SUPPLEMENTAL PHASE III
EXTENT OF CONTAMINATION (EOC) WORK PLAN
COMPANY VEHICLE OPERATIONS PROPERTY
YPSILANTI, MICHIGAN

Prepared For:
ENCORE, LLC

OCTOBER 2003
REF. NO. 17303 (6)

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LIST OF ACRONYMS

BBL	Blasland, Bouck & Lee
bgs	below ground surface
COC	Constituent of Concern
CRA	Conestoga-Rovers & Associates
CVO	Company Vehicle Operations
CVOC	Chlorinated Volatile Organic Compound
ENCORE	Environmental Corporate Remediation
EOC	Extent of Contamination
FMG	Field Method Guidelines
GM	General Motors
GSI	Groundwater/Surface Water Interface
HSA	Hollow Stem Auger
IRA	Interim Response Action
MDEQ	Michigan Department of Environmental Quality
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NA	Natural Attenuation
NAPL	Non-Aqueous Phase Liquid
PAH	Polynuclear Aromatic Hydrocarbon
PAOC	Potential Area of Concern
PCB	Polychlorinated Biphenyls
PID	Photoionization Detector
PRPs	Potentially Responsible Parties
QA/QC	Quality Assurance/Quality Control
SVOC	Semivolatile Organic Compound
TAL	Total Analyte List
TCL	Total Contaminant List
U.S. EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WRBC	Willow Run Business Campus

1.0 INTRODUCTION

Conestoga-Rovers & Associates (CRA) was retained by Environmental Corporate Remediation (ENCORE), a wholly owned subsidiary of General Motors (GM), to prepare this Supplemental Phase III Extent of Contamination (EOC) Work Plan (Work Plan) for the Company Vehicle Operations (CVO) Area (Site) at the former Willow Run Assembly Plant located in Ypsilanti, Michigan. Figure 1.1 presents the Site location.

The Site is located on the former Willow Run Assembly Plant property, which currently houses the Willow Run Business Center (WRBC), as well as the GM CVO facility. This Work Plan addresses issues identified at the CVO area only. The CVO area is bordered on the north and east by Tyler Pond, which influences groundwater flow at the property. The WRBC exists to the west, and Tyler Road abuts the southern Site boundary.

Specifically, this Work Plan presents additional investigative activities that will be conducted to:

- Further define the groundwater flow pattern;
- Characterize the clay confining unit;
- Identify and characterize potential preferential subsurface pathways from the Site to Tyler Pond;
- Gather additional stratigraphy information for the south bank of Tyler Pond;
- Determine the appropriate locations for groundwater/surface water interface (GSI) monitoring points;
- Characterize the storm water discharge from the Site to the Pond;
- Delineate subsurface impacts previously observed at two locations (sink hole and pond bank); and
- Identify other potential waste burial sites beneath the CVO parking lot.

2.0 BACKGROUND

Previous investigative activities have been conducted to characterize soil and groundwater impacted by both chlorinated and non-chlorinated volatile organic compounds ([CVOCs/VOCs], CRA, May 2003) at the Site. Results indicated that impacted groundwater is generally moving towards Tyler Pond and impacts at the pond bank exceed chronic GSI criteria established by the Michigan Department of Environmental Quality (MDEQ). Two areas of higher contamination exist, Area 1 and Area 2, where chemical oxidation was used in a Groundwater Interim Response Action (IRA) to reduce concentrations. Groundwater injections were completed in 2001, 2002, and 2003. Additionally, in July 2003, a Soil IRA was completed in Area 1 to remove material that was found to be an ongoing source of groundwater contamination. In spite of these IRAs, groundwater monitoring data indicates that migration may be expanding and further investigation is needed to fully understand hydrogeologic conditions and fate and transport mechanisms so additional remedial efforts can be considered.

Subsurface conditions at the Site are very complex. Although the subject groundwater system is shallow groundwater flow and contaminant transports are heavily influenced by utility corridors, various fill areas, and Tyler Pond which is a discharge boundary for the groundwater unit. The following sections summarize historical information regarding the Site and activities completed.

2.1 POTENTIAL AREAS OF CONCERN

The additional investigations outlined in this Work Plan will further investigate three Potential Areas of Concern (PAOCs) located at the Site. Background information on these PAOCs is presented in the following sections. Figure 2.1 presents the locations of the PAOCs on the Site.

- PAOC 18, the Kaiser-Frazer Dump Area, located along the southern bank of Tyler Pond coalesces with PAOC 2 at the northwest corner of the Site. Polynuclear aromatic hydrocarbons (PAHs) and lead in soil are the COCs at PAOC 18;
- PAOC 19, is the CVO Property, where groundwater is impacted with CVOCs; and
- PAOC 21, the Sink Hole Waste Area, was recently identified during test pitting activities conducted in June 2003.

2.1.1 PAOC 18 - KAISER-FRAZER DUMP AREA

It is reported that Kaiser-Frazer dumped "paint sludge" in the area between the CVO fence line and Tyler Pond during the 1940's and 1950's (Blasland, Bouck & Lee, Inc (BBL), 1997). In February of 1994, an estimated 90 cubic yards of visible surface waste material, including 30 drum remnants were removed from this area (removal by Weston on behalf of GM). Waste and soils were removed until visually clean underlying soils were exposed. Post-removal results indicate the presence of lead and PAHs above applicable Part 201 screening criteria remain in the soil.

During Site investigations conducted by CRA in 2002 and 2003, stained soils have been observed along the southern bank of Tyler Pond. Analytical results indicate that VOCs, semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs) and diesel and gasoline range organics were present in the stained black soils collected from the bank. Inorganics were not analyzed in these samples.

2.1.2 PAOC 19 – CVO PROPERTY

Several VOCs were detected in soil and groundwater during a Phase I Hydrogeologic Investigation conducted in September 1994 at PAOC 19 (BBL, 1997). VOC compounds have never been stored in the tanks near this area. VOCs and SVOCs were historically detected in soil, and VOCs in groundwater analyzed from PAOC 19.

The Groundwater IRA was being conducted to address PAOC 19. It was designed to reduce VOC concentrations in two areas with higher concentrations at the Site to levels that will support natural attenuation (NA), and to achieve compliance with acute GSI values, in accordance with the recently revised MDEQ Part 201 rules (December 21, 2002). Groundwater concentrations remain above chronic and acute GSI values at the Site, although, the GSI wells closest to Tyler Pond do not exhibit acute GSI criteria exceedances. The Groundwater IRA is currently being evaluated to determine if additional groundwater treatment or barrier methods are needed to address groundwater impacts and GSI concerns.

2.1.3 PAOC 21 – SINK HOLE WASTE AREA

During test pitting activities completed in June 2003 to identify the source of the sinkhole, buried waste was observed in the excavation. The location of the sinkhole is near the northwest Site boundary as shown on Figure 2.1.

The excavation identified solidified bags of concrete, rusted deteriorated drum remnants, yellow fragments of paints and pigments, garbage, remnants of fiberglass drums, solidified brown primers, copper cables and bricks at depths between 1.25 feet and 4 feet bgs.

2.2 TYLER POND

A large dredging remediation project was completed by the Potentially Responsible Parties (PRPs) on Tyler Pond between 1995 and 1999 to remove PCB sediments from the Pond. During this project, several sections of the south bank of the Pond were used as access points for equipment and material causing areas to collapse and require stabilization or rebuilding with clay. The most complete investigation of the southern bank of Tyler Pond was completed in 1994/1995 by BBL. Due to the changes in the bank from the dredging operation the bank stratigraphy described by these borings is no longer valid.

2.3 BASIS FOR INVESTIGATION

Based on the results of the Groundwater IRA, additional remedial design requirements, review of historical reports, limited additional investigations and the preparation of hydrogeologic cross sections of the Site it became clear that additional information regarding the subsurface at the Site is required. This Work Plan is designed to collect subsurface information for the following purposes:

- Further define the groundwater flow pattern;
- Characterize the clay confining unit;
- Identify and characterize potential preferential subsurface pathways from the Site to Tyler Pond;
- Gather additional stratigraphy information for the south bank of Tyler Pond;
- Determine the appropriate locations for GSI monitoring points;
- Characterize the storm water discharge from the Site to the Pond;
- Delineate subsurface impacts previously observed at two locations (sink hole and pond bank); and
- Identify other potential waste burial sites beneath the CVO parking lot.

3.0 INVESTIGATION PROGRAM

Detailed stratigraphy logs will be completed for each borehole and monitoring well installed. In the case where a borehole and monitoring well are paired, the borehole will be completed first and logged. The monitoring well will then be installed five feet from the borehole at the appropriate depth as indicated in the adjacent borehole. Permanent monitoring wells will be installed using 4-¼ inch inside diameter hollow stem augers (HSA). Temporary wells and soil borings will be completed using a GeoProbe direct push rig. Continuous soil samples will be collected from each location to record soil stratigraphy and to screen for organic vapors using a photoionization detector (PID).

The investigative program described in this Work Plan consists of three phases:

- General Site investigation;
- Individual PAOC investigations; and
- GSI investigation.

The following subsections present an overview of these phases. Field related activities (borings, well development, groundwater sampling, etc.) will be conducted following ENCORE Field Method Guidelines (FMG). Applicable ENCORE FMGs are provided in Appendix A. All soil borings and monitoring well locations presented on Figures 3.1, 3.2, and 3.3 are approximate and will be field fit based on actual field conditions.

3.1 GENERAL SITE INVESTIGATION

The general Site investigation is designed to characterize:

- Groundwater flow direction;
- The clay confining layer in the central portion of the Site;
- The geology along the south bank of Tyler Pond; and
- Investigate the CVO parking lot for additional buried waste areas.

3.1.1 GROUNDWATER FLOW

Six monitoring wells (MW-19-01 through MW-19-07) will be installed at the locations shown on Figure 3.1. The monitoring wells will be installed to assess the groundwater flow direction in the south and east portions of the Site. Two of the monitoring wells (MW-19-06 and MW-19-07) are located in the center of the Site to determine if radial groundwater flow patterns exist, which could occur due to the presence of utilities in the area. The borings associated with the installation of wells MW-19-01 through MW-19-05 will be advanced 6 inches into the confining clay layer. The water table monitoring wells (MW-19-01) will be installed straddling the water table, so that the top two feet of the ten-foot screen is above the water table.

Soil samples will be collected from monitoring wells MW-19-01 through MW-19-05 at the 0-2 foot below ground surface (bgs) interval and the two-foot interval above the water table and analyzed for Total Contaminant List (TCL) VOCs. As discussed in Section 3.1.2, the deep boreholes adjacent to MW-19-06 and MW-19-07 (SB-19-01 and SB-19-02) will be sampled for soil and will be used to determine the screen placement of these wells. Groundwater samples will be collected from monitoring wells MW-19-01 through MW-19-07 for TCL VOCs.

Table 3.1 summarizes the environmental and geotechnical analyses to be conducted on samples from each soil boring and monitoring well installation. In addition to the samples specified in Table 3.1, if odor, staining or elevated PID readings are observed a sample will be collected from the impacted interval and submitted for laboratory analysis. Table 3.2 summarizes the well screen placement and groundwater analysis required for each monitoring well.

3.1.2 CONFINING LAYER

Three soil borings (SB-19-01 through SB-19-03) will be installed at the locations shown on Figure 3.1. The borings will be installed to a minimum of 50 feet to characterize the clay-confining layer throughout the center of the Site.

Soil samples will be collected from all three borings at the 0 to 2 foot bgs interval and the two-foot interval above the water table. These samples will be analyzed for TCL VOCs. Geotechnical soil samples from these three deep borings will be collected from the saturated sands for grain size analysis and 1 foot into the clay confining layer for permeability testing (Shelby tube) and grain size analysis. The clay confining layer at all three locations will be compared, if consistent only one Shelby tube will be submitted for permeability and grain size analysis.

Table 3.1 summarizes the environmental and geotechnical analyses to be conducted on samples from each soil boring. In addition to the samples specified in Table 3.1, if odor, staining or high PID readings are observed a sample shall be collected from the impacted interval and submitted for laboratory analysis.

3.1.3 TYLER POND BANK INVESTIGATION

Fourteen soil borings (SB-19-04 through SB-19-15) will be installed at the locations shown on Figure 3.1 to provide current stratigraphy data along the portions of the south bank of Tyler Pond that was reworked during the dredging activities in the late 1990's. The soil borings completed near the top of the bank (SB-19-04 and SB-19-10 through SB-19-14) will be completed at least 3 feet into the confining clay layer. The soil borings completed on the pond bank (SB-19-05 through SB-19-09, and SB-19-15) will be completed at least 1 foot into the clay layer.

Soil samples for chemical analysis will be collected from the boreholes if odors, staining or high PID readings are observed. If samples are collected they will be submitted for laboratory analysis for TCL VOCs, SCL SVOCs, Total Analyte List (TAL) inorganics and PCBs. Samples from the saturated sands will be collected for grain size analysis will be collected form all soil borings (SB-19-04 through SB-19-15). Shelby tubes from the saturated sands will be collected from four borings for permeability testing (SB-19-04, SB-19-10, SB-19-13, and SB-19-14). Geotechnical samples will be collected from the surficial clay from SB-19-05, SB-19-07, and SB-19-15 for grain size analysis and from the confining clay at SB-19-07 for grain size analysis and permeability testing (Shelby Tube).

Table 3.1 summarizes the environmental and geotechnical analyses to be conducted on samples from each soil boring. Stratigraphy logs from wells installed to delineate the VOC plumes will also be used to evaluate the bank of Tyler Pond.

3.1.4 BURIED WASTE AREA INVESTIGATION

To delineate the extent of the waste material beneath the CVO parking lot an EM38 conductivity survey will be completed. It is anticipated that the paint waste will be identified based on a resistive response, in comparison to the more conductive subgrade material.

The EM38 consists of transmitter and receiver coils located at either ends of a rigid boom. These coils are separated by 3 feet, which yields a depth of penetration of approximately 5 feet. The EM38 is connected to a data logger, which can either be triggered manually or set to automatic data collection as the survey progresses.

Prior to conducting the EM38 survey, a location grid will be established over the former sinkhole and surrounding area. Conductivity measurements will be collected along 5-foot spaced grid lines over the area of investigation, and all grid lines will be designated with a Cartesian coordinate system as required by the EM38 data logger. The EM38 will operate in auto mode, with data collection at approximate intervals of 2 feet along the survey lines. The locations of any surficial metal objects or debris encountered on survey lines will be noted in a hardcover bound fieldbook.

The EM38 survey can not be completed where reinforced concrete is present. In areas where reinforced concrete is present and subsurface information is not available, boreholes will be advanced to determine if waste material is present. Following the EM38 survey, any areas where waste material is suspected will be investigated using boreholes and/or test pitting activities. An addendum to this Work Plan will be prepared to detail the location of soil borings and/or test pitting activities, and the laboratory analysis to be completed.

3.2 PAOC INVESTIGATIONS

3.2.1 PAOC 18 – KAISER-FRAZER DUMP AREA

Seven boreholes (SB-18-58 through SB-18-64) will be installed to delineate impacted soils observed at B-7 and B-11 as shown on Figure 3.2. Additional borings will be installed to complete the delineation as required. Borings will be completed by hand auger in the wooded area of the bank. Following delineation activities, at least one temporary monitoring well will be installed to determine if the groundwater has been impacted. If visually impacted material is observed, a soil sample will be collected from that interval and analyzed for TCL VOCs, TCL SVOCs, TAL inorganics, and PCBs.

Geotechnical samples will be collected from three of the PAOC 18 borings to provide stratigraphy data for the bank of Tyler Pond in the area of PAOC 18. Samples for grain size analysis will be collected from the saturated sands and surficial clay from SB-18-62 through SB-18-64. In addition, the confining clay at SB-19-64 will be sampled for grain size and permeability analysis.

Table 3.1 summarizes the environmental analyses to be conducted on samples from each soil boring. An addendum to this Work Plan will be prepared to detail the location and analysis of the temporary monitoring well(s) to be installed.

3.2.2 PAOC 19 – CVO PROPERTY

Sixteen monitoring wells (MW-19-08 through MW-19-23) will be installed to further delineate the extent of the high VOC plume concentrations. Eight monitoring wells will be used to delineate the Area 1 plume (MW-19-08 through MW-19-15), five wells will delineate the Area 2 plume (MS-19-19 through MW-19-23), and three wells will delineate the impacts potentially moving towards the pond between the two areas (MW-19-16 through MW-19-18). Four of the wells (MW-19-11, MW-19-13, MW-19-16, and MW-19-19) will be used to monitor if the bedding of the utility lines are acting as preferential pathways for impacted groundwater to vent to Tyler Pond.

Soil samples will be collected from the 0-2 foot bgs interval and the two-foot interval above the water table and analyzed for TCL VOCs and TAL inorganics at MW-19-12, MW-19-14, and MW-19-15 for TCL VOCs, TCL SVOCs, TAL inorganics and PCBs at MW-19-17, MW-19-18, and MW-19-20. If field observations (i.e., odor, staining or high PID readings) are observed during the installation of the other nine monitoring wells, a soil sample will be collected from the impacted interval and submitted for laboratory analysis. The deep borehole adjacent to MW-19-11 will be sampled for soil as described in Section 3.1.2. Groundwater samples will be collected from all monitoring wells for TCL VOCs. Additional groundwater analysis may be submitted for TCL SVOCs, TAL inorganics and PCBs based on the results of the soils samples for these constituents.

Sudan Four shall be used to field test soils located directly above the confining clay layer for the presence of Non-Aqueous Phase Liquid (NAPL) at MW-19-09 and MW-19-10. Additional soil samples (Shelby tubes) will be collected from the monitoring wells placed along the bank of Tyler Pond (MW-19-014, MW-19-15, MW-19-17, MW-19-18, MW-19-20 and MW-19-23). Samples will be collected for grain size analysis from the surficial clay and saturated sands from each of these wells. Shelby tubes will be collected for permeability testing from the saturated sands from five of the six wells listed above (MW-19-18 is excluded). The discharge from the four storm sewer outfalls (Outfalls 11 through 14) will be sampled during dry and wet weather conditions and submitted for TCL VOCs analysis.

Table 3.1 summarizes the environmental and geotechnical analyses to be conducted on samples from each soil boring and monitoring well installation. In addition to the samples specified in Table 3.1, if odor, staining or high PID readings are observed a sample shall be collected from the impacted interval and submitted for laboratory analysis. Table 3.2 summarizes the well screen placement and groundwater analysis required for each monitoring well. Table 3.3 summarizes the storm sewer discharge sample parameter for wet and dry weather flow.

3.2.3 PAOC 21 – SINK HOLE WASTE AREA

Five boreholes (SB-21-01 through SB-21-05) will be installed to delineate the waste material observed in the sink hole test pit as shown on Figure 3.3. Borehole SB-21-01 will be advanced through the known waste material location to delineate a depth of the waste material. Additional borings will be installed to complete the delineation if required. If groundwater is encountered with the in waste area, a monitoring well will be installed to determine if groundwater in the area has been impacted.

If visually impacted material is observed, a soil sample will be collected from that interval and analyzed for TCL VOCs, TCL SVOCs, TAL inorganics, and PCBs. Table 3.1 summarizes the environmental samples to be collected for each soil boring.

3.3 GSI WELL PRE-SCREENING

Following review of the hydrogeological information gathered from the installation of the soil borings and monitoring wells, a GSI investigation will be conducted. Temporary groundwater wells will be installed and sampled to determine the appropriate locations for permanent GSI wells. An addendum to this Work Plan will be prepared to detail the location of these samples.

4.0 SAMPLING METHODOLOGY

Field related activities including soil boring installation, monitoring well installation, sample collection, etc. will be conducted in accordance with ENCORE FMGs. Applicable ENCORE FMGs are provided in Appendix A. All samples will be recorded electronically on the ENCORE Sample Key, following each sampling event. Samples will be shipped to the laboratory under chain of custody procedures.

4.1 SAMPLE NOMENCLATURE

Each sample will be labeled with a unique sample number consistent with the ENCORE sample designation system.

Series – Project Number – Date – Initials – xxx

The series is a letter or letters that designates a group of samples (GW, groundwater; S, soil; N, non-aqueous phase liquid; RB, rinse equipment blank; WSS, water storm sewer). Initials refer to the sampler's initials. The xxx sample identification number will carry forward from previously collected samples at the Site.

4.2 QUALITY ASSURANCE/QUALITY CONTROL

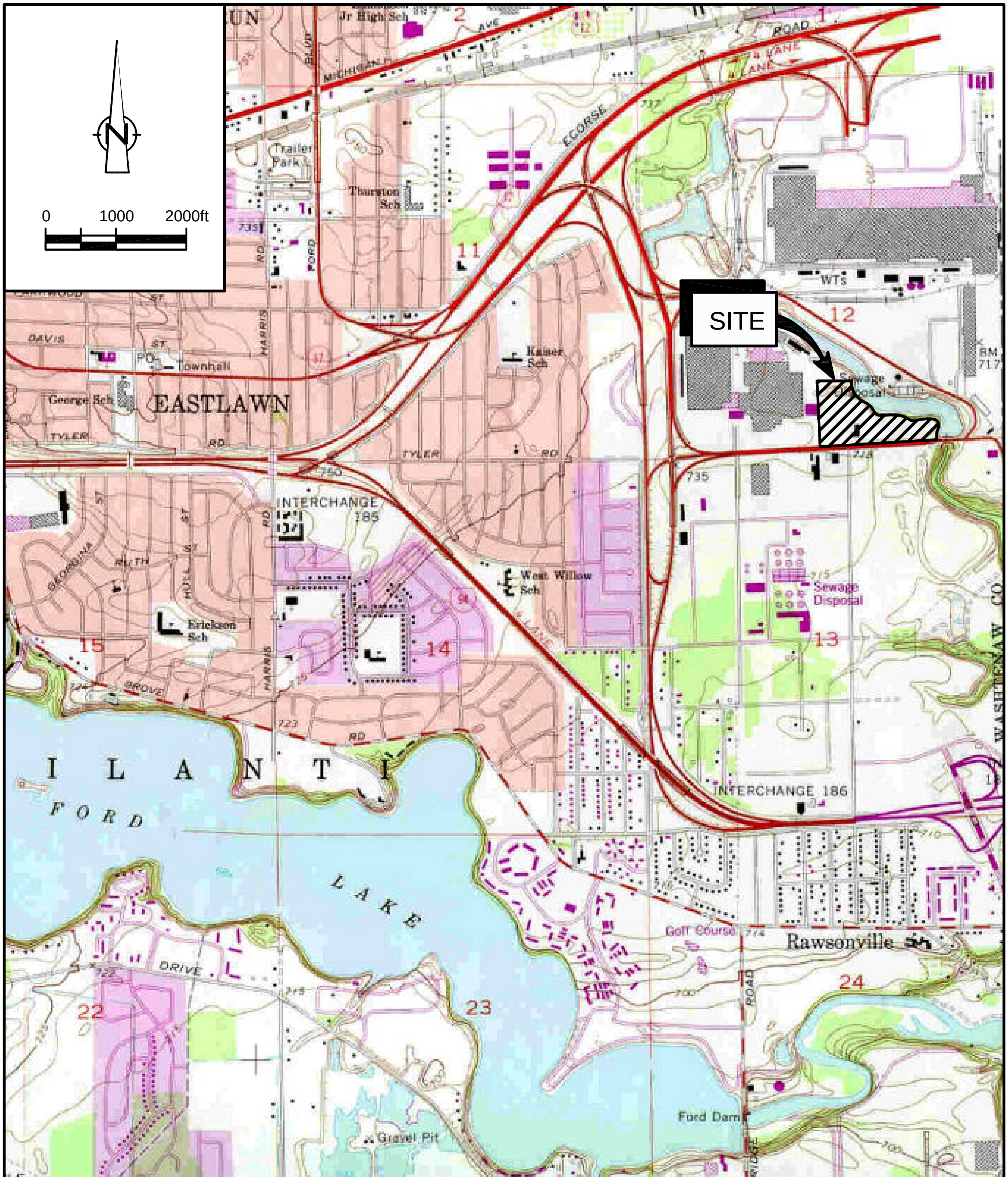
Quality Assurance/Quality Control (QA/QC) field samples (duplicates and matrix spike/matrix spike duplicates (MS/MSD)) will be collected in accordance with ENCORE FMGs. Validation of analytical data will be performed by the CRA Chemistry department utilizing approved United States Environmental Protection Agency (U.S. EPA) guidelines.

5.0 SCHEDULE

Figure 5.1 presents the schedule for completing the fieldwork discussed in this Work Plan.

6.0 REFERENCES

BBL. 1997. Description of Existing Conditions Report, Former Willow Run Assembly Plant Property, Ypsilanti, Michigan.



SOURCE: USGS QUADRANGLE MAP;
YPSILANTI EAST, MICHIGAN

figure 1.1

SITE LOCATION
SUPPLEMENTAL PHASE III EOC WORK PLAN
COMPANY VEHICLE OPERATIONS AREA
Ypsilanti, Michigan

YPSILANTI

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17303-04(006)GN-DE001 OCT 29/2003

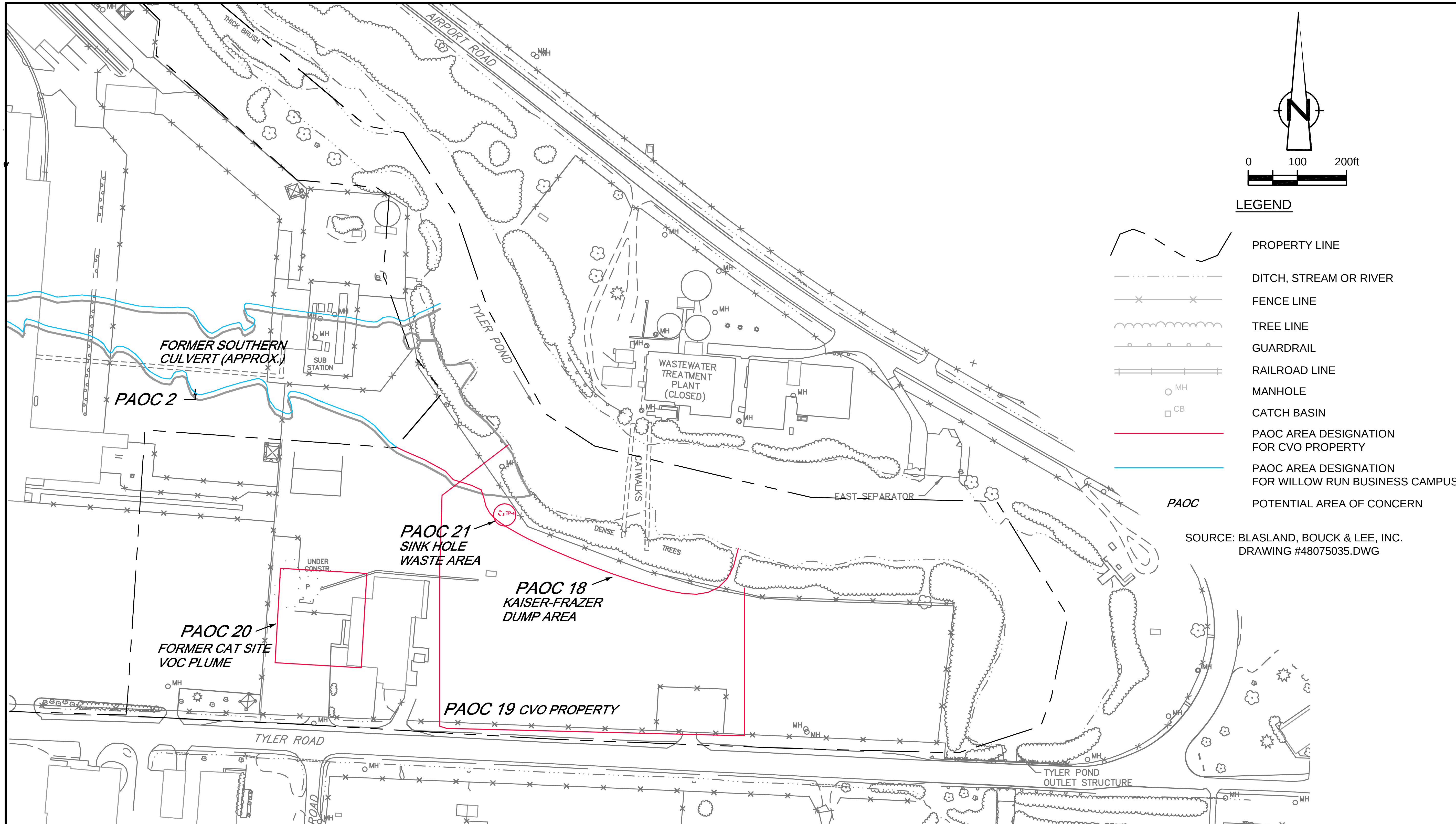

figure 2.1

LOCATIONS OF PAOCs
SUPPLEMENTAL PHASE III EOC WORK PLAN
COMPANY VEHICLE OPERATIONS AREA
Ypsilanti, Michigan

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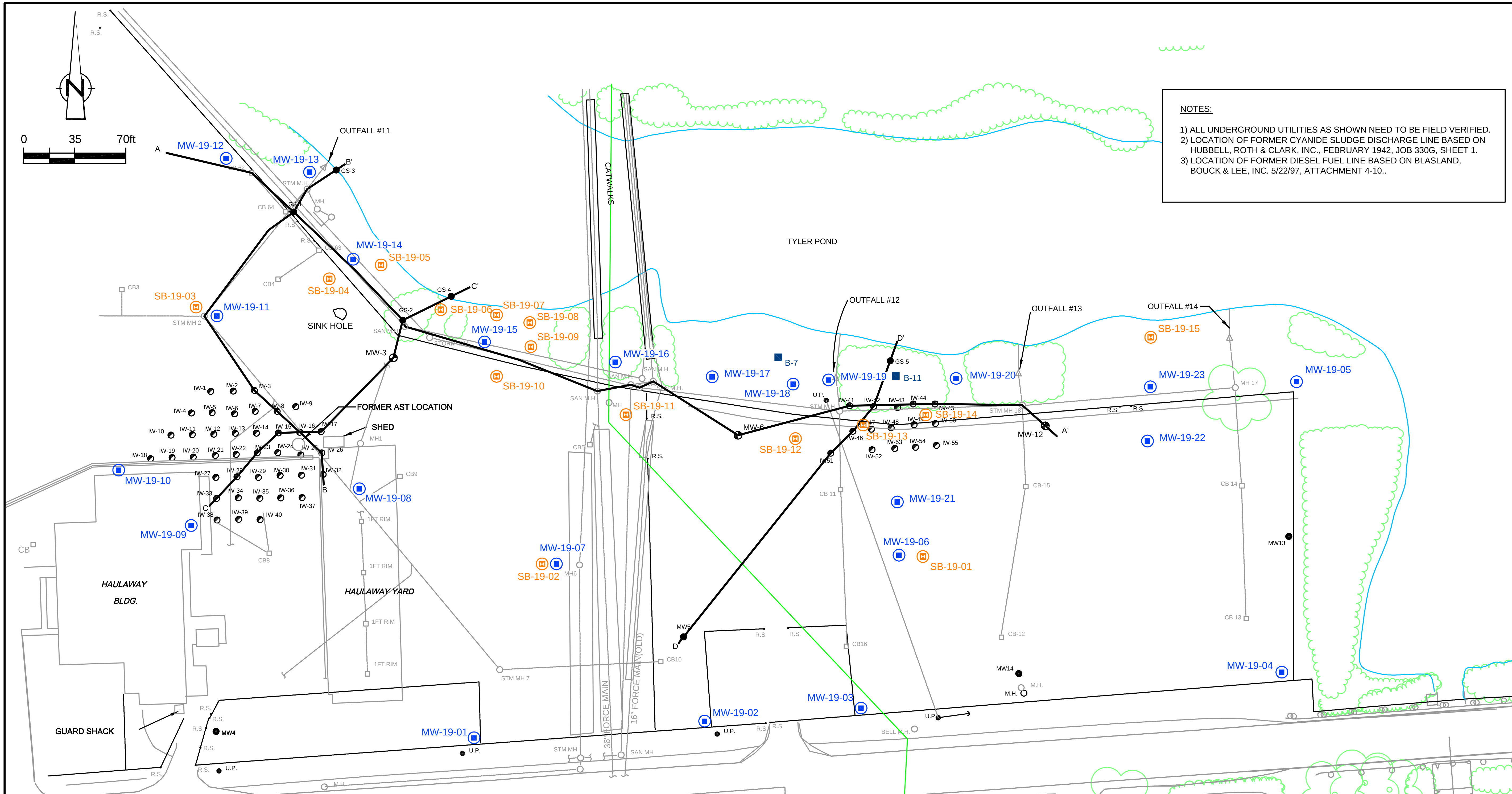

NOTES:

1) ALL UNDERGROUND UTILITIES AS SHOWN NEED TO BE FIELD VERIFIED.
2) LOCATION OF FORMER CYANIDE SLUDGE DISCHARGE LINE BASED ON HUBBELL, ROTH & CLARK, INC., FEBRUARY 1942, JOB 330G, SHEET 1.
3) LOCATION OF FORMER DIESEL FUEL LINE BASED ON BLASLAND, BOUCK & LEE, INC. 5/22/97, ATTACHMENT 4-10..

LEGEND

- DITCH, STREAM OR RIVER
- FENCE LINE (SURVEYED)
- TREE LINE
- FORMER DIESEL FUEL LINE
- INJECTION WELL LOCATION (CRA)
- STORM SEWER SHOWN AS PER SITE SITE UTILITIES UNDERGROUND PLAN JOB NO. 200 BMP2078.DWG
- MW-45 HISTORICAL
- GS-3 MONITORING WELLS (CRA)
- STORM SEWER SHOWN AS PER INVERTS FOUND BY FIELD OBSERVATIONS, AUGUST 2002
- SLUDGE LINE
- CB15 CATCH BASIN (SURVEYED)
- MH18 MANHOLE (SURVEYED)
- PAVEMENT VARIATION (SURVEYED)
- U.P. UTILITY POLE (SURVEYED)
- R.S. FENCE GATE POST (SURVEYED)
- PROPOSED MONITORING WELL
- PROPOSED SOIL BORING

ENCORE

figure 3.1

GENERAL SITE AND PAOC 19 PROPOSED MONITORING LOCATIONS
SUPPLEMENTAL PHASE III EOC WORK PLAN
COMPANY VEHICLE OPERATIONS AREA
Ypsilanti, Michigan

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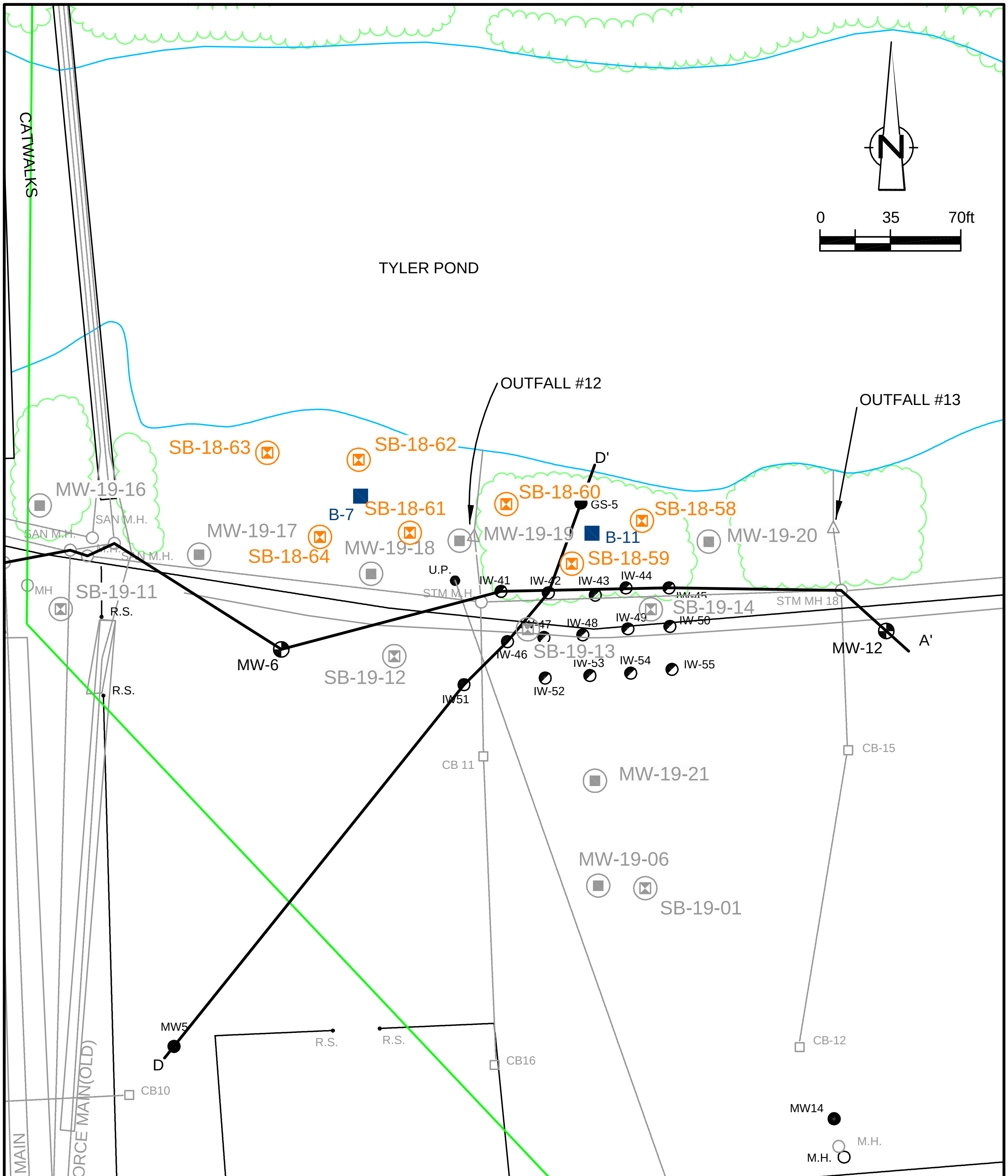

figure 3.2

PAOC 18 PROPOSED
MONITORING LOCATIONS
SUPPLEMENTAL PHASE III EOC WORK PLAN
COMPANY VEHICLE OPERATIONS AREA
Ypsilanti, Michigan

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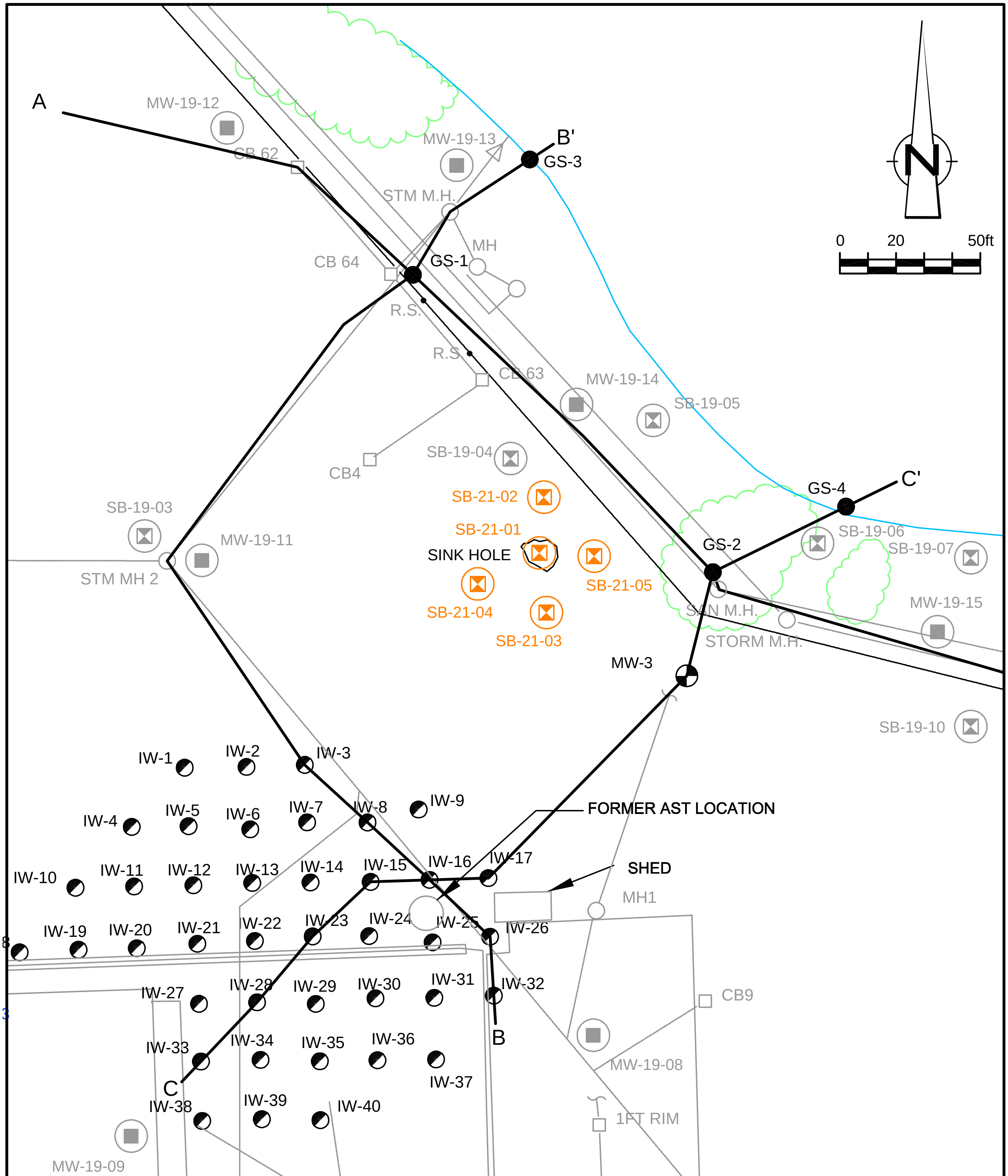

figure 3.3

PAOC 21 PROPOSED
MONITORING LOCATIONS
SUPPLEMENTAL PHASE III EOC WORK PLAN
COMPANY VEHICLE OPERATIONS AREA
Ypsilanti, Michigan

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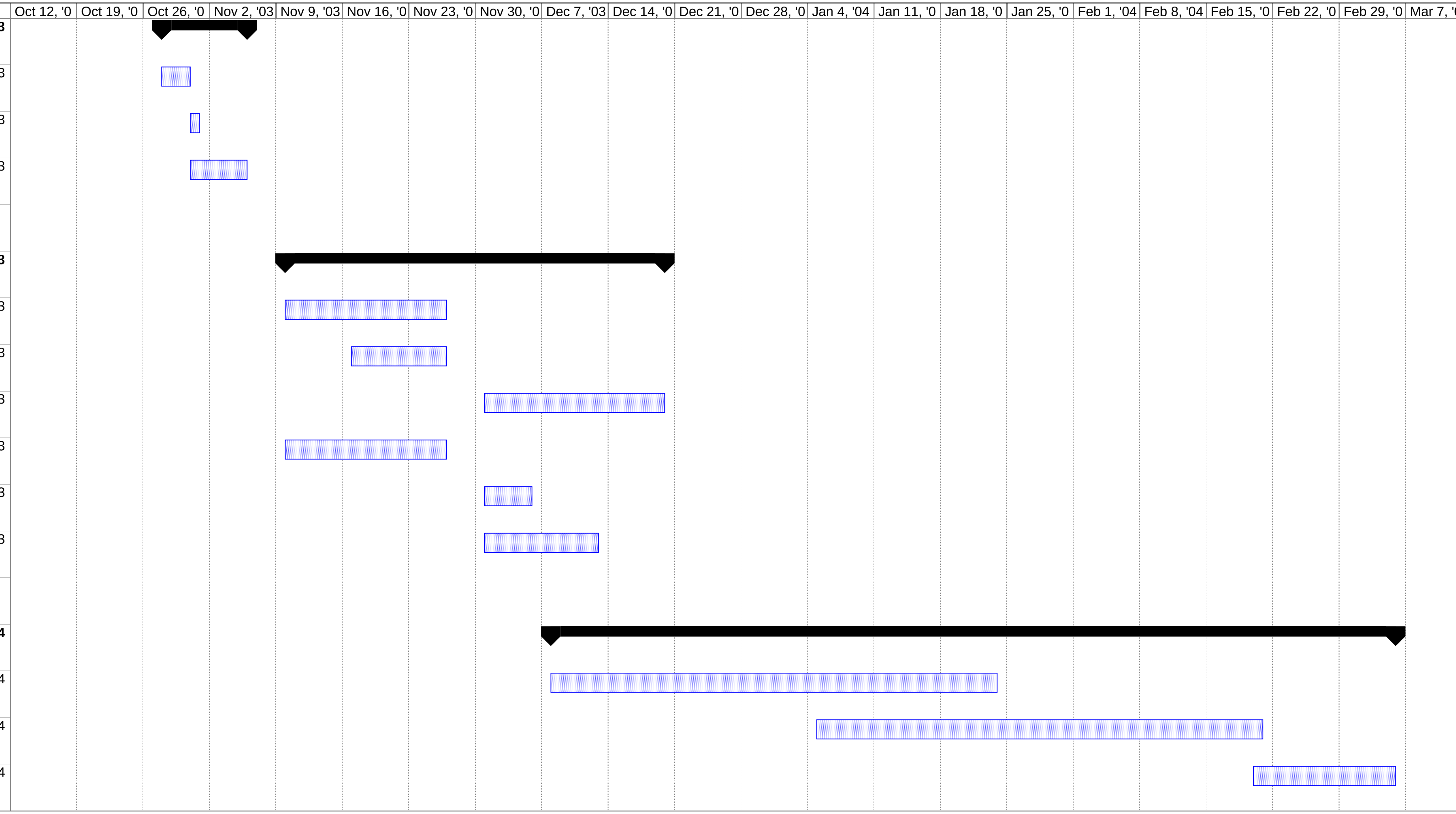
Figure 5.1

Supplemental Phase III EOC Work Plan Schedule
CVO Area
Yspilanti, Michigan

ID	Task Name	Start	Finish
1	**Contractor Procurement**	**Tue 10/28/03**	**Wed 11/5/03**
2	Site Walkthrough	Tue 10/28/03	Thu 10/30/03
3	Bids Due	Fri 10/31/03	Fri 10/31/03
4	Contractor Decisions	Fri 10/31/03	Wed 11/5/03
5			
6	**Field Work**	**Mon 11/10/03**	**Fri 12/19/03**
7	Drilling/Geoprobe	Mon 11/10/03	Wed 11/26/03
8	Well Development	Mon 11/17/03	Wed 11/26/03
9	Groundwater Sampling	Mon 12/1/03	Fri 12/19/03
10	Electromagnetic Survey	Mon 11/10/03	Wed 11/26/03
11	GSI Investigation	Mon 12/1/03	Fri 12/5/03
12	Additional Scope	Mon 12/1/03	Fri 12/12/03
13			
14	**Summary Report**	**Mon 12/8/03**	**Fri 3/5/04**
15	Data Reciept	Mon 12/8/03	Fri 1/23/04
16	Report Preparation	Mon 1/5/04	Fri 2/20/04
17	Finalization	Fri 2/20/04	Fri 3/5/04



17303 Field Work Schedule
Date: Wed 9/17/08

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

TABLE 3.1

SOIL SAMPLING PROGRAM
SUPPLEMENTAL PHASE III EOC WORK PLAN
CVO AREA
YPSILANTI, MICHIGAN

Boring/Well Number	Target Depth	Environmental Parameters		Geotechnical Samples/Parameters	
		Sample Intervals[1] (feet bgs)	Chemical Analysis[2]	Sample Intervals	Analysis
SB-18-58	10'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
SB-18-59	10'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
SB-18-60	10'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
SB-18-61	10'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
SB-18-62	10'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Surficial Clay Saturated Sands	Grain Size Grain Size
SB-18-63	10'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Surficial Clay Saturated Sands	Grain Size Grain Size
SB-18-64	10'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Surficial Clay Saturated Sands Confining Clay	Grain Size Grain Size Grain size & Shelby Tube
MW-19-01	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs	NA	NA
MW-19-02	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs	NA	NA
MW-19-03	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs	NA	NA
MW-19-04	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs	NA	NA
MW-19-05	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs	NA	NA
MW-19-06[3]	top of clay	NA	NA	NA	NA
MW-19-07[3]	top of clay	NA	NA	NA	NA
MW-19-08	top of clay	Field Observations[4]	TCL VOCs	NA	NA

TABLE 3.1

SOIL SAMPLING PROGRAM
SUPPLEMENTAL PHASE III EOC WORK PLAN
CVO AREA
YPSILANTI, MICHIGAN

Boring/Well Number	Target Depth	Environmental Parameters		Geotechnical Samples/Parameters	
		Sample Intervals[1] (feet bgs)	Chemical Analysis[2]	Sample Intervals	Analysis
MW-19-09	top of clay	Field Observations[4] Directly above Clay layer	TCL VOCs Sudan Four	NA	NA
MW-19-10	top of clay	Field Observations[4] Directly above Clay layer	TCL VOCs Sudan Four	NA	NA
MW-19-11	sewer bedding	NA	NA	NA	NA
MW-19-12	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TAL Inorganics	NA	NA
MW-19-13	sewer bedding	Field Observations[4]	TCL VOCs, TAL Inorganics	NA	NA
MW-19-14	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TAL Inorganics	Surficial Clay Saturated Sands	Grain Size Grain Size & Shelby Tube[6]
MW-19-15	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TAL Inorganics	Surficial Clay Saturated Sands	Grain Size Grain Size & Shelby Tube[6]
MW-19-16	sludge line bedding	Field Observations[4]	TCL VOCs, TAL Inorganics	NA	NA
MW-19-17	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
MW-19-18	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
MW-19-19	sewer bedding	Field Observations[4]	TCL VOCs, TAL Inorganics	NA	NA
MW-19-20	top of clay	0-2 feet bgs 2 feet above the water table	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Surficial Clay Saturated Sands	Grain Size Grain Size & Shelby Tube[6]
MW-19-21	top of clay	Field Observations[4]	TCL VOCs, TAL Inorganics	NA	NA
MW-19-22	top of clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
MW-19-23	top of clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Surficial Clay Saturated Sands	Grain Size Grain Size & Shelby Tube[6]

TABLE 3.1

SOIL SAMPLING PROGRAM
SUPPLEMENTAL PHASE III EOC WORK PLAN
CVO AREA
YPSILANTI, MICHIGAN

Boring/Well Number	Target Depth	Environmental Parameters		Geotechnical Samples/Parameters	
		Sample Intervals[1] (feet bgs)	Chemical Analysis[2]	Sample Intervals	Analysis
SB-19-01	50'	0-2 feet bgs 2 feet above the water table	TCL VOCs	Saturated Sands Confining Clay	Grain size Grain size & Shelby Tube[5]
SB-19-02	50'	0-2 feet bgs 2 feet above the water table	TCL VOCs	Saturated Sands Confining Clay	Grain size Grain size & Shelby Tube[5]
SB-19-03	50'	0-2 feet bgs 2 feet above the water table	TCL VOCs	Saturated Sands Confining Clay	Grain size Grain size & Shelby Tube[5]
SB-19-04	3' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Saturated Sands	Grain size & Shelby Tube
SB-19-05	1' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Surficial Clay Saturated Sands	Grain Size Grain Size
SB-19-06	1' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Saturated Sands	Grain Size
SB-19-07	1' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Surficial Clay Saturated Sands Confining Clay	Grain Size Grain Size Grain size & Shelby Tube
SB-19-08	1' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Saturated Sands	Grain Size
SB-19-09	1' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Surficial Clay Saturated Sands	Grain Size Grain Size
SB-19-10	3' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Saturated Sands	Grain size & Shelby Tube
SB-19-11	3' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Saturated Sands	Grain size
SB-19-12	3' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Saturated Sands	Grain size
SB-19-13	3' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Saturated Sands	Grain size & Shelby Tube
SB-19-14	3' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Saturated Sands	Grain size & Shelby Tube
SB-19-15	1' into clay	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	Surficial Clay Saturated Sands	Grain Size Grain Size

TABLE 3.1

SOIL SAMPLING PROGRAM
SUPPLEMENTAL PHASE III EOC WORK PLAN
CVO AREA
YPSILANTI, MICHIGAN

Boring/Well Number	Target Depth	Environmental Parameters		Geotechnical Samples/Parameters	
		Sample Intervals[1] (feet bgs)	Chemical Analysis[2]	Sample Intervals	Analysis
SB-21-01	20'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
SB-21-02	20'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
SB-21-03	20'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
SB-21-04	20'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA
SB-21-05	20'	Field Observations[4]	TCL VOCs, TCL SVOCs, TAL Inorganics, PCBs	NA	NA

Notes

[1] Additional samples may be collected at intervals where field observations indicate impacts (i.e. odors, staining, elevated PID readings).

[2] "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW846, 3rd Edition, updated November 1986

VOCs	8260
SVOCs	8270
PCBs	8082
Inorganics	U.S. EPA Method SW846-6000/7000 series

[3] Continuous sampling not required, set based on stratigraphy identified in adjacent boring.

[4] Sample to be collected if field observations indicated impacts (i.e. staining, odors, elevated PID readings).

[5] A Shelby tube will be collected from the confining clay at each of the three deep borings. The clay will be visually compared and if similar only one Shelby tube will be submitted for permeability and porosity analysis.

[6] Hold Shelby tube for analysis.

TABLE 3.2

GROUNDWATER SAMPLING PROGRAM
SUPPLEMENTAL PHASE III EOC WORK PLAN
CVO AREA
YPSILANTI, MICHIGAN

Well Number	Screen Installation Interval	Groundwater Analysis[1]
MW-19-01	Water Table	TCL VOCs
MW-19-02	Water Table	TCL VOCs
MW-19-03	Water Table	TCL VOCs
MW-19-04	Water Table	TCL VOCs
MW-19-05	Water Table	TCL VOCs
MW-19-06	Water Table	TCL VOCs
MW-19-07	Water Table	TCL VOCs
MW-19-08	Top of Clay	TCL VOCs
MW-19-09	Top of Clay	TCL VOCs
MW-19-10	Top of Clay	TCL VOCs
MW-19-11	Sewer bedding	TCL VOCs
MW-19-12	Water Table	TCL VOCs
MW-19-13	Sewer bedding	TCL VOCs
MW-19-14	Water Table	TCL VOCs
MW-19-15	Water Table	TCL VOCs
MW-19-16	Sludge line bedding	TCL VOCs
MW-19-17	Water Table	TCL VOCs[2]
MW-19-18	Water Table	TCL VOCs[2]
MW-19-19	Sewer bedding	TCL VOCs
MW-19-20	Water Table	TCL VOCs[2]
MW-19-21	Water Table	TCL VOCs
MW-19-22	Water Table	TCL VOCs
MW-19-23	Water Table	TCL VOCs

Notes

- Top of Clay - The bottom of the ten foot screen will be set 6" into the confining clay layer, identified in the well installation borehole.
- Water Table - The ten foot screen will straddle the water table, the top two feet of the screen installed above the observed water table.

1 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW846, 3rd Edition, updated November 1986

VOCs	8260
SVOCs	8270
PCBs	8082
Inorganics	U.S. EPA Method SW846-6000/7000 series

2 Additional analysis, SVOCs, PCBs, inorganics to be determined based on soil analytical results.

TABLE 3.3

STORM SEWER DISCHARGE SAMPLING PROGRAM
SUPPLEMENTAL PHASE III EOC WORK PLAN
CVO AREA
YPSILANTI, MICHIGAN

Outfall	Analysis	
	Wet Weather	Dry Weather
11	TCL VOCs	TCL VOCs
12	TCL VOCs	TCL VOCs
13	TCL VOCs	TCL VOCs
14	TCL VOCs	TCL VOCs

[2] "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW846, 3rd Edition, updated November 1986

VOCs U.S. EPA Method SW846-8260

APPENDIX A

APPLICABLE ENCORE FIELD METHOD GUIDELINES

REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 2.3
WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS CORPORATION	
REVISION NO.: 0	REVISION DATE:

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SOIL BORINGS

REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 2.3
WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS CORPORATION	
REVISION NO.: 0	REVISION DATE:

SOIL BORINGS

INTRODUCTION

The following presents a description of the methods generally employed for the installation of boreholes and the collection of subsurface soil samples. Boreholes are typically installed to define geologic conditions for hydrogeologic and geotechnical evaluation; to allow the installation of monitoring wells and piezometers; and to allow the collection of subsurface soil samples (generally above the water table) for chemical analysis.

Several manual methods are available for the collection of shallow subsurface soil samples (e.g., hand augers, post-hole augers, vibratory hammers). However, the most common methods used by GM to advance boreholes are rotosonic drilling techniques, hollow-stem augers (HSA), or the use of a direct-push equipment. Rotosonic drilling and direct-push techniques are preferred boring approaches at GM Facilities. FMG 2.2 - Drilling Techniques, provides insight into the advantages/disadvantages of these drilling methods.

PROCEDURES REFERENCED

- FMG 1.3 - Utility Clearance.
- FMG 2.2 - Drilling Techniques.
- FMG 2.6 - Soil Classification.
- FMG 2.7 - Rock Classification.
- FMG 6.1 - Soil.

PROCEDURAL GUIDELINES

The following activities must be undertaken prior to undertaking a borehole installation and subsurface soil sampling program.

i) Assemble all equipment and supplies required per the Work Plan.

ii) Obtain a site plan and any previous stratigraphic logs. Determine the exact number and location of boreholes to be installed and the depths of samples for chemical analysis.

iii) Contact the analytical group to arrange/determine:

- Laboratory;
- Glassware/sample jars;
- Cooler;
- Shipping details;
- Start date; and
- Expected duration.

iv) Establish borehole locations in field using available landmark or by surveying methods if necessary.

v) Arrange for utility clearance of franchised utilities and site utilities.

vi) Determine notification needs with the Project Manager. Have the regulatory groups, landowner, GM Facility personnel, and laboratory been informed of the sampling event?

vii) Determine the methods for handling and disposal of drill cuttings, wash waters, and spent decontamination fluids.

Once the prior planning and preparation activities are completed, the borehole installation and subsurface soil sampling program can proceed. The typical series of events which takes place is:

- Locating and marking of borehole locations (if not already completed).
- Equipment decontamination.
- Final visual examination of proposed drilling area for utility conflicts/final hand auger or post-hole check to verify utility absence.
- Advancement of borehole and collection of the soil sample.
- Field screening of soil sample.
- Description of soil sample. (Form FMG 2.6-01 - Stratigraphy Log - Overburden (Page 1/Page 2) will be used to record data.)
- Sample preparation and packaging.
- Abandonment of boreholes.
- Surveying of borehole locations and elevations.
- Field note completion and review.

i) <u>Locating and Marking of Boreholes/Final Visual Check</u>

The proposed borehole locations marked on the site plan are located in the field and staked. On most sites, this will likely be done several days in advance of the drill rig arriving on site. Unless boreholes are to be installed on a fixed grid, the proposed locations are usually strategically placed to assess site conditions.

Once the final location for the proposed boring has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds. This last visual check should confirm the locations of any adjacent utilities (subsurface or overhead) and verification of adequate clearance. If gravity sewers or conduits exist in the area, any access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

ii) Borehole Advancement

If possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to verify the absence of buried utilities and pipelines. This procedure should clear the area to the full diameter of the drilling equipment which will follow.

If it is necessary to relocate any proposed borehole due to terrain, utilities, access, etc., the Project Manager must be notified and an alternate location will be selected.

Prior to use and between each borehole location at an environmental site, the drilling and sampling equipment must be decontaminated. All decontamination must be conducted in accordance with the project-specific plans or the methods presented in FMG 9.0 - Equipment Decontamination.

The clean augers/tooling are covered with clean plastic sheeting to prevent contact with foreign materials. For geotechnical, geologic, or hydrogeologic studies where contaminants will not be present, it is sufficient to clean the drilling equipment simply by removing the excess soils.

Collection of soil samples is one of the most important considerations in selecting drilling methods. Therefore, the need for reviewing drilling techniques (FMG 2.2 - Drilling Techniques) and the Site objectives must first be considered. Soil Classification will be completed in accordance with FMG 2.6 - Soil Classification. Sections iii) and iv) describe borehole soil sampling procedures using direct-push tooling and HSA/split-spoon sampling (Standard Penetration Testing - SPT), respectively.

iii) Direct-Push/Macro-Core™ Soil Sampler

The operation of the direct-push/Macro-Core™ Soil Sampler (or equivalent) consists of "pushing" the sampler into the subsurface and then retrieving it using a direct-push soil probing machine. The collected soil core is contained within an internal soil liner (acetate, polyethylene, or teflon) and removed from the sampler once returned to the ground surface. Sampler length is variable depending on equipment available (2 feet, 4 feet, 5 feet). Once the soil liner has been removed and the outer sampler decontaminated, a new liner is inserted and the sampler reassembled. The clean sampler is then driven back down the same hole to collect the next soil sample.

The Macro-Core™ sampler can be used in either the open-tube or closed-point sampling mode. The open-core sample mode is most commonly used in stable soil conditions. In unstable soils, the piston rod point system prevents collapsed soil from entering the sampler as it is advanced back down the hole. Once at the sample depth, the piston rod is unthreaded and released. The sampler is then driven into the subsurface to fill the sampler with soil, the piston point rides on top of the soil, as it enters the sampler.

Once recovered the soil liner with collected soils is opened (cut lengthwise) and examined to collect soil screening information, soil logging information, and soils for chemical analysis.

iv) Standard Penetration Testing (SPT) Sampling and Testing Procedure

This method is used to obtain representative samples of subsurface soil materials and to determine a measure of the in situ relative density of the subsurface soils. The test methods described below must be followed to obtain accurate SPT values. The split spoon is typically driven in advance of an HSA string which allows collection of the disturbed but representative sample.

SPT sampling is performed by using a split barrel sampler in accordance with ASTM D1586. The split barrel sampler, or split spoon, consists of an 18- or 24-inch long, 2-inch outside diameter tube, which comes apart length wise into two halves. The split spoon is typically driven in advance of an HSA string which allows collection of the disturbed but representative soil sample.

Once the borehole is advanced to the target depth and the borehole cleaned of cuttings, representative soil samples are collected in the following manner:

- The split-spoon sampler should be inspected to ensure it is properly cleaned and decontaminated. The driving shoe (tip) should be relatively sharp and free of severe dents and distortions.
- The cleaned split-spoon sampler is attached to the drill rods and lowered into the borehole. Do not allow the sampler to drop onto the soil.
- After the sampler has been lowered to the bottom of the hole, it is given a single blow to seat it and make sure that it is in undisturbed soil. If there still appear to be excessive cuttings in the bottom of the borehole, remove the sampler from the borehole and remove the cuttings.
- Mark the drill rods in three or four successive 6-inch (0.15 m) increments, depending on sampler length, so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-inch (0.15 m) increment.

The sampler is then driven continuously for either 18 or 24 inches (0.45 or 0.60 m) by use of a 140-pound (63.5 kg) hammer. The hammer may be lifted and dropped by either the cathead and rope method, or by using a trip, automatic, or semi-automatic drop system. The hammer should free-fall a distance of 30 inches (±1 inches) (760 mm, ±25 mm) per blow. Measure the drop at least daily to ensure that the drop is correct. To ensure a free-falling hammer, no more than 2 1/4 turns of the rope may be wound around the cathead (see ASTM D1586). The number of blows applied in each 6-inch (0.15 m) increment is counted until one of the following occurs:

- A total of 50 blows have been applied during any one of the 6-inch (0.15 m) increments described above;
- A total of 100 blows have been applied;
- There is no advancement of the sampler during the application of ten successive blows of the hammer (i.e., the spoon is "bouncing" on a stone or bedrock); or
- The sampler has advanced the complete 18 or 24 inches (0.45 or 0.60 m) without the limiting blow counts occurring as described above.

In some cases where the limiting number of blow counts has been exceeded, the Consultant may direct the driller to attempt to drive the sampler more if collection of a greater sample length is essential.

On the field form, record the number of blows required to drive each 6-inch (0.15 m) increment of penetration. The first 6 inches is considered to be a seating drive. The sum of the number of blows required for the second and third 6 inches (0.15 m) of penetration is termed the "standard penetration resistance" or the "N-value".

Note: If the borehole has sloughed and there is caved material in the bottom, the split spoon may push through this under its own weight, but now the spoon is partially "pre-filled". When the spoon is driven the 18 or 24 inches representing its supposedly empty length, the spoon fills completely before the end of the drive interval. Two problems arise:

1. *the top part of the sample is not representative of the in-place soil at that depth; and*
2. *the SPT value will be artificially higher toward the bottom of the drive interval since the spoon was packed full. These conditions should be noted on the field log.*

The sampler is then removed from the borehole and unthreaded from the drill rods. The open shoe (cutting end) and head of the sampler are partially unthreaded by the drill crew and the sampler is transferred to the geologist/engineer work surface.

Note: A table made out of two sawhorses and a piece of plywood is appropriate, or a drum, both covered with plastic sheeting.

The open shoe and head are removed by hand, and the sampler is tapped so that the tube separates.

Note: Handle each split spoon with clean disposable gloves if environmental issues are being investigated.

Measure and record the length of sample recovered making sure to discount any sloughed material that is present on top of the sample core.

Caution must be used when conducting SPT sampling below the groundwater table, particularly in sand or silt soils. These soils tend to heave or "blow back" up the borehole due to the difference in hydraulic pressures between the inside of the HSA and the undisturbed soil. To equalize the hydraulic pressure, the inside of the HSA must be filled with water or drilling mud. The drilling fluid level within the boring or HSAs needs to be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling. Since heave or blow back is not always obvious to the driller, it is essential that the water level in the borehole always be maintained at or above the groundwater level.

Heaving conditions and the use of water or mud should be noted on the field logs.

SPT sampling below the water table in sands and silt occasionally results in low SPT values being obtained due to the heaving effect disturbing the soil especially if the water level in the hole has not been maintained at the in situ water level. Suspect low N values should be noted on the field logs. If it is critical to have accurate N values below the water table, other methods can be employed, such as conducting a dynamic cone penetration test. This quick and easy test involves attaching a cone shaped tip to the end of the drill rods, and driving the tip into the ground similar to the SPT method, except that the borehole is not pre-augered. Cones may be driven 20 to 40 feet through a formation without augering. Blow counts are recorded for each foot (0.3 m) of advancement.

A variation of split barrel sampling involves the use of a longer barrel in conjunction with HSAs. The sampling barrel is installed inside the auger with a swivel attachment to limit rotation of the barrel. After completion of a 5-foot auger penetration, the auger is left in place and the barrel retrieved from the borehole. The sampler should be handled and the sample retrieved in the same way as described above for SPT sampling.

Thin-Walled Samplers (Shelby Tubes)

Thin-walled samplers are used to collect relatively undisturbed samples (as compared to split-spoon samples) of soft to stiff clayey soils. Shelby tubes are commonly used. The Shelby Tube has an outside diameter of 2 or 3 inches and is 3 feet long. These undisturbed samples are used for certain laboratory tests of structural properties (consolidation, hydraulic conductivity, shear strength) or other tests that might be influenced by sample disturbance. Procedures for conducting thin-walled tube sampling are provided in ASTM D1587, and are briefly described below.

- The soil deposit being sampled must be cohesive in nature, and relatively free of sand, gravel, and cobble materials, as contact with these materials will damage the sampler.
- Clean out the borehole to the sampling elevation using whatever method is preferred that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above groundwater level during the sampling operation.
- Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the center of a casing or HSA as carefully as possible to avoid disturbance of the material to be sampled.
- Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler into the formation without rotation by a continuous and relatively rapid motion; usually hydraulic pressure is applied to the top of the drill rods.
- Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.
- In no case should the length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 inches for cuttings.
- The tube may be rotated to shear the bottom of the sample 2 to 3 minutes after pressing in, and prior to retrieval to ensure the sample does not slide out of the tube. Lift the weight of the rods off of the tube prior to rotating.
- Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.
- Package and transport the sample in accordance with FMG 6.10 - Sample Handling and Shipping.

On occasion it maybe required to extract the sample from the tube in the field.

- A sample extruder, which consists of a clamp arrangement to hold the tube and a hydraulic ram to push the sample through the tube, is usually mounted on the side of the rig. To prevent cross-contamination, be certain that the extruder is field cleaned between each sample.
- The sample is then extruded into a carrying tray; these are often made from a piece of 4-inch or 6-inch diameter PVC pipe cut lengthwise. Be certain that the carrying tray is field cleaned between each sample. The sample is carried to the work station to describe the sample, trim the potentially cross contaminated exterior, and place it in the appropriate container.
- The Shelby tube may then be thoroughly field cleaned and decontaminated for reuse. Since they are thin-walled, the tubes are easily damaged, crimped, or otherwise distorted during handling or pushing. The Shelby tube should be inspected before use and any which are significantly damaged should be rejected.

v) <u>Borehole Completion</u>

At the completion of the soil boring, once the soil/groundwater samples have been collected, the borehole annulus is then abandoned. Borehole abandonment options are identified in FMG 2.5 - Borehole Abandonment/Sealing. Each boring will be surveyed to establish vertical/horizontal information; field ties (i.e., swing ties) will also be collected to document the boring location. Once completed, a stratigraphic log will be prepared for reporting purposes.

EQUIPMENT/MATERIALS

- Drilling equipment.
- Form 2.6-01 - Stratigraphy Log - Overburden (Page 1/Page 2).
- Tape measure.

REFERENCES

ASTM D420-93 - Guide to Site Characterization for Engineering, Design, and Construction Purposes.

ASTM D1452-80 - Practice for Soil Investigation and Sampling by Auger Borings.

ASTM D1586-84 - Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM D1587-94 - Practice for Thin-Walled Tube Geotechnical Sampling of Soils.

ASTM D2488-93 - Practice for Description and Identification of Soils (Visual-Manual Procedure).

EPA OSWER-9950.1,1986. RCRA Ground-Water Monitoring Technical Enforcement Guidance Document.

National Water Well Association, Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. 1989.

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GENERAL MOTORS CORPORATION	
REVISION NO.: 1	REVISION DATE: SEPTEMBER 16, 2002

WELL CONSTRUCTION MATERIALS

INTRODUCTION

In environmental subsurface investigations, the information used to evaluate subsurface conditions often relies heavily on the installation of quality groundwater monitoring wells. The application and use of the proper well construction materials to the specific well installation is crucial to obtaining representative and reliable groundwater samples.

The two general types of wells are groundwater monitoring wells and pumping (also referred to as recovery, extraction, or withdrawal) wells. The specific use of a groundwater well dictates the types of materials used to construct it.

This FMG outlines the general types and use of well construction materials and considerations involved in selecting appropriate materials for specific well installation applications. Installation of these materials are described in detail in the specific well installation FMGs listed below.

PROCEDURES REFERENCED

- FMG 3.2 - Overburden Wells.
- FMG 3.3 - Top of Bedrock Wells.
- FMG 3.4 - Deep Bedrock Wells.
- FMG 3.5 - Pump Wells.
- FMG 3.6 - Piezometers.

EQUIPMENT DESCRIPTIONS

Well Screen

Well screen is the portion of the well pipe that contains appropriately sized openings and allows groundwater to enter the well. The screen materials used in groundwater monitoring wells are crucial to ensuring the installation of an efficient, productive, and durable groundwater well.

The diameter of the well screen is generally dependent upon the application of the well. For monitoring wells used in groundwater level measurements and groundwater sampling, screen diameter will generally be 2.0-inch inner diameter (ID) flush-threaded screen segments (piezometers are typically 1.0-inch inner diameter but may be 2-inch also). These screen segments are typically available in 10-foot lengths. Four-inch diameter or larger well screens are usually reserved for recovery or production well applications where larger diameters permit greater groundwater withdrawal rates. Larger diameter wells also allow a well to serve additional functions such as housing oil recovery systems.

Screen material will be either thermoplastic Schedule 40 Poly Vinyl Chloride (PVC) (ASTM D1785, ASTM D2665, ASTM F480) or Schedule 5 Type 316 stainless steel, depending primarily on the depth of the well and the groundwater quality (degree and nature of contamination). Shallower depths and generally low levels of contaminants in groundwater allow for PVC applications, whereas greater depths and severely degraded groundwater quality, or the presence of free-phase oils or solvents, may necessitate stainless steel due to its greater strength and resistance to chemical degradation. It should be noted that PVC and stainless steel are appropriate for the vast majority of environmental applications, and are generally accepted by regulatory agencies. Well materials other than PVC or stainless steel should be used only in certain instances, to be determined and approved by the Project Manager on a case-by-case basis.

Certain applications such as investigation of inorganic (metals) concentrations in groundwater, or the presence of low pH (acidic) conditions, may preclude the use of stainless steel wells. Stainless steel, which contains molybdenum in addition to its iron content, may leach out metal compounds which could lead to misleading groundwater analysis results.

PVC may likewise leach out or degrade specific thermoplastic elements of its composition which may compromise the well integrity or groundwater analyses. PVC generally performs well in acidic groundwater conditions; however, it may degrade in the presence of certain organic compounds such as ketones, aldehydes, or chlorinated compounds in high concentrations. Certain additives to the PVC may also affect groundwater quality.

Well screen slot sizes and well screen type will also be consistent for groundwater monitoring wells. Screen slot size is typically 0.010 inches; 0.020-inch slot size may be more appropriate for coarser formation materials or where the well may serve as a recovery well for free-phase oils. For monitoring applications, slot type should be either factory machine-slotted or continuous-wrap slotted. Perforated, bridge-slotted or louver-slotted well screens are generally not acceptable for most environmental applications and should be avoided.

Screen slot sizes may vary from these two sizes when used in production or recovery (pumping) well applications where the need to maximize groundwater withdrawal is essential. In such cases, screen slot sizes can be manufactured to exact specifications for a particular well based on particle size analysis results and formation transmissivity or permeability.

Well Riser Pipes and Casings

Well riser pipe is a solid extension of the well screen that extends from the screen up to the surface. The riser pipe protects the well screen, prevents outside groundwater from entering the well, and allows groundwater pumped from down in the open interval to be routed up through the well to the surface.

Well riser pipe should be of the same material and size as the well screen described above. In instances to be determined and approved by the Project Manager on a case-by-case basis only, differing materials may be approved for use in the same well (e.g., stainless steel well screen connected to PVC riser). Well risers should extend to the surface and should either be cut at grade in flush-mount completions or as an approximately 3-foot stickup to be covered with a steel protective casing.

Well riser pipe sections shall be flush-threaded and fitted with neoprene, rubber, or other appropriately constructed, durable o-rings to properly seal the threaded pipe joints. Glues or cements are not to be used in well construction.

In installations of bedrock monitoring wells, which have an open rock monitoring interval and a permanent well casing that extends from bedrock to the surface, the permanent casing (or casings in telescoping wells) shall be made of carbon steel or low-carbon steel (greater than 0.8 percent carbon and less than 0.8 percent carbon, respectively). The well casing should be a minimum of 4 inches in diameter (at least 4 inches diameter for the innermost casing).

On sites wells where dense, non-aqueous phase liquid (DNAPL) is present or may be a concern, in screened wells it is advisable to install a collection sump on the base of the well below the well screen to collect infiltrated DNAPL for possible measurement and/or sampling. Sumps should be installed as a 1- to 5-foot section of solid riser material with a sealed bottom placed below the well screen.

Sand Packs

The filter pack, or sand pack, installed in a well replaces formation material immediately around a well with a more permeable material (sand). The sand pack separates the well screen from the formation, increases the hydraulic diameter of the well, and prevents fines (silt or clay) from entering or clogging the well screen.

Sand pack of an appropriate size shall be utilized based on the well screen slot size being used. Sand pack size should be chosen so that the majority of the sand (sand pack has inherent variation in its particle grain size distribution) is larger than the screen slot size while sized small enough to prevent deleterious amounts of formation fines from entering the well through the sand pack. Screen slot sizes of 0.010-inch and 0.020-inch typically use a sand pack such as Morie or U.S. Silica No. 1, No. 0, No. 00N, or equivalent.

Sand pack shall be washed silica sand with a silica content of at least 95 percent. Sands should meet one or more of the following requirements: NSF 61, AWWA B-100, ANSI, or equivalent standards for uniformity and chemical inertness. In cases to be determined and approved by the Project Manager on a case-by-case basis only, differing sand pack materials may be approved for use in a well. Sand packs used for production and recovery wells with larger screen slot sizes will use larger particle sized sand packs of the same type and quality. The slot size and sand pack size for recovery wells should be chosen based on results of formation grain size distribution analysis.

Seals

Bentonite and grout seals are installed above the sand pack to isolate the monitoring interval and prevent groundwater from infiltrating into the well screen from other water-bearing zones. Seals also prevent migration of backfill or formation materials downward into the sand pack.

Bentonite is the generic name for a group of a naturally occurring clay minerals (montmorillonites) that come in a variety of forms: pellets, chips, granulated, or powdered. This material is commercially available as "Wyoming Bentonite". When hydrated it swells to many times its original volume and forms an ultra-low permeability clay seal.

Bentonite chips or pellets are generally used to create a seal immediately above the sand pack. The chips/pellets are dropped inside the augers or well casing by hand down through the water column onto the top of the sand pack. Care must be taken to prevent "bridging" of the bentonite particles in the casing above the target zone. Measurements of the depth to the top of the seal must be obtained during installation of the seal to ensure its proper position and thickness. In the absence of significant water in a casing or borehole, potable water must be added to hydrate the bentonite. The bentonite seal will be allowed to set for a minimum of one-half hour, in order to hydrate properly, before additional seals (grout) are applied. Once the bentonite has set for one-half hour the grout seal may be placed, as described below.

In saline groundwater environments, such as where ocean water may infiltrate the monitoring interval, a zeolite-based seal material may be used, as saline conditions may hamper the performance of bentonite pellets.

Portland cement grout (grout) forms a concrete-like seal that can be more manageable than bentonite (e.g., able to be pumped through a water pump). Grout is generally placed on top of the hydrated bentonite seal to form a solid cement seal around the well riser up to the surface. In certain circumstances, only under approval of the GM Project Manager, soil cuttings may be used to backfill the borehole in lieu of grout.

The grout mixture will consist of one 94-pound bag of Portland cement and 3 to 5 pounds of powdered bentonite added per sack of cement. Two pounds of calcium chloride may also be added (under certain conditions, e.g., very cold days) to accelerate the setting time of the grout, as well as to increase the dry strength of the grout. The grout will be thoroughly mixed with 6.5 gallons of potable water per sack of cement. Grout is generally placed using either the tremie or Halliburton grouting methods. These are described in the specific well installation FMGs.

Protective Casings and Surface Seals

Once the well screen, riser, and all seals have been placed to ground surface, the well riser must be protected. This includes protection from vehicles, damage, surface water infiltration, and weather. This is typically accomplished using either a flush-mount roadbox or a stickup casing.

Flush-mount roadboxes are circular steel casing segments with a heavy-duty steel lid with locking bolts. These units are widely available and come in a number of diameters and lengths, depending on the well diameter. A stickup protective casing is generally a length of carbon or stainless steel pipe with a locking top.

For a typical 2-inch monitoring well, the roadbox should be at least 6 inches in diameter; a stickup casing should be at least 4 inches in diameter. A roadbox should be at least 12 inches in length (they are typically 16 to 18 inches long) and is installed flush with the ground surface. A stickup casing should be at least 5 to 6 feet long such that approximately 2.5 to 3 feet is below ground surface and 2.5 to 3 feet is protruding above grade. In wells where a permanent steel casing is installed (serves as the well riser pipe) and brought to the ground surface, it may be used as the protective casing provided it is equipped with a semi-permanent, metal, locking cap or cover that can be affixed to the steel casing.

Flush-mount installations should have at least the last 18 inches of the open borehole filled with coarse sand, placed up to ground surface to allow drainage of surface water infiltration down through and out of the roadbox. This also prevents infiltrating surface water from accumulating up over the top of the well riser and draining down into the well. This sand drain is not necessary in the locking cap stickup casings.

Both roadbox and stickup casings must be secured in the ground with concrete, which also serves as a surface seal.

In areas of high vehicle traffic activity, protective steel bollards should be installed. This is typically a vertically oriented, concrete-filled, steel pipe (minimum 4 inches diameter) cemented at least 3 feet into the ground, acting as a "guard rail" for the well casing and preventing it from being damaged by vehicles. Three bollards should be placed around a well to provide adequate protection.

EQUIPMENT/MATERIALS

- Drilling equipment.
- Well screen and riser materials.
- Sand pack.
- Bentonite pellets/chips.
- Powdered bentonite.
- Portland cement.

REFERENCES

ASTM D1785-99, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

ASTM D2665-00, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

ASTM F480-00, Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), Schedule 40 and Schedule 80.

ASTM A53/A53M-01, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless for Ordinary Uses.

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WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
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WELL DEVELOPMENT

INTRODUCTION

This procedure is for the development of groundwater monitoring wells that have been installed in overburden, top of bedrock, or deep bedrock formations. Before a newly constructed well can be used for water quality sampling, measuring water levels, or aquifer testing, it must be developed. Well development refers to the procedure used to clear the well and formation around the screen of fine-grained materials (sands, silts, and clays) produced during drilling or naturally occurring in the formation.

Well development is completed to remove fine grained materials from the well but in such a manner as to not introduce fines from the formation into the sand pack. Well development continues until the well responds to water level changes in the formation (i.e., a good hydraulic connection is established between the well and formation) and the well produces clear, sediment-free water to the extent practical.

PROCEDURES REFERENCED

- FMG 3.2 - Overburden Wells.
- FMG 3.3 - Bedrock Wells.
- FMG 10.0 - Waste Characterization.

PROCEDURAL GUIDELINES

The well development procedures presented below are the recommended standards. However, due to variations in conditions, changes in these standards may be necessary in order to facilitate successful monitoring well development.

Well development can be accomplished by using in-place pumps or by using portable equipment; either peristaltic, bladder, or other appropriate pumps depending on well depth. In the case of developing wells installed utilizing the mud rotary methods (least preferred method) it would be beneficial to surge the well prior to and during development to help break down the filter cake that may have built up on the well screen.

- Don appropriate safety equipment.
- All equipment used for development purposes entering each monitoring well will be cleaned using a soapy wash (laboratory grade), tap water rinse, isopropyl alcohol rinse (or other rinse agent that is appropriate for site-specific conditions), and distilled/deionized water rinse.
- Uncap well and allow water level to stabilize. Attach appropriate pump and lower tubing into well.
- Turn on pump. If well runs dry, shut off pump and allow to recover.
- Collect the groundwater sample in a glass jar to determine relative turbidity, and measure and record the temperature, pH, turbidity, and specific electrical conductance.
- The above steps will be repeated until groundwater is relatively silt-free; no further change is noted; the temperature, pH, turbidity, and specific conductance readings have stabilized to within 10 percent.
- The time period between development and groundwater sampling will be dependent upon the project objectives, and the chemicals of concern (COC's). When sampling for COC's sensitive to turbidity presence (i.e., SVOC's, PCB's, Metals), an extended time period between the development activity and the sampling event will be observed. On REALM/ENCORE Sites sampling will be conducted in accordance with the following:

Primary COC:	*Time Period Between Development and Sampling:*
General Chemistry	24-hours
VOC's	24-hours
SVOC's, PCB's, Metals	2-weeks

Waste Disposal

- All waste generated will be disposed in accordance to the methods and procedures contained in FMG 10.0 - Waste Characterization.
- All water generated during cleaning and development procedures will be collected and contained in accordance to the site-specific disposal requirements.
- Personal protective equipment, such as gloves, disposable clothing, and other disposable equipment, resulting from personnel cleaning procedures and from soil sampling and handling activities, will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

EQUIPMENT/MATERIALS

- Appropriate health and safety equipment.
- Knife.
- Power source (e.g., generator, battery).
- Field book.
- Form FMG 3.7-01 - Well Development and Stabilization Form.
- Well keys.
- Graduated pails.
- Pump and tubing.
- Cleaning supplies (including non-phosphate soap, buckets, brushes, laboratory-supplied distilled/deionized water, tap water, isopropyl alcohol or other site-specific rinse agent (e.g. nitric acid solution), aluminum foil, plastic sheeting, etc.).
- Water level meter.
- pH/temperature/conductivity meter.
- Turbidity meter.
- Clear glass jars (e.g., drillers' jars).

REFERENCES

Environmental Protection Agency (1986), RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1.

Environmental Protection Agency (1987), A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001.

Environmental Protection Agency (1988), Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, EPA/540/G-89/004.

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GROUNDWATER SAMPLING

INTRODUCTION

This procedure is for the collection of groundwater samples for laboratory analysis.

The objective of most groundwater quality monitoring programs is to obtain samples that are representative of existing groundwater conditions, or samples that retain the physical and chemical properties of the groundwater within an aquifer.

One of the most important aspects of groundwater sampling is acquiring samples that are free of suspended silt, sediment, or other fine grained particulates. Fine grain materials may often have a variety of chemical components sorbed to the particle or have the ability to sorb chemicals from the aqueous phase to the particle which will bias the subsequent analytical results.

Constituents known to have an affinity for fine grained particulates are: polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), and inorganics. Monitoring programs where these constituents are suspected or known to be prevalent must employ sampling methods that minimize particulate presence.

The sampling method of "preference" for GM sites where particulate sorption is an issue is the "low stress/low flow" technique described within this FMG. Experience has shown that the "low stress/low flow" technique typically achieves representative groundwater samples with minimal particulate interference. In addition to the "low stress/low flow" technique, a "typical sample method" has been presented for the collection of constituents less sensitive to particulates presence (i.e., VOCs), or "direct-push sample methods" generally employed as a "pre-screening tool" to evaluate VOC presence. Direct-push sample procedures will result in groundwater samples with particulates present.

Lastly, in "extreme" cases "ultra-low flow" techniques have been employed at select sites where "low stress/low flow" methods were used, yet particulate-sensitive constituents continue to bias the analytical results. Ultra-low flow techniques are conducted at purging rates below 100 mL per minute, and should only be utilized after careful review and a procedural variance has been approved.

PROCEDURES REFERENCED

- FMG 1.4 - Data Recording - Field Books/Digital Recording.
- FMG 5.1 - Water Level Measurements.
- FMG 8.0 - Field Instruments - Use/Calibration
- FMG 9.0 - Equipment Decontamination.

PROCEDURAL GUIDELINES

The following describes three techniques for groundwater sampling: "Low Stress/Low Flow Methods", "Typical Sample Methods", and "Direct-Push Methods".

"Low Stress/Low Flow Methods" will be employed when it is critical to collect groundwater samples truly representative of the groundwater present, and to minimize the impact of sediment/ colloid presence. Analysis typically sensitive to turbidity/sediment issues are PCBs, SVOCs, and inorganic constituents.

The "Typical Sample Methods" will be employed where the collection of parameters less sensitive to turbidity/sediment issues are being collected (VOCs and general chemistry).

The "Direct-Push Methods" are typically employed for pre-screening areas for chemical presence to aid in determining well placement, or the need for further study.

Note: If non-aqueous phase liquids (NAPL) (light or dense) are detected in a monitoring well, groundwater sample collection will not be conducted and the Project Manager must be contacted to determine a course of action.
If deemed necessary to sample groundwater from below a LNAPL layer, a suggested sampling procedure has been presented at the end of this Procedural Guidelines section.

Preparatory Requirements

- Verify well identification and location using borehole log details and location layout figures. Note the condition of the well and inform the Project Manager of any required repair work.
- Prior to opening the well cap, measure the breathing space above the well casing with a PID to establish baseline levels. Repeat this measurement once the well cap is opened. If either of these measurements exceeds the air quality criteria in the Health and Safety Plan, field personnel should adjust their PPE accordingly.
- Prior to commencing the groundwater purging/sampling tasks, water level and total well depth measurements must be obtained to determine the volume of water in the well. Refer to

FMG 5.1 - Water Level Measurements for details. In some settings it maybe necessary to allow time for the water level to equilibrate. This condition exists if a water tight seal exists at the well cap and the water level has fluctuated above the top of screen; creating a vacuum or pressurized area within the well casing. Three water level checks will verify static water level conditions or changing conditions.

- Calculate the water volume in the well. Typically overburden well volumes consider only the quantity of water standing in the well screen and riser; bedrock well volumes are calculated on the quantity of water within the open corehole and within the overburden casing.
- Estimate the natural groundwater flow rate into well to determine the approximate pumping rate for purging/sampling activities.

Well Purging and Stabilization Monitoring (Low Stress/Low Flow Method)

- The GM method of preference for groundwater sampling will be the low stress/low flow method described below.
- Bladder pumps/submersible variable rate pumps (i.e., Grundfos™ Rediflo or equivalent) or peristaltic pumps are typically employed.
- Slowly lower the pump, safety cable, tubing and electrical lines into the well to the depth specified by the project requirements. The pump or tubing should be placed in the well as early as possible before sampling is initiated (this is to minimize well disturbance). In some programs it may be necessary to install the pumping equipment/tubing approximately 24 hours prior to purging. Peristaltic tubing placement should include a tubing "clamp" at the well head, to minimize vibration transfer into the water column. The pump or tubing intake must be at the mid-point of the well screen to prevent disturbance and resuspension of any sediment in the screen base. Bedrock well sampling may require pump/tubing placement in specific fracture zone areas or other areas which will be identified within the project Work Plan.
- Before starting the pump, measure the water level again with the pump in the well leaving the water level measuring device in the well when completed.
- Purge the well at 100 to a maximum of 500 milliliters per minute (mL/min). During purging, the water level should be monitored approximately every 5 minutes, or as appropriate. A steady flow rate should be maintained that results in drawdown of 0.3 feet or less. The rate of pumping should not exceed the natural flow rate conditions of the well being sampled. Care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record adjustments made to the pumping rates and water levels immediately after each adjustment.
- Calibrate field instrument and document calibration activity. Calibration shall be performed in accordance with manufacturer's recommendations and FMG 8.0 - Field Instruments - Use/Calibration.

- During the purging of the well, monitor and record the field indicator parameters (pH, temperature, conductivity, oxidation-reduction (redox) reaction potential (ORP), dissolved oxygen (DO), and turbidity) approximately every 5 minutes. Stabilization is considered to be achieved when the final groundwater flow rate is achieved, and three consecutive readings for each parameters are within the following limits:
  - pH — ±0.1 pH units of the average value of the three readings;
  - temperature — ±3 percent of the average value of the three readings;
  - conductivity — ±0.005 milliSiemen per centimeter (mS/cm) of the average value of the three readings for conductivity <1 mS/cm and ±0.01 mS/cm of the average value of the three readings for conductivity >1 mS/cm;
  - ORP — ±10 millivolts (mV) of the average value of the three readings;
  - DO — ±10 percent of the average value of the three readings; and
  - turbidity — ±10 percent of the average value of the three readings, or a final value of less than 5 nephelometric turbidity units (NTU).
- Should stabilization not be achieved for all field parameters, purging is continued until a maximum of 20 well screen volumes have been purged from the well. Since low-flow purging (LFP) likely will not draw groundwater from a significant distance above or below the pump intake, the screen volume is based upon a 5-foot (1.4 m) screen length. After purging 20 well screen volumes, purging is continued if the purge water remains visually turbid and appears to be clearing, or if stabilization parameters are varying slightly outside of the stabilization criteria listed above and appear to be approaching stabilization.
- If low-turbidity samples are critical to the project goals, purging will be extended until turbidity has been reduced to 5 NTU or less.
- The pump must not be removed from the well between purging and sampling.

<u>Well Purging and Stabilization Monitoring (Typical Method)</u>

- Typically peristaltic pumps or bladder pumps or submersible pumps are preferred. In most cases bailer use is not desirable due to the "surging" action of bailer entry and removal. Exception is noted for VOC sampling where bailers are often used.
- The pump intake/tubing is typically placed at the mid-point of the screen within overburden wells. Bedrock well sampling may require pump/tubing placement in specific fracture zone areas or other areas which will be identified within the project Work Plan.
- Purge the well until three consecutive well volume measurements of temperature and specific conductivity are approximately plus or minus 10 percent and if the pH values are within 1 pH unit of the last three value averages, and the groundwater turbidity values are less than the project Work Plan requirements. If stabilization has not occurred within the first five well volumes removed, continue purging and monitoring until eight well volumes have been pumped. Purging rates should not exceed the natural flow rate of groundwater into the well.

Elevated purging rates may result in excessive drawdown of the water column, introducing sediment/particulate presence.

- Groundwater turbidity may be evaluated by a visual examination for sediment/silt presence or use of a nephlometer. Work Plan-specific goals may exist for turbidity values which may require extending the purging, or require an alternate pumping system.
- Purging and stabilization activities using a bailer are generally performed at the top of the water column, within the riser piping/above the well screen. This will minimize sediment disturbance/suspension in the screen area, and move water from the formation into the well screen/riser area in an effort to remove stagnant groundwater within the well. Bottom-loading bailers are generally employed. The lowering and removal actions are performed slowly to minimize well disturbance. Once stabilization has been attained, the sample aliquots are collected directly from the bailer.
- In the event the well goes dry (poor yielding formations), the purging activities will be performed on 3 consecutive days, noting the field stabilization parameters on each day. After the third day of purging is complete, the sample collection will be performed once sufficient groundwater recharge has occurred.

Direct-Push Sampling Technique

Generally, the direct-push sampling methods are employed for "pre-screening" groundwater quality (typically VOCs) in selected areas. This method is generally used to evaluate the need for permanent monitoring wells, or determine the need for further study. The sampling technique is a direct-push protected-screen sampling technique as described in ASTM D6001 (Standard Guide for Direct Push Water Sampling for Geoenvironmental Investigations). The direct-push sampling technique is summarized as follows:

- Advance borehole to the target depth below the groundwater table.
- Remove the drill rod, assemble the direct–push sample tool and attach it to the drill rod.
- Lower the sample device to the bottom of the borehole using the drill rod.
- Advance the sample device approximately 3 feet into the bottom of the borehole by hydraulically pushing the drill rod.
- Withdraw the drill rods approximately 1 to 2 feet to retract the screen sleeve and to expose the sampler screen to the formation.
- Alternatively a number of direct-push tools exist that do not require an advance borehole, and can be driven directly to the target depth and retracted for sample collection.
- Allow at least 15 minutes from exposing the sampler screen to sample collection to allow silt in the sampler to settle. In tight formations, a longer wait time may be required to allow sufficient groundwater to enter the screen. In some clays the sample device may not collect sufficient water volume to obtain a sample.

- Lower a small bailer into the sampler, discard initial bail (to acclimate bailer), and collect a water sample. A few bailer volumes may be required to obtain a sufficient volume of water sample. Alternatively, a "Waterra" check ball affixed to tubing maybe employed to collect a groundwater sample, or a peristaltic pump.
- Remove and clean the sampler device after completion of sample collection. Decontaminate sampler for next sample event.

This sampling technique is prone to sediment presence due to the lack of a screen sandpack and the limited purging performed before sample collection. A project variance will be required if non-VOC constituents are being considered for analysis.

Sampling Techniques

- If an alternate pump is utilized (i.e., typical method), the first pump discharge volumes (or bailer volumes) should be discarded to allow the equipment a period of acclimation to the groundwater.
- Samples are typically collected directly from the pump with the groundwater being discharged directly into the appropriate sample container. Avoid handling the interior of the bottle or bottle cap and don new gloves for each well sampled to avoid contamination of the sample.
- Order of sample collection:
  - VOCs;
  - SVOCs and PCBs;
  - Total organic carbon (TOC);
  - Total organic halogens (TOX);
  - Extractable organics;
  - Total metals;
  - Dissolved metals;
  - Phenols;
  - Cyanide;
  - Sulfate and chloride;
  - Nitrate and ammonia; and
  - Radionuclides.
- For low stress/low flow sampling, samples should be collected at a flow rate between 100 and 250 mL/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 feet.
- The pumping rate used to collect a sample for VOCs should not exceed 100 mL/min. Samples should be transferred directly to the final container 40 mL glass vials completely full

and topped with a teflon cap. Once capped the vial must be inverted and tapped to check for headspace/air presence (bubbles). If air is present the sample vial will be discarded, and re-collected until free of air.

- Field filtration will be performed if dictated by the project Work Plan. Sediment presence can interfere or bias sample results; false positive findings have been observed when turbid samples for hexavalent chromium (and other analytes) are analyzed. Field filtration can eliminate this concern; generally applicable to only inorganic/PCB analysis. In-line disposable filter cartridges are generally the easiest and quickest method for field filtration.
- Sample labels/sample identification. All samples must be labeled with:
  - A unique sample number;
  - Date and time;
  - Parameters to be analyzed;
  - Project Reference ID; and
  - Sampler's initials.
- Labels should be secured to the bottle(s) and should be written in indelible inks.

Groundwater Sampling Techniques Below LNAPL Layers

Sampling and analysis of groundwater below a LNAPL layer is typically discouraged, and not performed at REALM/ENCORE sites. The rationale for avoiding groundwater analysis below a LNAPL layer is as follows:

- The potential for sample "contamination" with a trace amount of NAPL is very possible; analytical data will be biased "high" based upon this concern.
- Analytical data generated from this scenario does not represent "dissolved" constituent presence in groundwater. Dissolved constituents are "best" determined in downgradient locations.

In some instances it may be required to perform groundwater sampling and analysis below a LNAPL layer, possibly at the request of a regulatory group. If absolutely necessary, this type of sampling may be accomplished in accordance with the following:

- Determine the LNAPL depth and thickness using an interface probe or clear bottom loading bailer.
- Determine the sampling depth, selecting a sample point as far away as possible from the LNAPL interface.
- Using a "capped" outer tube or piping (i.e., 1-inch diameter polyethylene), insert the outer tube to the selected sample interval. The cap should be a slip-on cap affixed to the outer tube using a short "leash" (i.e., stainless steel wire or equivalent). This allows cap recovery once the sampling is complete.

- Insert the sample line (3/8-inch diameter tubing) into the outer tube and "push out" the end cap for sample line entry into the sampling interval.
- Perform purging and sampling using a peristaltic pump.
- Monitor the groundwater level and/or the NAPL level to ensure the LNAPL layer is not drawn to sampling depth. If LNAPL drawdown occurs evaluate the need to proceed further, and consider terminating sampling activity.
- This sample should not be referred to on any analysis as a groundwater sample. It should always be referred to as a groundwater/NAPL mixture (GW/NAPL designation).

EQUIPMENT/MATERIALS

- pH meter, conductivity meter, nephlometer, ORP meter, DO meter, temperature gauge.
- Field filtration units (if required).
- Purging/sampling equipment:
  - Peristaltic pump (not suitable for VOCs[1]/SVOCs, or drawing water from depths greater than 25 feet[2]);
  - Suction pumps (not suitable for LFP, VOCs/SVOCs, or depths greater than 25 feet);
  - Submersible pumps (suitable for VOCs/SVOCs only at low flow rates);
  - Air lift pumps (not suitable for VOCs/SVOCs);
  - Bladder pumps (suitable for LFR and VOCs/SVOCs);
  - Inertia pumps (gaining acceptability for VOCs/SVOCs, generally not suited for GM programs); and
  - Bailers.
- Water level probe.
- Sampling materials (containers, log book/forms, coolers, chain-of-custody).
- Project Work Plan.
- Health and Safety Plan.

Note[1]: Peristaltic pump use for VOC collection is acceptable on select EPA/RCRA sites; this technique has gained acceptance in select areas. Where it is permissible to collect VOCs using a peristaltic pump, collection must be performed at a low flow rate (Michigan allows VOC sampling with the peristaltic pump).
Acceptability of the collection of VOCs using the peristaltic pump should be evaluated before the sampling program commences, commonly performed during the project Work Plan development and approval process.

Note[2]: Exception is noted in locations that the suction line can be placed at the desired sample depth (i.e., 100 feet), and the natural recharge maintains a water level within 25 feet of the ground surface.

Field Notes

Field notes must document field activities and measurements collected during the sampling activities. FMG 1.4 - Data Recording - Field Books/Digital Recording describes the data/recording procedure for field activities. The log book/field file should document the following for each well sampled:

- Identification of well.
- PID readings before and after well opening (if required).
- Well depth.
- Static water level depth and measurement technique.
- Sounded well depth.
- Presence of immiscible layers and detection/collection method.
- Well yield – high or low.
- Purge volume, pumping rate, and final disposition.
- Time well purged.
- Measured field parameters and meter calibration records.
- Purge/sampling device used.
- Well sampling sequence.
- Sample appearance.
- Sample odors.
- Sample volume.
- Types of sample containers and sample identification.
- Preservative(s) used.
- Parameters requested for analysis.
- Field analysis data and method(s).
- Sample distribution and transporter.
- Analytical laboratory.
- Chain-of-custody number for shipment to laboratory.
- Field observations on sampling event.
- Name(s) of sampling personnel.

- Climatic conditions including air temperature.
- Problems encountered and any deviations made from the established sampling protocol.

A standard log form for documentation and reporting groundwater purging and sampling events are presented on Form FMG 6.4-01 - Well Purging Field Information, Form FMG 6.4-02 - Sample Collection Data Sheet, and Form FMG 6.4-03 - Monitoring Well Record for Low-Flow Purging.

Groundwater/Decontamination Fluid Disposal

The project Work Plan will identify the required disposal procedures for groundwater and decontamination fluids. Groundwater disposal methods will vary on a case-by-case basis but may range from:

- Off-site treatment at private treatment/disposal facilities or public owned treatment facilities.
- On-site treatment at Facility-operated facilities.
- Direct discharge to the surrounding ground surface, allowing groundwater infiltration to the underlying subsurface regime.
- Direct discharge to impervious pavement surfaces, allowing evaporation to occur.

Decontamination fluids should be segregated and collected separately from wash waters/groundwater containers. Often small volumes of solvents used during the day can be allowed to evaporate if left in an open pail. In the event evaporation is not possible or practical, off-site disposal arrangements must be made.

REFERENCES

ASTM D5474 - Guide for Selection of Data Elements for Groundwater Investigations.

ASTM D4696 - Guide for Pore-Liquid Sampling from the Vadose Zone.

ASTM D5979 - Guide for Conceptualization and Characterization of Groundwater Systems.

ASTM D5903 - Guide for Planning and Preparing for a Groundwater Sampling Event.

ASTM D4448 - Standard Guide for Sampling Groundwater Wells.

ASTM D6001 - Standard Guide for Direct Push Water Sampling for Geo-Environmental Investigations.

USEPA Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures (EPA/540/S -95/504).

USEPA RCRA Groundwater Monitoring: Draft Technical Guidance (EPA/530-R-93-001).