Groundwater Characterization Sampling and Analysis

General Motors (GM) Corporation in Massena, New York

October 2006

Work Plan

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Section 1
Introduction

1.1 Introduction

Camp Dresser & McKee (CDM) developed this Groundwater Characterization Sampling and Analysis Work Plan for General Motors (GM) Corporation in Massena, New York. The intent of this plan is to present the technical approach and sampling and analysis procedures that will be used to provide additional characterization of the General Motors Powertrain site, specifically of stratigraphy and groundwater downgradient of the Process Water and 500,000-gallon Lagoons and at the downgradient extent of the GM property along the proposed alignment of the Groundwater Control Trench (GWCT). This additional characterization is being performed to provide current and comprehensive information on the nature and extent of groundwater impacts. The data from this characterization effort will be used for evaluation and design of potential remedial measures to address groundwater contamination previously identified at the GM site.

This Work Plan is based on agreements reached during a meeting in Syracuse, New York on May 23, 2006 where the intent, focus and scope of additional characterization was discussed with representatives of GM and its consultants, the U.S. Environmental Protection Agency (EPA), New York State Department of Environmental Conservation (NYSDEC), New York State Department of Health (NYSDOH) and the St. Regis Mohawk Tribe (SRMT) Environmental Division.

1.2 Background Information

1.2.1 Site Description

General Motors Powertrain owns and operates an aluminum and iron casting facility in the Town of Massena, County of St. Lawrence, state of New York. The facility consists of approximately 270 acres, including two parcels of land located between N.Y. Route 37 and the Raquette River.

The GM facility is bordered on the north by the St. Lawrence River, on the east by the St. Regis Mohawk Indian Reservation, on the south by the Raquette River, and on the west by the Reynolds Metals Company and property owned by Conrail, as shown on **Figure 1-1**.

1.2.2 Site History

GM has operated an aluminum casting plant at this location since 1958. From 1968 to 1980, polychlorinated biphenyls (PCBs) were a component of the hydraulic fluids used in some diecasting machines at the facility. PCBs provided protection against fire and thermal degradation in the high temperature manufacturing environment. GM no longer uses the same diecasting process or PCBs at the facility.

RA\2940-000\SITE\FIG1-
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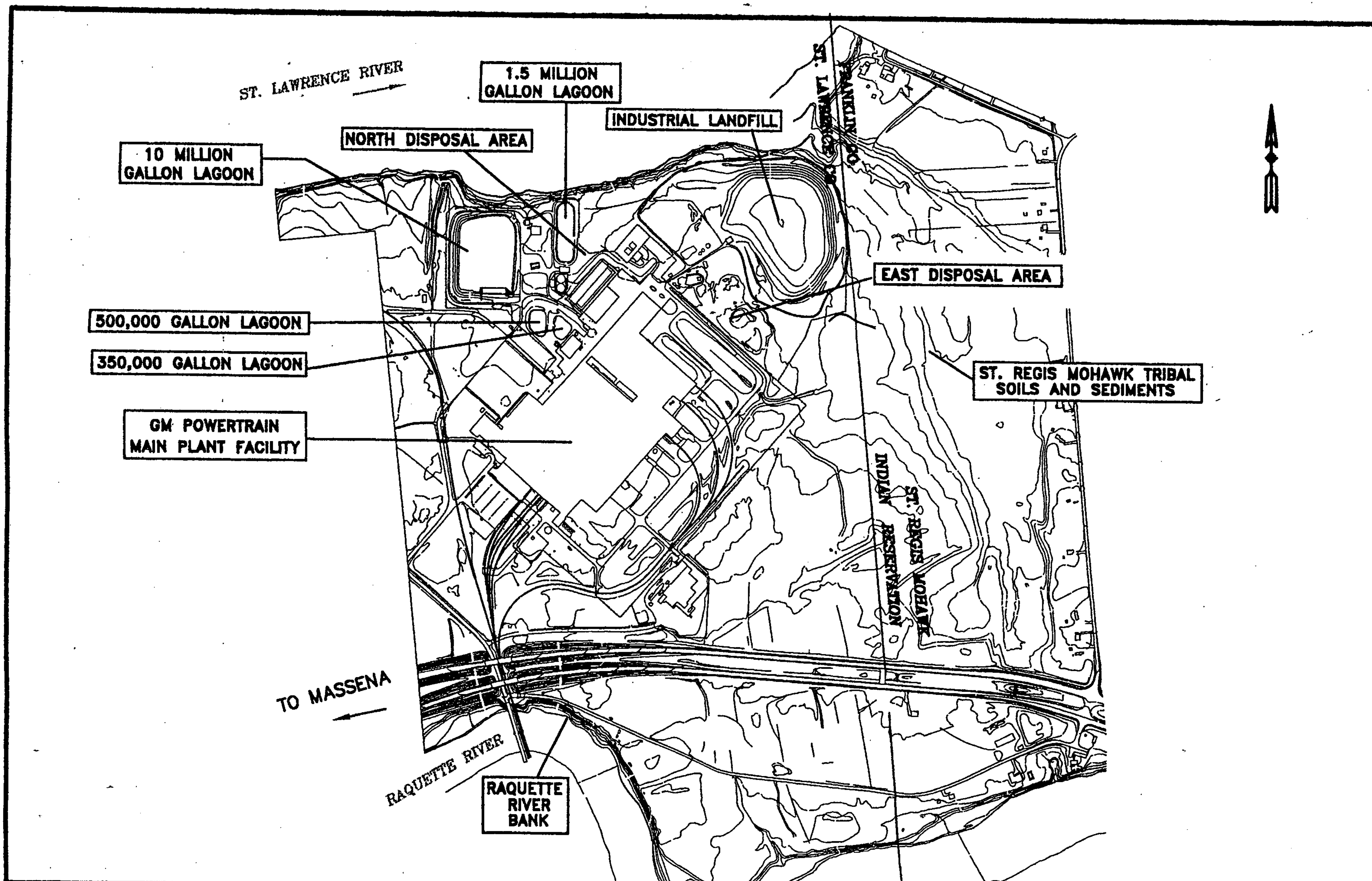


CDM environmental engineers, scientists, planners, & management consultants

General Motors
Massena, New York
Location Plan
Figure No. 1-1

As a result of past waste disposal practices, the GM site was placed on the Superfund National Priorities List (NPL) in September 1983. In response, GM performed a Remedial Investigation and Feasibility Study (RI/FS) to characterize the nature and extent of contamination and to analyze alternatives for remediating the site. On April 16, 1985, EPA and GM entered into an Administrative Order on Consent (Index No. II CERCLA-50201) for GM's performance of the RI/FS.

EPA selected cleanup plans that were included in EPA's December 17, 1990 OU-I ROD and March 31, 1992 OU-II ROD. In April 1992, EPA issued a Unilateral Administrative Order (UAO) requiring that GM implement the remedies selected in the OU-I ROD. In August 1992, EPA issued a UAO directing GM to proceed with the remedial actions presented in the OU-II ROD.

GM submitted a *Preliminary Design Report for the Industrial Landfill, East Disposal Area/Containment Area and Site-Wide Groundwater Controls* (CDM, 1994) in June 1994, and an *Intermediate Design Report for Site-Wide Groundwater Controls* (CDM, 1994) in August 1994. EPA provided comments on the Preliminary Design Report and guidance for the final design of the groundwater control trench (GWCT) in a letter received on March 11, 2004. GM submitted a *Final Design Report for Site-Wide Groundwater Controls* (CDM, 2004) and 95% Design Submittal on December 1, 2004.

EPA provided comments on the Final Design Report in a letter dated September 16, 2005 and GM provided responses to EPA comments in a letter dated October 24, 2005. In response to EPA comments, GM proposed that additional characterization of stratigraphy and groundwater quality along the downgradient extent of the GM property could facilitate resolution of some of the issues raised in EPA's September 16, 2005 letter. Discussions and correspondence between GM and EPA culminated in a meeting in Syracuse, NY on May 23, 2006. The decisions and agreements made at that meeting are the basis for this Groundwater Characterization Sampling and Analysis Work Plan.

1.3 Objectives of the Sampling and Analysis Plan

The objectives of this plan are to collect sufficient additional hydrogeologic, geotechnical and current groundwater quality data to sufficiently delineate the lateral and vertical extent groundwater impacts downgradient of the Process Water and 500,000-gallon Lagoons and at the downgradient extent of the GM property along the proposed alignment of the GWCT. The data from this characterization effort will be used for evaluation and design of potential remedial measures to address groundwater contamination previously identified at the GM site including the vertical and lateral extent of the proposed GWCT.

1.4 Document Organization

Section 1, above, provides the general background information on the origin and objectives of the proposed additional groundwater characterization sampling and analysis. Section 2 outlines the characterization approach and scope of work. Section 3 provides the methodology for the planned soil boring/monitoring well installation, hydraulic testing and sampling and analysis. General Motors' REALM group has developed Field Method Guidance (FMGs) for many of the activities proposed for this program. Related REALM FMGs are included in Appendix A for reference. The methodology outlined in Section 3 has been developed considering the FMGs but is more site-specific where the FMGs are intended to be general. If practices different than the FMGs are warranted by site-specific objectives and/or conditions encountered in the field, the decisions and agreements of field personnel, and project managers will be documented. A Quality Assurance Project Plan, previously developed by Blasland, Bouck & Lee (BBL) and Hughes Environmental Services for earlier work has been updated by BBL and will be submitted under separate cover.

Section 2
Characterization Scope of Work

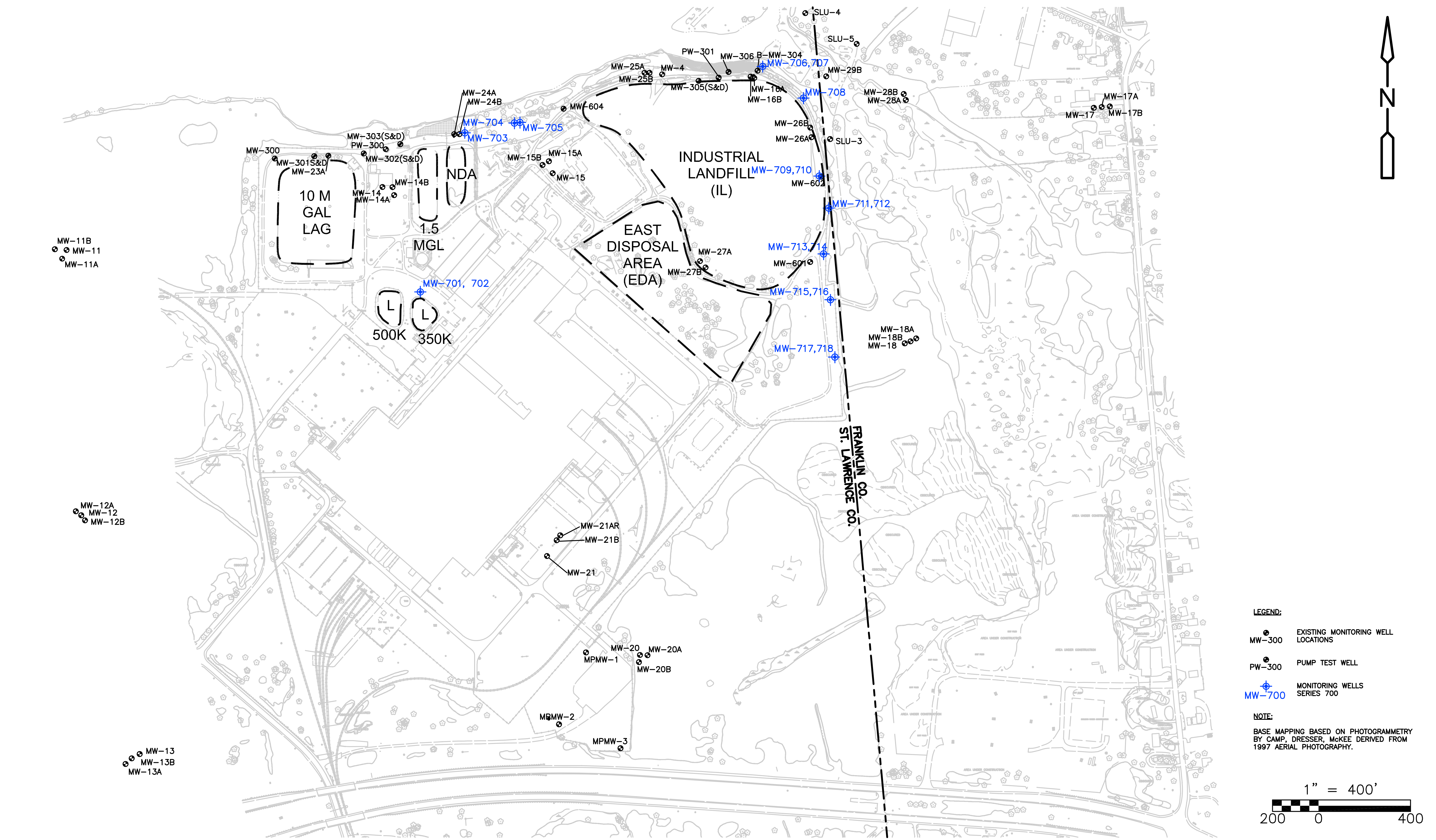
2.1 Characterization Approach

The approach to additional characterization of the GM site for evaluation and design of potential remedial measures is to advance soil borings and install monitoring wells downgradient of the 350, 000 and 500,000-gallon (process water) Lagoons and at the downgradient extent of the GM property along the proposed alignment of the GWCT. The location, spacing and targeted screen intervals of new monitoring wells is designed to compliment existing monitoring well locations and provide sufficient coverage of the site for remedial decision purposes. In addition, two comprehensive rounds of groundwater samples will be collected from existing and newly installed monitoring wells to obtain a current representation of the extent and magnitude of groundwater impacts. As described in Section 1, the approach, scope and general locations were discussed and agreed to during a meeting with GM, EPA, NYSDEC/DOH and the SRMT. This document, which will be reviewed by all parties involved, will describe the specific locations and methodology for additional groundwater characterization.

2.2 Scope of Work

This Sampling and Analysis Work Plan addresses the following scope of work:

- Advancement of soil borings at 10 locations on the GM site. Locations are distributed downgradient of the Process Water and 500,000-gallon Lagoons and at the downgradient extent of the GM property along the proposed alignment of the GWCT as shown on Figure 2-1.
- Collection of blow-count data and soil samples for stratigraphic and geotechnical analysis.
- Installation and development of 18 new monitoring wells at the locations shown on Figure 2-1.
- Hydraulic conductivity testing of the newly installed monitoring wells.
- Performance of a location and elevation survey for existing and newly installed monitoring wells.
- Collection of two rounds of groundwater samples from existing and newly installed monitoring wells.
- Groundwater sampling will be performed in the fall of 2006 and spring of 2007.
- Synoptic rounds of water level elevations including the wells at the mineral processing area will be collected at the time of groundwater sampling so updated groundwater contour maps can be generated. In addition, surface water elevations will be measured within the St. Lawrence River, the Cove, and the Turtle Creek Stream at the Holding Pond. GM will monitor wells and locations on the SRM property adjacent to the site if access is granted.



LEGEND:

- MW-300 — EXISTING MONITORING WELL LOCATIONS
- PW-300 — PUMP TEST WELL
- MW-700 — MONITORING WELLS SERIES 700

NOTE:

BASE MAPPING BASED ON PHOTOGRAMMETRY BY CAMP, DRESSER, McKEE DERIVED FROM 1997 AERIAL PHOTOGRAPHY.

1" = 400'

200 0 400

GENERAL MOTORS POWERTRAIN
MASSENA, NEW YORK

EXISTING AND PROPOSED GROUNDWATER MONITORING LOCATIONS

FIGURE 2-1

CDM Camp Dresser & McKee

filename: P:\2940\36892\P5 PERC\TSTFG001.DWG xref's: [GMSITE2,TSEPL001,R11X17]

- Preparation of a data summary report to include:
  - Soil boring and monitoring well installation logs
  - Geotechnical test results
  - Hydraulic conductivity test results
  - Updated stratigraphic cross sections
  - Groundwater contour maps, and
  - Tabular and graphical presentations of groundwater quality.

Section 3
Methodology

3.1 Soil Boring and Sampling

3.1.1 Soil Boring

Soil borings will be advanced for soil sampling and monitoring well installation using a truck or track-mounted drill rig and drive-and-wash or spun casing techniques. Spun casing will only be used at locations where cobbles or boulders preclude advancement of casing by drive and wash method. Mud rotary techniques will be employed to enlarge borings to sufficient size to install permanent casings where required. Downhole tools and casings will be steam-cleaned prior to use at the site or between borings. GM potable water will be used during drilling. Drilling water and solids will be containerized in drums and placed on pallets adjacent to the drill site for subsequent management by GM.

To reduce the potential of introducing contamination to deep screen intervals, casings will be telescoped for wells to be installed at the base of the Upper Glaciolacustrine unit and the top of the Lower Till. Shallow wells (e.g., water table, Upper Clay or Upper Till) will not require telescope or permanent casing. Large diameter (5 or 6-inch) shallow (~5-foot) casings will be installed at each drilling location to contain circulating fluids and direct them into recirculation mud tubs. For telescoped borings, 5-inch casing will be advanced to a depth of approximately 20 feet below ground surface (bgs) and 4-inch casings will be advanced approximately 5 feet into the top of the Lower Till and the borings advanced as an open borehole below that.

At the following locations permanent casing will be installed to further reduce the potential for introducing contaminants to deep screen intervals:

MW-702: Permanent 5-inch casing will be installed before advancing below 25 feet.
MW-703: Permanent 5-inch casing will be installed 5 feet into the Lower Till.
MW-705: Permanent 5-inch casing will be will be installed at ~30 bgs before advancing into the Upper Glaciolacustrine (UGL) unit.
MW-707: Permanent 5-inch casing will be set 5 feet into the Lower Till
MW-708: Permanent casing will be set 5 feet into the lower till (6-inch casing from ground surface to 20 feet and 4-inch casing from ground surface to 5 feet into the Lower Till).

Note: All material above the UCL was removed from proposed MW-706 location as part of the Interim Remedial Measure Northeast of the Industrial Landfill. Therefore, temporary casing rather than permanent casing will be set and the boring advanced into the UGL to set MW-706.

The borings listed above will be drilled first to the depth where casing will be set. Once the casing depth is reached the drive and wash rig will move off and the mud rotary rig will be used to install the casings to the appropriate depth. After the grout has been allowed to sit for at least 24-hours, the borings will be advanced to total depth and the wells set using the drive and wash rig. Drilling fluids will be changed as each new casing size is employed and before open-hole drilling such that new water is used below the depth of each temporary or permanent casing.

Approximate boring depths are summarized in **Table 3-1**.

3.1.2 Soil Sampling

Continuous soil samples will be collected using 24-inch long split-spoon samplers with a 2-inch outside diameter (OD) split-spoon samplers will be driven with a 140 lb hammer falling 30 inches in accordance with ASTM Method D1586 for the Standard Penetration Test (SPT). A soil catcher device will be used to help retain the sample. When less than the full penetration length is recovered, the portion of sample recovered will be assumed to be from the shallower depths penetrated.

Continuous sampling will be performed only at the first and deepest boring at each drilling location. Screen intervals for adjacent monitoring wells will be based on soil characterization of the initial boring at that location. One split-spoon sample will be collected for grain size analysis from the screen interval of each of the shallower wells at a cluster location. Additional split-spoon samples may be collected if there is lateral variability with the adjacent boring. Three inch split-spoon sampler may be used with a corresponding 300 lb hammer if greater sample volume is desired for geotechnical testing. Visual inspection and field headspace screening with a photoionization detector (PID) will be performed for all soil samples. Field headspace screening data will be recorded on the associated monitoring well log.

Soil samples for chemical analysis will be collected from any zone that exhibits elevated PID readings (>5 ppmv), sheens (or other visual evidence of contamination), the presence of NAPL, or petroleum or solvent odor.

Relatively undisturbed, tube soil samples (Shelby tubes) will be collected at specific intervals to be selected in the field. Target intervals include fine grained materials such as the Upper Clay units at locations along the potential alignment of the proposed GWCT. Shelby tube samples will be collected to provide for geotechnical strength testing and analyses including consolidation (ASTM D4186), triaxial strength (ASTM D4767), laboratory vane shear (ASTM D4648), grain size with hydrometer (ASTM D422), moisture content (ASTM D2216), and Atterberg limits (ASTM D4318). It is anticipated that approximately five to ten Shelby tube samples will be collected from locations distributed along the potential GWCT alignment where clays are present.

Table 3-1
Proposed Soil Boring and Monitoring Wells
Additional Site Characterization
General Motors Powertrain
Massena, NY

Well Number	Station	Horizon	~ Screen Interval (bgs)	Location Rationale
MW-701	NA	Upper Till	15-20	Downgradient of Central Lagoons
MW-702	NA	Below UT	30-35	Downgradient of Central Lagoons
MW-703	7+50	Lower Till	40-50	Downgradient of NDA
MW-704	10+00	Upper Till	15-25	Downgradient of NDA
MW-705	10+00	Upper GL	30-40	Downgradient of NDA
MW-706	21+20	Upper GL	20-25	Downgradient of Industrial Landfill
MW-707	21+20	Lower Till	40-45	Downgradient of Industrial Landfill
MW-708	23+20	Upper GL	35-40	Downgradient of Industrial Landfill
MW-709	27+10	Upper Till	5-15	Downgradient of Industrial Landfill
MW-710	27+10	Lower Till	30-35	Downgradient of Industrial Landfill
MW-711	28+50	Upper Till	10-20	Downgradient of Industrial Landfill
MW-712	28+50	Lower Till*	30-40	Downgradient of Industrial Landfill
MW-713	30+50	Lower Till*	10-20	East of EDA
MW-714	30+50	Lower Till*	35-40	East of EDA
MW-715	32+50	Lower Till*	10-20	East of EDA
MW-716	32+50	Lower Till*	30-40	East of EDA
MW-717	35+00	Lower Till*	10-20	East of EDA
MW-718	35+00	Lower Till*	30-40	East of EDA

UT= Upper Till
GL= Glaciolacusterine
EDA= East Disposal Area
NDA= North Disposal Area

Wells in the Upper Glaciolacustrine will be screened at the base of the permeable unit.
Wells in the Upper till will be screened approximately 10 feet below the till/UGL contact
Except as described above, screen intervals will placed across the most permeable intervals encountered.
*Or if encountered Glaciolacustrine or sandy unit.

Soil samples will also be collected for grain size analyses from more granular, dense soils (i.e., the tills and Upper Glaciolacustrine unit). Soil samples for grain size analyses will be collected from across screen intervals and to provide representative samples of the Upper Till, Lower Till and Upper Glaciolacustrine units. Data from grain size testing will be provide accurate quantified soil characterization and to estimate hydraulic conductivity (results of which can be compared to hydraulic testing results).

3.1.3 Sampling Equipment Decontamination

All sampling equipment will be properly decontaminated prior to its use in the field to prevent cross-contamination.

The decontamination procedure required for soil sampling equipment on this project is:

a. Steam clean or wash and scrub with low phosphate detergent followed by
b. Potable water rinse

A rinsate blank will be collected to confirm the adequacy of decontamination. The rinsate blank will be analyzed for PCBs.

3.1.4 Soil Sample Documentation

The sampling process is designed to and will be conducted in a manner that provides samples suitable for the intended geotechnical analyses and is properly documented to assure comparability at a later date. At the time the samples are obtained, the sampling team will record the following information:

Sample site location (e.g., baseline station and offset, or process or equipment item);

Depth or position;

Date and time of sampling;

Sample identification number;

Identification of sampler;

Analyses requested; and

Material characterization.

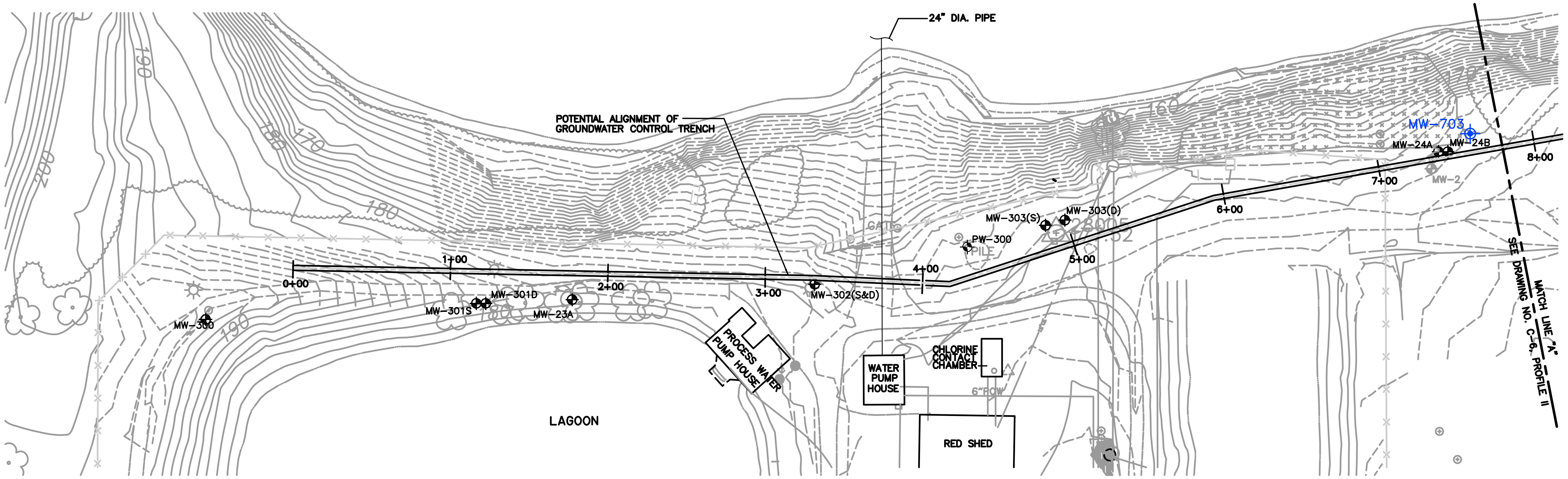
Upon sample collection, the sampling team will initiate and maintain chain-of-custody procedures during transportation of samples to the geotechnical laboratory. Samples not requiring testing will be archived at the GM site until after completion, submittal and review of the Data Summary Report in case additional geotechnical testing is necessary. Archived samples will not be refrigerated.

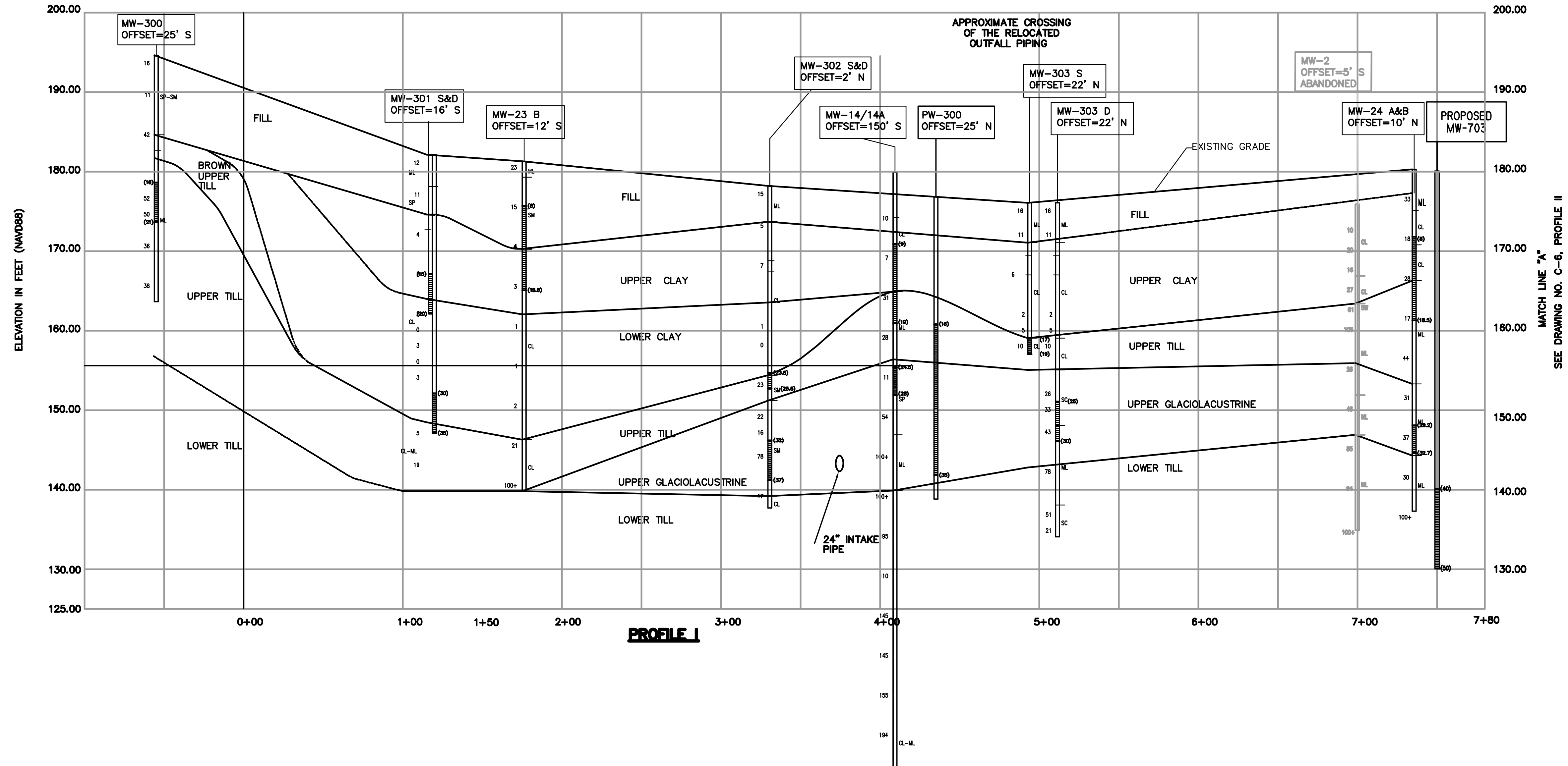
3.2 Monitoring Well Installation

Eighteen (18) new monitoring wells are proposed for installation as part of this program. The approximate locations, target stratigraphic intervals and estimated screen intervals and rationale for each are summarized in Table 3-1. Locations are shown in plan view on **Figure 2-1** and more detailed plan and profiles along the downgradient property boundary are provided as **Figures 3-1 through 3-4**. For reference purposes, proposed well locations are stated relative to the 0+00 point of the proposed GWCT in the December 2004 *Final Design Report for Site-Wide Groundwater Controls*.

Screen intervals and well construction details will be finalized based on the stratigraphy and soil conditions encountered in the field. The following provides additional detail on the intent for screen placement to serve as guidance for setting wells.

- Shallow wells will be screened across or just below the expected water table (based on water level readings from shallow wells in the vicinity). Screen intervals will be placed across the most permeable interval encountered within the approximate proposed screened depth (determined by relative grain size and sorting). If visual, olfactory or field screening with a photoionization detector (PID (for volatile organic compounds, (VOCs)) indicates the presence of contamination, the screen interval should be set to intercept that interval. Screens will be five-feet long unless observations in the field indicate a 10-foot interval would be more appropriate (i.e., a 10 foot permeable zone is encountered in the target horizon). A 10-foot screen will be used for all shallow wells screened above the upper Glaciolacustrine unit. Along the SRMT property line, ten foot screens are anticipated as the Upper Till deposits in this area are expected to be heterogeneous but generally of low hydraulic conductivity. A two foot sump will be installed below the screened intervals.





REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: E. ASHLEY
DRAWN BY: R. KELLEY
SHEET CHK'D BY: R. BOELTER
CROSS CHK'D BY: M. SCHULTZ
APPROVED BY: M. SCHULTZ
DATE: AUGUST 2006

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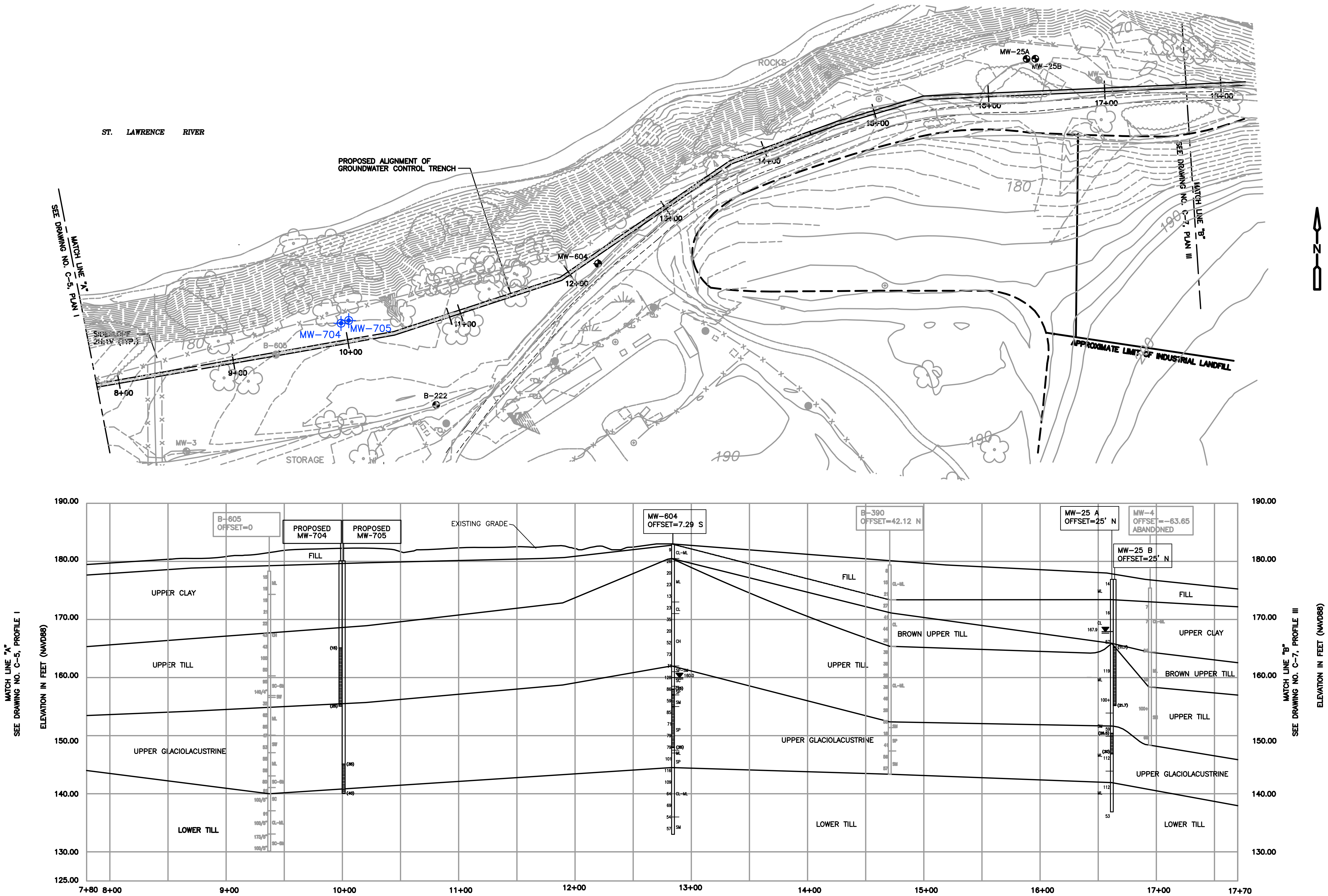
GENERAL MOTORS POWERTRAIN
MASSENA, NEW YORK

SITE-WIDE GROUNDWATER CHARACTERIZATION

EXISTING AND PROPOSED GROUNDWATER MONITORING LOCATIONS PLAN & PROFILE I

PROJECT NO. 2940-36892
FILE NAME: CSTPP005
FIGURE NO. 3-1
ACCESSION NO.



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DESIGNED BY: E. ASHLEY
DRAWN BY: R. KELLEY
SHEET CHK'D BY: R. BOELTER
CROSS CHK'D BY: M. SCHULTZ
APPROVED BY: M. SCHULTZ
DATE: AUGUST 2006

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MASSENA, NEW YORK

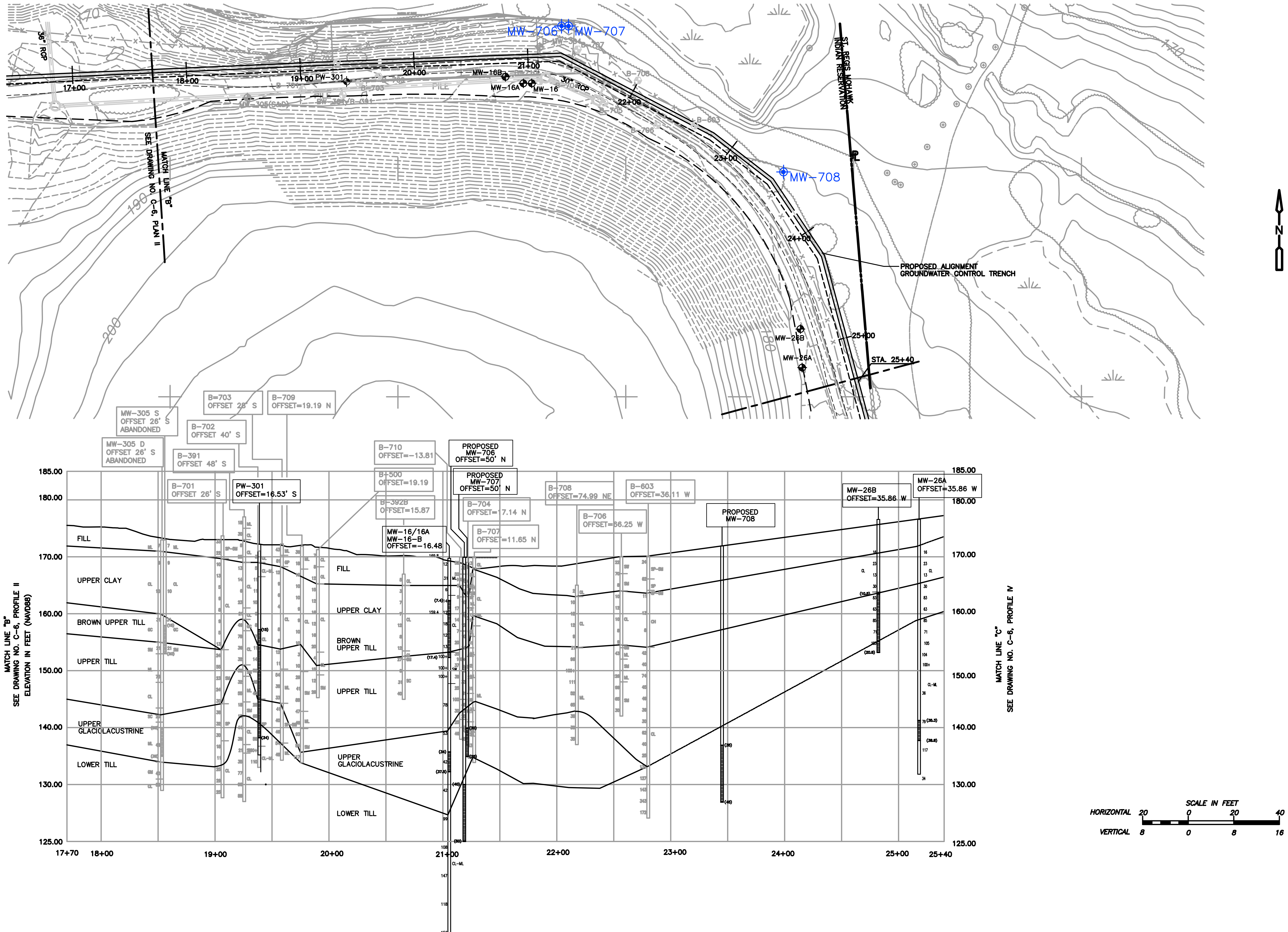
SITE-WIDE GROUNDWATER CHARACTERIZATION

EXISTING AND PROPOSED GROUNDWATER MONITORING LOCATIONS PLAN & PROFILE II

PROJECT NO. 2940-36892
FILE NAME: CSTPP005

FIGURE NO.
3-2

ACCESSION NO.



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DESIGNED BY: E. ASHLEY
DRAWN BY: R. KELLEY
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CROSS CHK'D BY: M. SCHULTZ
APPROVED BY: M. SCHULTZ
DATE: AUGUST 2006

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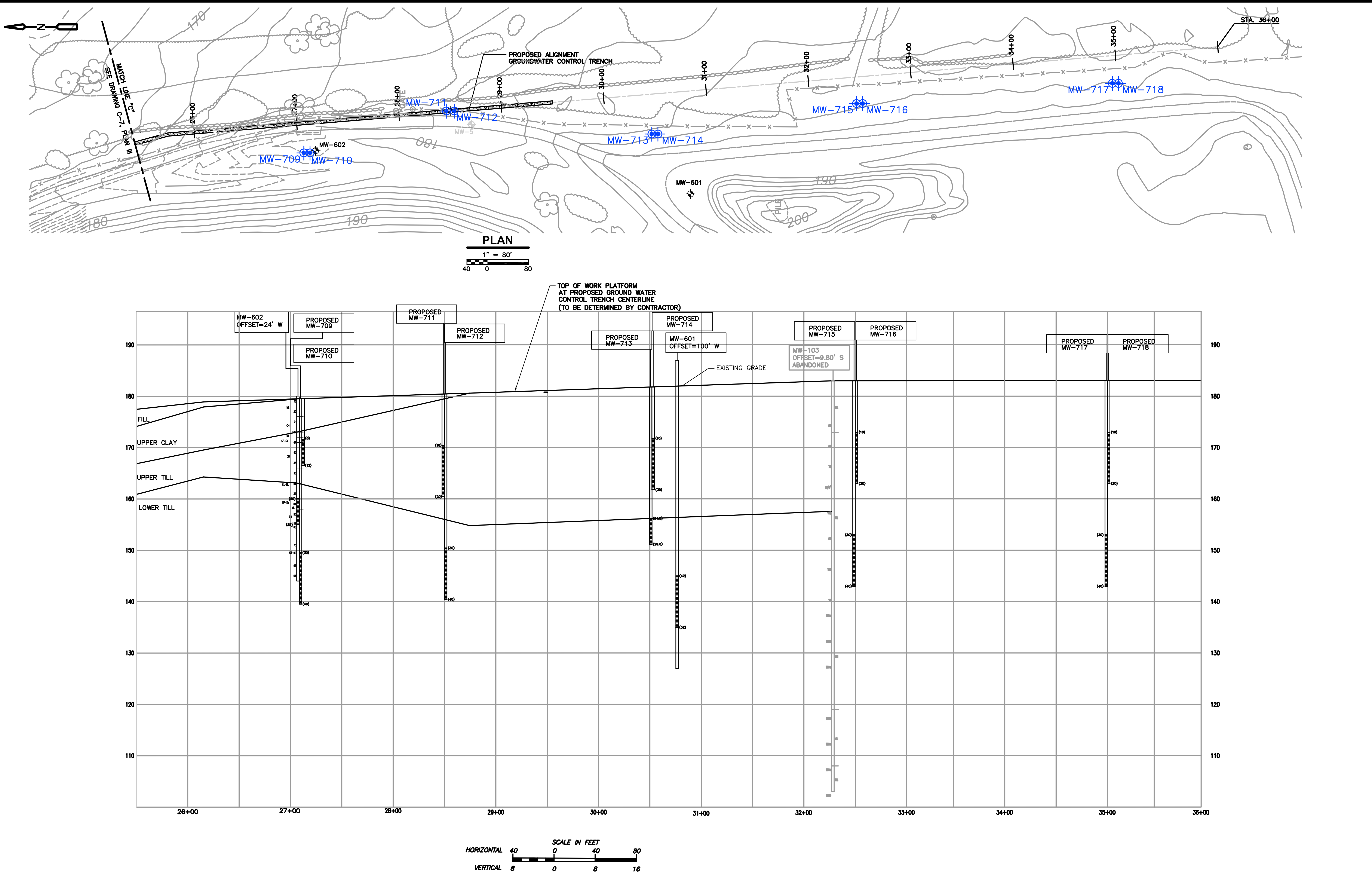
SITE-WIDE GROUNDWATER CHARACTERIZATION

EXISTING AND PROPOSED GROUNDWATER MONITORING LOCATIONS PLAN & PROFILE III

PROJECT NO. 2940-36892
FILE NAME: CSTPP007.DWG
FIGURE NO. 3-3
ACCESSION NO.



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DESIGNED BY: E. ASHLEY
DRAWN BY: R. KELLEY
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CROSS CHK'D BY: M. SCHULTZ
APPROVED BY: M. SCHULTZ
DATE: AUGUST 2006

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MASSENA, NEW YORK

SITE-WIDE GROUNDWATER CHARACTERIZATION

EXISTING AND PROPOSED GROUNDWATER MONITORING LOCATIONS PLAN & PROFILE IV

PROJECT NO. 2940-36892
FILE NAME: CSTPP008.DWG
FIGURE NO. 3-4
ACCESSION NO.

Filename: P:\2940\36892\95 PERC\CSTPP008.DWG Xref's: [C24X36H, GMSITE2, PROFILE1,] Plotted by: KELLEYRJ Time: 07/14/2006 11:16:40 AM
[GENERAL MOTORS - REALM POWERTRAIN SITE]

Wells screened in the Upper Glaciolacustrine unit will be screened at the base of unit and/or the most permeable portion of the unit encountered. Also the screen interval should extend across any portion of the unit exhibiting contamination as described above. Screens will be five-feet long unless observations in the field indicate a 10-foot interval would be more appropriate (i.e., a 10 foot permeable zone is encountered in the target horizon). The bottom of the monitoring well screen will be set at the contact between the Glaciolacustrine unit and the lower till unit. A two foot sump will be installed below the screen interval extending into the lower permeability unit. The annular space between the sump and the formation will be backfilled with Bentonite to prevent contaminants from entering the lower formation.

- Wells screened in the Lower Till will be constructed with the top of the screen interval approximately 10 feet below the contact of the Upper Glaciolacustrine unit/top of the Lower Till. Casing will be advanced approximately five feet into the top of the Lower Till and the boring advanced as an open hole below that. Screen intervals will be 10 feet in length due to the anticipated heterogeneity and generally low hydraulic conductivity of this unit. A two foot sump will be installed below the screened interval.

Monitoring wells will be constructed of two-inch interior diameter (ID), Schedule-40 PVC with 0.010-inch continuous-wrap screens. Sand pack will consist of Morie, U.S. Silica or equivalent No. 00 or 0 filter sand. Only sand and well materials in original packaging will be used. The driller will be instructed to have both grain sizes on site and the coarser sand will be used, if appropriate, based on the grain size of the interval being screened (i.e., if it is medium or coarser sand). Sand pack will be placed to approximately two-feet above the top of the screen interval and an approximately two-foot thick bentonite clay seal placed above the sand pack. The remainder of the annular space will be grouted to the ground surface.

Each well will be completed at the ground surface with a locking protective casing. Because many of the wells to be installed as part of this program could and may be used as post-closure monitoring wells, surface completions will be designed, to the extent practicable, to allow for temporary closure, protection of the well during construction activities and retrofitting as post-closure monitoring wells. The subcontracted drilling company will be instructed to provide 10-foot long steel protective surface casings which will be installed to stick up approximately three feet above the ground surface and extend approximately seven feet bgs. These surface completions will be designed to allow the casing to be cut off or unscrewed approximately 2 feet bgs, capped and buried prior to any remedial construction activities that could damage the well. The well would then be located after the completion of remedial construction by the surveyed location (see below) and a metal detector, and the surface completion reconstructed.

Each new well will be labeled with an identification tag providing well name, date installed, well construction components and screen intervals.

3.3 Well Survey

Upon completion of the drilling and monitoring well installation program, all new wells and existing wells will be surveyed for location (northing and easting), and ground surface, top of interior and top of exterior (protective) casing elevations.

3.4 Well Development

Upon completion, each newly installed well will be developed using surging and over-pumping techniques. The purposes of well development are to:

- remove drilling fluids from the monitoring well;
- establish hydraulic connection between the well and the formation; and
- reduce the turbidity of groundwater samples.

Due to the fine grained composition of soils in the Massena area, it may not be possible to develop the new monitoring wells to the extent that they produce water with low turbidity (i.e., less than 50 nephthelometric turbidity units, NTUs). In addition, it is anticipated that some of the newly installed wells may not yield sufficient water for effective well development. Therefore, the focus of well development will be to establish good hydraulic communication with the formation through surging and to remove as much drilling fluid, developed silt and formation water as possible through pumping.

Well development will be performed using a WaTerra HydroLift reciprocating inertial pumping system with and without surge blocks. New polyethylene tubing and a Derlin check valve will be dedicated to each well. Additional pumping without surging will be performed using Whale-brand submersible electric centrifugal pumps which will either be new or decontaminated between wells.

3.5 Hydraulic Conductivity Testing

All 18 newly installed wells will be subject to hydraulic conductivity testing. Hydraulic conductivity will be tested by one of two methods, slug test or short-term pumping specific capacity test. The deciding factor will be the productivity (specific capacity) of the individual well and the feasibility of handling the water produced during testing. If the wells readily produce water and it is feasible to contain, transport and dispose of pumped water, the short-term specific capacity test will be performed.

Slug tests are performed by dropping and/or retrieving a slug of water or a sealed, weighted PVC pipe and recording the instantaneous change and rebound of the water to the static pre-test water level. Rapid evacuation (pumping) can also be used on wells with low specific capacity. The data from slug tests will be analyzed using analytical solutions developed by Bouwer and Rice (1976) as updated in 1989 by Bouwer (Groundwater, Vol. 27, No. 3 May-June 1989).

Short-term specific capacity testing is performed by pumping the monitoring well at a sustainable constant rate until the water level in the well stabilizes (or nearly stabilizes). The test results in a measurement of quantity (pumping rate) per unit drawdown. The equation relating pumping and drawdown to the hydraulic properties of the formation is:

$$Q/s = T/(264\log(T*t/(2693rw*rw*S))-65.5)$$

where
Q = pumping rate (gpm)
s = drawdown (ft)
T = Transmissivity (gpd/ft)
S = Storativity
rw = Nominal well radius (ft)
t = time after pumping started (min)

With pumping rate, drawdown, time, and assumed storativity all known, T can be solved. The hydraulic conductivity can then be obtained by dividing T by pre-pumping saturated thickness of sand pack or screen length. (Walton, W.C. 1962, Selected Analytical Methods for Well and Aquifer Evaluation, Illinois State Water Survey, Bulletin 19.)

3.6 Groundwater Sampling

Two rounds of groundwater sampling will be performed; one in fall 2006 and another in spring 2007. These two rounds are expected to approximately represent seasonally low and high groundwater conditions, respectively. Regulatory oversight agencies USEPA and NYSDEC have the option of collecting spilt samples. Prior to sampling a comprehensive, synoptic round of groundwater elevation measurements will be collected, which includes all new and existing including those at the former minerals processing facility site monitoring wells. These data will be used to develop site-wide groundwater contour maps for spring and fall conditions.

Groundwater samples will be collected from the 18 newly installed wells and 54 existing wells (if access to wells on the SRMT property is obtained). To allow representative aquifer conditions to become reestablished, groundwater sampling of newly installed wells will be performed a minimum of two weeks after well development and hydraulic conductivity testing.

Groundwater sampling will be performed using low flow purge and sampling techniques. Samples will be collected and analyzed for the compounds addressed by the GM site RODs, specifically: PCBs, total phenols and the VOCs trichloroethene (TCE), 1,2-dichloroethene (DCE) and vinyl chloride (VC). Samples will be collected, documented, maintained and transported in accordance with GM's REALM/ENCORE FMG provided in Appendix A and with the site-specific groundwater sampling protocols described below.

3.6.1 Groundwater Cleanup Levels

The chemicals of concern and Record of Decision- (ROD-) specified groundwater cleanup levels for the GM Powertrain Superfund Site, Massena, New York, are as follows:

- polychlorinated biphenyls (PCBs) – 0.1 micrograms per liter (µg/L);
- total phenols – 1 µg/L;
- 1,2-dichloroethylene (1,2-DCE) – 100 µg/L;
- trichloroethylene – 5 µg/L; and
- vinyl chloride – 2 µg/L.

Every attempt will be made to make the detection levels for the analyses of the chemicals consistent with the ROD-specified cleanup levels within the method guidelines. The groundwater sampling activities are being performed to add to the current baseline of groundwater quality data available for the site.

3.6.2 Monitoring Well Sampling Locations and Analyses

The locations of all groundwater monitoring wells are shown on Figure 2-1. All 54 existing and 18 new monitoring wells will be sampled and analyzed for PCBs using EPA Method 8082, total phenols using USEPA Method 9065 (or 9066), and ROD-specific volatile organic compounds (VOCs) using Method 8260 low level method. Note that 9of the 54 monitoring wells (MW-17, MW-17A, MW-17B, MW-18, MW-18A, MW-18B, MW-28A, MW-28B, and MW-29B) are located on the St. Regis Mohawk Reservation and will require permission from the landowner to sample. The EPA and the SRMT Environmental Division will assist GM in obtaining permission to sample these monitoring wells. The Minerals Processing monitoring wells will not be included in the sampling event as they are sampled every other year under NYSDEC oversight.

3.6.3 Sampling Procedures

Samplers will evaluate each well for the presence of non aqueous phase liquids (NAPL) using an oil-water interface probe. Samplers will inspect the measurement tape for evidence of a sheen of LNAPL and will send the probe to the bottom of the well to evaluate the presence of absence of DNAPL. If NAPL is identified in a well, GM will attempt to collect a sample of that material. No dissolved-phase groundwater sample will be collected from any well containing NAPL because the presence of that material is sufficient indication of groundwater impacts at that location and the quality of the water in a well bore containing NAPL may not be representative of formation groundwater.

The groundwater sampling procedure that will be used is a modified version of the REALM/ENCORE's Field Method Guidelines for "Low Flow Groundwater Sampling", and USEPA's Region II Standard Operating Procedure "Ground Water Sampling Procedure Low Stress (Low Flow) Purging and Sampling" (1998). The primary modifications entail additional effort to minimize agitation of the water column during sampling and pumping at low rates. The objective of both of these modifications is to mitigate sampling artifacts that result from mobilizing particulates that are not moving with the groundwater. The low pumping rates are needed to more closely simulate the low hydraulic conductivity and fine-grained nature of the materials screened by site wells. The formations screened produce very little water, consequently, low pumping rates will minimize drawdown in the well, which decreases the entrance velocity of groundwater into the well, which otherwise could mobilize particulates and entrain them in groundwater samples.

Water level measurements and the presence or absence of sediment in the well bore will be assessed and recorded for each monitoring well prior to sampling. The presence and/or absence of silt deposits will be determined by measuring and recording the total depth of the well and by comparing this information to the well log. If any well contains sediment accumulation amounting to 20% or more of the well screen length, then the sediment will be removed before the well sampling procedures begin. A WaTerra and/or Whale pump or equivalent will be used to attempt to remove the silt from the well. All water extracted from the borehole during the sediment removal procedures will be collected in 55-gallon drums and transported to GM's wastewater treatment facility. Additional readings of the total depth of the well will determine the sediment removal success. The wells will be allowed to rest approximately two weeks after well development before resumption of the low-flow sampling procedures.

During and after the initial low-flow pumping of the well, the following field indicator parameters will be monitored and recorded into a field logbook at approximate 5- to 15-minute intervals:

- turbidity;
- temperature;
- specific conductance;
- pH;
- dissolved oxygen (DO); and
- water-level elevation.

Higher flow rates may be used during the initial phases of purging. The time between measurements will be based on conditions in the field and an actual measured volume in the flow-through cell. GM may seek to make some modifications in the field in consultation with the on-site USEPA representative.

The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for a minimum of three consecutive readings. All deviations encountered in the field will be documented in the field logbook. Water purged from the well prior to sampling will be contained and transported to GM's wastewater treatment facility.

Once the indicator parameters are obtained and the appropriate laboratory-supplied sample containers are prepared, sampling may proceed. Groundwater sample collection will be performed using a peristaltic pump (or bladder pump for those wells where the depth to groundwater is greater than 25 feet and/or for all VOC sampling) with dedicated plastic tubing. The pump intake will not be moved from the approximate midpoint of the screen interval during sampling. Non dedicated sampling equipment (e.g., probes and pumps) will be decontaminated prior to use and between well locations. Dedicated disposable sampling equipment (e.g., plastic tubing) will be used as much as possible. Unfiltered samples will be collected at all locations, (unless a LNAPL or DNAPL sample is collected). GM may also collect a field filtered sample if turbidity objectives are not achieved.

The following is a checklist of equipment to be used to collect groundwater samples:

- electronic water-level indicator;
- logbook;
- Horiba U-22 Water Quality Indicator or other similar water parameter monitor;
- peristaltic or bladder pump (dependant on depth of water level and analyses);
- dedicated discharge plastic tubing for each monitoring well;
- field data sheets and sample labels;
- chain of custody records and seals;
- calculator;
- sample containers;
- 5-gallon pail(s);
- shipping containers;
- glass beaker or graduated cylinder with milliliter volume increments (for pump rate measurements); and
- packing materials, distilled or deionized water, and ice.

The following are the specific well sampling steps for sample collection:

- Remove locking well cap; note location, time of day, weather, and date in field notebook or appropriate form.
- Slowly insert plastic tubing (or bladder pump) into well just above the midpoint of the well screen.
- Secure plastic tubing into place with duct tape.

- Begin low-flow pumping and collecting the water at a target flow rate of approximately 25 to 50 milliliters per minute (ml/min). The pump rate should, if possible, be adjusted to cause minimal ($\leq$0.3) water drawdown in the well. Measure and record adjustments made to the pumping rate and the water-level elevation(s) after each adjustment.

- Monitor indicator parameters: during the low-flow pumping of the well, monitor and record the field parameters (turbidity, temperature, conductivity, pH, water level, and DO) approximately every 5 to 15 minutes. The well is considered stabilized with three consecutive reading as follows (Puls and Barcelona, 1996):

  $\pm$ 0.1 unit for pH
  $\pm$ 3% for conductivity
  $\pm$ 10 % for DO
  < 10 NTUs for turbidity*

  *As low-turbidity samples are critical for this project, purging will be extended until turbidity values of ≤ 5 NTUs are reached, if possible. If wells do not yield water with sufficiently low turbidity, additional purging, or redevelopment will be considered.

- Collect samples at a flow rate of approximately 50 ml/min or less and such that drawdown of the water level within the well is limited. All sample containers should be filled with minimal turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container. Continue collecting water samples until a sufficient volume is collected for all laboratory samples. VOC samples will be collected first, then phenols and PCB water samples.

- Record pertinent observations of the sample (e.g., physical appearance, the presence or lack of odors, sheens) in the field notebook.

- All procedures will follow the work plan as closely as possible. GM will discuss potential modification(s) with the USEPA on-site representative for concurrence prior to implementing the modification(s). Modifications made in the field will be documented in the field notes. If field conditions exist that preclude stabilizing certain parameters, document, to the extent possible, an explanation of why the parameters did not stabilize.

- Remove pump and tubing. After collecting the samples, the tubing must be properly discarded.

- Measure and record final depth to water and record in logbook.

- Close and lock the well and properly dispose of any PPE or disposable equipment.

- As needed, decontaminate pump and probes before sampling next well.

Any sampling equipment (pumps, tubing, support cable, and electrical wires) coming into contact with the sample must be decontaminated before daily use and after each well is sampled. Decontamination includes:

- Pre-rinse: Operate pump with 8 to 10 gallons of potable water for 5 minutes and flush other sampling equipment with potable water for 5 minutes.

- Wash: Operate pump with 8 to 10 gallons of a nonphosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use detergent sparingly.

- Rinse: Operate pump for 5 minutes and flush other equipment with potable water for 5 minutes.

- Disassemble pump and wash pump parts. Place disassembled pump parts into a solution of nonphosphate detergent. Scrub pump parts with a delicate brush.

- Rinse pump parts with distilled water. Following assembly, operate pump again with distilled water and flush for 5 minutes.

All decontamination waters will be captured and transported to GM's wastewater treatment facility. Dedicated sampling equipment will be bagged and disposed of properly.

3.6.4 Sample Handling, Documentation, Packing and Shipping

The analytical laboratory will supply appropriate pre-cleaned sample containers along with sample labels and preservative(s). Samples will be collected directly from the sampling device into appropriate pre-cleaned laboratory containers. Proper labels will be attached to each sample container. After samples are placed in appropriate containers, they will be placed in a cooler and carefully packed to minimize the possibility of container breakage. Sufficient ice will be placed in the cooler to maintain a shipping/handling temperature of 4 degrees centigrade (+/-2°) until laboratory receipt. A chain-of-custody form will be completed and sealed in the shipping container prior to shipment. Samples will be shipped to the analytical laboratory within 24 hours of sample collection.

All documents, records, and information relating to the performance of the work at the site will be retained. The field crew will maintain a field notebook, which will contain a record of activities performed at the site. The specific measurements of sampling activities will be recorded in the field notebook and/or on separate documentation forms. Data will include sample location, water levels, well depths, and physical observations of the water. Chain-of-custody forms will provide the record of responsibility for sample collection, transport, submittal, and laboratory analyses. The forms will be filled out, signed, and dated by field personnel.

3.6.5 Quality Assurance/Quality Control

This work plan will be performed in accordance with the site QAPP. Specific QA/QC procedures to be included during the performance of the work are:

- Samples should be collected from monitoring wells in order of increasing concentration, to the extent known.
- All data will be documented on field data sheets or within site logbooks.
- All mechanical equipment will be operated in accordance with operating instructions as supplied by the manufacturer. Equipment checkout and calibration activities will occur prior to sampling operations and will be documented (see the site QAPP for additional details).
- All groundwater sampling equipment will be cleaned prior to use in the first well and after each subsequent well; and
- Duplicates, matrix-spike, matrix-spike duplicate (MS/MSD), trip blanks, and rinsate blanks will be collected for use in evaluating data quality.

Additional details for QA/QC are available in the new site QAPP.

3.6.6 Deliverables

At the completion of the project, a summary completion report will be prepared and submitted to the EPA that will include all sampling procedures, details, and analytical results. All groundwater analytical data will be validated by qualified personnel. Water-quality results will be compared in tabular and/or graphical form to historical groundwater sampling results.

Appendix A

Field Method Guidelines

FIELD METHOD GUIDELINES

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FMG 2.0
2.2 Drilling Techniques

DRILLING TECHNIQUES

INTRODUCTION

This section will provide a brief description of common methods for conducting subsurface investigations. It should be noted that every drilling technology has its limitations.

PROCEDURES REFERENCED

- FMG 2.3 - Soil Borings.
- FMG 2.4 - Bedrock Coring.
- FMG 2.6 - Soil Classification.
- FMG 2.7 - Rock Classification.
- FMG 3.2 - Overburden Wells.
- FMG 3.3 - Top of Bedrock Wells.
- FMG 3.4 - Deep Bedrock Wells.
- FMG 3.6 - Piezometers.

PROCEDURAL GUIDELINES

It is important that the drilling method or methods used minimize disturbance of subsurface materials and not contaminate the subsurface and groundwater. The actual drilling method would be dependent upon site-specific geologic conditions. It is important to note that the drilling equipment selected be decontaminated before and between borehole locations to prevent cross contamination (see FMG 9.0 - Equipment Decontamination). Where possible drilling methods that minimize waste generation (soil cuttings), and wastewater generation (decontamination water), should be selected for GM investigation/remedial tasks.

In other settings it may be desirable to dictate drilling procedures that minimize turbidity/maximize the ability to achieve sediment-free groundwater. Generally, rotosonic techniques or rotary spun casing techniques achieve these objectives, or oversizing the borehole/sand pack may be considered, as well.

Rotosonic Drilling

This method consists of a combination of rotation with high frequency vibration to advance a core barrel to a desired depth. Once the vibration is stopped, the core barrel is retrieved, and the sample is vibrated or hydraulically extracted into plastic sleeves or sample trays. Monitoring wells shall be installed through the outer casing with minimal formation disturbance and mixing of formation materials. Rotosonic drilling generally requires less time than more traditional methods and minimizes soil mixing and soil disturbance (preferred for well locations where low turbidity is an important objective). Continuous, relatively undisturbed samples can be obtained through virtually any formation. Conventional sampling tools can be employed as attachments (i.e., hydropunch, split spoon, Shelby tube, etc.). No mud, air, water, or other circulating medium is required. The rotosonic method can drill easily through formations such as rock, sand, clay, or glacial till. The main limitation of this method is the availability of equipment, the large area required (i.e., drill units are quite large), and costs.

Direct-Push (Geoprobe™)

Direct-push refers to the sampler being "pushed" into the soil material without the use of drilling to remove the soil. This method relies on the amount of the drill weight combined with percussion for advancement of the tool string. Discrete soil samples are continuously obtained as well groundwater and vapor samples can also be collected utilizing this method. Subsurface investigations typically probe to depths of 30 feet or more, depths will vary based on site-specific geology.

Direct-push method is widely used for UST investigations and property investigations. This method is used extensively for initial site screening activities to delineate vertical and horizontal plume presence and can significantly reduce investigative costs.

This method is becoming more popular due to the limited cuttings that are produced during the sampling process and the sampling process speed.

The use of the Geoprobe™ 6600 also allows for the installation of 2-inch diameter monitoring wells in that the 4 1/4-inch hollow-stem auger method can be utilized.

Rotary Method

This method consists of a drill rod attached to a drill bit (soils: tricone, drag; rock: button studded, diamond studded) that rotates and cuts through the soils and rock. The cuttings produced are forced to the surface between the borehole wall and the drill rod by drilling fluids which generally consist of water, drilling mud, or air. The drilling fluids not only force the cuttings to the surface but also keep the drilling bit cool. Using rotary methods for well installations can be difficult as it usually requires several steps to complete the installation. First, the borehole is drilled; then temporarily cased; then the well is installed; and then the temporary casing is removed. In some cases, the borehole may remain open without installing a casing but this will only occur in limited instances (i.e., cohesive soils).

i) Water Rotary

When using water rotary, the potable water supply shall be analyzed for contaminants of concern. Water rotary is the preferred rotary method since the potable water is the only fluid introduced into the borehole during drilling. However, the use of water as a fluid is generally only successful when drilling in cohesive soils. The use of potable water (only) also reduces well development time, when compared to mud rotary.

ii) Air Rotary (typically used in rock)

When using air rotary, the air compressor must have an in-line oil filter system assembly to filter the oil mixed with the air coming from the compressor. This will help eliminate contaminant introduction into the formation. The oil filter system shall be regularly inspected. Air compressors not having an in-line oil filter system are not acceptable for air rotary drilling. A cyclone velocity dissipater or similar air containment system shall also be used to funnel the cuttings to one location rather than letting the cuttings blow uncontrolled out of the borehole. Air rotary may not be an acceptable method for well installation where certain contaminants are present in the formation. Alternatively, it may be necessary to provide treatment for the air being exhausted from the borehole during the installation process.

iii) Mud Rotary

Mud rotary is the least preferred rotary method because contamination can be introduced into the borehole from the constituents in the drilling mud (i.e., Ohio, Michigan). The drilling muds are generally non-toxic and do not introduce contaminants into the borehole, however, it is possible for mud to commonly infiltrate and affect water quality by sorbing metals and polar organic compounds (Aller et al., 1991). Chemical composition and priority pollutants analysis may be obtained from the manufacturer. Mud rotary shall utilize only potable water and pure (no additives) bentonite drilling muds. The viscosity of the drilling mud shall be kept as low as possible in order to expedite well development. Proper well development is essential to ensure the removal of all the drilling mud and to return the formation to its previously undisturbed state.

Hollow-Stem Auger

The hollow-stem continuous-flight auger is among the most frequently used in the drilling of monitoring wells (overburden wells) or for placement of overburden casings for bedrock wells.

The primary advantages of hollow-stem augering are that:

- Generally, no additional drilling fluids are introduced into the formation.

- Representative geologic soil samples can be easily obtained using split-spoon samples in conjunction with the hollow-stem augers.
- Monitoring wells can be installed through the augers eliminating the need for temporary borehole casings.

Disadvantages of hollow-stem augering are:

- Creates problems for select parameters.
- Large volumes of cuttings are typically generated.
- Decontamination is fairly time consuming/labor intensive.
- Relatively slow when compared to direct-push methods (soil sampling tasks).

Installing monitoring wells through hollow-stem augers is a relatively simple process although precautions need to be taken to ensure that the well is properly backfilled. This can be particularly problematic in cases where flowing sand is present.

Hollow-stem augers are available with inside diameters of 2.5, 3.25, 4.0, 4.25, 6.25, 8.25, and 10.25 inches. The most commonly used are 4.25 inches for 2-inch (5 cm) monitoring wells and 6.25 inches for 4-inch (10 cm) monitoring wells. Boreholes can usually be drilled with hollow-stem augers to depths up to 100 feet (30 m) in unconsolidated clays, silts, and sands. Removing augers in flowing sand conditions while installing monitoring wells may be difficult since the augers have to be removed without being rotated. A bottom plug or pilot bit assembly should be utilized to keep out soils and/or water that have a tendency to plug the bottom of the augers during drilling. If flowing sands are encountered, potable water (analyzed once for contaminants of concern) may be poured into the augers to equalize the pressure to keep the formation materials and water from coming up into the auger once the bottom plug is removed.

Dual-Wall Reverse Circulation Air Method of Drilling

This method consists of two concentric strings of drill pipe (an outer casing and a slightly smaller inner casing). The outer drill pipe is advanced using rotary drilling with a donut-shaped bit attached to the dual casing string cuts an area only the width of the two casings and annulus between. Compressed air is continually forced down the annulus between the inner casing carrying the drill cuttings and groundwater. At the surface, the inner casing is connected to a cyclone hopper where the drill cuttings and groundwater fall out the bottom of the hopper, and air is disbursed out the top. The dual wall provides a fully cased borehole in which to install a monitoring well. The only soil or groundwater materials exposed at any time are those at the drill bit. Therefore, the potential for carrying contamination from one stratum to another is minimal. Depth-specific groundwater samples can be collected during drilling; however, since the groundwater is aerated, analysis for volatile compounds may not be valid.

Well Points

In some limited cases, well points (sand points) are driven into place without the use of augers. This method provides no information on the geologic condition (other than the difficulty of driving which may be related to formation density). Well points are most often used simply to provide dewatering of a geologic unit prior to excavation in the area. Well points are also used in monitoring shallow hydrogeologic conditions such as in stream beds.

REFERENCES

Numerous publications are available describing current monitoring well design and construction procedures.

Driscoll, F.G., 1986. Groundwater and Wells, 2nd Edition. Johnson Division.

EPA/625/6-90/0166 (July 1991), Handbook Ground Water Volume II: Methodology.

Freeze, R.A. and Cherry, J.A., 1979. Groundwater. Prentice Hall, Inc.

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

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

In addition, the following ASTM publications apply:

ASTM D5474 Guide for Selection of Data Elements for Ground-Water Investigations

ASTM D5787 Practice for Monitoring Well Protection

ASTM D5521 Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers

ASTM D5978 Guide for Maintenance and Rehabilitation of Ground-Water Monitoring Wells

ASTM D5299 Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes and Other Devices for Environmental Activities

ASTM D5092 Standard Practice for Design and Installation of Ground Water Monitoring Wells in an Aquifer.

FMG 2.0
2.6 Soil Classification

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LIST OF FORMS
(Following Text)

REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 2.6
WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS CORPORATION	
REVISION NO.: 0	REVISION DATE:

SOIL CLASSIFICATION

INTRODUCTION

The stratigraphic log is a factual description of the soil at the borehole location and is relied upon to interpret the soil characteristics, and their influence and significance in the subsurface environment. The accuracy of the stratigraphic log is to be verified by the person responsible for interpreting subsurface conditions. An accurate description of the soil stratigraphy is essential for a reasonable understanding of the subsurface conditions. Confirmation of the field description by examination of representative soil samples by the project geologist, hydrogeologist, or geotechnical engineer (whenever practicable) is recommended.

The ability to describe and classify soil correctly is a skill that is learned from a person with experience and by systematic training and comparison of laboratory results to field descriptions.

It is GM's Policy to log soils according to the Unified Soil Classification System (USCS) described in the following.

PROCEDURES REFERENCED

- FMG 2.1 - Test Pits.
- FMG 2.3 - Soil Borings.

PROCEDURAL GUIDELINES

Several methods for classifying and describing soils or unconsolidated sediments are in relatively widespread use. The Unified Soil Classification System (USCS) is the most common. With the USCS, a soil is first classified according to whether it is predominantly coarse grained or fine grained.

The description of fill soil is similar to that of natural undisturbed soil except that it is identified as fill and not classified by USCS group, relative density, or consistency. Those logging soils must attempt to distinguish between soils that have been placed (i.e., fill) and not naturally present; or soils that have been naturally present but disturbed (i.e., disturbed native).

It is necessary to identify and group soil samples consistently to determine the subsurface pattern or changes and non-conformities in soil stratigraphy in the field at the time of drilling. The stratigraphy in each borehole during drilling is to be compared to the stratigraphy found at the previously completed boreholes to ensure that pattern or changes in soil stratigraphy are noted and that consistent terminology is used.

Visual examination, physical observations and manual tests (adapted from ASTM D2488, visual-manual procedures) are used to classify and group soil samples in the field and are summarized in this subsection. ASTM D2488 should be reviewed for detailed explanations of the procedures. Visual-manual procedures used for soil identification and classification include:

- Visual determination of grain size, soil gradation, and percentage fines.
- Dry strength, dilatancy, toughness, and plasticity (thread or ribbon test) tests for identification of inorganic fine grained soil (e.g., CL, CH, ML, or MH).
- Soil compressive strength and consistency estimates based on thumb indent and pocket penetrometer (preferred) methods.

The three main soil divisions are: coarse grained soil (e.g., sand and gravel), fine grained soil (e.g., silt and clay), and soil with high natural organic matter content (e.g., peat and marl).

<u>Coarse Grained Soil</u>

The USCS group symbols for coarse grained soil are primarily based on grain or particle size, grain size distribution (gradation), and percent fines (silt and clay content).

Coarse grained soils are then further subdivided according to the predominance of sand and gravel. Course grained soil is made up of more than 50 percent, by weight, sand size, or larger (75 μm diameter, No. 200 sieve size or larger). It is noted that there are other definitions for coarse grained or coarse textured soil and for sand size such as soil having greater than 70 percent particles equal to or greater than 50 μm diameter.

Descriptions for grain size distribution of soil include; poorly graded (i.e., soil having a uniform grain size, SP and GP) and well graded (i.e., poorly sorted; having wide range of particle sizes with substantial intermediate sizes, SW and GW).

Coarse grained soils are further classified based on the percentage of silt and clay it contains (fines content). Coarse grained soils containing greater than 12 percent fines is commonly described as dirty. This description arises from the soil particles that adhere when the soil is rubbed between the hands or adhere to the sides of the jar after shaking or rolling the soil in the jar. The jar shake test which results in segregation of the sand and gravel particles is also used as a visual aid in determining gravel and sand percentages.

Examples of the group symbol, name, and adjectives used to describe the primary, secondary, and minor components of soil are; GW - Sandy Gravel (e.g., 70 percent gravel and 30 percent sand) or Sandy Gravel trace silt (less than 10 percent silt), and SP - Sand, uniform.

Relative density is an important parameter in establishing the engineering properties and behavior of coarse grained soil. Relative density of non-cohesive (granular) soil is determined from standard penetration test (SPT) blow counts (N values) (after ASTM Method D1586).

The SPT gives a reliable indication of relative density in sand and fine gravel. N values in coarse grained soil are influenced by a number of factors that can result in overestimates of relative density (e.g., in coarse gravel and dilatent silty fine sand) and can be conservative and underestimate the relative density (e.g., sand below the groundwater table and uniform coarse sand). These effects will be assessed by the project geotechnical engineer, if required, and need not be taken into account by field personnel.

Other dynamic methods, such as modified SPT and cone penetration tests, are used on occasion to supplement or replace the SPT method for certain site-specific conditions. The details of all modifications to the SPT or substitute methods should be recorded as they are required to interpret test results and correlate to relative density.

Fine Grained Soil

A soil is fine grained if it is made up of half or more of clay and silt (i.e., fines greater than 50 percent by weight passing the 75 µm (No. 200) sieve size). A description of visual-manual field methods and criteria (after ASTM D2488) that are used to further characterize and group fine grained soil (e.g., CL, CH, ML, or MH) including dry strength, dilatancy, toughness, and plasticity (thread or ribbon test) follows. Fine grained soils are subdivided on a basis of the liquid limit and the degree of plasticity.

The accurate identification of silts and clays can be aided by the use of some single field tests. Clay is sticky, will smear readily, and can be rolled into a thin thread even when the moisture content is low. When it is dry clay forms hard lumps. Silt on the other hand, has a low dry strength, can be rolled into threads only at high moisture content, and a wet silt sample will puddle when it is tapped.

Criteria for Describing Dry Strength

Description	***Criteria***
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.

High	The dry specimen crumbles into powder with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

Criteria for Describing Dilatency

Description	***Criteria***
None	No visible change in small wetted specimen when rapidly shaken in palm of hand.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing or stretching.

Criteria for Describing Toughness

Description	***Criteria***
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Criteria for Describing Plasticity

Description	***Criteria***
Nonplastic	A 1/8-inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be re-rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be re-rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Examples of group symbol identification based on visual-manual procedures and criteria for describing fine grained soil are:

Group Symbol	*Dry Strength Plasticity*	*Dilatency*	*Toughness*
ML	None to low Slight	Slow to rapid	Low or thread cannot be formed
CL	Medium to high Low	None to slow	Medium
MH	Low to medium Low	None to slow	Low to medium
CH	High to very high High	None	High

A requirement for positive classification by USCS group symbols (as described in Test Method ASTM D2487) is laboratory determination of particle size characteristics, liquid limit and plasticity index. The need for this type of testing will be determined by the project geologist, hydrogeologist, or geotechnical engineer.

Examples of name terminology that accompanies the group symbols are ML - Sandy Silt (e.g., 30 percent sand) and CL - Lean Clay with sand (e.g., 15 to 29 percent sand).

The correlation between N value and consistency for clays is rather unreliable. It is preferable to determine consistency using more appropriate static test methods, particularly for very soft to stiff clay soil. N value estimates of consistency are more reasonable for hard clay.

Unconfined compressive strength (Su) may be estimated in the field from the pocket penetrometer test method. To obtain a pocket penetrometer estimate of consistency and compressive strength, the soil core is cut perpendicular to the core length, the length of core (minimum 4 inches) is held in the hand and a moderate confining pressure is applied to the core (not sufficient to deform the core); the penetrometer piston tip is slowly inserted into the perpendicular face of the core until the penetrometer indents into the soil core to the mark indicated on the tip of the penetrometer piston; the penetrometer estimate of soil compressive strength (Su) is the direct reading of the value mark on the graduated shaft (in tons per square foot or other unit of pressure as indicated) indicated by the shaft ring marker, or in some models, by the graduated piston reading at the shaft body. To obtain an average estimate, this procedure is completed several times on both ends and mid cross-section of the core. For Shelby tube (or thin wall sampler) samples the pocket penetrometer tip is applied to the exposed bottom of the sample at several locations.

Estimates of compressive strength for clay soil of very soft to stiff consistency are better established by in situ shear vane tests or other static test methods.

The description of consistency (or strength) is an important element in determining the engineering properties and strength characteristics of fine grained cohesive soil. Consistency terms (e.g., soft, hard) are based on the unconfined compressive strength (Su) and shear strength or cohesion (cu) of the soil.

The ease and pattern of soil vapor and groundwater movement in the subsurface is influenced by the natural structure of the soil. Soil structure, for the most part, depends on the deposition method and, to a lesser extent, climate.

Visual Appearance/Other Features

Those logging soils should also note the presence, depth and components of fill soils (if evident), and note the distinction between disturbed native soils (i.e., excavation likely performed) vs. undisturbed native soils.

Other features such as root presence/structure, and soil fractures should also be recorded. Soil fractures should be described noting fracture orientation (i.e., horizontal/vertical), length/aperture and appearance of soil infilling, oxidation and/or weathering (if present).

Field Sample Screening

Upon the collection of soil samples, the soil is screened with a photoionization detector (PID) for the presence of organic vapor. This is accomplished by running the PID across the soil sample. Record the highest reading and sustained readings.

Note: The PID measurement must be done upwind of the excavating equipment or any running engines so that exhaust fumes will not affect the measurements.

Another method of field screening is head space measurements. This consists of placing a portion of the soil sample in a sealable glass jar, placing aluminum foil over the jar top, and tightening the lid. Alternatively, plastic sealable bags maybe utilized for field screen in lieu of glass containers. The jar should only be partially filled. Shake the jar and set aside for at least 30 minutes. After the sample has equilibrated, the lid of the jar can be opened; the foil is punctured with the PID probe and the air (headspace) above the soil sample is monitored. Record this headspace reading on the field form or in the field book.

Note: Perform all headspace readings in an area that is not subject to wind. Also, in the winter, it is necessary to allow the samples to equilibrate in a warm area (e.g., site trailer, van, etc.). This requirement is dictated by the Work Plan.

All head space measurements must be completed under similar conditions to allow comparability of results.

NAPL Detection

During soil examination and logging, the sampler shall carefully check for the presence of light or dense non-aqueous phase liquid (NAPL). NAPL may be present in gross amounts or present in small/minute quantities. The adjectives and corresponding quantities used when describing NAPL within a soil matrix are as follows:

Visual Description	***Fraction of Soil Pore Volume Containing NAPL***
Saturated	>0.5
Some	0.5 to 0.25
Trace	<0.25

A complete description of NAPL, must describe the following:

- Color.
- Quantity.
- Density (compared to water i.e., light/floats or heavy/sinks).
- Odor (if observed).
- Viscosity (i.e., mobile/flowable, non-mobile/highly viscous-tar like).

The presence of an "iridescent sheen" by itself does not constitute "NAPL presence", but may be an indicator that NAPL is close to the area.

NAPL presence within a soil matrix may be confirmed by placing a small soil sample within water, shaking, and observing for NAPL separation (i.e., light or dense), from the soil matrix.

Trace amounts of NAPL are identified/confirmed by a close visual examination of the soil matrix, [i.e., separate soil by hand (wearing disposable gloves)] and perform a careful inspection of the soil separation planes/soil grains for NAPL presence.

Often during the sample examination with a knife, an iridescent sheen will be noted on the soil surface (i.e., clay/silts) if the knife has passed through an area of NAPL.

There are a number of more sophisticated tests available to confirm/identify NAPL presence, these are:

- UV fluorescent analysis.
- Hydrophobic dyes.
- Centrifugation.
- Chemical analysis.

Typically consultants will utilize organic vapor detection results, visual examination, soil/water shake testing, and chemical analysis, to confirm NAPL presence. The more complex techniques described may be incorporated on sites where clear colorless NAPL is present and its field identification is critical to the program.

Note: When describing the presence of vegetative matter in the soil sample, do not use the term "organic" as this often leads to confusion with regards to the presence of organic chemicals (i.e., NAPL).

EQUIPMENT/MATERIALS

- Pocket knife or small spatula.
- Small handheld lense.
- Form FMG 2.6-01 - Stratigraphic Log - Overburden (Page 1/Page 2).
- Tape measure.

REFERENCES

American Society for Testing and Materials (1991), Standard D1452-80, "Practice for Soil Investigation and Sampling by Auger Borings", "Annual Book of ASTM Standard", Section 4, Volume 04.08.

ASTM Standards on Environmental Sampling (1995), Standard D2488-93, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)"

ASTM Standards on Environmental Sampling (1995), Standard D4700-91, "Guide for Soil Sampling from the Vadose Zone".

ASTM Standards on Environmental Sampling (1995), Standard D1586-92, "Test Method for Penetration Test and Split-Barrel Sampling of Soils".

ASTM Standard D2487, "Classification of Soils for Engineering Purposes (Unified Soil Classification System)".

Geotechnical Gauge, Manufactured by W.F. McCollough, Beltsville, MD.

Sand Grading Chart, by Geological Specialty Company, Northport, Alabama.

FMG 3.0
3.1 Well Construction Materials

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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.

Campbell, M.D., and Lehr, J.H., Water Well Technology, McGraw Hill, 1973.

Cold Weather Concreting, ACI Committee 306, Materials Journal, Volume 85, Issue 4, July 1, 1988.

Driscoll, Fletcher G., Groundwater and Wells, Johnson Filtration Systems, Inc., 1986.

Freeze, R. Allen, and Cherry, John A., Groundwater, Prentice-Hall, 1979.

USEPA, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, Office of Solid Waste and Emergency Response, 1986.

WELL DEVELOPMENT AND STABILIZATION FORM

PROJECT NAME: ____________________ PROJECT NO.: __________

DATE OF WELL DEVELOPMENT: ____________________

DEVELOPMENT CREW MEMBERS: ____________________

PURGING METHOD: ____________________

SAMPLE NO.: ____________________

SAMPLE TIME: ____________________

WELL INFORMATION

WELL NUMBER: ____________________

WELL TYPE (diameter/material) ____________________

MEASURING POINT ELEVATION: ____________________

STATIC WATER DEPTH: ____________________ ELEVATION: __________

BOTTOM DEPTH: ____________________ ELEVATION: __________

WATER COLUMN LENGTH: ____________________

SCREENED INTERVAL: ____________________

WELL VOLUME: ____________________

Note: For 2-inch diameter well: 1 foot = 0.14 gallons (Imp) or 0.16 gallons (US)
1 meter = 2 liters

	UNITS	*1*	*2*	*3*	*4*	*5*	*TOTAL/ AVERAGE*
VOLUME PURGED (volume/total volume):							
FIELD pH:							
FIELD TEMPERATURE:							
FIELD CONDUCTIVITY:							
CLARITY/TURBIDITY VALUES:							
COLOR:							
ODOR:							
COMMENTS:							

COPIES TO: ____________________

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

FMG 3.0
3.7 Well Development

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WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS CORPORATION	
REVISION NO.: 1	REVISION DATE: APRIL 14, 2003

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 (COCs). When sampling for COCs sensitive to turbidity presence (i.e., SVOCs, PCBs, 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
VOCs	24 hours
SVOCs, PCBs, 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.

FMG 5.0
5.1 Water Level Measurement

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WATER LEVEL MEASUREMENTS

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WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS CORPORATION	
REVISION NO.: 0	REVISION DATE:

WATER LEVEL MEASUREMENTS

INTRODUCTION

This procedure describes measurement of water levels in groundwater monitoring and extraction wells, piezometers and boreholes. This procedure does not cover automated measurement of water levels with a transducer/datalogger, and does not cover measurement of phase-separated liquids.

Water levels in monitoring wells will be measured prior to each sampling event and at other times as indicated in the project Work Plan. Water levels will be acquired in a manner that provide accurate data that can be used to calculate vertical and horizontal hydraulic gradients and other hydrogeologic parameters. Accuracy in obtaining the measurements is critical to insure the useability of the data.

PROCEDURES REFERENCED

- FMG 6.5 - Non-Aqueous Phase Liquid (NAPL).
- FMG 8.0 - Field Instruments – Use/Calibration.
- FMG 9.0 - Equipment Decontamination.

PROCEDURAL GUIDELINES

In order to provide reliable data, water levels must be collected over as short a period of time as practical. Barometric pressure can affect groundwater levels and, therefore, observation of significant weather changes during the period of water level measurements must be noted. Tidal fluctuations, navigation controls on rivers, rainfall events, and groundwater pumping can also affect groundwater level measurements. Personnel collecting water level data must note if any of these controls are in effect during the groundwater level collection period. Due to possible changes during the groundwater level collection period, it is imperative that the time of data collection at each station be accurately recorded.

In conjunction with groundwater level measurements, surface water (e.g., ponds, lakes, rivers, and lagoons) often are monitored as well. This information is very helpful (and can be critical) in understanding the hydrogeologic setting of the site and most importantly how contaminants may move beneath the site.

The depth to groundwater will be measured with an electronic depth-indicating probe. Prior to obtaining a measurement, a fixed reference point on the well casing shall be established for each well to be measured. Unless otherwise established, the reference point is typically established and marked on the north side of the well casing. Avoid using protective casings or flush-mounted road boxes for reference, due to the greater potential for damage or settlement.

If provided for in the project Work Plan, the elevation of the reference point shall be obtained by accepted surveying methods, to the nearest 0.01 foot.

The water level probe will be lowered into the well until the meter indicates (via indicator light or tone) the water is reached. The probe will be raised above water level and slowly lowered again until water is indicated. The cable will be held against the side of the inner protective casing at the point designated for water level measurements and a depth reading taken. This procedure will be followed three times or until a consistent value is obtained. The value will be recorded to the nearest 0.01 foot on Form FMG 5.1-01 - Groundwater Level Monitoring Report or other designated data recording location if specified in the project Work Plan.

Upon completion, the probe will be raised to the surface and together with the amount of cable that entered the well casing, will be decontaminated in accordance with methods described in FMG 9.0 - Equipment Decontamination.

EQUIPMENT/MATERIALS

- Battery-operated, non-stretch electronic water level probe with permanent markings at 0.01-foot increments (traceable to national measurement standards), such as the Solinst Model 101 or equivalent.
- The calibrated cable on the depth indicator will be checked against a surveyor's steel tape once per quarter year. A new cable will be installed if the cable has changed by more than 0.01 percent (0.01 foot for a 100-foot cable). See also FMG 8.0 - Field Instruments – Use/Calibration.

REFERENCES

ASTM D4750 - Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).

ASTM D6000 - Guide for Presentation of Water-Level Information from Ground-Water Sites.

Form FMG 5.1-01

GROUNDWATER LEVEL MONITORING REPORT

WELL NUMBER

Page ____ of ____

PROJECT ______________________ **PROJECT MANAGER** ______________
LOCATION ______________________ **FIELD REP.** ______________
CLIENT ______________________ **DATE** ______________
ELEVATION REFERENCED TO: ______________________

Date	Time	Elapsed Time (days)	Depth of Water from ( ) in ft	Elevation of Water	Remarks	Read By

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

FMG 5.0
5.2 In-Situ Hydraulic Conductivity (Slug Test) Procedure

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WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: SEPTEMBER 16, 2002
GENERAL MOTORS CORPORATION	
REVISION NO.: 1	REVISION DATE: NOVEMBER 12, 2002

IN SITU HYDRAULIC CONDUCTIVITY (SLUG TEST) PROCEDURE

INTRODUCTION

This procedure describes the protocol for performing in situ hydraulic conductivity (slug) tests, including preparation, collection of valid field data, and preliminary evaluation of the data.

A slug test is performed to assess the horizontal hydraulic conductivity of a water-bearing zone. Slug tests are accomplished by stressing the screened water-bearing zone through an instantaneous displacement (with a slug) (or removal of water with a bailer) and subsequently measuring and recording the water level response in the well versus time. If the removal of the slug or bailer does not result in the well recovering more than 5 percent of the "90 percent recovery time", then it is considered an "instantaneous" displacement.

Slug testing in select monitoring wells will be performed after the wells have been installed and developed as covered in the Work Plan. Slug testing data will be acquired in a manner that provides valid data that can be used to calculate the horizontal hydraulic conductivity of the formation tested.

There are two types of slug tests: falling-head tests and rising-head tests. It is generally preferable to do a rising-head slug test due to a number of potential problems that can arise with falling-head tests (some of these may lead to inaccurate hydraulic conductivity estimates). It is recommended water level measurements should be collected automatically using a datalogger/ pressure transducer system if at all possible, but they may be collected manually using a battery-operated water level measurement probe if necessary.

PROCEDURES REFERENCED

- FMG 3.0 - Monitoring Wells, Pump Wells, and Piezometers.
- FMG 5.1 - Water Level Measurements.
- FMG 8.0 - Field Instruments – Use/Calibration.
- FMG 9.0 - Equipment Decontamination.
- FMG 10.0 - Waste Characterization.

PROCEDURAL GUIDELINES

A slug test involves rapidly changing the water level in a well and then measuring the water-level response over time. A very quick change in the water level in a well should be effected at the beginning of a slug test using one of several methods:

- Preferably by inserting or withdrawing a solid or sealed object with an appropriate overall density.
- By changing the air pressure in a well (only when a pressure transducer is used).
- Only if absolutely necessary, adding or removing a slug of water (bailer).

The method chosen will depend on project needs, equipment availability, water disposal/ treatment options, pertinent laws and regulations, and operator experience.

The protocols that follow assume that a person effectively can perform one of the above methods for rapidly changing the water level in a well at the start of a slug test, and can then use either a manual or automatic procedure for measuring water level response over time.

<u>Considerations</u>

Certain activities should be avoided in slug testing. In general, a person should **not** conduct any type of slug testing in a well if:

- The well contains a pipe, a tube, or an obstruction in a depth range where the water level would change.
- The casing diameter in a well varies in the depth range where the water level would level change.
- The water level in a well has not yet recovered to nearly static conditions (e.g., 95 percent or more) after a prior disturbance (e.g., drilling, purging, development, previous well testing, etc.).
- Non-aqueous phase liquid (NAPL) is present in a well.

A ***rising-head*** test should generally **not** be conducted:

- By bailing multiple times, rather than creating an instantaneous water level change.
- By pumping to remove water, unless the amount of water to be removed by the pump can be removed nearly instantaneously and any backflush can be eliminated.
- By using bailers. If bailers must be used, avoid:
  - using a bailer that has a leaky check valve, or

- using a bailer with a diameter so close to that of the casing that groundwater is suctioned into the well while the bailer is raised.

- If the slug cannot be removed nearly instantaneously (e.g., if removal takes over 5 percent of the 90 percent recovery time).

Falling-head tests are generally **not** recommended due to inherent problems associated with reproducibility, the introduction of fluids, and general application restrictions. They are recommended in circumstances when no other option is available. Consult with the Project Manager or an experienced hydrogeologist before undertaking a falling-head test program. Note: Under no circumstances should a falling-head test be performed in a well where the static water level is within the screened section of the well.

Field Documentation

The following data should be obtained prior to heading into the field and/or in the field during slug testing and recorded appropriately (e.g., on Form FMG 5.2-01 - Slug Test Data Report), in a field book, and/or onto an electronic form copied to computer disk):

- Client name.
- Site name.
- Testing company.
- Name of tester.
- Date and time of test.
- Well number.
- Well location.
- Well casing, screen and borehole diameters.
- Well open hole section diameter.
- Total depth of well.
- Any unusual well, weather, or hydrologic features or conditions.
- Top-of-riser distance above ground surface.
- Test procedure used (slug, pneumatic, etc.).
- Transport and disposal methods for any water removed.
- Well drilling method (hollow-stem auger, mud rotary, etc.).
- Decontamination procedures.
- Problems and solutions to problems encountered during testing.
- Static water level.

Other information needed for proper slug-test data interpretation includes:

- Depth interval of screen or open section in well.
- Sandpack porosity (if water levels intersect screen).
- Sandpack diameter (if water levels intersect screen).
- Stratigraphic horizon materials and elevations.
- Hydraulic conductivity of bounding low hydraulic conductivity units, if present.
- Ground surface elevation.

Testing

The steps for conducting a slug test are as follows. An attempt to utilize dataloggers to collect water level measurements should be made if at all possible. Manual measurements should only be used if absolutely necessary but can, and should, be used to collect backup data. The steps for conducting a slug test using automatic water level measurements are as follows:

1. Conduct a review of the Work Plan and the Health and Safety Plan with the project field supervisor, and plan, as needed, for notifications to responsible parties and for site access.
2. Gather equipment needed and inspect for operation.
3. Decontaminate all necessary equipment before entering a site and between each well or as required in the Work Plan or in accordance with FMG 9.0 - Equipment Decontamination, if different.
4. Measure and record the static water level (SWL) in the well to be tested, the depth to bottom, and record whether the bottom is a hard or soft (silty) base.
5. Test the pressure transducer and data logger, and obtain well-bottom and SWL pressures, using the following steps:
   - Place the pressure transducer at least several feet below the top of water as well as below the projected depth of the lowest part of the slug to be used.
   - Make pressure readings until three uniform values are read consecutively.
   - Raise the datalogger 1 foot from its original position. View the pressure reading to confirm that the change in position was accurately reported by the transducer. Repeat the procedure, if required, lowering the transducer a greater distance and again confirming the readings.
   - Return the transducer to its original position and secure the suspension cable to the well casing. Again, make pressure readings until three uniform values are read consecutively. Compare with the original readings to make sure no drift occurs.

6. Perform the following pre-test activities if a rising-head test is to be performed:
   - Allow the slug that will be used to move slowly down into the groundwater. If possible, fully immerse the slug. If there is not enough water in the well for the slug to be fully immersed, then let the bottom of the slug gently come to rest on the well bottom if a hard base can be confirmed, or in the case of a soft well base, enough above the well bottom to avoid immersion in silt. For bailers, prevent agitation of sediment on the bottom of the well as sediment in the bailer may keep the check valve from properly sealing. Ensure that the slug will not bind with the transducer cable and cause the transducer to move.
   - Measure falling pressures during recovery using the pressure transducer until the water level in the well re-equilibrates to near-static conditions (95 percent recovery).
   - Set the pressure transducer below the base of the immersed slug.
7. Start the slug test by creating a nearly instantaneous displacement in water level:
   - For a ***rising-head*** test:
     - Pull the slug rapidly upwards, either remove it from the well (preferred), or secure/suspend it within the well several feet above the SWL if conditions prohibit removing it (for example, significant depth to water coincides with taking manual water level measurements). When using a bailer ensure, upon retrieving the bailer to the surface, that it is not leaking and contains the appropriate volume of water (full if entirely immersed, etc.).
     - Simultaneously pull slug and initiate the datalogger, beginning the measuring/ recording of rising water levels in the well at the predetermined time frequencies (a logarithmic time scale is usually employed).
     - If a bailer is used, listen for cascading water while the bailer is being raised or is suspended, a sign of check valve failure; if failure occurs, clean and repair the valve and start over.
     - If a bailer is used, measure the volume of water removed by the bailer after retrieval.
   - For ***falling-head*** tests, if employed, prepare the test in the same manner as for the rising-head test, but instead add a solid slug or a known volume of water as opposed to removing a slug or bailer of water.
8. Continue measuring the water levels as they change over time until the water in the well rises or falls to the limit specified in the Work Plan (if not specified then usually 90 percent recovery or 1 hour, whichever comes first (check with Project Manager to be sure). A preset logarithmic sampling interval, with increasing intervals of time, is ideal, usually predetermined by the datalogger's default setup. Check the datalogger to ensure data were collected.
9. Compare the volume of groundwater recovered in the bailer, if one is used, with the volume of groundwater estimated to have been removed from the well (V) based on the

initial recorded water level displacement (H) and borehole radius (r), e.g., $V=H\pi r^2$. If, for a rising-head test, the static water level lies within the screened section of the well, then the sandpack porosity (n) and radius (R) must accounted for also in the volume calculation, e.g., $V=H\pi r^2 + nH\pi(R-r)^2$. A similar comparison can be performed if a slug is used. If the volume recovered and the calculated volume do not reasonably correlate, based on site-specific conditions, the test should be performed again.

10. Record all general data in a field book and all pertinent testing data on Form FMG 5.2-01 - Slug Test Data Report.
11. Decontaminate all necessary equipment in accordance with the Work Plan or methods described in FMG 9.0 - Equipment Decontamination.
12. Properly containerize and label spent decontamination fluid or groundwater removed from the well in accordance with the Work Plan or methods described in FMG 10.0 - Waste Characterization.
13. Lock all well caps and secure the site as needed.
14. Submit the slug test data to a qualified scientist or engineer assigned by the Project Manager for interpretation. The data should be interpreted by an experienced hydrogeologist. Calculations should be based on an appropriate model for the known hydrogeologic conditions in the field. Evaluation of slug test data should be performed using an acceptable analytical method; GM preference is that slug tests be evaluated using either the Bouwer and Rice (1976) or Hvorslev (1951) method.

Any variations from these procedures should first be approved by the project field supervisor and/or Project Manager.

EQUIPMENT/MATERIALS

- A battery-operated water level measurement probe, marked in 0.01-foot increments.
- Form FMG 5.2-01 - Slug Test Data Report.
- Data logger and laptop computer with fully charged battery (if required).
- A solid or sealed slug (or a clean bailer).
- Clean rope or string for raising and lowering a slug.
- Appropriate container for withdrawn groundwater and/or decontamination fluids.
- If snow or soil removal from over a well might be required, a shovel.
- Site-access and well-cap keys, as needed.
- Site maps (property lines, wells, topography, etc.), as needed.
- If a well to be slug tested is an artesian flowing well, duct tape, couplings, and extra casing of appropriate diameter for increasing casing height so as to enable measurement of a static water level.

- Pressure transducer of appropriate pressure range for the depths of water to be tested, if needed.

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SLUG TEST DATA REPORT

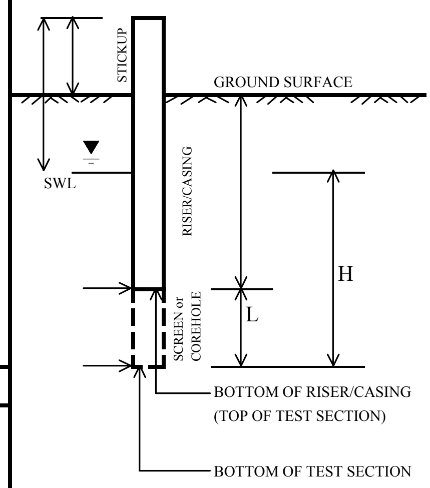
WELL NO.

Page 1 **of**

PROJECT ______________________ **PROJECT MGR.** ______________
LOCATION ______________________ **FIELD REP.** ______________
CLIENT ______________________ **TEST DATE** ______________

Well Type (overburden, bedrock, etc.) ______________
Installation Date ______________
Displacement method (slug, bailer, pneumatic) ______________
Test Section Length, L (ft.) ______________
Borehole Diameter (in.) ______________
Casing/Riser Diameter (in.) ______________
Interval type (screen, open rock, etc.) ______________
Saturated Thickness, H (ft.) ______________
Soil Description, depths ______________
____

SKETCH/REMARKS



ALL DIMENSIONS IN FEET - Not To Scale

DEPTH/HEIGHT/ELEVATION:

Stick-Up/Stick-Down (ft.) ______________ Static Water Level (ft.) ______________
Top Of Test Interval (ft.) ______________ Depth to Bottom (ft.) ______________
Bottom Of Test Interval (ft.) ______________

WATER LEVEL MEASUREMENT DATA

Clock Time	Time (min:sec)	Elapsed Time (min)	Depth To Water From ________ (ft)	Water Elevation (ft)	Comments

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

FMG 6.0
6.1 Soil

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SOIL

LIST OF FORMS
(Following Text)

SOIL

INTRODUCTION

The following procedure describes typical soil sample collection methods for submission of samples to a laboratory for chemical analysis. Three sample situations are presented: soil sampling from surficial soils, soil sampling from subsurface samplers such as a split-spoon sampler or a direct push sampler, and lastly soil sampling from a test pit.

Soil sampling procedures may vary from project to project due to different parameters of concern, different guidance provided by the state/province where the site is located, or the specific objectives for the project. Therefore, it is essential that the sampling team members carefully review the Work Plan requirements and the rationale behind the program. The primary goal of soil sampling is to collect representative samples for examination and chemical analysis (if required).

Grab Versus Composite Samples

A grab sample is collected to identify and quantify compounds at a specific location or interval. The sample shall be comprised of no more than the minimum amount of soil necessary to make up the volume of sample dictated by the required sample analyses. Composite samples are a mixture of a given number of sub-samples and are collected to characterize the average chemical composition in a given surface area or vertical horizon.

PROCEDURES REFERENCED

- FMG 2.1 - Test Pits.
- FMG 2.2 - Drilling Techniques.
- FMG 2.3 - Soil Borings.
- FMG 2.6 - Soil Classification.
- FMG 6.10 - Sample Handling and Shipping.
- FMG 9.0 - Equipment Decontamination.

PROCEDURAL GUIDELINES

1. SURFICIAL SOIL SAMPLE COLLECTION

1.1 Sample Strategy -Random, Biased, and Grid-Based Sampling

Unless there is a strong indication of contaminant presence, such as staining, then soil sample locations may be randomly selected from several areas within the site.

If any areas show evidence of contamination, such as staining or vegetative stress, biased samples shall be collected from each area to characterize the contamination present in each area. Background and control samples are also biased, since they are collected in locations typical of non-site-impacted conditions.

When soil sampling investigations involve large areas, a grid-based soil sampling program is used. There is no single grid size that is appropriate for all sites. Common grid sizes are developed on 50-foot and 100-foot centers. It is acceptable to integrate several different grid sizes in a single investigation.

For surficial soil sampling programs, it is also important to consider the presence of structures and drainage pathways that might affect contaminant migration. It is sometimes desirable to select sampling locations in low lying areas which are capable of retaining some surface water flow since these areas could provide samples which are representative of historic site conditions (worst-case scenario if surface water flow was a concern).

1.2 Sample Interval

Surficial soils are generally considered to be soil between ground surface and 6 to 12 inches below ground surface. However, for risk assessment purposes, regulatory authorities often consider soil from ground surface to 2 feet below ground surface to be surficial soil. The exact interval to be considered as surficial soil is often a matter of discussion with the regulatory authorities that review the Work Plan. The sample interval is important to the manner in which the data are ultimately interpreted. Another important factor is the type of soil. If there are different types of soil present at the site, this may have a bearing on the sample interval. For example, it may be important to separately sample a layer of material with high organic carbon content which overlies a layer of fine grained soil.

1.3 Surface Sampling Procedure

Soil sampling techniques are dependent upon the sample interval of interest, the type of soil material to be sampled, and the requirements for handling the sample after retrieval. The most common method for collection of surficial soil samples involves the use of a stainless steel trowel. Soil samples may also be collected with spoons and push tubes. The sampling equipment is cleaned between sample locations. A typical surficial soil sampling protocol is outlined below:

- Surficial soil samples will be collected using a precleaned stainless steel trowel or other appropriate tool. Each sample will consist of soil from the surface to the depth specified within the Work Plan.
- A new pair of disposable gloves will be used at each sample location.
- Any surficial debris (i.e., grass cover, gravel) should be removed from the area where the sample is to be collected using a separate precleaned device. Gravel presents difficulties for the laboratory in terms of sample preparation and is typically not representative of contaminant concentrations in nearby soil.
- A precleaned sampling tool will be used to remove the sample from the layer of exposed soil.
- When only one sample container is required, the collected soil will be placed directly into the clean, pre-labeled sample jar. When more than one sample container requires filling or samples will be split for duplicate analyses; the soils will first be homogenized in a precleaned stainless steel bowl; and then placed into the respective sample containers. It is important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. When round bowls are used for sample mixing, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Soil samples collected for volatile organic compounds analyses shall not be mixed.
- Samples will be placed on ice or cooler packs in laboratory supplied shipping coolers after collection.

Exception is noted for the collection of volatile organic compounds (VOCs) which require special sample collection methods. VOCs are collected directly into a sample vial (triplicate volume typically required) without headspace, or collected using an EnCore Sampler™ (triplicate samples collected in accordance with manufacturer's instructions). Samples for VOCs are typically collected first, without homogenization or extra handling to limit the loss of volatile constituents.

The VOC sample collection methodology will be identified in the Work Plan, which will dictate the sample method. The methodology for VOC sampling varies from area to area, so carefull review of this issue in advance of the field efforts is required.

2. SUBSURFACE SAMPLE COLLECTION

Subsurface soil sample collection is typically performed with the help of a drill unit, direct-push probing unit, or hand-driven/held samplers. Typically a boring is advanced incrementally to permit intermittent or continuous sampling to the required depth of chemical sample collection;

or alternatively sampling may be initiated if certain conditions are observed (i.e., chemical presence or volatile presence identified from monitoring). Sample collection criteria and locations, are normally stipulated by the Work Plan.

Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test or other sampling technique is performed on essentially undisturbed soil is acceptable. The drilling method is to be selected based on the subsurface conditions. Each of the following procedures have proven to be acceptable for specific subsurface conditions:

- Conventional drilling with continuous flight hollow-stem auger (HSA) method (with inside diameter between 2.2 and 6.5 inches) using split-spoon samplers (Standard Penetration Test – STP) or Shelby tube samplers; or
- Direct-push samplers, advanced using a percussion/vibratory hammer (Geoprobe™ or equivalent); or
- Hand–held/driven split-spoon sampling equipment or portable hammer and split-spoon sampling equipment (final depth will be limited).

Several drilling methods are not acceptable. These include: jetting through an open tube sampler and then sampling when the desired depth is reached; use of continuous flight solid auger equipment below the groundwater table in non-cohesive soils; casing driven below the sampling depth prior to sampling; and advancing a borehole with bottom discharge bits.

The following subsections describe the specific methods for completing split-spoon sampling, Shelby tube sampling, and direct-push sampling. Section 2.4 - Soil Core Chemical Sample Collection Procedure describes the soil sampling procedure for chemical analysis, once a soil core is recovered from any of the above sample collection devices.

2.1 Split–Spoon Sampling Method

This method is used to obtain representative samples of subsurface soil materials for sample collection. The test methods described below must be followed to ensure that the soils captured in the split-spoon or Shelby tube are relatively undisturbed/representative of the desired soil interval and obtain accurate SPT values. The SPT values reflect the subsurface soils density and is typically measured when performing geotechnical work or environmental borings. This information although not directly relevant to the collection of chemical samples, is collected because it is beneficail in terms of stratigraphy interpretation and understanding the conditions below grade.

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. Larger spoons are available for use when a larger sample volume is required (4-inch diameter spoons).

Once the borehole (i.e., HSA) 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 D1586-84). 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 field supervisor 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 field supervisors work surface.

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

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. The drilling fluid level within the boring or HSA 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.

Section 2.4 - Soil Core Chemical Sample Collection Procedure describes the soil sampling procedure for chemical analysis, once a soil core is recovered from a split-spoon sampler.

2.2 Thin-Walled (Shelby Tubes) Sample Method

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 (such as collection of soils for chemical analysis) that might be influenced by sample disturbance. Procedures for conducting thin-walled tube sampling are provided in ASTM D1587-94, 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.

On occasion it maybe required that extraction of the sample from the tube be conducted in the field for chemical sample collection. The following procedure should be followed.

- 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 select the area for sample collection (see Section 2.4 - Soil Core Chemical Sample Collection Procedure). Form FMG 6.1-01 - Soil Sample Selection Details shows the method for obtaining a soil sample from a Shelby tube soil core.
- 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.

Section 2.4 - Soil Core Chemical Sample Collection Procedure describes the soil sampling procedure for chemical analysis, once a soil core is recovered from a Shelby tube sampler.

2.3 Direct-Push Sample Method

The operation of the direct-push samplers (i.e., Macro-Core™ Soil Sampler or equivalent) consists of "pushing and/or vibrating" the sampler into the subsurface using a direct-push unit (i.e., Geoprobe™ soil probing machine or equivalent). The sampler is typically a hollow tube with a threaded drive head, and threaded cutting shoe; provided with an internal sleeve (i.e., liner) that the soil sample is captured in.

Once driven to the required depth, the sampler body/soil liner and soil core is removed from the borehole for inspection and sample collection. Once above grade the sampler is opened by the probe operator and the liner removed and cut open (opened with a dual blade cutting tool), to expose the soil for inspection and sampling.

The sampler body and ends are decontaminated, and a new liner is inserted and the sampler reassembled for collection of the next interval. The clean sampler is then advanced 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-tube is most commonly used method, typically employed in stable soil conditions when the borehole does not collapse. The closed-point system seals the cutting shoe opening until the sampler is at the next sample interval, this prevents collapsed soil from entering the sampler as it is advanced back down the hole. Once at the sample depth, the closed-point is unthreaded and released from the cutting shoe area, such that it rides on top of the soil core as it is being driven into the next interval.

Section 2.4 - Soil Core Chemical Sample Collection Procedure describes the soil sampling procedure for chemical analysis, once a soil core is recovered from a direct-push sampler.

2.4 Soil Core Chemical Sample Collection Procedure

The following describes the collection of soil samples for chemical analysis from a split-spoon soil core, Shelby tube soil core, or direct-push sample core. Form FMG 6.1-01 - Soil Sample Selection Details shows the soil sample selection details. Sample preparation and selection is as follows:

- Record soil core recovery and soil stratigraphy data.
- Discard upper and lower ends of sample core (3 inches ±).
- If clayey soils are present use a precleaned stainless steel knife to cut the remaining core longitudinally, alternatively if sandy soils are present, use a clean stainless steel spoon to scrape away the soil surface.
- Screen the exposed soil surface with a PID to monitor for the presence of volatile organics.

- With a sample knife or spoon, remove soil from the center portion of the core and place in the sample jar (when only one aliquot is required), or when more than one aliquot is required place soils in a precleaned stainless steel bowl for homogenization.
- Do not sample large stones and natural vegetative debris.
- Homogenize the soil and place directly into the sample jars.
- Place collected samples on ice or cooler packs in laboratory-supplied shipping coolers.

When only one sample container is required, the collected soil will be placed directly into the clean, pre-labeled sample jar. When more than one sample container requires filling or samples will be split for duplicate analyses; the soils will first be homogenized in a precleaned stainless steel bowl; and then placed into the respective sample containers. It is important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. When round bowls are used for sample mixing, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Soil samples collected for volatile organic compounds analyses shall not be mixed.

Exception is noted for the collection of VOCs which require special sample collection methods. VOCs are collected directly into a sample vial (triplicate volume typically required) without headspace, or collected in triplicate using an EnCore Sampler™ (triplicate samples collected per manufacturers instructions). Samples for VOCs are typically collected first, without homogenization or extra handling to limit the loss of volatile constituents.

The VOC sample collection methodology will be identified in the Work Plan, which will dictate the sample method. The methodology for VOC sampling varies from area to area, so carefull review of this issue in advance of the field efforts is required.

3. TEST PIT SOIL SAMPLE COLLECTION

Subsurface soil samples from a test pit are usually "grab samples", used to characterize the soil at a specific depth or depth interval (e.g., 2 to 4 feet). On occasion, composite samples are collected from a test pit over a greater depth interval (e.g., 5 to 15 feet) to characterize a soil or fill horizon.

Soil samples can be collected from the soils within the backhoe/excavation bucket or from the test pit excavation face (only after the safety concerns identified below have been addressed). Samples that require a discrete depth interval should be collected from the excavation face. Samples are procured using a cleaned steel trowel, shovel, or stainless steel spoon.

Safety Concerns:
1. Do not enter the test pit unless Confined Space Entry requirements have been reviewed and applied (if required); and proper shoring of the excavation walls has been performed, (if necessary.)

2. *Personnel observing or sampling test pit operations must never stand within the "turning radius" or "reach-zone" of the excavation equipment. Operator error, or equipment failure could result in severe injury or death if struck by the backhoe bucket or the backhoe itself.*
3. *Lastly, personnel should be alert to test pit side wall conditions which typically undermine the ground surface and create unstable soils surrounding the test pit area.*

The following describes the collection of grab samples for chemical analysis:

- Record soil stratigraphy and test pit data/observations, select area from which sample is required.
- Direct backhoe operator to scoop up soils from the desired area and place at ground surface.
- If clayey soils are present use a precleaned stainless steel knife to scrape away the surface soils that may have contacted the backhoe bucket; alternatively, if sandy soils are present, use a clean stainless steel spoon to scrape away the soil surface.
- Screen the exposed soil surface with a PID to monitor for the presence of volatile organics.
- With a sample knife or spoon, remove soil from the center portion of the area cleared and place in the sample jar (when only one aliquot is required), or when more than one aliquot is required place soils in a precleaned stainless steel bowl for homogenization.
- Do not sample large stones and natural vegetative debris.
- Homogenize the soil and place directly into the sample jars.
- Place collected samples on ice or cooler packs in laboratory supplied shipping coolers.

When only one sample container is required, the collected soil will be placed directly into the clean, pre-labeled sample jar. When more than one sample container requires filling or samples will be split for duplicate analyses; the soils will first be homogenized in a precleaned stainless steel bowl; and then placed into the respective sample containers. It is important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. When round bowls are used for sample mixing, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Soil samples collected for VOC analyses shall <u>not</u> be mixed.

Exception is noted for the collection of VOCs which require special sample collection methods. VOCs are collected directly into a sample vial (triplicate volume typically required) without headspace, or collected in triplicate using an EnCore Sampler™ (triplicate samples collected per manufacturers instructions). Samples for VOCs are typically collected first, without homogenization or extra handling to limit the loss of volatile constituents.

The VOC sample collection methodology will be identified in the Work Plan, which will dictate the sample method. The methodology for VOC sampling varies from area to area, so carefull review of this issue in advance of the field efforts is required.

Field Notes

All conditions at the time of sample collection should be properly documented in the field log book. This should include a thorough description of the collection method, sample characteristics, including grain size, color, and general appearance, as well as date/time of sampling and labeling information. The location of the sampling point should be described in a sketch and three measurements (swing ties) should be taken to adjacent permanent structures so that the sample location can be readily identified in the field at a future date if necessary. It is often advisable to have a licensed land surveyor accurately survey the locations.

Decontamination

In all sampling scenarios measures to prevent cross-contamination must be employed. The sampling device selected must be constructed of an inert material with smooth surfaces that can be readily cleaned (see FMG 9.0 - Equipment Decontamination).

Heavy equipment used for test pit operations must also be cleaned between each location when collecting samples for chemical analysis.

EQUIPMENT/MATERIALS

- Drilling equipment and soil sampling tools.
- Decontamination fluids and rinse water.
- Subsurface boring log.
- Tape measure.
- Water level probe.

REFERENCES

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).

ASTM D4700-91 - Guide for Soil Sampling from the Vadose Zone.

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.

FMG 6.0
6.4 Groundwater Sampling

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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.

<u>Preparatory Requirements</u>

- 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.

Well Purging and Stabilization Monitoring (Typical Method)

- 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.

<u>Sampling Techniques</u>

- 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).

WELL PURGING FIELD INFORMATION FORM

JOB# ______ - ___

SITE/PROJECT NAME: ____________________

WELL# ______

WELL PURGING INFORMATION

PURGE DATE (MM DD YY)	SAMPLE DATE (MM DD YY)	WATER VOL. IN CASING (LITRES/GALLONS)	ACTUAL VOLUME PURGED (LITRES/GALLONS)

PURGING AND SAMPLING EQUIPMENT

PURGING EQUIPMENT.........DEDICATED Y N (CIRCLE ONE)

SAMPLING EQIPMENT.........DEDICATED Y N (CIRCLE ONE)

PURGING DEVICE ___ A - SUBMERSIBLE PUMP, B - PERISTALTIC PUMP, C - BLADDER PUMP, D - GAS LIFT PUMP, E - PURGE PUMP, F - DIPPER BOTTLE, G - BAILER, H - WATERRA®

SAMPLING DEVICE ___

X- ________ PURGING OTHER (SPECIFY)

X- ________ SAMPLING OTHER (SPECIFY)

PURGING DEVICE ___ A - TEFLON, B - STAINLESS STEEL, C - POLYPROPYLENE, D - PVC, E - POLYETHYLENE

SAMPLING DEVICE ___

X- ________ PURGING OTHER (SPECIFY)

X- ________ SAMPLING OTHER (SPECIFY)

PURGING DEVICE ___ A - TEFLON, B - TYGON, C - ROPE x- ________ (SPECIFY), D - POLYPROPYLENE, E - POLYETHYLENE, F - SILICONE, G - COMBINATION TEFLON/POLYPROPYLENE

SAMPLING DEVICE ___

X- ________ PURGING OTHER (SPECIFY)

X- ________ SAMPLING OTHER (SPECIFY)

FILTERING DEVICES 0.45 ___ A - IN-LINE DISPOSABLE B - PRESSURE C - VACUUM

FIELD MEASUREMENTS

WELL ELEVATION ______ (m/ft)

GROUNDWATER ELEVATION ______ (m/ft)

DEPTH TO WATER ______ (m/ft)

WELL DEPTH ______ (m/ft)

pH	TURBIDITY	CONDUCTIVITY	ORP	DO	SAMPLE TEMPERATURE
(std)	(ntu)	(μm/cm) AT 25°C	(mV)	(mg/L)	(°C)
(std)	(ntu)	(μm/cm) AT 25°C	(mV)	(mg/L)	(°C)
(std)	(ntu)	(μm/cm) AT 25°C	(mV)	(mg/L)	(°C)
(std)	(ntu)	(μm/cm) AT 25°C	(mV)	(mg/L)	(°C)
(std)	(ntu)	(μm/cm) AT 25°C	(mV)	(mg/L)	(°C)

FIELD COMMENTS

SAMPLE APPEARANCE: ________ ODOR: ________ COLOR: ________ TURBIDITY: ________

WEATHER CONDITIONS: WIND SPEED ________ DIRECTION ________ PRECIPITATION Y/N OUTLOOK ________

SPECIFIC COMMENTS ________

I CERTIFY THAT SAMPLING PROCEDURES WERE IN ACCORDANCE WITH APPLICABLE GM PROTOCOLS

DATE PRINT SIGNATURE

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

SAMPLE COLLECTION DATA SHEET - GROUNDWATER SAMPLING PROGRAM

PROJECT NAME ______________________ PROJECT NO. ______________

SAMPLING CREW MEMBERS ______________________ SUPERVISOR ______________

DATE OF SAMPLE COLLECTION ______________________

[Note: For 2" dia. well, 1 ft. = 0.14 gal (imp) or 0.16 gal (us)]

Sample I.D. Number	Well No.	Measuring Point Elev. (ft. AMSL)	Bottom Depth (ft. btoc)	Water Depth (ft. btoc)	Water Elevation (ft. AMSL)	Well Volume (gallons)	Bailer Volume No. Bails	Volume Purged (gallons)	Field pH	Field Temp.	Field Cond.	Time	Sample Description & Analysis

Additional Comments: ______________________

Copies to: ______________________

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

MONITORING WELL RECORD FOR LOW-FLOW PURGING

Project Data:

Project Name: ______________________ Date: ______________________

Ref. No.: ______________________ Personnel: ______________________

____

Monitoring Well Data:

Well No.: ______________________ Screen Length (ft): ______________________

Measurement Point: ______________________ Depth to Pump Intake (ft)[1]: ______________________

Constructed Well Depth (ft): ______________________ Well Diameter, D (in): ______________________

Measured Well Depth (ft): ______________________ Well Screen Volume, V_s (mL)[2]: ______________________

Depth of Sediment (ft): ______________________ Initial Depth to Water (ft): ______________________

Time	*Pumping Rate (mL/min)*	*Depth to Water (ft)*	*Drawdown from Initial Water Level [3] (ft)*	*pH*	*Temperature °C*	*Conductivity (mS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Turbidity (NTU)*	*Volume Purged, V_p (mL)*	*No. of Well Screen Volumes Purged [4]*

Notes:

(1) The pump intake will be placed at the well screen mid-point or at a minimum of 2 ft above any sediment accumulated at the well bottom.

(2) The well screen volume will be based on a 5-foot screen length, $V_s = p*(D/2)^2*(5*12)*(2.54)^3$

(3) The drawdown from the initial water level should not exceed 0.3 ft.

(4) Purging will continue until stabilization is achieved or until 20 well screen volumes have been purged (unless purge water remains visually turbid and appears to be clearing, or unless stabilization parameters are varying slightly outside of the stablization criteria and appear to be stablizing), No. of Well Screen Volumes Purged= Vp/Vs.

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6.5 Non-Aqueous Phase Liquid (NAPL)

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NON-AQUEOUS PHASE LIQUID (NAPL)

NON-AQUEOUS PHASE LIQUID (NAPL)

INTRODUCTION

This procedure is for monitoring the presence of dense and light non-aqueous phase liquids (DNAPL and LNAPL), and collection of NAPL samples for laboratory analysis in monitoring, observation, and extraction wells.

It should be noted that groundwater sampling and analysis should not be performed in locations where NAPL has been identified.

PROCEDURES REFERENCED

- FMG 5.1 - Water Level Measurements.
- FMG 9.0 - Equipment Decontamination.

PROCEDURAL GUIDELINES

- Conduct well identification, inspection, and opening in accordance with FMG 5.1 - Water Level Measurements.
- NAPL level measurements are best conducted using a dual phase interface probe. The interface probe uses an optical liquid sensor, in conjunction with an electric circuit to detect the top of a phase-separated liquid and the interface between the phase layer and water (water level). The procedure for use of this probe is:
- For LNAPL:
  - Lower the probe tip into the center of the well until discontinuous beeping is heard (this indicates the top of the LNAPL has been detected). Grasp the calibrated tape at the reference point and note reading. Confirm the reading by slowly raising and lowering the probe to the level of the phase layer.
  - Once the top of the phase layer is confirmed, slowly lower the probe until a continuous sound is heard. This indicates that the water level has been encountered. Grasp the tape at the reference point and note the reading. Confirm this water level measurement.
  - Decontaminate the submerged end of the tape and probe prior to the next use in accordance with the Work Plan requirements.

- For DNAPL:
  - Lower the probe tip in the center of the well to the bottom of the well, a discontinuous beeping will be heard if DNAPL is present. Grasp the calibrated tape at the reference point and note reading.
  - Once the bottom of the well is confirmed, slowly raise the probe until a continuous sound is heard. This indicates that the water level has been encountered and represents the top of the DNAPL layer. Grasp the tape at the reference point and note the reading. Confirm this water level measurement.
  - Decontaminate the submerged end of the tape and probe prior to the next use.
- Alternative NAPL measurement methods exist in the event an interface probe is unavailable or not functioning properly. These methods tend to be less accurate than the interface probe but may be used to establish an estimated NAPL measurement.
  - **Clear Bailer** – A clear bottom-loading bailer may be used to estimate NAPL thickness if floating or denser than water. If NAPL presence is suspected, the bailer is carefully lowered to the location of suspected NAPL presence (top of water column/base of water column), and slowly removed and examined for NAPL. If present, the column of NAPL within the clear bailer can be measured to estimate the NAPL thickness within the groundwater column.
  - **Weighted Cord** – Primarily used for DNAPL measurements, a weighted "cotton" string or cord may be lowered to the base of the well and inspected upon retrieval. Typically, the lower DNAPL layer will "coat" the string indicating the approximate thickness of this layer.

<u>Well NAPL Sampling</u>

- Prior to sampling, the level of NAPL in the well should be measured as identified above.
- Various sampling devices can be employed to acquire fluid samples from the top and bottom of the well, including the following:
  - Bottom-loading bailer;
  - Double check value bailer (produces most reliable results);
  - Peristaltic pump for shallow wells (<25 feet in depth); or
  - Inertia pump for deeper wells (up to 300 feet in depth).
- Transfer NAPL to sample containers for shipment to laboratory. NAPL can be sampled to evaluate the physical properties of the fluid or to evaluate chemical composition.
- Decontaminate equipment prior to next use.

Note: Groundwater sampling shall not be performed in locations where NAPL is present.

EQUIPMENT/MATERIAL

- Interface probe.
- Bottom-loading bailer.
- Double check valve bailer.
- Peristaltic pump.
- Inertia pump.
- Work Plan.
- Health and Safety Plan.

REFERENCES

Cohen, Robert M., Mercer, James W. (GeoTrans, Inc.), Robert S. Kerr Environmental Research Laboratory "DNAPL Site Evaluation" Office Research and Development. U.S. Environmental Protection Agency

Cohen, R.M., Brayda, A.P., Shaw, S.T., and Spaulding, C.P.; Fall 1992 "Evaluation of Visual Methods to Detect NAPL in Soil and Water", Groundwater Monitoring Review, Volume 12 No. 4, pp. 132-141.

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6.9 Field Quality Control Samples

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FIELD QUALITY CONTROL SAMPLES

INTRODUCTION

This section describes the preparation and frequency of analysis of field quality control blanks, replicates, and interlaboratory splits for water and solids sampling.

PROCEDURES REFERENCED

- FMG 6.4 - Groundwater.
- FMG 6.10 - Sample Handling and Shipping.

PROCEDURAL GUIDELINES

Not all of the field quality control samples may be required for a given project. The specific field quality control samples will be specified in the project work plan, field sampling plan (FSP), or quality assurance project plan (QAPP).

As part of the QA/QC program, all field quality control samples will be sent blind to the laboratories. To accomplish this, the samples will be sent in the same form as regular samples, including all containers, sample numbers, and analytes. The sample ID for field quality control samples should allow data management and data validation staff to identify them as such. Under no circumstances should the laboratory be allowed to use reference materials, rinsate blanks, or trip blanks for matrix spike and matrix spike duplicate analysis. The laboratory should be instructed to contact the project QA/QC coordinator when a laboratory quality control sample is not specified on the sample analysis request form for a sample digestion group so that one can be assigned.

All field quality control samples will be packaged and shipped with other samples in accordance with procedures outlined in FMG 6.10 - Sample Handling and Shipping. Sample custody will be maintained in accordance with procedures outlined in FMG 6.10 - Sample Handling and Shipping.

Field quality control samples will be prepared at least once per sampling event, and certain types will be prepared more often at predetermined frequencies. If the number of samples taken does not equal an integer multiple of the intervals specified in the project work plan, field sampling plan (FSP), or quality assurance project plan (QAPP), the number of field quality control samples is specified by the next higher multiple. For example, if a frequency of 1 quality control sample per 20 is indicated and 28 samples are collected, 2 quality control samples will be prepared.

WATER SAMPLING

Table 6.9-1 lists the quality control sample types and suggested frequencies for surface water and groundwater sampling programs. Because groundwater quality control sampling may require assessment of drill rig cross-contamination, additional blanks of the solids sampling type may be required. A detailed explanation of each quality control sample type with the required preparation follows.

TABLE 6.9-1

FIELD QUALITY CONTROL SAMPLE REQUIREMENTS FOR WATER SAMPLING

Quality Control Sample Name	*Abbreviation*	*Preparation*		*Frequency*[a]
		Location	*Method*	
Bottle blank	BB	Field	Unopened bottle	1 per sample episode, 1 per bottle lot, 1 per bottle type
Travel blank	TTB	Laboratory	Deionized water and preserved, if necessary	1 per sample episode, 1 per preservative
Trip blank	TB	Laboratory	Deionized water and preserved	1 pair per cooler or VOA samples
Equipment rinsate (unfiltered)	ER-U	Sampling site	Deionized water collected after pouring through and over decontaminated equipment	1 per 20 samples, 1 per preservative
Equipment rinsate (filtered)	ER-F	Sampling site	Deionized water from collection container, filtered and preserved	1 per 20 samples, 1 per preservative
Replicate	DUP or TRIP	Sampling site	Natural sample	1 replicate per 20 samples
Laboratory split	LS	Sampling site	Natural sample	1 per 20 samples
Reference material	RM	Field laboratory (in large container), sample bottle filled at site	RM ampules for each analyte group	1 set per 50 samples, 1 per episode to alternate laboratory

[a] Frequencies provided here are general recommendations; specific frequencies should be provided in the project work plan, field sampling plan, or quality assurance project plan.

Bottle Blank

The bottle blank is an unopened sample bottle. One bottle blank per bottle lot is included in the sample chain for each sampling episode. If more than one type of bottle will be used in the sampling (e.g., poly or glass), then a bottle blank should be submitted for each type of bottle.

To prepare a bottle blank in the field, set aside one unopened sample bottle from each bottle lot sent from the analytical laboratory. If bottles are purchased directly from a supply house, all bottles should first be cleaned in accordance with FMG 6.10 - Sample Handling and Shipping. Label the bottle as "Bottle Blank" on the sample label, and send the bottle to the laboratory with the field samples in accordance with FMG 6.10 - Sample Handling and Shipping.

Travel Blank

The travel blank is a sample bottle prepared in the laboratory containing deionized water and preservative. This blank is carried to each sample site with the other filled sample bottles. One travel blank is sent to the laboratory. The travel blank is prepared at the laboratory by filling a sample bottle with deionized water and adding appropriate preservative (i.e., for metals samples use a 10 percent nitric acid solution to bring sample pH to 2 or less). In the field, label the bottle as "Travel Blank" on the sample label, place the travel blank sample in a cooler or other sample-receiving container for transport to each sample site during a sampling episode, and send the travel blank to the laboratory in accordance with FMG 6.10 - Sample Handling and Shipping.

Trip Blank

Trip blanks will be used to help identify cross-contamination in the shipment of water samples for analyzing volatile organic compounds (VOCs) only. Trip blanks will be prepared in the laboratory by pouring deionized water into two 40 mL VOC vials and tightly closing the lids. Each vial will be inverted and tapped lightly to ensure no air bubbles exist.

The blanks will be transported unopened to and from the field in the cooler with the VOC samples. One trip blank pair will be sent with each cooler of samples for analyzing VOCs. The exception is high-flow tributary sampling, which requires that the trip blank be prepared after the samples have been brought in from the field.

Equipment Rinsate Blank

Equipment rinsate blanks will be used to help identify possible contamination from the sampling environment or from improperly decontaminated sampling equipment. Equipment rinsate blanks will be prepared by processing a representative amount of laboratory deionized water through the decontaminated sample collection equipment, then transferring the water to the appropriate sample containers and adding any necessary preservatives. Equipment rinsate blanks will be prepared for all inorganic, organic, and conventional analytes at least once per sampling event.

The actual number of equipment rinsate blanks prepared during an event will be determined on a case-by-case basis by the project QA/QC coordinator.

Low-Flow Tributary Sampling

Because the sampling container for low-flow sampling is a laboratory-cleaned, amber glass jug, the only piece of equipment that is likely to contribute to contamination is the Teflon®/ polyethylene sample intake. The intake will be thoroughly decontaminated using industrial detergent, methanol, and hexane. After the intake is air-dried, it will be screwed into a newly opened 2.5 L jug of deionized water (the deionized water containers supplied by the laboratory are identical to those used for sampling). The deionized water will be poured through the intake into the appropriate sample containers, which will be preserved as needed. Because the intake tube extends to the back of the jug, not all of the deionized water in the jug can be transferred to the sample containers. When water can no longer pour through the intake, the jug will be replaced with a full one; any remaining water in the old jug will be discarded. When preparation of the rinsate blank is completed, the intake will be removed from the jug and placed in a sealable bag or screwed onto a sampling jug and covered with a plastic bag.

High-Flow Tributary Sampling

Before high-flow tributary sampling begins, a test run on one of the ISCO automatic samplers that will double as an equipment rinsate blank will be performed. Preparation of the blank will consist of running deionized water through the ISCO sampler and into a set of sampling containers at predetermined intervals.

Groundwater Sampling

GM-preferred protocols for groundwater sampling are presented in FMG 6.4 - Groundwater.

Field Replicates

Field replicate (duplicate or triplicate) samples are co-located samples collected in an identical manner over a minimum period of time to provide a measure of the analytical (field and laboratory) variance, including variance resulting from sample heterogeneity. Field replicates will consist of two or three samples collected consecutively at the same location and placed in different bottles for separate analysis. The exception to this is high-flow tributary sampling, which requires the procedure given below. Each replicate will have a unique sample number to distinguish it from the others. The replicate samples will be sent to the laboratory and analyzed for identical chemical parameters but will not be distinguishable by the laboratory as being replicates. Field replicates will be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent.

High-Flow Tributary Sampling

Collection of field replicate samples for high-flow events will differ from the other elements because of the nature of the sample preparation, which requires the samples to be homogenized before replication. Replicates will always be made from the composited portion of the sample because the grab sample does not provide enough sample volume for all the parameters. For each analyte group, a composite sample will be prepared using the six flow-weighted aliquots in the same manner that a regular sample is prepared. To prepare the replicates, the container with the composited sample will be inverted three times for proper mixing (very lightly for organic compounds) and split evenly into two to three identical containers. This process will be repeated until sufficient volume is obtained.

1. At the appropriate frequency during sample collection, collect an adequate volume of sample at the sample site to accommodate duplicate samples. For example, if 40 mL water samples are taken and two sample bottles are required for analysis of all parameters, collect a total of at least six additional water samples (i.e., two 40 mL samples for each of the triplicate samples).
2. Label one bottle as a normal field sample and label the other bottles according to the numbering sequence described in the sample identification system in the SAP.
3. Send the bottles to the primary CLP laboratory with the field samples in accordance with FMG 6.10 - Sample Handling and Shipping.

Reference Material

Reference materials are materials of known composition that have been prepared by and obtained from EPA-approved sources and that have undergone multilaboratory analyses using a standard method. Reference material samples provide a measure of analytical performance and/or analytical method bias of the laboratory. Several reference materials may be required to cover all analytical parameters.

SOLIDS SAMPLING

Table 6.9-2 lists the quality control sample types and frequencies to be incorporated into a solids sampling program. A detailed explanation of each quality control sample type with the required preparation follows.

TABLE 6.9-2

FIELD QUALITY CONTROL SAMPLE REQUIREMENTS FOR SOLIDS SAMPLING

Quality Control Sample Name	*Abbreviation*	*Preparation*		*Frequency*
		Location	*Method*	
Bottle blank	BB	Field	Unopened bottle	1 per sample episode, 1 per bottle lot
Travel blank	TTB	Laboratory	Opened at sample site and closed	1 per sample episode
Trip blank	TB	Laboratory	Deionized water and preserved, if necessary	1 pair per cooler or VOA samples
Equipment rinsate blank	ER-5	Sample site	Deionized water collected after pouring through/over decontaminated equipment	1 per 20 samples
Field cross-contamination blank	CCB	Sample site	Filter wipe with decontaminated collection equipment	1 per 20 samples
Field external contamination blank	ECB	Sample site	Unused material used for CCB	1 per 20 samples
Replicate	DUP or TRIP	Sample site	Natural sample	1 replicate per 20 samples
Laboratory split	LS	Sample site	Natural sample	1 per 20 samples
Reference material	RM	Sample site	RM	1 set per 40 samples, 1 per episode to alternate laboratory

[a] Frequencies provided here are general recommendations; specific frequencies should be provided in the project work plan, field sampling plan, or quality assurance project plan.

Bottle Blanks

The bottle blank is an unopened sample bottle. One bottle blank per bottle lot is included in the sample chain for each sampling episode. Bottle blanks are prepared in the field by setting aside one unopened sample bottle from each bottle lot sent from the analytical laboratory. If bottles are purchased directly from a supply house, all bottles should first be cleaned in accordance with FMG 6.10 - Sample Handling and Shipping. Label the bottle "Bottle Blank" on the sample label, and send the bottle to the laboratory with field samples in accordance with FMG 6.10 - Sample Handling and Shipping.

Travel Blank

The travel blank is an unopened sample bottle carried to each sample site with the other filled sample bottles. The bottle is then opened at a single site for a short period to reflect the sampling time. The purpose of this blank is to evaluate possible contamination from sample bottle handling and transport and from airborne materials. The travel blank is prepared by labeling one bottle as "Travel Blank" on the sample label and placing the travel blank bottle in the sample receiving container for transport to each sample site during each sampling episode. At a single sample site, preferably the one with the highest potential for airborne contamination, open the bottle for a time equal to that required to fill a sample bottle with solids. Cap the bottle and place it in the sample-receiving container. Send the bottle to the laboratory with the field samples in accordance with FMG 6.10 - Sample Handling and Shipping.

Trip Blank

Trip blanks will be used to help identify cross-contamination in the shipment of water samples for analyzing volatile organic compounds (VOCs) only. Trip blanks will be prepared in the laboratory by pouring deionized water into two 40 mL VOC vials and tightly closing the lids. Each vial will be inverted and tapped lightly to ensure no air bubbles exist.

The blanks will be transported unopened to and from the field in the cooler with the VOC samples. One trip blank pair will be sent with each cooler of samples for analyzing VOCs. The exception is high-flow tributary sampling, which requires that the trip blank be prepared after the samples have been brought in from the field.

Equipment Rinsate Blank

Equipment rinsate blanks will be used to help identify possible contamination from the sampling environment or from improperly decontaminated sampling equipment. Equipment rinsate blanks will be prepared by processing a representative amount of laboratory deionized water through the decontaminated sample collection equipment, then transferring the water to the appropriate sample containers and adding any necessary preservatives. Equipment rinsate blanks will be prepared for all inorganic, organic, and conventional analytes at least once per sampling event. The actual number of equipment rinsate blanks prepared during an event will be determined on a case-by-case basis by the project QA/QC coordinator.

Field Cross-Contamination Blank

The field cross-contamination blank is a sample bottle prepared at the sample site that contains filter wipes of decontaminated field collection equipment. This blank will check the effectiveness of the decontamination procedures. At the appropriate frequency during sample collection, prepare a field cross-contamination blank at the sample site by vigorously rubbing the sample collection equipment with two clean filter blanks. Do no use Kimwipes® because they contain significant impurities. Place the filters in the sample bottle and label it as the "Cross-Contamination Blank" on the sample label. Send the bottle to the laboratory with the field samples in accordance with FMG 6.10 - Sample Handling and Shipping.

Field External Contamination Blank

The field external contamination blank is a sample bottle prepared at the sample site containing a single unused filter wipe used for the field cross-contamination blank. At the appropriate frequency during sample collection, prepare a field external contamination blank at the sample site by placing a clean, unused filter blank from the same lot used for the cross-contamination in a sample bottle. Label the bottle "External contamination Blank" on the sample label, note filter name and lot number in the field logbook, and send the bottle to the laboratory with the field samples in accordance with FMG 6.10 - Sample Handling and Shipping.

Replicates

A replicate (duplicate or triplicate) sample consists of two or three samples taken from the same location and time and placed in different sample bottles for separate analysis. Each replicate will be analyzed for all chemical parameters. The laboratory split sample bottles are also filled at this time (see below). At the appropriate frequency during sample collection, collect an adequate volume of sample at the sample site to accommodate the replicate and laboratory split samples per the appropriate SAP; process the samples per the SAP for each replicate; and send the bottles to the laboratory with the field samples in accordance with FMG 6.10 - Sample Handling and Shipping.

Laboratory Split

The laboratory split sample is sent to the referee laboratory. The sample is taken with the replicate sample. As with the replicates, the laboratory split will be analyzed for all chemical parameters. To prepare the laboratory split, follow sample bottle filling and processing instructions for replicates above, label the bottle "Laboratory Split" on the sample label, and send the bottle to the referee CLP laboratory in accordance with FMG 6.10 - Sample Handling and Shipping.

Reference Material

Reference materials are materials of known composition that have been prepared by and obtained from EPA-approved sources and that have undergone multilaboratory analyses using a standard method. Reference material samples provide a measure of analytical performance and/or analytical method bias of the laboratory. Several reference materials may be required to cover all analytical parameters.

FMG 6.0
6.10 Sample Handling and Shipping

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SAMPLE HANDLING AND SHIPPING

INTRODUCTION

Sample management is the continuous care given to each sample from the point of collection to receipt at the analytical laboratory. Good sample management ensures that samples are properly recorded, properly labeled, not lost, broken, or exposed to conditions which may affect the sample's integrity.

All sample submissions must be accompanied with a chain-of-custody (COC) document to record sample collection and submission.

The following sections provide the minimum standards for sample management.

PROCEDURAL GUIDELINES

Field Handling

Prior to entering the field area where sampling is to be conducted, especially at sites with defined exclusion zones, the sampler should ensure that all materials necessary to complete the sampling are on hand.

If samples must be maintained at a specified temperature after collection, proper coolers and ice/cool-packs must be brought out to the field. Consideration should be given to keeping reserve cooling media on hand if sampling events will be of long duration. Conversely, when sampling in extremely cold weather, proper protection of water samples, trip blanks, and field blanks must be considered.

Personnel performing groundwater sampling tasks must check the sample preparation and preservation requirements to ensure compliance with the Work Plan QAPP. Typical sample preparation may involve pH adjustment (i.e., preservation), sample filtration and preservation, or simply cooling to 4°C. Sample preparation requirements vary from site to site and vary depending upon the analytical method for which the samples will be analyzed.

The sampling personnel must also confirm before the sample event, the amount of bottle filling required for the respective sample containers. VOC samples must not have any headspace within the sample collection vial; whereas when collecting select analytes (i.e., metals) a headspace must be provided to allow addition of the required preservative.

Sample Labeling

Samples must be properly labeled as soon as practical after collection.

Note that the data shown on the sample label is the minimum data required. The sample label data requirements are listed below for clarity.

i) Project name.
ii) Sample number.
iii) Sampler's initials.
iv) Date of sample collection.
v) Time of sample collection.
vi) Analysis required.
vii) Preservatives.

The Work Plan Quality Assurance/Quality Control (QA/QC) specification should be reviewed to determine any additional requirements.

Quite often the analytical laboratory supplying the containers will provide blank sample labels. If these are adequate and convenient they can be used.

Under certain field conditions it is impractical to complete and attach sample labels to the container at the point of sample collection. However, to ensure that samples are not confused, a clear notation should be made on the container with a permanent marker indicating the last three digits of the sample number. If the containers are too soiled or small for marking, the container can be put into a zip-lock bag which can then be labeled.

No one sample number format is adequate for every type of sampling activity. Prior to the start of every project or sub-sampling event within the project, Project Managers and field personnel should devise a sample number format. Sample number formats should be as simple and short as possible. Simple number formats will reduce transcription errors by both Consultants and lab personnel. The sample number format should be comprehensive enough to allow for easy location of detailed sample data within the Site log books. Sample format must also be consistent with any future data management activities.

Unless otherwise instructed, labels should not contain specific names of the sample source (i.e., "Well No. 16"). Provision of such specific data on the label can produce biased lab results.

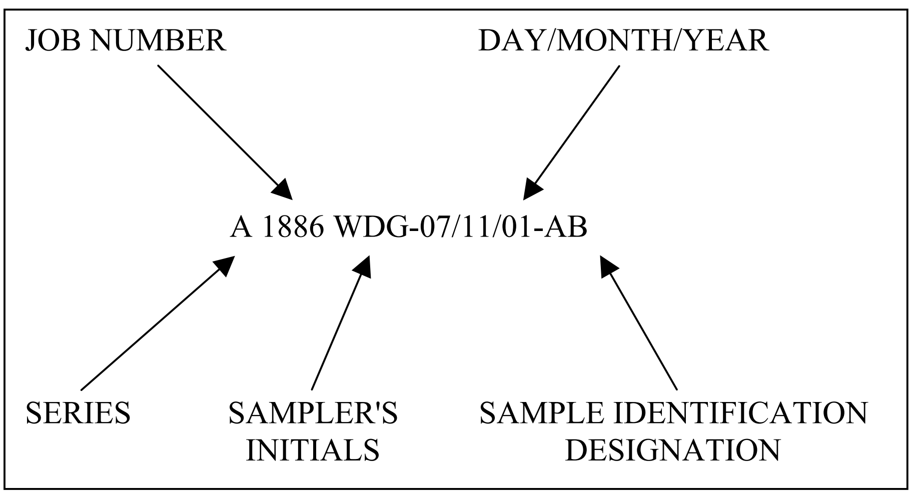
Sample Labels/Sample Identification

All samples must be labeled with:

- A unique sample number (never to be re-used, nor likely to be).
- Date and time.
- Parameters to be analyzed.
- Job number.
- Sampler's initials.

Labels should be secured to the bottle and should be written in indelible inks. It is also desirable to place wide clear tape over the label before packing in a cooler for label protection during transportation.

The unique sample identification number may follow the format recommended below, or a specific sample protocol for labeling may be specified in the project Work Plan.



This format has been selected to maximize the information content of the sample number. Minor modifications are certainly reasonable.

i) Series is a letter which designates a group of samples. This might include sample round, or might designate sample type (e.g., sediment, soil, volatile analysis, Round 2 Lower Aquifer wells), or sample source. For example, "A" might mean samples of influent to some treatment system, "B" might mean samples of effluent. Letters should be used, not numbers. Series is optional.

ii) Job number together with the series number, will allow easier tracking of samples.

iii) Sampler's initials will allow identification of the sampler, and so allow all project personnel to contact the correct person for information regarding that sample and its collection. The use of three initials is requested. Special arrangements will need to be made if two individuals have the same initials.

iv) Sample date will allow monitoring of actual holding time of samples and should ensure that all sample numbers are unique, even if sample location designation is used in a system, as opposed to assigned at random.

v) Sample identification designation will identify the sample, and can be any numerical or letter designation.

The decision of how to assign sample numbers should be made at the beginning of a job or phase, and should be consistent throughout the job.

Packaging

When possible, sample container preparation and packing for shipment should be completed in a well organized and clean area, free of any potential cross-contaminants.

Sample containers should be prepared for shipment as follows:

i) Containers should be wiped clean of all debris/water using paper towels (paper towels must be disposed of with other contaminated materials).

ii) Clear, wide packing tape should be placed over the sample label for protection.

While there is no one "best" way to pack samples for shipment, the following packing guidelines should be followed.

i) Plan time to pack your samples (and make delivery to shipper if applicable). Proper packing and manifesting takes time. A day's worth of sampling can be easily wasted due to a few minutes of neglect when packing the samples.

ii) Always opt for more coolers and more padding rather than crowd samples. The cost associated with the packing and shipment of additional coolers is usually always small in comparison with the cost of having to re-sample due to breakage during shipment.

iii) Do not bulk pack. Each sample must be individually padded.

iv) Large glass containers (1 L and up) require much more space between containers.

v) Ice is not a packing material due to the reduction in volume when it melts.

The following is a list of standard guidelines which must be followed when packing samples for shipment.

i) When using ice for a cooling media, always double bag the ice in zip-lock bags.

ii) Double-check to ensure trip and temperature blanks have been included for all shipments containing VOCs, or where otherwise specified in the QA/QC plan.

iii) Enclose the COC form in a zip-lock bag.

iv) Ensure custody seals (two, minimum) are placed on each cooler. Coolers with hinged lids should have both seals placed on the opening edge of the lid. Coolers with "free" lids should have seals placed on opposite diagonal corners of the lid. Place clear tape over custody seals.

v) Ensure that all "Hazardous Material" stickers/markings have been removed from coolers being used which previously contained such materials.

Note: Never store sterile sample containers in enclosures containing equipment which use any form of fuel or volatile petroleum based product. An alternate means of secure storage must be planned for.

When conducting sampling in freezing conditions at sites without a heated storage area (free of potential cross contaminants), trip blanks and temperature blanks not being used in a QA/QC role should be isolated from coolers immediately after receipt. Trip and temperature blanks should be double-bagged and kept from freezing.

Chain-of-Custody

COC forms will be completed for all samples collected. The form documents the transfer of sample containers.

The COC record, completed at the time of sampling, will contain, but not be limited to, the sample number, date and time of sampling, and the name of the sampler. The COC document will be signed and dated by the sampler when transferring the samples.

Each sample cooler being shipped to the laboratory will contain a COC form. The COC form will consist of four copies which will be distributed as follows: The shipper will maintain a copy while the other three copies will be enclosed in a waterproof envelop within the cooler with the samples. The cooler will then be sealed properly for shipment. The laboratory, upon receiving the samples, will complete the three remaining copies. The laboratory will maintain one copy for their records. One copy will be returned to the Field QA/QC Officer upon receipt of the samples by the laboratory. One copy will be returned with the data deliverables package.

COC records are legal documents. They must be completed and handled accordingly.

The following list provides guidance for the completion and handling of all COCs.

i) COCs used should be Consultant standard forms or those supplied by the analytical laboratory. Do not use any COC forms from other labs, even if the heading is blocked out.

ii) COCs must be completed in black ball-point ink only.

iii) COCs must be completed neatly using printed text.

iv) If a simple mistake is made, line out the error with a single line and initial and date next to it.

v) Each separate sample entry must be sequentially numbered.

vi) The use of "Ditto" or quotation marks to indicate repetitive information in columnar entries should be avoided. If numerous repetitive entries must be made in the same column, place a continuous vertical arrow between the first entry and the next different entry.

vii) When more than one COC form is used for a single shipment, each form must be consecutively numbered using the "Page ___ of ___" format.

viii) If necessary, place additional instructions directly onto the COC. Do not enclose separate loose instructions.

ix) Include a contact name and phone number on the COC in case there is a problem with the shipment.

x) Do not indicate the source of the sample as this may produce a biased lab result.

xi) Before using an acronym on a COC, define clearly the full interpretation of your designation [i.e., Polychlorinated Biphenyls - (PCBs)].

Shipment

In all but a few cases the QA/QC plan for the field work will require shipment of samples by overnight carrier. A great many problems can be avoided by proper advance planning.

Prior to the start of the field sampling, the carrier should be contacted to determine if pickup can be made at the field site location. If pickup at the field site can be made, the "no-later-than" time for having the shipment ready must be determined.

If no pickup is available at the site, the nearest pickup or drop-off location should be determined. Again, the "no-later-than" time for each location should be determined.

Sufficient time must be allowed not only for packaging but also for delivery of samples if this becomes necessary. Driving at high rates of speed in order to make the drop time is unacceptable.

Sample shipments must not be left at unsecured or questionable drop locations (i.e., if the cooler will not fit in a remote drop box do not leave the cooler unattended next to the drop box).

Some overnight carriers do not in fact provide "overnight" shipment to/from some locations. Do not assume; call the carrier in advance before the start of the field work.

Copies of all shipment manifests must be maintained in the field file.

FMG 8.0
Field Instruments – Use / Calibration

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LIST OF FORMS
(Following Text)

FIELD INSTRUMENTS – USE/CALIBRATION

INTRODUCTION

A significant number of field activities involve usage of electronic instruments to monitor for environmental screening and heath and safety purposes. It is imperative the instruments are used and maintained properly to optimize their performance and minimize the potential for inaccuracies in the data obtained, and to insure worker's health and safety is not compromised.

This FMG provides guidance on the usage, maintenance and calibration of electronic field equipment, whether for equipment owned by the Consultant or Contractor, or equipment obtained from a rental agency.

PROCEDURES REFERENCED

- FMG 1.4 - Data Recording – Field Books/Digital Recording.

PROCEDURAL GUIDELINES

- All monitoring equipment will be in proper working order, and operated for the purpose for which it was intended, in accordance manufacturer's recommendations.
- Field personnel will be responsible for insuring the equipment is maintained and calibrated in the field to extent practical, or returned for office or manufacturer maintenance or calibration if warranted. Calibration is discussed in greater detail below.
- A copy of the Operating Instructions, Maintenance and Service Manual for each instrument used on a project will be kept on site at all times.
- Instruments will be operated only by personnel trained in the proper usage and calibration. In the event certification of training is required, personnel will have documentation of such certification with them on site at all times.
- Personnel must be aware that certain instruments are rated for operation within a limited range of conditions such as temperature and humidity. Usage of such instruments in conditions outside these ranges will only proceed with proper approval by a project manager and/or health and safety supervisor as appropriate.

- Instruments that contain radioactive source material, such as x-ray fluorescence analyzers or moisture-density gauges require specific transportation, handling, and usage procedures that are generally associated with a license from the Nuclear Regulatory Commission (NRC) or an NRC-Agreement State. Under no circumstance will operation of such instruments be allowed on site unless by properly authorized and trained personnel, using the proper personal dosimetry badges or monitoring instruments.

Calibration

Calibration of an electronic instrument is critical to insure it is operating properly for its intended use. Such instruments are often sensitive to changes in temperature or humidity, or chemical vapors in the working atmosphere, and as a result their response and ability to monitor conditions and provide data can change significantly.

Calibration of instruments shall be performed in accordance with the manufacturer's recommendations. This includes the following parameters:

- Frequency.
- Use of proper calibration gases or chemical standards.
- Requirements for factory calibration.

Instrument calibration shall be performed in accordance with the following manufacturer recommendations or the suggested "minimum" calibration frequency:

Instrumentation Classification/Group		***Instrumentation***	***Representative Manufacturer Recommended Calibration Frequency***	***Minimum Recommended Calibration Frequency***
Health and Safety	Air Monitoring (Real-Time):	PID, FID, compound-specific or multi-gas meter (typ.), etc.	No Recommendation, Daily or As Needed	Daily
	Air Sampling (non-Real-Time):	Flow meter, personal air sampling device, etc.	Per Manufacturer's Recommendations	Per Manufacturer's Recommendations
Other Monitoring	Water Sampling:	pH, Cond., Temp., ORP, DO, etc.	Per Manufacturer's Recommendations	Daily, or As Needed
	Physical Parameters:	Velocity/flow meter, pressure transducer, water level meter, oil-water interface probe, etc.	Per Manufacturer's Recommendations	Per Manufacturer's Recommendations
	Other:	Miscellaneous (Troxler nuclear density, etc.)	Per Manufacturer's Recommendations	Per Manufacturer's Recommendations

Notes:

1. Some instrumentation requires factory calibration only.
2. If a significant change in conditions occurs, or in dangerous atmosphere conditions, more frequent calibration should be performed.

Calibration Gas Safety

Several instruments such as photoionization detectors (PIDs), flame ionization detectors (FIDs), oxygen meters, explosimeters, combustible gas indicators, and many others require use of calibration gasses contained in compressed gas cylinders. Many of these gases are combustible or explosive. Care shall be taken to minimize the potential for injury from the use of such compressed gases. Transport, handling, and storage of cylinders, where necessary, shall be performed in accordance with applicable DOT regulations and site requirements.

Calibration will only be performed in areas free of sources of spark, flame, or excessive heat. Smoking will not be allowed in the vicinity of calibration gas usage areas.

Documentation of Calibration

Instrument calibration activities will be documented. Form FMG 8.0-01 - Instrument Calibration Record shall be used to record applicable calibration and maintenance activities. In addition, protocol for documentation outlined in FMG 1.4 - Data Recording - Field Books/Digital Recording shall be followed.

Intrinsically Safe Requirements

Certain work locations may be such that dangerous, ignitable, or explosive conditions exist. In such cases, it may be necessary to utilize only equipment that is rated as "Intrinsically Safe". Intrinsically safe instrumentation is designed with limited electrical and thermal energy levels to eliminate the potential for ignition of hazardous mixtures.

For site work requiring operation of monitoring instruments in Class I, Division I locations [as defined by the National Fire Protection Agency (NFPA)] only instrumentation rated as Intrinsically Safe will be used. Such equipment (including all accessories and ancillary equipment) must be rated to conform to Underwriters Laboratories (UL) Standard 913, for use in a Class I, Division 1, Groups A, B, C, and D locations. It is also recommended the equipment conform with CSA Standard 22.2, No. 157-92.

Upon completion of the field activities, equipment shall be returned to the possession of the Consultant, Contractor, or Rental Agency accompanied by a written summary of any problems encountered with its use or calibration.

Equipment shall be properly prepared for shipping, including insuring that residual gases (if applicable) are removed from the instrument, and accompanying containers of compressed gases or fluids are properly labeled and sealed.

Equipment Decontamination

Equipment that comes in contact with Site media (water level meters, water quality meters) must be cleaned **before** removal from the site to ensure that chemicals are not transferred to other sites. It is the responsibility of the person who requisitioned the equipment to ensure appropriate cleaning before returning the equipment. Equipment decontamination procedures are typically site specific for unique site compounds.

EQUIPMENT/MATERIALS

- Monitoring equipment specific to work plan tasks.
- Manufacturer's instructions, operation and maintenance information.
- Associated calibration gases, aqueous standards, etc.
- Appropriate shipping containers to facilitate transport without damage to equipment.

REFERENCES

Underwriters Laboratories, Inc. (http://www.ul.com/hazloc/define.htm) Standard UL 913.

National Fire Protection Agency (http://www.nfpa.org/).

Canadian Standards Association (CSA) (http://www.csa.ca) Standard 22.2 No. 157.

Form FMG 8.0-01

INSTRUMENT CALIBRATION RECORD

PROJECT ______________________ PROJECT MANAGER ______________

LOCATION ______________________ FIELD REP. ______________

CLIENT ______________________ DATE ______________

Instrument	Date Calibrated	By	Standard Used	Decontamination, Maintenance, or Repair Performed	Remarks

Other Remarks: ____

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

FMG 9.0
Equipment Decontamination

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EQUIPMENT DECONTAMINATION

REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 9.0
WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS CORPORATION	
REVISION NO.: 0	REVISION DATE:

EQUIPMENT DECONTAMINATION

INTRODUCTION

This procedure describes decontamination of field equipment potentially exposed to contaminants. Proper decontamination is required to reduce the risk of transfer of contaminants from areas of contamination to other areas and to minimize the potential for cross-contamination that would compromise sample quality. The degree of decontamination required will be dependent on the nature of the activity, equipment used, and on the amount of exposure to contaminants.

PROCEDURES REFERENCED

- FMG 2.0 - Subsurface Investigations.
- FMG 5.0 - Aquifer Characterization.
- FMG 6.0 - Sample Collection for Laboratory Analysis.
- FMG 8.0 - Field Instruments – Use/Calibration.
- FMG 10.0 - Waste Characterization.

PROCEDURAL GUIDELINES

Decontamination activities must be performed in a controlled area outside any exclusion zones established on the site. Care must be taken to minimize the potential for transfer of contaminated materials to the ground or onto other materials. Regardless of the size or nature of the equipment being decontaminated, the process will utilize a series of steps that involve removal of gross material (dirt, grease, oil, etc.), washing with a detergent, and multiple rinsing steps. In lieu of a series of washes and rinse steps, steam cleaning with low-volume, high-pressure equipment (i.e., steam cleaner) is acceptable.

Drill rigs, backhoes, and other exploration equipment must be decontaminated prior to initiating site activities, in between exploration locations to minimize cross-contamination potential, and prior to mobilizing off site after completion of site work. Heavy equipment is generally best deconned with a combination of steam-cleaning equipment and detergent scrubbing. Particular attention should be paid to parts in direct contact with contaminants, e.g., shovels, tires, augers, drilling decks, etc.

Control and containerization of all decontamination fluids is critical. A decontamination pad must be constructed that is appropriate for the size and type of equipment being decontaminated. At a minimum, the decontamination pad will have the following elements:

- An impermeable barrier capable of containing decontamination fluids.
- A low point where fluids will collect and can be pumped into appropriate containers.
- Durability to withstand equipment such as vehicle and foot traffic.
- Appropriate ancillary equipment such as racks to place decontaminated equipment to drain without further exposure to contaminated fluids.
- Labels to alert personnel as to the potential presence of contaminated materials.

<u>Decontamination of Specific Sampling Equipment</u>

The following specific decontamination procedure is recommended:

- Brush loose soil off of equipment.
- Wash equipment with laboratory grade detergent (i.e., Alconox or equivalent).
- Rinse with tap water (three rinses minimum).
- Rinse equipment with reagent grade methanol for VOC samples (this requirement may not be appropriate for sites where methanol is a contaminant of concern).
- Rinse equipment with nitric acid for metal samples (especially important for sites with potentially high metals concentrations.
- Rinse equipment with distilled water.
- Allow water to evaporate before reusing equipment

<u>Decontamination of Monitoring Equipment</u>

Because monitoring equipment is difficult to decontaminate, care should be exercised to *prevent* contamination. Sensitive monitoring instruments should be protected when they are at risk of exposure to contaminants. This may include enclosing them in plastic bags allowing an opening for the sample intake. Ventilation ports should not be covered.

If contamination does occur, decontamination of the equipment will be required; however, immersion in decontamination fluids is not possible. As such, care much be taken to wipe the instruments down with detergent-wetted wipes or sponges, and then with deionized water-wetted wipes or sponges.

PART C

FIELD METHOD GUIDELINES

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Disposal of Wash Solutions and Contaminated Equipment

All contaminated wash water, rinsates, solids and materials used in the decontamination process that cannot be effectively decontaminated (such as polyethylene sheeting) will be containerized and disposed of in accordance with applicable regulations and GM requirements. All containers will be labeled with an indelible marker as to contents and date of placement in the container, and any appropriate stickers required (such as PCBs).

Sampling of containerized wastes will be performed immediately upon completion of the investigations to minimize storage time on site. Storage of decontamination wastes on site will not exceed 90 days under any circumstances.

EQUIPMENT/MATERIALS

Decontamination equipment and solutions are generally selected based on ease of decontamination and disposability.

- Polyethylene sheeting.
- Metal racks to hold decontaminated equipment.
- Soft-bristle scrub brushes or long-handle brushes for removing gross contamination and scrubbing with wash solutions.
- Large galvanized wash tubs, stock tanks, or wading pools for wash and rinse solutions.
- Plastic buckets or garden sprayers for rinse solutions.
- Large plastic garbage cans or other similar containers lined with plastic bags can be used to store contaminated clothing.
- Contaminated liquids and solids should be segregated and containerized in DOT-approved plastic or metal drums, appropriate for off-site shipping/disposal if necessary.

REFERENCES

ASTM D5088 - Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites.