oxygen, ORP, specific conductance, pH, and temperature are moderately to extremely sensitive to contact with atmospheric oxygen and will be measured in-line using a flow-through cell. Turbidity also will be measured separately to reduce the influence of suspended solids that are retained in the flow-through cell. Indicator parameters will be monitored continuously during purging and values recorded every 5 minutes or whenever at least 1 system volume has cycled through the flow cell.

4.1.1.1 Dissolved Oxygen, ORP, Specific Conductance, pH, and Temperature

The stabilization criteria for dissolved oxygen, ORP, specific conductance, pH, and temperature are three successive readings separated by a time interval sufficient to pump at least one sampling tubing volume plus flow-through cell volume of water through the system at a flow rate equal to or greater than 100 milliliters per minute (mL/min) but less than 500 mL/min while not lowering the water level in the well more than 0.3 foot, within the following ranges:

- Dissolved oxygen: ±10 percent for values greater than 0.5 mg/L
- Eh (ORP): ±10 millivolts (mV)
- Conductivity: ±3 percent (micromhos per centimeter (μmho/cm))
- pH: ±0.1 unit
- Temperature: ±3 percent (degrees Celsius,°C)

Note: A minimum of three system volumes must be purged before evaluating whether stabilization criteria are met and purging is complete before sampling.

4.1.1.2 Turbidity

It should be noted that natural turbidity levels in ground water may exceed 5 nephelometric turbidity units (NTU). If the other parameters stabilize but turbidity remains greater than 5 NTUs, field personnel should continue purging at the determined sustainable flow rate until turbidity readings are ±10 percent NTUs. If turbidity does not stabilize, the project manager should be notified. It should be noted that turbidity measurements may not stabilize within the aforementioned criteria before collecting a sample in accordance with the procedures for purging a low-recovery well.

5. Procedures and Guidelines

5.1 Water Quality Indicator Parameters

1. Set up and calibrate instruments in accordance with manufacturer's instructions.

2. Decontaminate sampling equipment and other instruments to be placed in the monitoring well riser before sampling in accordance with the FOP-06 Personnel and Equipment Decontamination Procedures.

3. Measure the depth to groundwater before performing low-flow sampling, as described in the FOP-02 Water Level and Total Depth Measurements. **Do not measure the depth to the bottom of the well at this time in order to reduce the possibility that accumulated sediment in the well will be disturbed.** Obtain total well depth from the monitoring well development log, or acquire total depth during water level measurements, but the well should not be sampled the same day as depth to bottom is measured.

4. Place field equipment and supplies on clean plastic sheeting to minimize contamination.

5. Determine the system volume, which is the volume of water that will pass through the tubing in the well, pump, and flow-through cell. A minimum of three system volumes must be purged before evaluating whether stabilization criteria are met and purging is complete before sampling.

6. Follow these procedures if using a peristaltic pump:

a. Connect the silicone tubing to the peristaltic pump.

b. Lower the Teflon tubing slowly to the top of the water column. The field team should use a tape measure to measure out the tubing.

c. Place the tubing intake at the depth where the highest contaminant concentrations are present. If this depth is unknown, place the tubing intake in the middle of the well screen if the entire length of the well screen is below the potentiometric surface. If the potentiometric surface is within the well screen, the intake should be set approximately 2 feet off the bottom of the well to minimize the intake of fines accumulated on the bottom of the well and maximize the length of water column above the tubing intake.

d. Cut the Teflon tubing, secure to the top of the well riser with a clamp, and connect to the silicone tubing in the peristaltic pump. Allow extra polyethylene tubing in case the water does not recharge as fast as the pumping rate, so the tubing can be lowered farther into the well.

e. Ensure that the pump flow direction is correct on the peristaltic pump. It is best to verify the flow direction before connecting the polyethylene tubing by inserting the silicone tubing in a cup of distilled water.

f. Connect silicone tubing to the water quality meter flow through cell (bottom connector). Run the outlet tubing (upper connector) to the 5-gallon bucket.

7. Follow these procedures if using a centrifugal pump:

a. Connect Teflon tubing to pump.

b. Lower the pump slowly to the required depth, and use a tape measure to measure the tubing.

c. Place the pump intake at the depth where the highest contaminant concentrations are present. If this depth is unknown, place the pump intake in the middle of the well screen if the entire length of the well screen is below the potentiometric surface. If the potentiometric surface is within the well screen, the intake should be set approximately 2 feet off the bottom of the well to minimize the intake of fines accumulated on the bottom of the well and maximize the length of water column above the tubing intake.

d. Connect the Teflon tubing to the bottom of the flow through cell. Run the outlet tubing from the upper connector to the 5-gallon bucket.

8. Start pumping. Purge rate should be less than 500 mL/min. Monitor the water level carefully after beginning the pumping process.

9. Turn on the groundwater parameter field instrument and let the readings stabilize. Once temperature has stabilized for 30 seconds, record initial groundwater parameters and depth to groundwater on a groundwater purging and sampling form.

10. Containerize purged groundwater initially in a plastic 5-gallon bucket and subsequently transfer to a clean 55-gallon steel drum, other labeled storage container, or handle as directed in the site waste management plan.

11. Purge to stability with a total water surface drop of 0.3 foot or less if water level is stable or only slowly dropping, to ensure stagnant water stored in the well casing is not being sampled and that only fresh groundwater is sampled.

12. Monitor carefully if water level has dropped more than 0.3 foot. Consider lowering the purge rate to keep the water level drop to less than 0.3 foot.

13. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

14. Disconnect the Teflon tubing from the flow-through cell if the well was purged. **Groundwater samples must never be collected from the outlet of the flow-through cell.** When collecting samples, ensure that the flow rate of the pump is equal to or less than the flow rate used to purge the monitoring well. Collect groundwater samples directly from the outlet of the polyethylene tubing starting with volatile organic compound (VOC) samples first.

15. Dissolved phase TAL metals are to be collected by attaching a 0.45-micron filter to the tubing and purging the water through the filter and into the sample jar.

16. Label the sample containers following the collection of groundwater samples, and place the samples in an ice bearing cooler away from sources of cross-contamination.

17. Remove the tubing from monitoring well and discard. Secure the well cap and lid on the well immediately after removing the tubing to prevent objects from being dropped in the well.

18. Decontaminate all equipment and instruments in accordance with the FOP-06 Personnel and Equipment Decontamination Procedures.

19. Store instruments in accordance with the manufacturer's instructions.

20. Purged groundwater will be handled in accordance with the project-specific plans.

6. Records Management

Project records will be managed in accordance with the Quality Management Plan Great Lakes Architect-Engineer Services II Contract (Jacobs, 2021). Project documents and records will be retained for10 years after the closing date of the prime contract. All information generated under this program is considered confidential and shall not be released to others without the written consent of the Contract Officer.

7. Quality Control and Quality Assurance

- Ensure that the water quality meters are calibrated and cared for in accordance with manufacturer's instructions.
- Keep sampling system and monitoring probes out of direct sunlight.
- Verify dissolved oxygen readings by checking reported dissolved oxygen against a chart and correlating theoretical readings at actual site temperatures. Do not record any dissolved oxygen readings that are outside theoretical limits or that do not make sense, such as negative concentrations.

- Check that the flow direction switch on the peristaltic pump is in the correct direction. Flow in the wrong direction may create bubbles in the well riser, thus affecting dissolved oxygen readings.

- Charge battery to peristaltic pump and water quality meter when not in use. Low battery on the water quality meter may not allow unit to connect properly with sonde.

8. Attachments

Groundwater Purging and Sampling Form.

9. References

Jacobs Engineering Group, Inc. 2021. *Quality Management Plan Great Lakes Architect-Engineer Services II (GLAES II) Contract (Jacobs, 2021)*. March.

EPA. *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.* September 19, 2017.

Monitoring Well

Field Data Sheet

Well Number: Field Crew: Purpose of Sampling:

Site: Field Conditions:

WELL CONDITION

Well Pad	Acceptable	Not Acceptable	Explain:
Protective Casing	Acceptable	Not Acceptable	Explain:
Well Casing	Acceptable	Not Acceptable	Explain:
Locking Cap	Acceptable	Not Acceptable	Explain:
Well Label	Acceptable	Not Acceptable	Explain:

PURGE METHOD

Date: Time: Method:

Total Well Depth (ft) =

Depth to Water (ft): =

Water Column (ft): =

Comments: 1 volume

OBSERVATIONS

Odor: None , Low , High , H_2S , Fuel Like , Other:

Comments:

FIELD PARAMETERS

Time	Volume (gal) --	Rate (mL/min) --	pH (s.u.) +/- 0.1 s,u,	DO (mg/L) +/- 10%	ORP (mV) +/- 10 mV	Specific Conductance (mS/cmc) +/- 3%	Temp (^oC) +/- 3%	Turbidity (NTU) <10 NTU	Depth to water (feet) --

SAMPLING

Date: Time:

Sample ID: Method of Sample Collection:

Analytical Parameters:

Q.C. Sample Type: MS/MSD Duplicate Duplicate Sample ID:

Q.C. Parameters:

Trash picked up? Well locked?

SIGNED/SAMPLER:

Field Standard Operating Procedure-25
Monitoring Well Development

Author: Steve Chumney 8/30/2021

Approver: Theresa Himmer 08/31/2021

Quality Assurance Manager

Field Standard Operating Procedure-25
Monitoring Well Development

1. Purpose

This procedure defines the requirements for the development of shallow groundwater monitoring wells.

2. Scope

These guidelines are for the development of shallow groundwater monitoring wells.

3. Equipment and Materials

- Potable water
- Decontamination supplies (5-gallon buckets, wash tubs, Alconox, latex gloves, etc.)
- Submersible pump/controller or peristaltic pump
- Tubing
- Disposable bailers
- Surge block for a 2-inch-diameter well
- Portable generator (minimum 3,500 W)
- Water level indicator
- YSI Multi-meter (or equivalent)

4. Procedures and Guidelines

After the installation of the monitoring well, development of the well should occur after the grout has set, at least 48 hours following placement of the grout. Overpumping is the most desirable method for well development. Procedures for developing monitoring wells also apply to re-developing existing monitoring wells. Monitoring wells will be developed using the following guidelines:

- All non-dedicated down well equipment (tubing, water level indicator, etc.) will be decontaminated prior to each well being developed. Dedicated tubing will be used for each well developed.
- After the well is opened, depth to water and total depth of well will be measured with a water level indicator and recorded in the site specific field logbook. Casing volumes (for a 2-inch diameter well) can be calculated using the following equation: Total depth of monitoring well (TD) – Depth to water (DTW) = height of water in monitoring well (h); therefore 1 casing volume = h × 0.16 for 2-inch-diameter wells.
- If there are indications of silt or fines at the bottom of the well (e.g. "spongy or soft feeling" when total depth of well is measured or shallower total depth measurement compared to historical data) a bailer or other applicable means may be used to collect sediment at the bottom of the well before installing the submersible pump.
- After fines have been removed from the well, a submersible pump (or a peristaltic pump) with dedicated tubing will be lowered into the well and set at the top of the well screen. The pump will be plugged into the controller and generator. The outflow end of the tubing will be secured in a 55-gallon drum used to containerize the development water.
- Turn pump on with a beginning flow rate of 100 mL/minute and begin developing the well. Measure the initial pH, temperature, specific conductance, and turbidity and enter measurements in the field logbook. Record initial color, odor, and clarity of the groundwater.
- Incrementally lower the intake down the well screen. Repeat the process going up the well screen.
- As the well is being developed, adjustments may have to be made to the flow rate of the pump. If the pumping rate does not produce significant drawdown (0.5 foot or more) than the pumping rate should be increased. The pumping rate should be increased incrementally until significant drawdown is produced. For submersible pumps, care should be taken to prevent the water level from falling below the pump intake.
- If necessary, gentle surging the well with a surge block can be initiated to further development. After surging, fines that have settled in the bottom of the well should be removed. This technique is not recommended for low-yield wells.
- At a minimum, the volume of water injected during the well development and three well purge volumes of water will be removed from the well with water quality measurements (pH, temperature, specific conductance, and turbidity) being recorded for every purge volume of water removed. Introducing of water from another source should only be used if stated in the approved work plan and with the project manager's approval.
- Well development will be considered complete when pH, temperature and specific conductivity measurements have stabilized (three consecutive readings where pH is within ± 0.1 unit, and temperature and specific conductivity are within 3 percent) or turbidity is less than 50 NTUs, or a maximum of 12 casing volumes of water has been removed from the monitoring well.
- Well development will cease if the well goes dry within one purge volume under a pumping rate of 100 mL/minute.
- The following data should be recorded in the field logbook for each monitoring well developed:
  - Well ID

- Date of well installation or redevelopment
- Time of well development
- Water levels before, during, and after development
- Water quality stabilization parameters (pH, temperature, specific conductance, and turbidity) initially, during and at the end of developing the well
- Quantity of water removed
- Type of equipment used (e.g., submersible pump, peristaltic pump, bailer)

Description of well development techniques (e.g., over pumping, surging).

5. Records Management

Project records will be managed in accordance with the Quality Management Plan Great Lakes Architect-Engineer Services II Contract (Jacobs, 2021). Project documents and records will be retained for10 years after the closing date of the prime contract. All information generated under this program is considered confidential and shall not be released to others without the written consent of the Contract Officer.

6. Quality Control and Quality Assurance

Field quality manager should review well development logs for accuracy and completeness and conformance to stabilization criteria outlined in the project plans.

7. Attachments

Well development log.

8. References

Jacobs Engineering Group, Inc. 2021. *Quality Management Plan Great Lakes Architect-Engineer Services II (GLAES II) Contract (Jacobs, 2021)*. March.

WELL DEVELOPMENT LOG

WELL ID:

Project Name:		Development Information	Development Method:	
Project Number:		Start Date:		
Installation Date:		Start Time:		
Development Team:		End Date:		
		End Time:		
Log Book ID/Page:				
Well Depth:	ft btoc	Contractor Information	Purging Equipment:	
Well Diameter:	in	Development:		
Screened Interval:	ft btoc			
Static Water Level:	ft btoc	Equipment:		
Well Materials:				

WELL STABILIZATION DATA

Time	Volume Removed	Water level (ft btoc)	Turbidity (NTU)	Clarity/Color	Temp. (°C)	pH	Sp. Cond. (mS/cm)	Remarks

STABILIZATION SUMMARY

Range or Average Pump Rate:	gpm	Purge Water Description:	
Maxium Drawdown during pumping:	ft		
Total quantity of material bailed:	gal	Comments:	
Total quantity of water discharged by pumping:	gal		