SAMPLING AND ANALYSIS PLAN
ADDENDUM #1
MOTTOLO SUPERFUND SITE
CERCLIS ID NO. NHD980503361
RAYMOND, NEW HAMPSHIRE

PREPARED FOR:
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Waste Management Division, Hazardous Waste Remediation Bureau
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December 2009
File No. 04.0024466.27

SAMPLING AND ANALYSIS PLAN ADDENDUM #1 MOTTOLO PIG FARM SUPERFUND SITE RAYMOND, NEW HAMPSHIRE

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*****THIS SAP ADDENDUM WAS VERBALLY APPROVED PRIOR TO THE START OF WORK*****

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TABLES

Note: GZA's original Table 2A and Table 4 are not applicable to this SAP addendum and have not been included.

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1.0 INTRODUCTION

1.1 SITE DESCRIPTION AND BRIEF HISTORY

The Mottolo Superfund Site is located off Blueberry Hill Road in Raymond, New Hampshire (see **Figure 1** to the right). The Site, formerly used as a pig farm, is approximately three miles south of the Town of Raymond's center and is surrounded by rural residential property, in various stages of development. The Mottolo property includes approximately 50 acres of primarily undeveloped, wooded land, divided roughly in half by a brook (Brook A), which originates beyond the southern property boundary and flows north through the property, eventually discharging to the Exeter River.

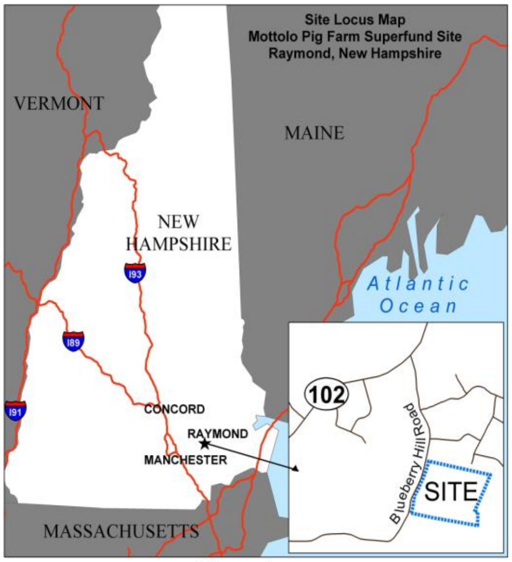

Figure 1

Refer to **Section 1.1** of GZA's Sampling and Analysis Plan (SAP) prepared for the Site, dated August 9, 2009, for additional details regarding the site history; source identification/evaluation, remedial activities; and ongoing monitoring.

1.2 OBJECTIVES OF THE SAMPLING AND ANALYSIS PLAN ADDENDUM

This addendum to the SAP has been prepared by GZA on behalf of New Hampshire Department of Environmental Services (NHDES) and the United States Environmental Protection Agency (EPA) Region I for the former Mottolo Pig Farm Superfund Site located off Blueberry Hill Road in Raymond, New Hampshire (Site).

The primary objective of this SAP addendum is to outline the additional bedrock groundwater investigation activities associated with the bedrock borehole installations, geophysical borehole logging, and groundwater sampling procedures and protocols, data quality objectives (DQOs), quality assurance sampling and documentation, and other project requirements. The SAP addendum has been prepared consistent with and references GZA's SAP for the Site and NHDES' Hazardous Waste Remediation Bureau current Master Quality Assurance Project Plan, EPA RFA#08036, available on the NHDES website[1].

GZA anticipates that referencing the standard operating procedures (SOPs) identified in GZA's SAP for the Site will adequately address regulatory concerns regarding the integrity of sampling and analytical methodologies to be employed. The SAP addendum addresses additional sampling and analyses, and SOPs not otherwise included in the SAP.

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[1] *http://des.nh.gov/organization/divisions/waste/hwrb/documents/hwrb_master_qapp.pdf*

1.3 SITE CLEANUP LEVELS

Section 1.3 *Site Cleanup Levels* has not changed and will be followed, as applicable. Refer to **Table 1** included in the SAP for applicable laboratory reporting detection limits (RDL).

1.4 DATA QUALITY OBJECTIVES

The August 9, 2009 SAP Section 1.4 *Data Quality Objectives* applies and will be followed, as applicable. In December 2009, three new deep bedrock wells will be installed at the site to investigate the potential chemical link between the Site and off-Site residential well contamination. In addition, potential vapor intrusion into residential homes located on Windmere Drive and Blueberry Hill Road near the site will be evaluated through the installation of one shallow monitoring well. The well will be installed in the overburden assuming that the water table is encountered. In the event that water is not encountered in the overburden, the borehole will be advanced and well installed into the overburden/shallow bedrock.

The three new deep bedrock wells will be identified as: MOT_MW-100D (located across from Windmere Drive); MOT_MW-101D (located across from 31 – 33 Blueberry Hill Road and located in the area of a bedrock lineament identified in 1999 by NHDES); and MOT_MW-102D (located near the former drum burial area and placed midway between the former on-site well house and well MOT_MW-2DR). The deep bedrock boreholes will be advanced to approximately 350 feet, 300 feet, and 275 feet, respectively. During the December 2009 investigation, the overburden/shallow bedrock well will be advanced adjacent to MOT_MW-101D, across from the Thomas residence to evaluate the potential for vapor intrusion. The overburden/shallow bedrock well will be identified as MOT_MW-101S. Based on the location of the water table at MOT_MW-101S, a field decision will be made as to whether the well shall be screened in the overburden or extend into the shallow bedrock. The overburden/shallow bedrock well will be advanced following the completion of MOT_MW-101D.

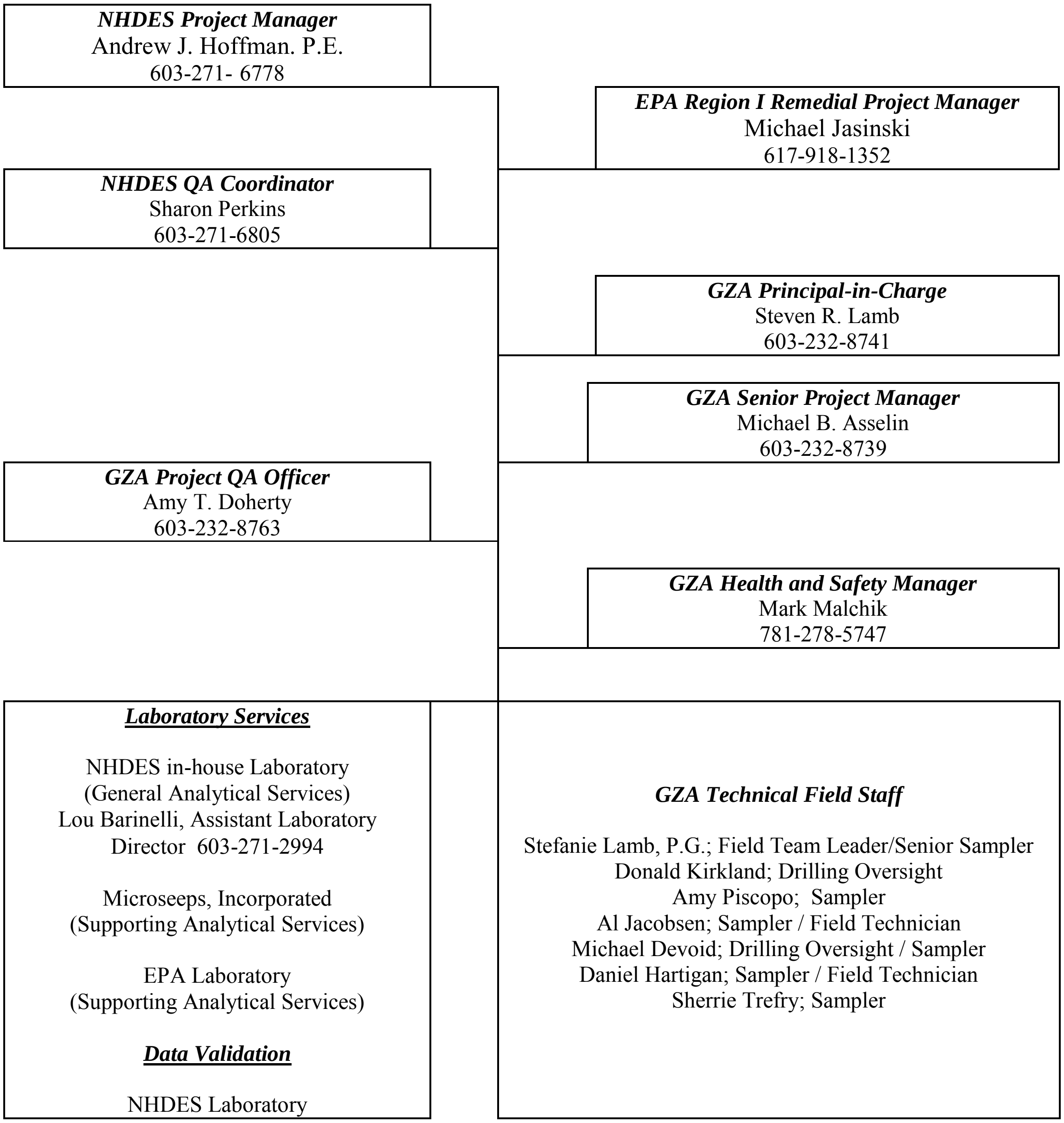
2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

In September of 2003, the responsibility for operating and maintaining the remedy at the Site was officially transferred from EPA to the NHDES. GZA has been retained by the NHDES to provide remedial consulting services for the project.

Within GZA, Mr. Michael B. Asselin and Mr. Steven R. Lamb will be responsible for the overall contract management, ensuring that established protocols and procedures are used and the management of day-to-day activities, staff scheduling, and assuring that the technical objectives are achieved. Ms. Amy Doherty will be the designated Quality Assurance Officer for the project. In this role, Ms. Doherty will oversee all quality assurance (QA) aspects of the project and data validation reports to confirm that data quality documentation is appropriate and that QA goals have been met.

The following organizational chart illustrates the roles and responsibilities of those individuals involved in the project, and their different organizations.

Project Organizational Chart



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<u>Laboratory Services</u>

NHDES in-house Laboratory
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Lou Barinelli, Assistant Laboratory Director 603-271-2994

Microseeps, Incorporated
(Supporting Analytical Services)

EPA Laboratory
(Supporting Analytical Services)

<u>Data Validation</u>

NHDES Laboratory

GZA Technical Field Staff

Stefanie Lamb, P.G.; Field Team Leader/Senior Sampler
Donald Kirkland; Drilling Oversight
Amy Piscopo; Sampler
Al Jacobsen; Sampler / Field Technician
Michael Devoid; Drilling Oversight / Sampler
Daniel Hartigan; Sampler / Field Technician
Sherrie Trefry; Sampler

3.0 TASK DESCRIPTIONS - FIELD MONITORING AND SAMPLING PROTOCOL

The following subsections discuss general methodology for the bedrock groundwater investigation activities. The following sections specifically include procedures for bedrock borehole installations and groundwater sampling, residential bedrock water level measurements, and data management requirements that will be implemented during the field program. Activities will be conducted in accordance with the SAP and this SAP Addendum #1, unless Site conditions require modifications. Any modifications shall be approved by NHDES in advance, following concurrence with EPA.

Note that specific field equipment required to complete a task, in addition to instrument calibration requirements, are included in GZA's appended SOPs and are referenced as appropriate below.

Table 1 includes a summary of the test methods being performed by the NHDES laboratory and the associated RDLs.

Table 2A included in the SAP is not applicable to the activities included in this addendum.

Table 2B refers to the selected residential drinking water wells from the greater residential drinking water program where water level measurements will be collected, their respective designations, associated sanitary parameters to be sampled, and the rationale for selection.

Table 3 refers to specific analytical methods, sample volume, containers, and hold time requirements for the current sampling event.

Table 4 included in the SAP is not applicable to the activities included in this addendum.

Table 5 refers to the specific Quality Control (QC) sampling requirements for the current sampling event.

Figure 1 consists of the Site Locus.

Figure 2 depicts the residential water level measurement locations as well as the proposed deep bedrock borehole locations.

All groundwater and residential water supply samples will be analyzed by NHDES' laboratory. GZA will be responsible for delivering samples to the NHDES laboratory. The laboratory Turn-Around-Time (TAT) requested for all samples will be the standard business day TAT.

3.1 DEEP BEDROCK BOREHOLE INSTALLATION AND GEOPHYSICAL CHARACTERIZATION

GZA will oversee New Hampshire Boring of Londonderry, New Hampshire complete three bedrock borehole (MO_MW-100D, MO_MW-101D, and MO_MW-102D) installations using standard air rotary drilling techniques in accordance with SOP A-9-1. Field screening of the drill cuttings and water will be screened in accordance with SOP A-9-2. Screening for DNAPL, should it be potentially encountered during drilling, will be performed using Sudan IV dye in accordance with A-9-3. SOPs A-9-1 through A-9-3 are included in **Appendix A**. The proposed locations of the boreholes are provided on **Figure 2**. GZA anticipates that the boreholes will extend to the following approximate depths (feet below ground surface [ft bgs]):

- MOT_MW-100D - 350 ft bgs;
- MOT_MW-101D - 300 ft bgs; and
- MOT_MW-102D - 275 ft bgs.

The rationale for deep bedrock well installation consists of:

- The need to establish a link between residual Site contamination and observed off-Site groundwater contamination;
- Well MOT_MW-100D location is selected to intercept groundwater moving toward 1 Windmere Drive and 41 Blueberry Hill Road and is located west of the bedrock lineament line shown in **Figure 2**;
- Well MOT_MW-101D location is selected to intercept groundwater moving toward 31-33 Blueberry Hill Road and is placed along the bedrock lineament line shown in **Figure 2**; and
- Well MOT_MW-102D location is selected to be just downgradient of the former drum burial area and located midway between the former on-Site well house and well MOT_OW-2DR.

See **Figure 2** for the relative well locations.

The bedrock fractures in the three deep bedrock wells will be characterized through a geophysical investigation which will consist of:

- 3-arm caliper;
- Fluid temperature;
- Fluid resistivity/conductivity;
- Acoustic televiewer (ATV);
- Optical televiewer (OTV); and
- Heat pulse flow meter (HPFM).

Refer to **Appendix C** for geophysical logging SOP provided by the subcontractor.

The objective of the geophysical investigation performed on the three bedrock wells is to identify the bedrock fracture zones in each well and to generate the subsurface information to design and install a multi-level groundwater sampling system such the “Waterloo” multi-level sampling system or equivalent. Once the multi-level sampling system is designed for each of the three deep bedrock wells, the multi-level sampling system will be installed in the three deep bedrock wells. The multi-level sampling system will limit vertical migration within the borehole.

3.2 WELL DEVELOPMENT

The overburden well MOT_MW-101S (discussed in Section 3.4) will be developed according to SOP A-15 included in **Appendix A**. The well development of the three deep bedrock boreholes is described in the Air Rotary/Air Drilling SOP A-9-1 included in **Appendix A**.

3.3 BULK AND INTERVAL BEDROCK GROUNDWATER SAMPLING

Bulk groundwater samples will be collected from the newly installed bedrock boreholes (MOT_MW-100D, MOT_MW-101D, and MOT_MW-102D) with the anticipation that results will represent average water quality estimated over the entire length of the borehole. Rationale for collecting these samples is to provide data comparable to residential bedrock drinking water samples. Interval sampling via a multi-level sampling system will consist of discrete sample collection within each of the three boreholes adjacent to isolated water bearing fractures.

Rationale for collecting interval samples through a multi-level sampling system is to further evaluate whether or not observed groundwater contamination is associated with certain fracture zones within the borehole. See SOP A-10 included in **Appendix A** for the sampling method.

3.4 INSTALLATION AND SAMPLING OF OVERBURDEN WELL

An overburden well (MOT_MW-101S) will be installed near bedrock well MOT_MW-101D to sample the overburden / shallow bedrock water across from the Thomas residence. Whether the well is just screened in the overburden or also screened in the shallow bedrock will depend upon the amount of water encountered when the overburden is drilled for MOT_MW-101S. If insufficient water is observed, a field decision will be made (in coordination with the GZA project manager) concerning whether to drill into the shallow bedrock. The decision process will be coordinated with NHDES. The installation of MOT_MW-101S will follow SOP A-14 included in **Appendix A**.

Rationale for collecting a groundwater sample in well MOT_MW-101S is to evaluate the potential for a VOC vapor intrusion threat to the residential homes on Windmere Drive and Blueberry Hill Road. The groundwater sampling of MOT_MW-101S will follow the low flow sampling SOP A-1 from the Mottolo August 2009 SAP, modified to collect groundwater quality data to evaluate potential vapor intrusion pathway. The modifications, including the placement of tubing, will be determined once the well is installed.

3.5 GROUNDWATER LEVEL MEASUREMENTS AND WATER SUPPLY SANITARY PARAMETER SAMPLING

Water level measurements will be collected at the three bedrock boreholes (MOT_MW-100D, MOT_MW-101D, and MOT_MW-102D); overburden / shallow bedrock well MOT_MW-101S; select on-site bedrock monitoring wells (MOT_OW-2DR and MOT_OW-4SR); and 17 residential water supply wells identified in **Table 2B** to evaluate groundwater flow direction in bedrock in accordance with SOP A-11 included in **Appendix A**.

Both prior to and after collecting water level measurements in residential water supply wells, water samples collected from the residential homes for sanitary parameters including E-coli and total coliform will be analyzed for in accordance with SOP A-11 included in **Appendix A** and more specifically with NHDES' factsheet attached to the SOP (WD-DWGB-22-24 2008 - Sanitary Practices for Monitoring Water Levels in Drinking Water Supply Wells). Refer to **Tables 3** and **5** for the required QC sampling including equipment blanks, duplicate samples, etc., with respect to residential well sampling. The residential samples will be identified on the chain of custody by marking their well IDs included in **Table 2B** in the *Sample Location/ID* column with the note "pre-WL" or "post-WL" in the *Comments* column depending on whether the sample was collected prior to or after the water level measurement.

3.6 LEVEL ELEVATION SURVEY

GZA's subcontractor (CLD Consulting Engineers of Manchester, New Hampshire) will perform differential GPS survey (sub-meter horizontal system) to locate select water supply/monitoring wells and a differential survey to collect top-of-casing, top-of-pvc, and ground surface of select water supply/monitoring wells (0.01 foot accuracy) using the on-site datum point (to be determined). The horizontal datum will be in NH State Plane Coordinate System (NAD83) and the vertical datum will be NAVD88. The survey work will be performed in accordance with the SOP included in **Appendix C**.

3.7 OTHER PLANNED ACTIVITIES

A supplemental study regarding arsenic in bedrock groundwater may be performed concurrent with the above tasks. Discussions with NHDES, USEPA, and the United States Geologic Survey are ongoing relative to the scope of this supplemental work.

In the event that VOC contamination is detected in well MOT_MW-101S at concentrations exceeding NHDES GW-2 standards, further vapor intrusion evaluations will be conducted on selected residential homes on Blueberry Hill Road and Windmere Drive.

Should additional activities be proposed, this SAP Addendum will be updated as necessary.

4.0 QUALITY CONTROL

The following describes the QC steps used to demonstrate reliability and confidence in the monitoring data collected for this project and includes field equipment maintenance and calibration, field QC sample collection, and data verification and validation.

4.1 EQUIPMENT MAINTENANCE AND CALIBRATION

Section 4.1 *Equipment Maintenance and Calibration* has not changed and will be followed, as applicable.

4.2 FIELD QUALITY CONTROL

Section 4.2 *Field Quality Control* has not changed and will be followed, as applicable.

4.3 DATA VERIFICATION AND VALIDATION

Section 4.3 *Data Verification and Validation* has not changed and will be followed, as applicable.

4.4 QUALITY ASSURANCE FIELD AUDITS

Section 4.4 *Quality Assurance Field Audits* has not changed and will be followed, as applicable.

5.0 DOCUMENTATION

5.1 FIELD DATA MANAGEMENT

Section 5.1 *Field Data Management* has not changed and will be followed, as applicable.

5.2 CHAIN-OF-CUSTODY PROCEDURES

Section 5.2 *Chain-of-Custody Procedures* has not changed and will be followed, as applicable. Revised Chain-of-Custody (COCs) forms include the additional analyses being performed as part of the Addendum is included in SOP A-8. These forms include COCs for the EPA mobile laboratory, the NHDES laboratory, and Microseeps.

5.3 TECHNICAL PROJECT REPORTS

Section 5.3 *Technical Project Reports* has not changed and will be followed, as applicable.

6.0 SAP MODIFICATIONS

This section of this SAP addendum, including Appendix B, is not applicable.

TABLES

TABLE 1 - SUMMARY OF ANALYTICAL TEST METHODS AND LABORATORY REPORTING LIMITS / DETECTION LIMITS AND REGULATORY ACTION LIMITS

Mottolo Pig Farm Superfund Site
Raymond, New Hampshire

Test Methods / Analytes - Groundwater	**Laboratory Reporting Detection Limits (RDLs)**	**Drinking Water Quality Standards Env-Ws-300 MCLs**	**Ambient Groundwater Quality Standards (AGQS)**	**ROD Interim Groundwater Cleanup Levels**
VOCs (mg/L) by EPA 524				
Vinyl Chloride	0.5	2	2	2
cis-1,2-Dichloroethene	0.5	70	70	70*
trans-1,2-Dichloroethene	0.5	100	100	70*
1,1-Dichloroethane	0.5	---	81	81
Tetrahydrofuran(THF)	10	---	154	700
1,1,1-Trichloroethane	0.5	200	200	200
Trichloroethene	0.5	5	5	5
Toluene	0.5	1,000	1,000	1000
Ethylbenzene	0.5	700	700	700
1,4 DIOXANE by EPA Method 8260B (mg/L)	2	N/A	3	---
Metals by EPA Method 200.8 (mg/L)				
Arsenic	0.0010	N/A	0.01	0.05
Arsenic (lll) Field filtered	0.0010	N/A	N/A	N/A
Metals by EPA Method 200.7 (mg/L)				
Iron	0.050	N/A	---	---
Potassium	0.2500	N/A	35	N/A
Magnesium	0.1000	N/A	N/A	N/A
Sodium	1.0000	N/A	N/A	N/A
Calcium	1.0000	N/A	N/A	N/A
Alkalinity, HCO_3/CO_3 by EPA SM 2320B (mg/L)	1.0	N/A	---	---
Chloride by Lachat 10-117-07-1-B (mg/L)	3.0	N/A	---	---
Sulfate by Lachat 10-511-00-1-A (mg/L)	1.0	N/A	500	---
Nitrite by Lachat 10-107-04-1-A (mg/L)	0.05	N/A	1	---
Nitrate + Nitrite by Lachat 10-107-04-1-A (mg/L)	0.1	N/A	N/A	---
Nitrate by Lachat 10-107-04-1-A (mg/L)	0.050	N/A	N/A	---
Ammonia by Lachat Method 10-107-06-1-A (mg/L)	0.2	N/A	---	---
Bromide(Br) by Method 300.0	0.5000	N/A	N/A	---
Total Organic Carbon by SM 5310B (mg/L)	0.5	N/A	---	---
Carbon Dioxide Microseeps SOP-AM20GAx (mg/L)	5	N/A	---	---
Methane by Microseeps SOP-AM20GAx (mg/L)	0.1	N/A	---	---
Ethane by Microseeps SOP-AM20GAx (mg/L)	0.025	N/A	---	---
Ethene by Microseeps SOP-AM20GAx (mg/L)	0.025	N/A	---	---
Volatile Fatty Acids by AM21G (mg/L)				
Acetic Acid	1	N/A	---	---
Propionic Acid	1	N/A	---	---
Butyric Acid	1	N/A	---	---
Pyruvic Acid	10	N/A	---	---
Lactic Acid	25	N/A	---	---

Notes:

1. RL and MDL information for Carbon Dioxide, methane, ethane, ethene and Volatile Fatty Acids was provided by Microseeps, Inc. All other RDL and MDL information was provided by NHDES laboratory.
2. Microseeps AM20GAx SOP is based on RSKSOP-175, which uses Henry's Law and satisfies EPA requirements.
3. "N/A" = Not Applicable (Drinking Water Standards only apply to the VOCs EPA Method 524) and "---" indicates no standard available at this time.
4. * ROD Interium Cleanup Level is 70 ug/L for total 1,2 dicholorethene .

TABLE 1 - SUMMARY OF ANALYTICAL TEST METHODS AND LABORATORY REPORTING LIMITS / DETECTION LIMITS AND REGULATORY ACTION LIMITS

Mottolo Pig Farm Superfund Site

Raymond, New Hampshire

Test Methods / Analytes - Drinking Water	Laboratory Reporting Detection Limits (RDLs)	Ambient Groundwater Quality Standards (AGQS)	ROD Interim Groundwater Cleanup Levels
E-coli/ Total Coli-form (mg/L) by 9222B	CTS/100 mL	CTS/100 mL	---

Notes:

1. RL information was provided by NHDES laboratory.
2. The AGQS included in the table is for total coliform.

TABLE 1 - SUMMARY OF ANALYTICAL TEST METHODS AND LABORATORY REPORTING LIMITS / DETECTION LIMITS AND REGULATORY ACTION LIMITS

Mottolo Pig Farm Superfund Site
Raymond, New Hampshire

Test Methods / Analytes - Drilling Water	Laboratory Reporting Detection Limits (RDLs)	Ambient Groundwater Quality Standards (AGQS)	ROD Interim Groundwater Cleanup Levels
VOCs (µg/L) by $FVOAW	**1.0**	---	---

Notes:

1. RLs provided by EPA Chelmsford Laboratory.

TABLE 1 - SUMMARY OF ANALYTICAL TEST METHODS AND LABORATORY REPORTING LIMITS / DETECTION LIMITS AND REGULATORY ACTION LIMITS

Mottolo Pig Farm Superfund Site
Raymond, New Hampshire

Test Methods / Analytes - Drill Cuttings	Laboratory Reporting Detection Limits (RDLs)	Soil Remediation Standards	ROD Interim Groundwater Cleanup Levels
VOCs (µg/kg) by $FVOAW	**50**	---	---

Notes:
1. RLs provided by EPA Chelmsford Laboratory.

TABLE 2B - RESIDENTIAL DRINKING WATER SAMPLE PLAN
Mottolo Pig Farm Superfund Site
Raymond, New Hampshire

12/18/2009

Location	Well ID	Sample Location	Sample Type	Current & Proposed Treatment	Well Depths
5 Strawberry Ln	MOT_DW-6A	Outside Front	Raw	Softener (outside faucets are not on softener)	160
	MOT_DW-6B	Outside Rear			
10 Strawberry Ln	MOT_DW-4	Outside front	Raw	No treatment	240
	MOT_DW-4A	Outside rear			
15 Strawberry Ln	MOT_DW-10	Outside Rear	Raw	No treatment	200
	MOT_DW-10A	Outside Front			
20 Blueberry Hill Rd	MOT_DW-52	Outside Front	Raw	Softener (front outside faucet is raw)	96
22 Blueberry Hill Rd	MOT_DW-25	Basement tank	Raw	Sediment Filter	Unknown
	MOT_DW-25A	Outside front	Raw (when filter taken offline)		
31-33 Blueberry Hill Rd	MOT_DW-13	Basement tank	Raw	POE for VOCs (TCE) installed in 2009; Softener. Chose to also stay on bottled water.	300
42 Blueberry Hill Rd	MOT_DW-53	Basement tank	Raw	Softener	250
44 Blueberry Hill Rd	MOT_DW-54	Outside front	Raw	No treatment	Unknown
1 Windmere Dr.	MOT_DW-29	Basement tank	Raw	POE for VOCs (TCE), POU for As, installed 2009; Softener	745
4 Windmere Dr.	MOT_DW-32	Basement tank	Raw	Softener	545
14 Windmere Dr.	MOT_DW-35	Basement	Raw	Softener	305
22 Windmere Dr.	MOT_DW-40	Basement tank	Raw	Softener	285
4 Raspberry Rd.	MOT_DW-57	Basement tank	Raw	Radon Treatment	Unknown
8 Blackberry Lane	MOT_DW-48	Outside front **after treatment shut off**	Raw (after shutting off treatment)	Softener	230
22 Jennifer Lane	MOT_DW-67	Outside front after bypass	Raw	Treatment, to be further defined	Unknown
15 Huckleberry Rd	MOT_DW-23	Outside front	Raw	No treatment	Unknown
21 Blake Rd	MOT_DW-16A	Basement tank	Raw	No treatment	545
29 Blake Rd	MOT_DW-55	Outside rear next to bulkhead, not hooked to softener	Raw	Softener	Unknown

Notes:

1. Sample raw water only.

TABLE 3 – MEDIA, ANALYSIS, TEST METHODS, CONTAINERS/ SAMPLE VOLUME, PRESERVATION, AND HOLD TIME
Mottolo Pig Farm Superfund Site
Raymond, New Hampshire

PARAMETER	MATRIX	NUMBER OF SAMPLES (including field QC$^{/1 \text{ and } 2}$)	ANALYTICAL METHOD	CONTAINERS (size and type)	PRESERVATION REQUIREMENTS$^{/4}$	MAXIMUM HOLDING TIME
Headspace VOCs	Drilling Water	3 field samples (bulk samples); 1 duplicate	$FVOAW	40mL amber VOA	4°C +/-2°C	7 days
Headspace VOCs	Drill Cuttings	3 field samples (bulk samples); 1 duplicate	$FVOAW	40mL VOA filled with 10mL DI water	4°C +/-2°C	7 days
VOCs	Bedrock Groundwater	3 field samples (bulk samples); 1 duplicate	524	4 - 40mL VOA/1	HCl, 4°C +/-2°C	14 days
Dissolved Arsenic		3 field samples (bulk samples); 1 duplicate	200.8	1- 500mL plastic	4°C +/-2°C	6 months
Dissolved Arsenic (lll)		3 field samples (bulk samples); 1 duplicate	200.8	1 -250 mL plastic	Field filtered from dissolved metals bottle with syringe and Meng filter tip, 4°C +/-2°C	6 months
Total Arsenic		3 field samples (bulk samples); 1 duplicate	200.8	1- 500mL plastic	HNO_3	6 months
Total Fe, K, Mg, Na & Ca		3 field samples (bulk samples); 1 duplicate	200.7			
Alkalinity (HCO3/CO3)		3 field samples (bulk samples); 1 duplicate	SM 2320B	1 – 500 mL plastic	4°C +/-2°C	14 days
Chloride		3 field samples (bulk samples); 1 duplicate	Lachat 10-117-07-1-B			28 days
Sulfate		3 field samples (bulk samples); 1 duplicate	Lachat 10-511-00-1-A			28 days
Nitrate/Nitrite		3 field samples (bulk samples); 1 duplicate	LACHAT 10-107-04-1-C			**48 hours ***
Bromide (Br)		3 field samples (bulk samples); 1 duplicate	300.0	1-250 mL plastic	4°C +/-2°C	28 days
Total Organic Carbon		3 field samples (bulk samples); 1 duplicate	SM 5310B	3 – 40 mL amber VOA	H_3PO_4, 4°C +/-2°C	28 days
1,4 Dioxane		3 field samples (bulk samples); 1 duplicate	8260B	3- 40mL VOA	4°C +/-2°C	14 days
Volatile Fatty Acids		3 field samples (bulk samples); 1 duplicate	AM21G	2- 40mL VOA	4°C +/-2°C	21 days

TABLE 3 – MEDIA, ANALYSIS, TEST METHODS, CONTAINERS/ SAMPLE VOLUME, PRESERVATION, AND HOLD TIME
Mottolo Pig Farm Superfund Site
Raymond, New Hampshire

PARAMETER	MATRIX	NUMBER OF SAMPLES (including field QC$^{/1 \text{ and } 2}$)	ANALYTICAL METHOD	CONTAINERS (size and type)	PRESERVATION REQUIREMENTS$^{/4}$	MAXIMUM HOLDING TIME
Fe++ (Field Screening)		3 field samples (bulk samples); 1 duplicate	(Field) Method 8146			Test immediately following sample collection
Ammonia		3 field samples (bulk samples); 1 duplicate	Lachat Method 10-107-06-1-A, using distillation option	1- 250mL amber	H_2SO_4, 4°C +/-2°C	28 days
Carbon Dioxide Methane/Ethane/Ethene		3 field samples (bulk samples); 1 duplicate	Microseeps SOP-AM20GAx’$^{(5)}$, revision 9, 11/21/2008 /SOP-PM 01C, revision 5, 1/20/2009	2 - 40mL VOA	benzalkonium chloride, 4°C +/-2°C	14 days
E-coli/ Total Coli-form	Residential Drinking Water	18 field samples; 1 duplicate (pre-water level measurement) 18 field samples; 1 duplicate (post-water level measurement)	9222B	1- 500mL plastic	Sterile container, <10°C	**30 hours ***

Notes:

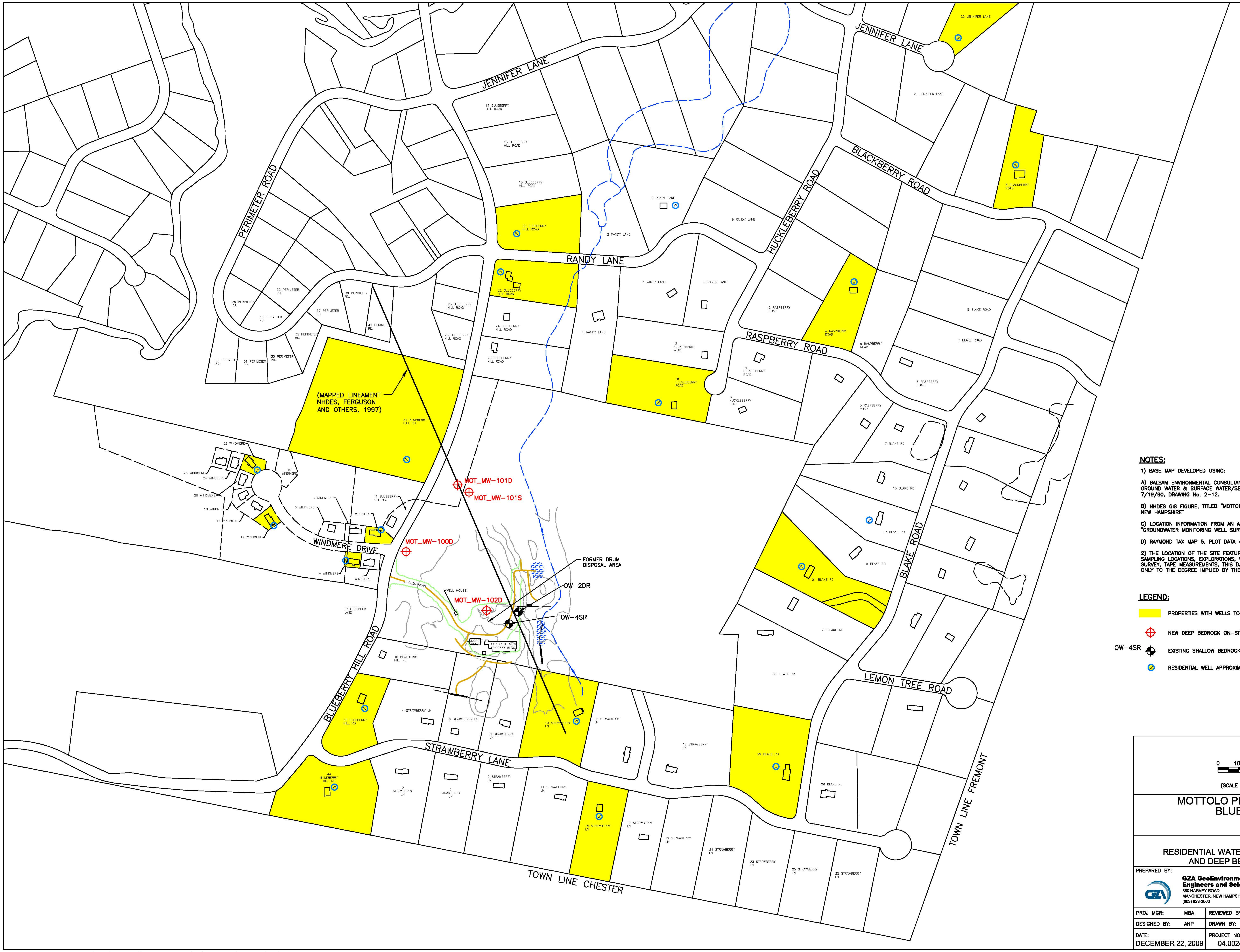
*** Nitrate/E-coli/Total Coli-form samples must be delivered to the lab by 2 P.M. on Fridays!**

1. Trip blanks will be included with each cooler containing VOC samples. Trip blanks will include HCL-preserved blanks for aqueous VOC samples (2 VOA Vials each). There will be one temperature blank per cooler.
2. Refer specifically to **Table 5** for equipment blank details as well as other QC sampling requirements. If non-dedicated sampling equipment is used, (filter tip & syringe) one equipment blank per sampling event will be required.
3. Metals samples will be preserved by the lab upon arrival.
4. Arsenic speciation kits will be included for every arsenic sample, which contain a 60mL syringe and Meng filter tip.

TABLE 5 – SUMMARY OF QUALITY ASSURANCE SAMPLES TO BE COLLECTED
Mottolo Pig Farm Superfund Site
Raymond, New Hampshire

SAMPLING MEDIA	SAMPLING FREQUENCY	ASSOCIATED SAMPLING EQUIPMENT	SAMPLE ID	DESIGNATED NOTE TO BE USED ON CHAIN-OF-CUSTODY	ANALYSES
EQUIPMENT BLANK SAMPLES					
Arsenic Speciation Kit	December 2009	Syringe And Filter Tip	EQUIP BLANK	"As syringe/filter tip"	Dissolved Arsenic, Dissolved Arsenic (lll)
Groundwater	December 2009	Peristaltic Pump /Tubing from MOT_MW-100S (Prior to Sampling)	EQUIP BLANK	"Peristaltic Pump/Tubing"	VOCs, Total As, Dissolved As, Dissolved As (lll)
	December 2009	Bladder Pump/Tubing (Prior to Site Sampling)	EQUIP BLANK	"Pre-Bladder Pump Setup"	VOCs, Total As, Dissolved As, Dissolved As (lll)
	December 2009	Bladder Pump/Tubing (After use in MOT_MW-102D & Decontamination)	EQUIP BLANK	"Post- Bladder Pump Setup"	VOCs, Total As, Dissolved As, Dissolved As (lll)
	December 2009	Water Level Meter (Collected: After routine decontamination and chlorine bleach [sodium hypochlorite] sanitation; and before the first residential first water level)	EQUIP BLANK	Decon & Sanitized Water Level	VOCs, Total As, E-coli/ Total Coli-form
DUPLICATE SAMPLES					
Groundwater	December 2009	*N/A*	MOT_MW-100D DUP	*N/A*	VOCs, Total Metals (As, Fe, K, Mg, Na & Ca), Dissolved Arsenic, Dissolved Arsenic (lll), Alkalinity, Chloride, Sulfate, Nitrate/Nitrite, Bromide, TOC & Ferrous Iron Field Screening, 1,4-Dioxane, Ammonia, Methane/Ethane/Ethene, Carbon Dioxide, and VFAs.
Drinking Water (2 duplicates, taken before and after the water level measurement)	December 2009	*N/A*	MOT_DW-4A DUP MOT_DW-4A DUP	*"Pre-water level measurement"* *"Post-water level measurement"*	E-coli/ Total Coli-form
TRIP BLANK/TEMPERATURE BLANK SAMPLES					
Aqueous VOCs (1 per cooler with aqueous VOCs samples)	December 2009	*N/A*	TRIP BLANK	*Identify all Sample IDs associated with Trip Blank in notes section of COC*	VOCs
Temperature Blank (1 per cooler)	December 2009	*N/A*	TEMP BLANK	*Include in notes section of COC that a temperature blank has been included in the cooler*	Temperature

FIGURE



NOTES:

1) BASE MAP DEVELOPED USING:

A) BALSAM ENVIRONMENTAL CONSULTANTS, INC. SITE PLAN TITLED "SITE AREA GROUND WATER & SURFACE WATER/SEDIMENT SAMPLING LOCATIONS", DATED 7/19/90, DRAWING No. 2-12.

B) NHDES GIS FIGURE, TITLED "MOTTOLO PIG FARM SUPERFUND SITE, RAYMOND, NEW HAMPSHIRE"

C) LOCATION INFORMATION FROM AN AUGUST 24, 2008, NOBIS DETAIL SHEET 4 "GROUNDWATER MONITORING WELL SURVEY"

D) RAYMOND TAX MAP 5, PLOT DATA 4/23/08.

2) THE LOCATION OF THE SITE FEATURES, TEST BORINGS, MONITORING WELLS, SAMPLING LOCATIONS, EXPLORATIONS, WERE APPROXIMATELY DETERMINED BY SURVEY, TAPE MEASUREMENTS, THIS DATA SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

LEGEND:

🟨	PROPERTIES WITH WELLS TO HAVE WATER LEVEL MEASURED
⊕	NEW DEEP BEDROCK ON-SITE WELLS TO BE SAMPLED
OW-4SR ●	EXISTING SHALLOW BEDROCK WELLS TO HAVE WATER LEVEL MEASURED
Ⓦ	RESIDENTIAL WELL APPROXIMATE LOCATION

(SCALE IS AN ESTIMATE BASED ON TAX MAPS)

MOTTOLO PIG FARM SUPERFUND SITE
BLUEBERRY HILL ROAD

RAYMOND, NH

RESIDENTIAL WATER LEVEL MEASUREMENT LOCATIONS AND DEEP BEDROCK WELL LOCATIONS MAP

PREPARED BY:

GZA GeoEnvironmental, Inc.
Engineers and Scientists
380 HARVEY ROAD
MANCHESTER, NEW HAMPSHIRE 03103
(603) 623-3600

PREPARED FOR:

NEW HAMPSHIRE DEPT. OF ENVIRONMENTAL SERVICES; BUREAU OF WASTE MANAGEMENT

PROJ MGR: MBA	REVIEWED BY: SRL	CHECKED BY: MBA	FIGURE
DESIGNED BY: ANP	DRAWN BY: MA	SCALE: EST 1:200'	2
DATE: DECEMBER 22, 2009	PROJECT NO. 04.0024466.27	REVISION NO. 0	SHEET NO.

APPENDIX A

GZA STANDARD OPERATING PROCEDURES

A-8

Updated Chain-of-Custody Forms

Microseeps
Lab. Proj. # ____________

CHAIN - OF - CUSTODY RECORD

Microseeps
COC cont. # ____________

Phone: (412) 826-5245 **Microseeps, Inc. - 220 William Pitt Way - Pittsburgh, PA 15238** Fax No. : (412) 826-3433

Company : ____________
Co. Address : ____________
Phone # : ____________ Fax # : ____________
Proj. Manager : ____________
Proj. Name/Number : ____________
Sampler's signature : ____________

Cooler Temp. ____________

Results to : ____________

Invoice to : ____________

Sample ID	Sample Description	Sample Type			Date	Time	# bottles	Parameters Requested											Remarks :
		Water	Vapor	Solid															

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

WHITE COPY : Accompany Samples YELLOW COPY : Laboratory File PINK COPY : Submitter

NH DES LABORATORY SERVICES LOGIN AND CUSTODY SHEET
(Laboratory Policy: Samples not meeting method requirements will be analyzed at the discretion of the NH DES Laboratory.)

LAB ACCOUNT (Billing) #04-0002104 **One Stop (PROJECT) ID# SUPERFND** **DES Site Number 198704094** **Temp. ^{0}C. _____**

Description: **Mottolo Pig Farm Superfund Site** Town: Raymond, NH

Comments:

NHDES Contact: Sharon Perkins (603) 271-6805
Collected By & Phone#: Don Kirkland (603) 493-2678
Daniel Hartigan (603) 828-2869

Sample Location /ID	Date/Time Sampled	# of Containers	Matrix	Headspace VOCs ($FVOAW)	Comments	Lab ID # (For Lab Use Only)

Preservation: None

Relinquished By____________________Date and Time____________________Received By________________ Matrix: A= Air S= Soil SED = Sediments AQ= Aqueous Other: ______

Relinquished By____________________Date and Time____________________

Relinquished By____________________Date and Time____________________ **Received For Laboratory By________________**

Page _______ of ________ Data Reviewed By________________________________ Date________________

Section No.: 22.0
Revision No.: 5 (HWRB)
Date: 11-2-06
Page 1 of 1

NH DES LABORATORY SERVICES LOGIN AND CUSTODY SHEET

(Laboratory Policy: Samples not meeting method requirements will be analyzed at the discretion of the NH DES Laboratory.)

LAB ACCOUNT (Billing) #04-0002104 **One Stop (PROJECT) ID# SUPERFND** **DES Site Number 198704094** **Temp. ^{0}C. _____**

Description: **Mottolo Pig Farm Superfund Site** Town: Raymond, NH

Comments:

*** The Lab will acidify the Dissolved Arsenic (III) and Dissolved Arsenic samples upon arrival**

NHDES Contact: Sharon Perkins (603) 271- 6805

Collected By & Phone#: Amy Piscopo (603) 391-8239, Michael Devoid (207) 233-8908, Daniel Hartigan (603) 828-2869, Al Jacobsen (603) 493-1599, Stefanie Lamb (207) 317-1441

Sample Location /ID	Date/Time Sampled	# of Containers	Matrix	524	Total As, Fe, K, Mg, Na & Ca	Dissolved Arsenic	Dissolved Arsenic (III)	Alkalinity (HCO3/CO3), Chloride, Sulfate Nitrate/ Nitrite	Bromide	TOC	Ammonia	1,4-Dioxane	E-coli / Total Coliform	Comments	Lab ID # (For Lab Use Only)

Preservation: VOCs (524) = HCL & 4ºC +/-2°C; Total As, Fe, K, Mg, Na & Ca = HNO_3 & 4ºC +/-2°C; Dissolved As, Dissolved As (III), Alkalinity, Chloride, Sulfate, Nitrate/Nitrite, Bromide, 1,4-Dioxane = 4ºC +/-2°C ; TOC = H_3PO_4 & 4ºC +/-2°C; Ammonia = H_2SO_4 & 4ºC +/-2°C; E-coli / Total Coliform = <10°C

Relinquished By______________________ Date and Time____________________ Received By___________________ Matrix: A= Air S= Soil SED = Sediments AQ= Aqueous Other: _______

Relinquished By______________________ Date and Time____________________ Received By___________________

Relinquished By______________________ Date and Time____________________ **Received For Laboratory By__________________**

Page _______ of ________ Data Reviewed By________________________________ Date________________

Section No.: 22.0
Revision No.: 5 (HWRB)
Date: 11-2-06
Page 1 of 1

A-9-1

Rotary Drilling

AIR ROTARY/AIR HAMMER DRILLING

PURPOSE

This Standard Operating Procedure (SOP) *Air Rotary Drilling/Air Hammer Drilling* provides general guidance for the completion of deep bedrock bore holes using standard air rotary/air hammer drilling techniques. Evaluation of bedrock groundwater quality and hydrogeologic characteristics of the bedrock formation and penetrated aquifer may be performed via the completed bore hole (i.e., geophysical logging, groundwater sampling, hydraulic conductivity testing, pump testing, etc.).

In air rotary/air hammer drilling, compressed air travels down the drill pipe and emerges into the borehole through holes in the bit or air hammer. The borehole is advanced by the rotating bit and the pneumatic action of the air hammer which breaks up the bedrock into small fragments (rock chips). Compressed air, supplied by the rig and/or compressor, carries the rock chips to the top of the borehole.

Air rotary drilling is typically used for softer formation materials, such as limestone, sandstone, and some of the softer metamorphic rocks whereas air hammer drilling is more commonly used to advance borings in hard metamorphic and igneous rocks.

The following is a list of equipment and material used in conjunction with air rotary/air hammer drilling and borehole development.

Equipment and Supplies	
• Air rotary/air hammer drill rig with appropriate drilling tools	• Toolbox
• Rotary drill bit (roller bit) or pneumatic "down-the-hole" hammer	• Appropriate health and safety gear and GZA-approved site-specific Health & Safety Plan (HASP)
• Screen strainer	• Digital camera
• Poly sheeting	• Flame ionization detector (FID)
• Tubing reel (2)	• Dry erase board
• Poly tubing (1-inch and 1-1/4 inch diameter)	• Steam cleaner
• Grundfos submersible pump or equivalent and	• Decontamination equipment and supplies
• Generator and controller for submersible pump	• Water level meter – 300’
• Ball valve and associated fittings used with poly tubing at discharge end to control flow rate	• Logbook, field sheets, pencil/pen/sharpies, calculator, and engineering scale
• Flow measurement supplies (graduated cylinder, graduated buckets and stop watch, etc.)	• Appropriate health and safety gear as specified in the Site specific HASP (i.e., gloves, safety glasses, steel-toe boots, etc.)
• Borehole field log	• Fiberglass surveyors tape
• Buckets, drums, or other for containerization of liquids (as needed)	• 6-foot folding rule
• Nylon zip ties	• Drillers jars and sample containers for off-site laboratory headspace screening analysis as instructed by the laboratory (amber 40 ml vials)

PROCEDURES

1. Obtain utility clearance prior to commencing drilling activities.

2. At predetermined locations, utilizing air rotary/air hammer drilling techniques, advance the borehole through the fill and overburden to the top of bedrock. In some cases due to water table or soil conditions, mud rotary drilling methods will be required to maintain an open borehole. In such cases, the mud/water mixture will be used instead of air as the drilling fluid.

3. Advance 5-inch-diameter steel casing from just above ground surface to bedrock surface by hydraulic pressure, driving and/or spinning.

4. Drill a 5-inch-diameter borehole though the 5-inch casing approximately 5 feet to 20 feet into the bedrock surface (penetration into bedrock to be determined based on competency of the bedrock and exploration objectives).

5. Within the 5-inch casing, advance 4-inch-diameter casing approximately 5 feet to 20 feet into the bedrock surface (penetration into bedrock to be determined based on competency of the bedrock). Grout the casing into place, allowing the grout to set up overnight. Remove the 5-inch casing.

6. Once the grout has cured, continue to advance the borehole with a 3-7/8-inch or 3-15/16-inch air rotary/air hammer bit to the target termination depth. Record the rate of borehole advancement (feet per minute) on the field log.

7. Use a washtub to separate soil and rock cuttings from the drilling water. Containerize drill cuttings (in 55-gallon drums) from boreholes advanced along Blueberry Hill Road and the former drum burial area. All the drums will be stored in the former drum burial area and stored until Spring 2010. GZA and the regulators will discuss how the material should be spread in the former drum storage area. Discharge the drill water to the ground surface unless field screening for total volatile organic compounds (VOCs) with a FID (refer to SOP A-9-2) indicates sustained readings of 5 parts per million (ppm) or greater (as discussed in bullets 11 and 12 below). In the event the drilling water cannot be released to the ground surface, the water will be containerized and treated on site prior to release to the ground surface.

8. Collect drill cuttings from beneath the drilling skirt using a screen strainer with a long handle. Obtain samples at 20-foot intervals and/or when fractures are encountered during and place on a clean sheet of poly. Be sure to segregate samples.

9. Visually inspect the drill cuttings for changes in lithology, color, texture, etc. In addition note odors and the presence of sheen, staining or globules in the drill cuttings or wash water. Record on the field log. Transfer cuttings to clean, glass drillers jars, labeled with

the boring number and sample depth. In the event that dense non-aqueous phase liquid (DNAPL) is suspected during drilling, confirm by perform screening via Sudan IV dye testing per SOP A-9-3.

10. Field screening for total VOCs will be performed on drill cuttings and drilling water samples using jar headspace methods with a FID or photoionization detector (PID) equipped with an 11.7 electron volt lamp. Refer to (SOP A-9-2). Drilling water will be placed on the ground surface as investigation derived waste contingent upon total VOC field screening results. Drill cuttings will be drummed. Due to the compressed air used during drilling, volatilization will occur during removal of the drill cuttings from the borehole. The FID should also be used to monitor the air space proximate to the borehole.

11. If field screening of drill cuttings or drill water are sustained at readings of 5 ppm or greater, or evidence of DNAPL is identified, stop drilling and contact the GZA project manager.

12. Drill cuttings and drill water samples exhibiting jar headspace readings of 5 ppm or greater will be containerized in 55-gallon open-top steel drums and/or stockpiled and covered with poly should characterization of drill cuttings or treatment of drilling water becomes necessary. Monitoring of total VOCs within the breathing zone around the drill rig will also be performed and documented in accordance with GZA's site-specific HASP. Samples for laboratory analysis will be taken by GZA as follows:

    - If a headspace space sample exceeds 5 ppm, a sample needs to be taken for laboratory analysis (EPA Chelmsford Laboratory). The project manager will arrange for sample transportation to the laboratory;
    - If a headspace sample is between 1 ppm and 5 ppm, ask for instructions from the GZA project manager as to whether a sample is taken for laboratory analysis. In the event the EPA Chelmsford laboratory has sample capacity, samples of the drill cuttings and drilling water will be taken at the same frequency as the GZA headspace field analysis. The project manager will arrange for sample transportation to the lab;
    - Drill cutting samples to be taken to the EPA Chelmsford laboratory will use an amber VOC 40 ml vial. Weigh ten grams of drill cuttings into a pre-weighted 40 ml VOC amber vial containing 10 ml if distilled water. Note on the chain of custody that the analytical results should on a "wet basis." Store the vials in a cooler with ice or "blue ice"; and
    - Drilling water samples to be taken to the EPA Chelmsford laboratory will use four amber VOC 40 ml vials per sample. Follow EPA protocol to limit air headspace in the vials. Store the vials in a cooler with ice or "blue ice." Refer to the attached EPA SOPs for additional details regarding sample collection and analysis.

13. When water bearing fractures are encountered during drilling, the drill rig shall be used to perform "blow tests". Blow tests are completed to estimate the net flow rate of the borehole. In the event that water bearing fractures are not readily apparent, perform blow tests at 20-foot intervals. At the completion of the borehole, a final blow test should be performed for a minimum of 15 minutes. Headspace field screening for VOCs will be performed on the drilling water and drill cuttings when the driller observes that water bearing fractures are encountered or every 20 feet if no observations are made of water bearing fractures. Drilling will be halted until the headspace field testing can determine if the encountered fractures yield detectable total VOC concentrations (equal to or greater than 5 ppm). The GZA field lead will confer with the GZA project manager and the GZA hydrogeologist on the headspace results before proceeding with drilling deeper (there is a concern with providing a path for cross-contamination between bedrock fractures if detectable VOC contamination is encountered).

14. Following completion of the borehole, collect the depth to water using a water level meter, referencing to the top of permanent casing and/or ground surface. Note that the depth to water will likely not represent static water level until the borehole has been purged and allowed to recover. Collect several measurements over time to estimate the rate of borehole recharge. Record this information on the boring log. Decontaminate the water level meter per SAP SOP A-7.

BEDROCK BOREHOLE DEVELOPMENT

1. Bedrock borehole development is performed by over-purging through the use of a submersible pump. Approximately three to five times the borehole volume (Note: For 4-inch-diameter borehole, divide the total borehole depth by 0.5 to approximate 3 borehole volumes) will be removed during development/purging. Removal of additional volume may be required until the purge water runs clear. Allow groundwater to recover to 90% of the static water level following the removal of each borehole volume.

2. Lower the submersible pump, associated tubing and controller leads into the borehole. Lowering of the pump assembly will be controlled by a tubing reel maintained at the ground surface by the drilling subcontractor and field personnel. Additional tubing (1-inch diameter), housing the water level meter probe and tape will also be lowered by similar means. The purpose of the tubing is to prevent the water level meter from becoming entangled in the pump tubing and controller leads, should the water level drop significantly during development/purging.

3. Once the submersible pump has been installed, collect an initial water level measurement (to 0.01 feet) using the top of the well casing as the reference point. Note that the water level measurement will likely not represent static water level conditions. Additional water level measurements will be made during development/purging of the borehole. The initial water level information will be compared to water level measurements during

development/purging in order to determine drawdown. All water level measurements collected during purging should be referenced and documented to the top of the well casing.

4. Start the pump and commence development/purging at approximately 5 gallons per minute. Note that the generator shall be operated downwind of the discharge line. Monitor and record the water level, drawdown and pumping rate at 10-minute intervals. Record development/purge volume in field book/field sheet.

5. Discontinue pumping after extraction of one well volume has been achieved. Allow water level to recover to within 90% of static level before beginning extraction of volume two. Continue in this sequence until a minimum of three well volumes have been purged and the water runs clear.

6. Purge water will be field screened for total VOCs. If total VOC field screening results indicate the presence of VOCs (equal to or greater than 5 ppm), purge water will be containerized and treated prior to discharge to the ground surface.

RECORDS AND DOCUMENTATION

All data, sampling information will be recorded on GZA's boring logs (sample attached). Specifically, the following items will be included:

- Type of drilling bit, including size;
- Depth at which bedrock was encountered;
- Termination depth of borehole;
- Description of rock cuttings;
- Time required to drill each 10-foot drilling rod length, including hydraulic feed pressure;
- Drilling observations and rate of drilling, chalking of drill rods;
- Changes in drill water color;
- Blow test results (flow rate measurement);
- Identification of fracture zones as suggested by drill rod drop, increase advancement of drill rods, water discolorization and flow rate increase;
- Clock time purging initiated;
- Calculation for one purge volume and the total volume purged;
- All purging rate adjustments and clock time adjustment made;
- Drawdown measurements;
- Clock time of all water levels measurements referenced to the casing;
- FID field screening results;

- Purge/development volume; and
- Water level measurements.

SPECIAL NOTES

In areas of known contamination, the following should be performed:

1. Rotary/air hammer drill bits, drill rods and associated tools will be sprayed with high pressure water and allowed to air dry upon completion of the borehole to preclude cross-contamination between successive boreholes.
2. In the event that contaminated groundwater is encountered while drilling, the groundwater will be containerized and treated prior to discharge to the ground surface.

APPLICABLE REFERENCES AND STANDARDS

Groundwater and Wells, published by Johnson Division UOP, Inc., Saint Paul, Minnesota, 1975.

Attachments: EPA SOPs
Sample Log

p:\04jobs\0024400s\04.0024466.00\04.0024466.27 - mottolo\sap addendum #1\sap appendix a - sops\sop a-9\sop a-9-1 rotary drilling.doc

GC/MS OPERATION FOR VOLATILE ORGANIC COMPOUNDS

The Office of Environmental Measurement and Evaluation
Investigations and Analysis Unit- Chemistry Laboratory
US EPA Region 1 New England
11 Technology Drive
North Chelmsford, MA 01863-2431

Prepared by: ______________________ 10/19/05
Joseph Montanaro, MS
Chemists, Investigations and Analysis Unit
Date

Approved by: ______________________ 10/19/05
Agnes Van Langenhove, Ph.D., Laboratory QA Officer
Investigations and Analysis Unit, OEME
Date

Approved by: ______________________ 10/19/05
Robert Maxfield, Chief, Investigations and Analysis Unit, OEME
Effective Date

Table Contents

1.0 Summary

This SOP describes the analysis of Volatile Organic Compounds (VOC) by GC/MS. Sample preparation, quality control and the operation of the GC/MS is described.

2.0 Purpose

To ensure that the same procedures are used for the analysis of Volatile Organic Compounds. To ensure that the proper quality control is run with the analysis. To aid other chemists in the operation of the GC/MS for VOC analysis.

3.0 Scope and Application

This procedure is to be used for the preparation and analysis of water, soil and drum samples for VOC analysis by the Finnigan Incos XL, Incos 50B, and Polaris Q GC/MS. It includes water samples for the drinking water and NPDES programs, and water, soil and drum samples for RCRA and CERCLA.

4.0 Personnel Qualifications

The analyst should have at least a four year degree in a physical science.

The analyst should be trained at least one week by an experienced analyst and possess a working knowledge of this method and quality control before initiating the procedure.

All personnel shall be responsible for complying with all quality assurance/quality control requirements that pertain to their organizational/technical function.

5.0 Interferences

Interferences may include:

- Target analytes, specifically, methylene chloride, tetrahydrofuran, and ketone(s).
- Artifacts resulting from systemic contaminants (moisture, column bleed, strong oxidation agents associated with the sample matrix).
- The addition of anti-foam reagent to laboratory blank(s) and samples are also common interferences.

These would be addressed in the project notes as per analyst.

6.0 Procedure

6.1 Instrumentation

6.1.1 Autosampler Devices:

There are four techniques to introduce sample(s) to the INCOS and Polaris GC/MS(s).

1) A single sample may be introduced manually via addition to the Tekmar LSC

2000/3100 sample concentrators. Internal and surrogate compounds are introduced to samples as they are loaded into the sparge cell with a luer lock syringe (5 ml or 25 ml).

The Tekmar LSC 2000/3100 sample concentrator(s) purge the aqueous samples, adsorbs the volatiles on a porous polymer trap and, then thermally desorbs them onto the GC.

2) Multiple samples are introduced by automation via the Tekmar ALS 2016. The process of loading sample(s) is manually as with the Tekmar LSC 2000/3100 sample concentrators. The ALS 2016 allows for sequential sample introduction.

3) The Varian Archon Purge and Trap system(s) hold fifty one 40 ml VOA vials. The aqueous samples are withdrawn from the vial and transferred to the Tekmar LSC 2000/3100 sample concentrators for purging. The internal and surrogate compounds are added automatically by each system.

4) The Varian Archon purges soil samples for low level analysis (Method 5035A) directly in 40 ml VOA vials with 5 mls of water (magnetic stir bars). The samples are prepared in the field with pre-weighed 40 ml VOA vials preserved with water.

All volatiles are purged from the samples with Helium gas into a porous polymer trap, prior to being thermally desorbed into the gas chromatograph.

6.1.2 Varian 3400 GC/HP 5980/TermoQuest Trace GC(s):

The GC(s) separate the thermally desorbed volatiles and elute them into the mass spectrometer.

6.1.3 Finnigan Incos XL/Incos 50B:

The Incos GC/MS(s) identify and quantitate the volatiles by using electron impact and a quadrupole mass spectrometer.

6.1.4 Finnigan Polaris Q:

The Polaris Q GC/MS(s) identify and quantitate the volatiles by using electron impact and an ion trap mass spectrometer.

6.1.5 Gateway/Dell Computers with Technivent Data System:

The Gateway/Dell computers and Technivent Data Systems run the software and control the mass spectrometer. The software operates using a windows based system. Samples are run under an Acquisition Mode OS/2 based operating system. The sample results are reduced using an automated Environmental Processing System (Hewlett Packard Enviroquant).

6.1.6 Instrument Maintenance Records:

The recording of all repairs, scheduled contractual preventive maintenance applications, and instrument modifications will be documented in the VOA Instrument Maintenance log book(s). The log book(s) are stored at the VOA work station(s) located with the instruments.

6.2 Sample Requirements

6.2.1 Aqueous samples:

Water samples for VOC analysis must be preserved with 1:1 HCl to a pH of <2. Measure with pH paper and record on the worksheet. This will be performed prior to analysis when samples are to be loaded via luer lock syringe or following the removal of the 40 ml vial post analysis. A minimum of four 40 ml vials is desired for each sample location.

6.2.2 Soil samples:

There are two generally preferred techniques for taking soil samples as per SW-846, Method 5035A (Closed-system Purge-and-trap and Extraction for Volatile Organics in Soil and Waste Samples), Draft Revision 1, July 2002.

The first technique involves the addition of a soil sample to a pre-weighed vial containing methanol and the other technique, direct addition of soil in the field to a pre-weighed vial containing water (magnetic stir bar inclusive). This method is referred to as a Low Level Soil or LS sample analysis.

Samples are collected using a 10 cc syringe barrel or equivalent and placed directly into the 40 ml VOA vials containing preservative. A sample of 10 grams is desired with excess water to be removed where possible. This can be achieved by taking approximately 6-8 cc of sample into the syringe. At each sampling location, two vials will be required for the High Level Soil or HS sample analysis. One vial will contain 10 ml of pre-weighted methanol and one vial will be empty. The methanol preserved vial is for analyzing levels of contamination if present and the second is for the calculation of percent solids.

Using the Low Level Soil (LS) sample analysis, requires the addition of the High Level Soil (HS) sample analysis vials. Ie. The High Level (HS) vials are used for dilutions, loss of sample in the analysis, or if a matrix effect applies to the Low Level Soil (LS) sample.

Alternatively, samples can be taken in the field using EnCore or equivalent sampling devices and prepared in the laboratory using the technique described in Section 6.3.2.

Refer to SOP for Soil Sampling, Region I, EIASOP-SOIL_SED_SOLID, Rev. 02, 02/18/04.

6.2.3 Sample Quantity:

WATER -	*Four 40ml VOA vials (Varian Archon) *Three 40ml VOA vials (Tekmar ALS 2016/Tekmar LSC 2000/3100 sample concentrators)
SOIL (LS) -	Two soil-water samples in pre-weighed vials (LS) and a soil-methanol pre-weighed vial (HS). An additional sample is to be taken for the percent solids determination. Sample should be analyzed or frozen within 48 hours from the period when it is taken. There are two freezers in the sample receipt and storage lab, room 190, that range from 0 degrees C to -50 degrees C.

SOIL (HS) -	*One soil-methanol pre-weighed vial (HS). An additional sample is to be taken for the percent solids determination.
Drums -	*One 40ml VOA vial is needed if the sample is not water soluble and/or organic product . The vial should have headspace to allow for expansion that is common with non aqueous liquid organic product(s).

* These samples require storage to 4 degrees C.

6.2.4 Trip Blanks:

The trip blank for water samples should be preserved the same way as the unknown sample, i.e. same number of drops of 1:1 HCl should be added. Trip blank water is available from the VOA group and a record of origin is kept in room 175.

6.2.5 Methanol Blanks:

Methanol blanks shall be run to analyze each Lot of water soluble reagent to determine purity. This applies to use for both standard and sample preparation. A record of this analysis is kept in room 175.

6.2.6 Hold blanks:

Hold blanks will be collected with all trip blanks originating from room 175. This sample will be stored in the Sample receipt and storage, room 190. A record of this analysis is kept in room 175.

6.2.7 Sample acceptance criteria:

Observe if any air bubbles are apparent. The sample is invalid, if there are significant air bubbles. A new sample must then be collected or the observed data will be qualified.

6.2.8 Sample storage:

Store samples at 4°C. The temperature of R-13 located in the Sample receipt and storage room 190, is checked each working day. Storage blank samples for R-13 are analyzed monthly. An R-13 Blank log book is stored with the verified storage blank samples. The vials containing the blank water are labeled with the date that they are put into the refrigerator and sequenced in the log book. The data from each analysis is stored at the VOA work station located with the instruments in room 175.

6.2.9 Hold times:

Holding time for all preserved VOC samples is 14 days. The holding time for un-preserved aqueous samples is 7 days. Low Level Soil (LS) sample(s) should be analyzed or frozen within 48 hours from the period when they are taken as described in Section 6.3.2. Frozen samples are allowed 14 days holding time.

6.3 Sample Preparation (Mid-Level soil and drum extraction)

Method 5035A (Closed-system Purge-and-trap and Extraction for Volatile Organics in Soil and Waste Samples):

6.3.1 Percent moisture determination for soil samples:

Check the balance calibration using Class 1 weights by recording the results in the balance log book and on the laboratory bench work sheet (soil extractions summary sheet). Balance log books are stationed with all balances in the laboratory. Weigh 5.00 g of sample to the nearest hundredth of a gram in an aluminum dish. Dry sample at 105°C for 24 hours. Following the removal of the sample(s) from a drying oven, allow to cool and record weight (soil extractions summary sheet) to the nearest hundredth of a gram.

$$\%\ \text{Moisture} = \frac{\text{gm wet sample - gm of dry sample}}{\text{gm of wet samples}} \quad \text{X } 100$$

6.3.2 Preparation of samples\method blanks:

Weigh 10 gm of soil or 100 ul of liquid drum sample in a tarred VOA vial. Record results on the laboratory bench work sheet (VOA soil extraction worksheet). Pipet 10 ml of water for Low Level Soil (LS) analysis or methanol for High Level Soil (HS) analysis. Cap and shake for 1 minute. Sample extract is now ready for dilution. A 50 fold dilution into water is the standard preparation. All dilution will be recorded in the instrument run log book(s). A VOA sample extraction and dilution summary bench worksheet is also included in all project folders.

6.3.3 Reporting Level Calculation(s):

$$\text{Method 5035A Reporting Level} = \frac{\text{(Extract volume)(dilution)(*low standard conc)}}{\text{(weight of dry sample)}}$$

*Refer to compound concentrations Section 6.9.2, Table 1

$$\text{Method 5035A Reporting Level Low Soils} = \frac{(0.005\text{L})\ (1)\ (1\text{ug/L})}{0.005\text{Kg (decimal \% solids)}} = 1\text{ ug/Kg}$$

$$\text{Reporting Level High Soils} = \frac{((0.010\text{L} + \textit{(gm of wet sample**)(\%moist.**)})(50)(1\text{ ug/L})}{0.010\text{ Kg (decimal \% solids)}} = 50\text{ ug/Kg}$$

***= in volume units to account for water from sample*

$$\textit{(Example) Dilution Factor} = \frac{\textit{5000 ul (volume purge tube)}}{\textit{100 ul (extract volume)}} = \textit{50}$$

$$\text{Reporting Level Drums} = \frac{(0.010L)(50)(1\ ug/L)}{0.0001\ Kg} = 5000\ ug/Kg$$

6.3.4 Matrix spike and matrix spike duplicate:

Add 40 ul of matrix spike solution to 40 ml of diluted extract, see below. The VOA vials are closed tightly and analyzed.

The compounds present in the matrix spike solution for Soil/Drum is the complete target analyte list at a concentration of 100 ug/ml (xylenes at 200 ug/ml).

A 50x dilution with water is made and the sample(s) analyzed.

6.3.5 Internal standards and surrogate compounds:

The internal and surrogate standards are automatically added to the sample from the Varian Archon sampler(s). These ampoules hold 5 ml of standard. Determine that the absolute areas of the quantitation ions of the internal standards and surrogate(s) have not decreased by more than 30% from the areas measured in the most recent continuing calibration check, or by more than 50% from the areas measured during initial calibration. Check the response factors and surrogates.

a. Internal standards - for both the soil and drum sample analysis, 1ul of a 50 to 250 ug/ml internal solution is added (5ml purge) using the Varian Archon.
Internal Standard, conc. 50 to 250 ug/ml

Chlorobenzene-d5
1,4-dichlorobenzene-d4
1,4-difluorobenzene
Pentafluorobenzene

b. Surrogates- to both the soil and drum sample add 1 ul of the 25 to 125 ug/ml surrogate solution.

Surrogate Standard, conc. 25 to 125 ug/ml
1,2-dichloroethane-d4
Toluene-d8
1,4-bromofluorobenzene

c. Internal standards - To all matrices, 5ul of the 10 to 50 ug/ml internal solution is added for per analysis (5ml purge) using the Tekmar ALS 2016 or Tekmar LSC 2000/3100 sample concentrators.

Internal Standard, conc. 10 to 50 ug/ml
Chlorobenzene, d5
1,4-dichlorobenzene, d4
1,4-difluorobenzene
Pentafluorobenzene

d. Surrogates- to both the soil and drum sample add 5 ul of the 5 to 25 ug/ml surrogate solution.

Surrogate Standard, conc. 5 to 25 ug/ml
1,2-dichloroethane, d4
Toluene, d8
1,4-bromofluorobenzene

6.3.6 Screening the extracts:

Screening the methanol soil or drum extract before GC/MS analysis: Refer to the Head space Screening SOP for VOC in Aqueous and Soil Samples, (EIA SOP-FLDVOA2, Revision 2, 10/11/02).

6.4 Sample Preparation (Mid-level Water)

Sample preparation SW-846 Method 8260B, Rev 2, 12/96 (Mid-level Water), samples analyzed by Method 624 are reported as a subset of 8260B:

6.4.1 Sample screening:

The samples are first screened by using the Head space technique.

6.4.2 Sample dilutions:

Based on the screening results dilutions may be necessary. Dilutions should be performed with volumetric glassware and disposable micro pipets.

6.4.3 Sample size:

Five ml of sample is purged.

6.4.4 Internal Standards, same as above:

6.4.5 Surrogate compounds, same as above:

6.4.6 Spiking Solution:

The compounds present in the matrix spike solution for Water is the complete target analyte list at a concentration of 100 ug/ml (xylenes at 200 ug/ml).
Spike at 20 ppb. 5ul of the 20 ug/ml solution to 5 ml of sample or 40ul to 40 ml.

6.5 Sample Preparation Method (Drinking Water)

Sample Preparation Method 524.2, Rev 4.1 12/96 (Drinking Water) or LL:

6.5.1 Aqueous sample screening:

The samples may be screened first if it is felt necessary by using the head space technique.

6.5.2 Sample dilutions:

Based on the screening results dilutions may be necessary. Dilutions should be performed in volumetric glassware.

6.5.3 Sample size:

5 mls (Finnigan Incos 50B/XL) or 25 mls (Finnigan Polaris Q) sample is purged.

6.5.4 Internal standards and surrogate compounds:

To a 25 ml sample is added 1 ul of 25 ug/ml solution containing the internal standards and surrogate compounds for an analysis (5 ml or 25 ml purge) using the Varian Archon. For the analysis using the Tekmar LSC 2016 or Tekmar LSC 2000/3100 sample concentrators, 5 ul of 5 ug/ml internal and surrogate compounds

SURROGATES	5 ml purge (ug/L)	25 ml purge (ug/L)
1,2 dichloroethane-d_4	5	1
Toluene-d8	5	1
1,4-Bromofluoro-benzene	5	1
INTERNAL STANDARDS		
Fluorobenzene	5	1

6.5.5 Spiking solution:

The compounds present in the matrix spike solution for Water is the complete target analyte list at a concentration of 100 ug/ml (xylenes at 200 ug/ml).

spike at 4 ppb. 8 ul of the 20 ug/ml solution to 40 ml of sample.

The samples are now ready for GC/MS analysis. Refer to the GC/MS operating section of this SOP.

BEFORE PROCEEDING, REFER TO SECTION 7.0, QUALITY CONTROL AND QUALITY ASSURANCE. THE TABLE OF ACCEPTANCE CRITERIA MUST BE MET BEFORE CONTINUING THE ANALYSIS.

6.6 Mass Spectrometer Tuning (FC-43)

See manual

6.7 Check for Air Leaks

Check for air leaks by observing the 18amu (water) and 28amu (nitrogen) peak counts. The ratio of 18/28 should be between 1-3 if no leaks are present. If the ratio is less than 0.5 look for the leak before proceeding.

6.8 p-Bromofluorobenzene (BFB) Criteria:

6.8.1 Gas chromatograph Setup:

GC column- RTX 502.2, 40m, 0.18mm id, 1.0 um film thickness. BFB acquisition is attained by analyzing a lab blank, standard or sample. This can be referenced in section(s) 6.9. and 6.10.

6.8.2 p-Bromofluorobenzene solution:

25 ng/ul (drinking water) or 50 ng/ul (all other matrices) of BFB. These concentrations are incorporated into the internal/surrogate solutions referred to in section(s) 6.3.5 and 6.5.4. This criteria must be achieved every 12 hours to check that the GC/MS system meets the mass spectral ion abundance criteria for BFB.

BFB Ion Abundance Criteria:

	CLP	DW
Mass	Ion Abundance Criteria	Criteria
50	8-40 % of mass 95	15-40%
75	30-66 % of mass 95	30-80%
95	base peak, 100 % rel abundance	base peak, 100 % rel abundance
96	5-9 % of mass 95 (see note)	5-9 % of mass 95
173	< 2 % of mass 174	< 2 % of mass 174
174	50-120 % of mass 95	>50%
175	4-9 % of mass 174	5-9%
176	93-101 of mass 174	>95<101
177	5-9 % of mass 176	5-9 % of mass 176

note: All ion abundances must be normalized to m/z 95, the nominal base peak, even though the ion abundance of m/z 174 may be up to 120 % that of m/z 95.

6.9 Calibration Of The Mass Spectrometer

6.9.1 Preparation of standards, table 1 and 2:

Standards are prepared from certified unopened glass sealed ampules every month. These standards are stored in R-9 and the date of receipt is recorded in the VOA Standard Inventory Log Book located with the refrigerator. The preparation of all standards is archived in a bound laboratory notebook. Entries are logged as follows:

V (standard reference notebook number)-month-date-year-alphabetical sequence.

Copies of all certification references are stored in three ring binders. Each standard is also archived in a bound laboratory notebook for daily calibration standards. Internal and surrogate standards are referenced for each method of acquisition. All materials above are stored at the VOA work station(s) located with the instruments. Verification of all standard preparation will be performed for each primary calibration as part of the project review form data evaluation process.

6.9.2 Water, soil and drum samples:

The standards are purged and analyzed like the samples. Five milliliters of the standards in Table 1 are run and analyzed and quantitated against the present calibration curve. Calibration curves are designated as hazardous waste (MW), high soils (HS), low soils (LS), or drinking water (DW).

6.9.3 Drinking Water:

The standards are purged and analyzed like the samples. Twenty five milliliters (or 5 ml) of the standards in Table 2 are run and analyzed and quantitated against the present calibration curve. The regulated compounds are indicated in bold.

TABLE 1
VOA for Water, Soils & Drums – MW/HS/LS CALIBRATION

STANDARD RANGE IN ug/L

COMPOUND	1	2	3	4	5	6	7
Chloromethane	1	5	10	20	25	50	100
Bromomethane	1	5	10	20	25	50	100
Vinyl Chloride	1	5	10	20	25	50	100
Chloroethane	1	5	10	20	25	50	100
Trichlorofluoromethane	1	5	10	20	25	50	100
Ethyl Ether	1	5	10	20	25	50	100
2-Propanone (acetone)	1	5	10	20	25	50	100
1,1,2-Trichloro-1,2,2-trifluoroethane	1	5	10	20	25	50	100
1,1-Dichloroethylene	1	5	10	20	25	50	100
Carbon Disulfide	1	5	10	20	25	50	100
Dichlorodiflouromethane	1	5	10	20	25	50	100
Methylene Chloride	1	5	10	20	25	50	100
Acrylonitrile	1	5	10	20	25	50	100
Trans-1,2-Dichloroethylene	1	5	10	20	25	50	100
1,1-Dichloroethane	1	5	10	20	25	50	100
Vinyl Acetate	1	5	10	20	25	50	100
2-Butanone (MEK)	1	5	10	20	25	50	100
2,2-Dichloropropane	1	5	10	20	25	50	100
Cis-1,2 dichloroethylene	1	5	10	20	25	50	100
Chloroform	1	5	10	20	25	50	100
Bromochloromethane	1	5	10	20	25	50	100
Tetrahydrofuran	1	5	10	20	25	50	100
1,1,1-Trichloroethane	1	5	10	20	25	50	100
1,2-Dichloroethane	1	5	10	20	25	50	100
Carbon Tetrachloride	1	5	10	20	25	50	100
Benzene	1	5	10	20	25	50	100
Cis-1,3-Dichloropropene	1	5	10	20	25	50	100
Trans-1,3-dichloropropene	1	5	10	20	25	50	100
1,1,2-Trichloroethane	1	5	10	20	25	50	100
Dibromochloromethane	1	5	10	20	25	50	100
Chlorobenzene	1	5	10	20	25	50	100
Toluene	1	5	10	20	25	50	100
1,1-Dichloropropene	1	5	10	20	25	50	100
Trichloroethylene	1	5	10	20	25	50	100
1,2-Dichloropropane	1	5	10	20	25	50	100

TABLE 1
VOA for Water, Soils & Drums – MW/HS/LS CALIBRATION

STANDARD RANGE IN ug/L

COMPOUND	1	2	3	4	5	6	7
Bromodichloromethane	1	5	10	20	25	50	100
Dibromomethane	1	5	10	20	25	50	100
4-Methyl-2-Pentanone (MIBK)	1	5	10	20	25	50	100
1,3-Dichloropropane	1	5	10	20	25	50	100
Tetrachloroethylene	1	5	10	20	25	50	100
1,2-Dibromomethane	1	5	10	20	25	50	100
2-Hexanone	1	5	10	20	25	50	100
1,1,1,2-Tetrachloroethane	1	5	10	20	25	50	100
Ethylbenzene	1	5	10	20	25	50	100
META/PARA XYLENE	1	5	10	20	25	50	100
Ortho Xylene	1	5	10	20	25	50	100
Styrene	1	5	10	20	25	50	100
BROMOFORM	1	5	10	20	25	50	100
1,1,2,2-Tetrachloroethane	1	5	10	20	25	50	100
Isopropylbenzene	1	5	10	20	25	50	100
Bromobenzene	1	5	10	20	25	50	100
1,2,3-Trichloropropane	1	5	10	20	25	50	100
N-Propylbenzene	1	5	10	20	25	50	100
2-Chlorotoluene	1	5	10	20	25	50	100
4-Chlorotoluene	1	5	10	20	25	50	100
Tert-Butylbenzene	1	5	10	20	25	50	100
1,3,5-Trimethylbenzene	1	5	10	20	25	50	100
1,2,4-Trimethylbenzene	1	5	10	20	25	50	100
Sec-Butylbenzene	1	5	10	20	25	50	100
1,3-Dichlorobenzene	1	5	10	20	25	50	100
Para-Isopropytoluene	1	5	10	20	25	50	100
1,4-Dichlorobenzene	1	5	10	20	25	50	100
1,2-Dichlorobenzene	1	5	10	20	25	50	100
N-Butylbenzene	1	5	10	20	25	50	100
1,2-Dibromo-3-Chloropropane	1	5	10	20	25	50	100
1,2,4-Trichlorobenzene	1	5	10	20	25	50	100
Hexachlorobutadiene	1	5	10	20	25	50	100
Naphthalene	1	5	10	20	25	50	100
1,2,3-Trichlorobenzene	1	5	10	20	25	50	100

TABLE 2
METHOD 524.2 – DW CALIBRATION
STANDARD RANGE IN ug/L

COMPOUND	1	2	3	4	5	6	7	8
Chloromethane	0.5	1	2	5	10	20	25	50
Bromomethane	0.5	1	2	5	10	20	25	50
Vinyl Chloride	0.5	1	2	5	10	20	25	50
Chloroethane	0.5	1	2	5	10	20	25	50
Trichlorofluoromethane	0.5	1	2	5	10	20	25	50
Ethyl Ether	0.5	1	2	5	10	20	25	50
2-Propanone (acetone)	0.5	1	2	5	10	20	25	50
1,1,2-Trichloro-1,2,2-trifluoroethane	0.5	1	2	5	10	20	25	50
1,1-Dichloroethylene	0.5	1	2	5	10	20	25	50
Carbon Disulfide	0.5	5	2	5	10	20	25	50
Dichlorodiflouromethane	0.5	1	2	5	10	20	25	50
Methylene Chloride	0.5	1	2	5	10	20	25	50
Acrylonitrile	0.5	1	2	5	10	20	25	50
Trans-1,2-Dichloroethylene	0.5	1	2	5	10	20	25	50
1,1-Dichloroethane	0.5	1	2	5	10	20	25	50
Vinyl Acetate	0.5	1	2	5	10	20	25	50
2-Butanone (MEK)	0.5	1	2	5	10	20	25	50
2,2-Dichloropropane	0.5	1	2	5	10	20	25	50
Cis-1,2 dichloroethylene	0.5	1	2	5	10	20	25	50
Chloroform	0.5	1	2	5	10	20	25	50
Bromochloromethane	0.5	1	2	5	10	20	25	50
Tetrahydrofuran	0.5	1	2	5	10	20	25	50
1,1,1-Trichloroethane	0.5	1	2	5	10	20	25	50
1,2-Dichloroethane	0.5	1	2	5	10	20	25	50
Carbon Tetrachloride	0.5	1	2	5	10	20	25	50
Benzene	0.5	1	2	5	10	20	25	50
Cis-1,3-Dichloropropene	0.5	1	2	5	10	20	25	50
Trans-1,3-dichloropropene	0.5	1	2	5	10	20	25	50
1,1,2-Trichloroethane	0.5	1	2	5	10	20	25	50
Dibromochloromethane	0.5	1	2	5	10	20	25	50
Chlorobenzene	0.5	1	2	5	10	20	25	50
Toluene	0.5	1	2	5	10	20	25	50
1,1-Dichloropropene	0.5	1	2	5	10	20	25	50
Trichloroethylene	0.5	1	2	5	10	20	25	50
1,2-Dichloropropane	0.5	1	2	5	10	20	25	50

TABLE 2
METHOD 524.2 – DW CALIBRATION
STANDARD RANGE IN ug/L

COMPOUND	1	2	3	4	5	6	7	8
Bromodichloromethane	0.5	1	2	5	10	20	25	50
Dibromomethane	0.5	1	2	5	10	20	25	50
4-Methyl-2-Pentanone (MIBK)	0.5	1	2	5	10	20	25	50
1,3-Dichloropropane	0.5	1	2	5	10	20	25	50
Tetrachloroethylene	0.5	1	2	5	10	20	25	50
1,2-Dibromomethane	0.5	1	2	5	10	20	25	50
2-Hexanone	0.5	1	2	5	10	20	25	50
1,1,1,2-Tetrachloroethane	0.5	1	2	5	10	20	25	50
Ethylbenzene	0.5	1	2	5	10	20	25	50
META/PARA XYLENE	1	2	4	10	20	40	50	100
Ortho Xylene	0.5	1	2	5	10	20	25	50
Styrene	0.5	1	2	5	10	20	25	50
BROMOFORM	0.5	1	2	5	10	20	25	50
1,1,2,2-Tetrachloroethane	0.5	1	2	5	10	20	25	50
Isopropylbenzene	0.5	1	2	5	10	20	25	50
Bromobenzene	0.5	1	2	5	10	20	25	50
1,2,3-Trichloropropane	0.5	1	2	5	10	20	25	50
N-Propylbenzene	0.5	1	2	5	10	20	25	50
2-Chlorotoluene	0.5	1	2	5	10	20	25	50
4-Chlorotoluene	0.5	1	2	5	10	20	25	50
Tert-Butylbenzene	0.5	1	2	5	10	20	25	50
1,3,5-Trimethylbenzene	0.5	1	2	5	10	20	25	50
1,2,4-Trimethylbenzene	0.5	1	2	5	10	20	25	50
Sec-Butylbenzene	0.5	1	2	5	10	20	25	50
1,3-Dichlorobenzene	0.5	1	2	5	10	20	25	50
Para-Isopropytoluene	0.5	1	2	5	10	20	25	50
1,4-Dichlorobenzene	0.5	1	2	5	10	20	25	50
1,2-Dichlorobenzene	0.5	1	2	5	10	20	25	50
N-Butylbenzene	0.5	1	2	5	10	20	25	50
1,2-Dibromo-3-Chloropropane	0.5	1	2	5	10	20	25	50
1,2,4-Trichlorobenzene	0.5	1	2	5	10	20	25	50
Hexachlorobutadiene	0.5	1	2	5	10	20	25	50
Naphthalene	0.5	1	2	5	10	20	25	50
1,2,3-Trichlorobenzene	0.5	1	2	5	10	20	25	50

6.9.4 Reporting Limits for All Methods:

TABLE 3

Method:	DW	MW	HS	LS	HS
Type:	Water	Water	Soil	Soil	Drum
COMPOUND	ug/L	ug/L	ug/Kg	ug/Kg	ug/Kg
Chloromethane	0.5	1	50	1	5000
Bromomethane	0.5	1	50	1	5000
Vinyl Chloride	0.5	1	50	1	5000
Chloroethane	0.5	1	50	1	5000
Trichlorofluoromethane	0.5	1	50	1	5000
Ethyl Ether	0.5	1	50	1	5000
2-Propanone (acetone)	0.5	1	50	1	5000
1,1,2-Trichloro-1,2,2-trifluoroethane	0.5	1	50	1	5000
1,1-Dichloroethylene	0.5	1	50	1	5000
Carbon Disulfide	0.5	1	50	1	5000
Dichlorodiflouromethane	0.5	1	50	1	5000
Methylene Chloride	0.5	1	50	1	5000
Acrylonitrile	0.5	1	50	1	5000
Trans-1,2-Dichloroethylene	0.5	1	50	1	5000
1,1-Dichloroethane	0.5	1	50	1	5000
Vinyl Acetate	0.5	1	50	1	5000
2-Butanone (MEK)	0.5	1	50	1	5000
2,2-Dichloropropane	0.5	1	50	1	5000
Cis-1,2 dichloroethylene	0.5	1	50	1	5000
Chloroform	0.5	1	50	1	5000
Bromochloromethane	0.5	1	50	1	5000
Tetrahydrofuran	0.5	1	50	1	5000
1,1,1-Trichloroethane	0.5	1	50	1	5000
1,2-Dichloroethane	0.5	1	50	1	5000
Carbon Tetrachloride	0.5	1	50	1	5000
Benzene	0.5	1	50	1	5000
Cis-1,3-Dichloropropene	0.5	1	50	1	5000
Trans-1,3-dichloropropene	0.5	1	50	1	5000
1,1,2-Trichloroethane	0.5	1	50	1	5000
Dibromochloromethane	0.5	1	50	1	5000
Chlorobenzene	0.5	1	50	1	5000
Toluene	0.5	1	50	1	5000
1,1-Dichloropropene	0.5	1	50	1	5000
Trichloroethylene	0.5	1	50	1	5000
1,2-Dichloropropane	0.5	1	50	1	5000

TABLE 3

Method:	DW	MW	HS	LS	HS
Type:	Water	Water	Soil	Soil	Drum
COMPOUND	ug/L	ug/L	ug/Kg	ug/Kg	ug/Kg
Bromodichloromethane	0.5	1	50	1	5000
Dibromomethane	0.5	1	50	1	5000
4-Methyl-2-Pentanone (MIBK)	0.5	1	50	1	5000
1,3-Dichloropropane	0.5	1	50	1	5000
Tetrachloroethylene	0.5	1	50	1	5000
1,2-Dibromomethane	0.5	1	50	1	5000
2-Hexanone	0.5	1	50	1	5000
1,1,1,2-Tetrachloroethane	0.5	1	50	1	5000
Ethylbenzene	0.5	1	50	1	5000
META/PARA XYLENE	1	2	100	2	10000
Ortho Xylene	0.5	1	50	1	5000
Styrene	0.5	1	50	1	5000
BROMOFORM	0.5	1	50	1	5000
1,1,2,2-Tetrachloroethane	0.5	1	50	1	5000
Isopropylbenzene	0.5	1	50	1	5000
Bromobenzene	0.5	1	50	1	5000
1,2,3-Trichloropropane	0.5	1	50	1	5000
N-Propylbenzene	0.5	1	50	1	5000
2-Chlorotoluene	0.5	1	50	1	5000
4-Chlorotoluene	0.5	1	50	1	5000
Tert-Butylbenzene	0.5	1	50	1	5000
1,3,5-Trimethylbenzene	0.5	1	50	1	5000
1,2,4-Trimethylbenzene	0.5	1	50	1	5000
Sec-Butylbenzene	0.5	1	50	1	5000
1,3-Dichlorobenzene	0.5	1	50	1	5000
Para-Isopropytoluene	0.5	1	50	1	5000
1,4-Dichlorobenzene	0.5	1	50	1	5000
1,2-Dichlorobenzene	0.5	1	50	1	5000
N-Butylbenzene	0.5	1	50	1	5000
1,2-Dibromo-3-Chloropropane	0.5	1	50	1	5000
1,2,4-Trichlorobenzene	0.5	1	50	1	5000
Hexachlorobutadiene	0.5	1	50	1	5000
Naphthalene	0.5	1	50	1	5000
1,2,3-Trichlorobenzene	0.5	1	50	1	5000

6.10 Sample Analysis

6.10.1 Gas chromatograph setup:

Activate Method 2 for the GC, hold at 35°C for 4 minutes to 150°C at 6°C/min to 220°C at 8°C/min and hold for 8 minutes. The carrier gas is helium at a rate of 15 ml/min initially at 35°C.

6.10.2 Setup of the Tekmar LSC 2000/3100:

The samples are purged for 11 minutes with a Helium flow rate of 40 ml/min. The Tekmar LSC 2000/3100 controls the purging sequence of the Tekmar ALS 2016 as well as the activating the gas chromatography/ mass spectrometer.

Multiple sampling sequences can be programmed with the Tekmar LSC 2000/3100 sample concentrators.

6.10.3 Setup of Tekmar LSC 2000\Aquatek 50:

The Tekmar LSC 2000/3100 sample concentrators require high purity Helium (99.999%, hydrocarbon tested gas supply at 20-200 psi), as a purge gas supplied via a tee union from the tank supplying the GC carrier gas. The purge gas line is connected to a hydrocarbon trap in between. The GC supplies and controls the carrier gas when it is connected to a concentrator. The trap is a VOCARB 3000 (K trap). Condition the trap overnight at 180oC by back flushing with 20 ml/min of helium and desorb the trap daily before analysis of samples. the trap is desorbed for 4 min at 250oC with 15 ml/min of Helium flow.

6.10.4 Sample introduction into purging device:

(ALS 2016 or LSC 2000/3100) sample concentrators

Warm the sample to room temperature, open the sample bottle, and carefully pour the sample into the syringe barrel to just short of overfilling. Replace the syringe plunger, invert the syringe. Vent any residual air, while adjusting the sample volume to 25 ml accurately (or 5 ml volume). For samples and blanks, add 5 ul of the fortification solution containing the internal standards and the surrogates to the sample through the syringe valve. For the calibration standards and laboratory fortified blanks, 5 ul of the fortification solution with internal standards is added through the valve.

Attach the sample syringe valve to the syringe valve purging device. Be sure that the trap is cooler than 25 C., then open the sample syringe valve and inject the sample into the purging chamber. Close both valves and start purging.

6.10.5 Operation of Varian Archon:

This unit operates through the Tekmar LSC 2000/3100 sample concentrator and runs samples directly from 40 ml volatile organic free vials. The GC/MS is to be configured in acquisition mode and awaiting a start signal from the autosampler device.

The set up for the Varian Archon is specific for the analysis to be performed. Methods for aqueous purge automate the transfer of 5 ml and 25 ml directly from a 40 ml VOA vial to a fritted purge vessel affixed to the LSC 2000. Once a method is selected, the first and last sample location are programmed into the selected Method. The runs are actuated in the Auto menu. A selected method is loaded and the start autosampler is activated. The LSC 2000/3100 sample concentrators are defaulted to single acquisition and method 1 so that continuous throughput is controlled from the Archon.

6.10.6 Gas-Chromatography/Mass Spectrometry:

Acquire and store data over the mass range 35-260 with a total cycle time(including scan overhead time) of 2 sec. or less. Cycle time must be adjusted to measure five or more spectra during the elution of each GC peak. Several alternative temperature programs are used.

Check the disc storage space before analyzing any samples. There should be approximately 150 MB of storage space. This can be checked with the File Manager.

6.10.7 Operation of the Tekmar ALS 2016

a. Load samples into the purge unit according to section 6.10 Sample analysis step 4.

b. Refer to section 6.1.11 Sample analysis, step 3. for the ALS 2016.

c. Acquisition mode, select the Icon.

d. Select the sequence method.

e. Proceed with the injection table first.

f. Select the method cal VOA.mth for all sample analysis but BFB run.

g. Macro C:\HPCHEM\1\METHOD\LASTEST CAL FILE.

h. Select to screen with HP CHEM.

i. Select as 1, Methods, 410CLPIN.M OR THE LATEST, BFB.CMD.

j. Proceed to fill in the sample sequence

k. Select on parameter and enter operator initials

l. Select file and save the sequence as MMMYYI##.SEQ

Example: JUL14G02.SEQ

m. Select start

n. Select simulate

o. Select start. The controller is waiting for a start signal. Press the start button on the LSC 2000. Check the GC program and make sure it is in Method 1 (Run).

6.10.8 Calibration tables

6.10.8.1 Calibration curve

A minimum of five levels of standards (6.9.2 Table 1 or 6.9.3 Table 2) are quantitated against a previously acquired curve and then updated. This allows the use of the compound table and retention times.

6.10.8.2 File

Load file (do this for each new standard that will be used to create the new calibration table), QUANT, Calculate and generate report. Go into Quant and print out the summary report. Check the cpd values and retention times. If the responses and concentrations correct proceed with:

a. Init Cal

b. Load file

c. Update Levels

d. Recalibrate, both the response and retention times. **Calib Level ID** - the concentration of the standard for this file **<u>must</u>** match the table on page 3 under Init Cal, Edit Compounds, View, Go into Initial Cal and Edit compounds if needed. Page 3 gives the sequence and conc.(VERY IMPORTANT TO KNOW THE LOCATION OF THE STANDARDS). Double click on the compound to see page 3 for information for the system during acquisition.

e. Replace

f. Perform update The message "Instrument name from data file does not match" is to be ignored. Select OK.

g. Repeat the above for all standards.

6.10.8.3 When done, select Initial Cal and print response factors

QEDIT and EXIT

Quant and Generate Report.

SAVE METHOD

SAVE METHOD (save under a different name)

If the response factors meet the criteria established in the method, the system is ready to analyze samples.

6.10.7.4. Manual quantitation:

If the calibration did not find all the peaks or the response factors have a large % RSD then do the following:

File

Load File

Quant

QEDIT

Select the compound of interest from the table, (double click) and evaluate the peak shape or interferences. To re-calculate the area, re-draw the baseline by placing the cursor at the left side of the peak at the baseline and hold the right button on the mouse down and move the line to the location to the right of the peak and release the button. The new area and value will be displayed.

Exit

Init Cal

Load file

Update Levels

Recalibrate, both the response and retention time **Calib Level ID** - the conc. of the std for this file **<u>must</u>** match the table on page 3 under Init Cal, Edit Compounds, View, Go into Initial Cal and Edit compounds if needed. Page 3 gives the sequence and conc.(VERY IMPORTANT TO KNOW THE LOCATION OF THE STANDARDS). Double click on the compound to see page 3 for information for the system during acquisition.

Replace

Do update (The message "Instrument name from data file does not match" is to be ignored)

OK.

The manually quantitated compound must be noted for validation as per the SOP for Peak Intergrations and for the Manual Manipulation of Computer Generated Data, Revision 1, 09/06/00.

6.10.8.5. Select initial cal and print response factors

Select QEDIT and EXIT. All changes should be saved.

Select quant and generate report (it will mark the ones where manual integration was performed). DO NOT CALCULATE AND GENERATE REPORT.

6.10.8.6. SAVE METHOD

Select File.

Select Save method and Save as a different name.

6.11 DATA REDUCTION

6.11.1 Data recording

The notation of all data acquisition shall be recorded into specified run log book(s) stored at the VOA work station located with the instruments. These run log book(s) contain the project number and survey name, the method for calibration, the data file ID name(s), the sample ID, and comments associated with the sample. The data file ID name(s) are assigned as follows:

XX (month)- XX (date) - X (year) – G,H or I - XX sequential ID

<u>Example – 08139G03</u> G=Incos 50 or H=Incos XL or I=Polaris Q

Dilution preparation will be archived in the comments section of the run log books and noted to the VOA sample extraction and dilution worksheet.

Analysts initials will be included in the "edit parameter" field when setting up the acquisition sequence for GC/MS injections with the two Finnigan Incos Mass Spectrometers using the Technivent software. The initials are then carried forward to the HP Enviroquant file when the acquisition file is converted with MassTransit software. The analysts initials are manually entered in both the Excalibur sequence and in the HP file after conversion with the Finnigan Polaris Q ion-trap MS. The MassTransit software does not carry this information forward during the conversion.

Electronic back up of raw data files shall be performed routinely with current storage technology. The file directories for the data cartridge will be inventoried using a data back up log notebook.

6.11.2 Manual reduction

a. Select environmental processing

b. ".D" file, type in the file name. If this file is not present in the directory (example - NOV11E) then the ".TKF" file must be converted to a ".D" file (OS2 to Windows) by using the Tekloop program (Finnigan icon program). The file is entered into the menu as a ".TKF" file and is converted to a ".D" file.

c. Chromatogram will appear

d. Place cross hairs on the peak and dc with the right mouse button.

e. Library search by dc right mouse on the spectra.

Access the programs listed as headers by clicking on them. A number of choices are available to look at the data.

a. FILE: Selecting method report

b. INIT: Draw chromatogram and label peak numbers

c. TUNER: evaluate spectra

d. INIT CAL: set up Quant
edit compounds
update levels
report response factors

e. CON CAL: update continuing calibration
update reference spectra with ongoing standard file
evaluate continuing calibration
edit continuing calibration criteria

f. QUANT: calculate and generate a detailed report to printer with multiplier factor of factor of 1.

edit Quant report options

QEDIT Quant results

trace mode quant

generate report - summary with multiplier factor reflecting dilution (aqueous sample matrix) or multiplication factor (soils or drum sample matrix) to screen (print).

g. LSC: generate LSC report

h. LIB: generate library search report

i. CUST REPT: create/modify template

j. TOOLS: dolist

doscan

locate a compound

locate all compounds

easy ID

MS/dup recovery report

k. JOB: queue quant rept

queue list of files

configure quant list

l. HELP: contents

search

tutorial

about

about envirolink

clean up macro remains

log errors

6.11.3 Multiple files:

These are to be noted in the project notes.

6.11.4 Data qualifiers and definitions

ND - Not detected above the reporting limit

RL - Reporting Limit

J - Approximate

NA - Not applicable

B - Blank contaminant

E - Estimated value exceeds the calibration range

L - Estimated value is below the calibration range

MCL - Maximum Contaminant level

6.11.5 Treatment of blank values

If a blank contaminant is observed, corrective action will be taken to eliminate the source of contamination and samples will be reanalyzed if contamination significantly impacts the analytical results.

b. The reported value for the analytes in the sample will be qualified with a B if the observed value is not 5 times greater than the blank value.

6.11.6 Reporting limits of target compounds

Quantitation of target analytes are based on the initial calibration. The reporting limits of all target compounds are based on the low level standard point in each calibration table for each compound as observed in section 6.9, tables 1 and 2 or as estimated in table 3 for Method 5035. For an example of reporting limit(s) determination, see example calculation in section 6.3.3.

6.11.7 Tentatively identified compound reporting

The highest ten tentatively identified compounds observed are reported as observed. The observed levels must be twice the level of the low level standard point in each calibration table. The probability fit must be greater than 60% from the NIST reference spectral library. The estimated quantity is reported out. The reporting limit is estimated at the twice the level of the low level initial calibration standard point in each calibration or as per 6.9.4. Reporting Limits for All Methods, Table 3.

7.0 Quality Control And Quality Assurance Section

The Quality control Officer has the results for the MDL study and the Precision and Accuracy Study for the Drinking Water Program, NPDES, RCRA, and CERCLA.

The Quality Control requirements found in each method are met before the samples results are accepted. This includes the calibration and internal standards, surrogates, LFB, LRB and matrix spikes. The precision and accuracy is determined for each survey by analyzing a matrix spike and duplicate spike.

7.1 Acceptance criteria for VOAs by GC/MS

AUDIT	METH	FREQUENCY	LIMIT	CORRECTIVE ACTION
BFB	All	Before analysis and every 12 hrs.	see SOP 6.8.2, method(s) [1],[2]	Repeat BFB Tune MS Clean source
Initial Calibration (Primary source)	All	Initially before the analysis of sample(s) When continuous calibration fails or as method requires	All waste matrices for VOA are 20% RSD: VOADW is 20% RSD; Linear - Regression $R^2 > 0.99$ method(s) [1],[2]	Evaluate chromatogram and integration Re- Calibrate
Continuous Calibration (Secondary source)	All except 624	Before analysis and every 12 hrs.	All waste matrices for VOA are is 30% RSD;VOADW is 30%; Linear - Regression+/- 15% of True Value method(s) [1],[2]	Evaluate Chromatogram and integration Repeat multi-cal
Lab Blk	All	Before sample analysis and every 12 hrs.	see SOP 6.11.5, method(s) [1],[2],[3]	Check blank source Bake trap Clean purge vessel Rinse syringes
Method Blk	All except 524.2	Before analysis and every 12 hours	see SOP 6.11.5, method(s) [1],[2],[3]	Check blank source Check reagent source Bake trap Clean purge vessel Rinse syringes
Trip Blk	All	One/set of samples	< Lab blank	Check storage blk Contact project officer
Lab Fortified Blk	524.2	Before analysis and every 12 hrs.	+ 30 %	Check peak integration Test for leaks Repeat
Matrix Spikes	All except 524.2	One MS/MSD for every project up to 20 samples	see SOP 6.3.4, method(s) [4]	Evaluate surrogate recovery Areas of internal standard Explain in report narrative

AUDIT	METH	FREQUENCY	LIMIT	CORRECTIVE ACTION
Duplicates	All	One for every project up to 20 samples	± 40 %	Evaluate surrogate recovery Areas of internal standard Explain in report narrative
Internal Std	All	Every sample including std, blk and QC samples	see SOP 6.3.5, method(s) [1],[2],[3]	Re-run the sample Check the solution
Surrogate Recoveries	All	Every sample including std, blk, and QC sample	see SOP 7.2, method(s) [4]	Evaluate integration Qualify the report
Response Factors	All	Initial and Continuous Calibration	see SOP 6.3.5, method(s) [1],[2]	Evaluate integration Check for leaks Eval trap Re-calibrate
Linear Range	All	all samples	Bracket by Standard	Dilute sample

[1]= Acceptance criteria from Reference Method 524.2 ,rev 4.1
[2]= Acceptance criteria from Reference Method 8260B,SW-846, rev 2.0
[3]= Acceptance criteria defined based on technical judgment
[4]= Acceptance criteria defined based laboratory generated control windows

7.2 Surrogates Recoveries:

These are updated using LIMS bi-annually.

7.3 Matrix Spike and Duplicate Recoveries.

These are updated using LIMS bi-annually.

7.4 Performance evaluation sample analysis

Performance evaluation samples (PE) for the WS and WP programs are run bi- annually.

Performance evaluation samples (PE) for Low/High Soil proficiency programs are run bi-annually.

7.5 Determination of detection limit

The detection limit is determined according to the method described in 40 CFR Part 136 Appendix B, "Definition and Procedure for the Determination of the Method Detection".

7.6 Corrective action procedure

The procedure for corrective action is outlined in section 14.0 of the EIA QA Plan, Rev 8., 06/02/05.

8.0 Waste Management

NERL encourages all chemist and biologists to investigate micro analytical techniques, innovative technologies, and chemical substitution in laboratory processes to reduce waste and prevent pollution. As analytical SOPs are reviewed, on an annual basis, the responsible chemist or biologist will incorporate waste minimization practices where practicable and where these practices have been demonstrated to return data of equivalent quality.

Chemists and biologists must refer to the Waste Management Program SOP for proper disposal of laboratory waste. Personnel should contact the Environmental, Safety and Health Department if changes in the analytical SOP will generate new waste streams. Questions regarding the proper disposal of laboratory waste and purchase of new reagents should be directed to the Environmental, Safety and Health Department in advance of actually initiating a change in the analytical method.

General procedures are contained in the aforementioned Waste Management Program SOP.

9.0 References

Environmental Investigation and Analysis Quality Assurance Plan, Rev 7., 07/14/04.

Standard Operating Procedures for Peak Intergrations and For Manual Manipulation of Computer Generated Data., Rev 1., 09/06/00.

Method 524.2, "Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry", Rev 4.1, (1995), US EPA, Cin, OH.

USEPA CONTRACT LABORATORY PROGRAM, STATEMENT OF WORK FOR ORGANIC ANALYSIS, OLM03.1, EPA-540/R-94/073, PB963503, August 1994.

TEST METHODS FOR EVALUATING SOLID WASTE, PHYSICAL/CHEMICAL METHODS. SW-846, Rev 2, December 1996.

SW-846, Method 5035A (Closed-system Purge-and-trap and Extraction for Volatile Organics in Soil and Waste Samples), Draft Revision 1, July 2002.

Standard Operating Procedure For Soil Sampling, Region I, EPA-New England, Rev. 02, 02/18/04.

40 CFR, Part 136, "Guidelines Establishing test Procedures for the Analysis of Pollutants".

10.0 Appendix

10.1 Start up from a power-off position.

a. Check the GC, if all the lights are on shut off the unit with the on/off switch in the rear of the GC.

b. Check the Tekmar, if it is beeping, press the EXIT pad on the unit.

c. Check the ALS, it may need to be started before the Tekmar. Turn off the Tekmar and start the ALS then the Tekmar.

d. Check the GC configuration. Answer the questions as follows:

-Build/modify then activate, check status

-Enable column standby -NO

-Set ____ for the GC ready - YES

-Wait for An__ - NO

-Wait for Detector -NO

-Wait for External Device -NO

-Wait if fault present -NO

-Initial relay - YES

-Set lock code - NO

-Turn hdwe. on/off - YES

-Detector oven - NO

-Injector oven - YES

-Aux oven - NO

-Coolant to column - NO

-All the rest of the answers are NO

e. MS, Go into calibrate to download the voltages

Green light is the Ion source voltages

Yellow light is for the pumps.

These lights are located above the red power button on the front lower right of the unit.

f. Ion gauge, Depress the on switch , the normal range is 4-5.

The gauge will not stay on if the pressure in the analyzer is to high.

10.2 Sampling method for soils.

10.2.1Soil sampling for High Level Soil sample analysis (HS) VOC analysis for solid matrices

This technique pertains to sampling methods for volatile organic compounds (VOCs) in solid matrices (sediment and soil). These samples will be analyzed using modified Method 5035A, closed-system purge-and-trap method for mid concentration soils. Samples will be collected using a 10cc syringe barrel and placed directly into 40 ml VOA vials containing preservatives.

At each sampling location, two vials will be used for the sample. One vial will contain 10 ml of methanol; and one vial will be empty. The methanol preserved sample is for analyzing levels of contamination if present, and the second is for calculation of percent solids. All vials containing preservatives will have been preweighed in the laboratory by a certified vendor.

Samples will be collected using dedicated 10cc syringes, which have had the ends cut to present an open barrel. When possible, the sample will be taken by pulling back the plunger of the syringe, and pushing the syringe into the sediments *in situ* to remove a plug of sediment. If the water depth exceeds 2-3 inches, or the sediment is highly heterogeneous in an area, an intact section of sediment may be removed using an Eckman or Ponar sampler, or a stainless steel bulb planter. This section will be placed in a clean stainless steel bowl with as little disturbance as possible, and the sediment will be collected from an undisturbed section using the syringe.

A sample of approximately 6-8 cc of sediment will be taken to obtain the needed 10 grams wet weight of sediment for the methanol preserved vial . The second vial to be used for the calculation of percent solids should be substantially filled. Aliquots of sample for each of the two VOA vials will be taken, placed into the vials, and immediately sealed with the vial cap.

Samples will be kept at 4 degrees centigrade. Sample preservation in methanol and water (bisulfite) must occur within 48 hours from when the sample is taken. The laboratory should be notified in advance to meet this criteria.

The following can be applied when selecting a suitable method for HS analysis.

Laboratory Derivations:

$$\text{Reporting Level(s)} = \frac{(\text{Extract Volume})(\text{Dilution})(\text{Standard})}{(\text{Sample Dry Weight})}$$

$$\text{Reporting Level(s)} = \frac{((0.010\text{L} + \textit{(gm of wet sample*)(\%moist.*)})(50)(5\ \text{ug/L})}{0.010\ \text{Kg (decimal \% solids)}} = \sim 250\ \text{ug/Kg}$$

(Based on 5 ppb std)
Methanol Preserved

**in volume units to account for water volume from sample*

$$\textit{(Example) Dilution Factor} = \frac{\textit{5000 ul (volume purge tube)}}{\textit{100 ul (extract volume)}} = 50$$

$$\text{Reporting Level(s)} = \frac{((0.010\ \text{L} + \textit{(gm of wet sample*)(\%moist.*)})(50)(1\ \text{ug/L})}{0.010\ \text{Kg (decimal \% solids)}} = \sim 50\ \text{ug/Kg}$$

(Based on 1 ppb std)
Methanol Preserved

10.2.2. Soil sampling for Low Level Soil sample analysis (LS) VOC analysis for solid matrices

This technique pertains to sampling methods for volatile organic compounds (VOCs) in solid matrices (sediment and soil). These samples will be analyzed using modified Method 5035A, closed-system purge-and-trap method for mid concentration soils. Samples will be collected using a 10cc syringe barrel and placed directly into 40 ml VOA vials containing preservatives.

At each sampling location, four vials will be used for the sample. Two vials will contain 5 ml of water preserved with sodium bisulfite; one vial will contain 5 ml of methanol; and one vial will be empty. The water and methanol preserved samples are for analyzing levels of contamination if present, and the second is for the calculation of percent solids. All vials containing preservatives will have been preweighed in the laboratory or by a certified vendor .

Samples will be collected using dedicated 10cc syringes, which have had the ends cut to present an open barrel. When possible, the sample will be taken by pulling back the plunger of the syringe, and pushing the syringe into the sediments *in situ* to remove a plug of sediment. If the water depth exceeds 2-3 inches, or the sediment is highly heterogeneous in an area, an intact section of sediment may be removed using an Eckman or Ponar sampler, or a stainless steel bulb planter. This section will be placed in a clean stainless steel bowl with as little disturbance as possible, and the sediment will be collected from an undisturbed section using the syringe.

A sample of approximately 3-4 cc of sediment will be taken to obtain the needed 5 grams wet weight of sediment for the water and methanol preserved vials. The remaining vial to be used for the calculation of percent solids should be substantially filled. Aliquots of sample for each of the four VOA vials will be taken, placed into the vials, and immediately sealed with the vial cap.

Samples will be kept at or below zero degrees centigrade. Alternatively, Encore sampling devices or equivalent may be used. Sample preservation in water must occur within 48 hours from when the sample is taken. The laboratory should be notified in advance to meet this criteria.

The following can be applied when selecting a suitable method for LS analysis.

Laboratory Derivations:

$$\text{Reporting Level(s)} = \frac{\text{(Extract Volume)(Dilution)(Standard)}}{\text{(Sample Dry Weight)}}$$

Reporting Level(s) =
(Based on 5 ppb std)
Water Preserved

$$\frac{(0.005\ \text{L})(1)(5\ \text{ug/L})}{0.005\ \text{Kg (decimal \% solids)}} = \sim 5\ \text{ug/Kg}$$

Reporting Level(s) =
(Based on 1 ppb std)
Water Preserved

$$\frac{(0.005\ \text{L})(1)(1\text{ug/L})}{0.005\ \text{Kg (decimal \% solids)}} = \sim 1\ \text{ug/Kg}$$

Project Review Form
VOA Analyses by GC/MS

Project Number__________ **Site**__________________ **LIMS Code**________ **Matrix**________

Note: Any omissions or problems with the data require resolution before proceeding to the next review step.

REQUESTED ANALYSIS AND DATA FOLDER COMPLETENESS CHECK

- ( ) Does the LIMS information match the COC requests?- Check LIMS Project Form
- ( ) Were all samples analyzed and identified correctly?
- ( ) Have the samples been analyzed according to the referenced method or SOP? Are all deviations approved and documented?
- ( ) Have holding times been met?
- ( ) Has sample preservation been checked and documented for all samples ?
- ( ) Is the raw data folder complete?
  - ( ) Copy of the Chain-of-Custody form and sample receipt checklist
  - ( ) Project notes
  - ( ) Soil extraction summary sheet for dry weight calculation
  - ( ) Laboratory notebook form
  - ( ) GC screening data (if applicable)
  - ( ) BFB tunes - summary and raw data
  - ( ) Initial and continuing calibrations - summarizations and raw data for all associated calibrations
  - ( ) Computer generated sample sequence list, copy of instrument run log
  - ( ) ID list with updated RFs
  - ( ) Quantitation reports, reprocessed after manual checks (manual integration stamp initialed and dated by analyst)
  - ( ) Extended GC/MS reports and TICs for samples
  - ( ) Surrogate and matrix spike recovery table, IS area table

Reviewed by: Date Reviewed:

DATA EVALUATION

- ( ) Have the proper number of QC samples been analyzed?
  - ( ) Blanks
  - ( ) PE Samples
  - ( ) LCS/ LFB
  - ( ) Second source standard
  - ( ) Calibration standards (initial, continuing)
  - ( ) Duplicates
  - ( ) MS/MSD
  - ( ) QC check sample
  - ( ) Other (specify)
- ( ) Is the information on the medium level soil extraction bench sheets correct?

( ) Is there documentation of standard preparation and traceability?
( ) Are blank contaminants within limits? If outside limits, is there documented approval to proceed with analysis?
( ) Are spike recoveries and other QC check samples within limits ?
( ) Are surrogate recoveries/IS areas within limits? Do samples require reanalysis?
( ) Are BFB tunes acceptable?
( ) Are initial and continuing calibrations acceptable? Spot check RRF from raw data. Check all outliers.
( ) If required, were all samples analyzed within 12 hr of BFB?
( ) Have samples been processed with updated response factors? Check quantitation time on raw data.
( ) Are manual and computer based calculations correct? Check significant figures and document with a sample calculation from raw data to final concentration (the reviewer initials and dates calculation.)
    ( ) Dry weight calculations
    ( ) Report factors
    ( ) Sample concentrations
    ( ) Other
( ) Are the concentrations of the compounds found within calibration range?
( ) Are duplicate results within QC acceptance windows ?
( ) Has the final report been checked for transcription errors?

Reviewed by: Date Reviewed:

FINAL REPORT

( ) Check the following information on the report accuracy.
    ( ) Sample IDs- laboratory and field
    ( ) Date sampled (collected) ( ) Date received ( ) Date analyzed
    ( ) Sample weight, % solids
    ( ) Reporting Limit (R.L.), dilution and scaling factor
    ( ) Qualifiers
    ( ) pH
( ) Is the method summary an accurate reflection of all encountered problems? Are observations about the samples noted? Are method blank contaminants mentioned?
( ) Are the reported results consistent with the significant figure policy?
( ) Has the final report been checked for transcription errors?

Reviewed by: Date Reviewed:

Comments:

* = See Comments N = No
NA = Not Applicable Y = Yes

Method Comparison Table

Method Parameter ⇓	SW-846 Method 8260B	EPA 600 Series Method 624	CLP VOA (Organic SOW)	EIASOP-VOAGCMS8
Applicability	Groundwaters, soils, sediments, sludges, non-water miscible wastes & others	Municipal and industrial discharge	Water, soil, and sediment.	Groundwaters, soils, sediments, sludges, non-water miscible wastes & others
Number of Analytes	121 total	31 total	33 total	70 total
Method Validation	Analyze 4 replicates of QC check standard. Compare to average recovery (R), standard deviation of recovery (S) and relative standard deviation (RSD) values given in Tables 6 (see page A-128) and 7 (see page A-130). Results for RSD must not exceed 2.6 times the single laboratory RSD or 20%, whichever is greater, and the mean recovery must lie within the interval R ± 3 times S or R ±30%, whichever is greater.	Analyze 4 replicates of QC check standard. Compare accuracy and precision results to Table 5 (see page A-75).	Not specified.	
QC Check Standards/ Samples	The MS/MSD percent recovery (R_i) should lie within the QC acceptance criteria determined from the analysis of laboratory control samples during method validation. If the MS recovery is out of criteria, a QC check standard must be analyzed and fall within those ranges. Express the accuracy assessment as a percent recovery interval of ± 2 standard deviations.	Analyze one QC check standard each working day. (Frequency may be reduced if MS recoveries meet QC criteria). Compare %R to Table 5 (See page A-75). If MS results fall outside acceptance criteria, a QC check standard must be analyzed and fall within acceptance criteria.	Not specified.	The MS/MSD percent recovery (R_i) should lie within the QC acceptance criteria established by the laboratory.

Method **Parameter ⇓**	**SW-846 Method 8260B**	**EPA 600 Series Method 624**	**CLP VOA (Organic SOW)**	**EIASOP-VOAGCMS8**
Initial Calibration	Minimum of 5 levels, lowest near but above MDL. %RSD should be < 15 for every compound, however for CCCs < 30. RF for SPCCs = 0.300 for chlorobenzene and 1,1,2,2-tetrachloroethane; = 0.100 for chloromethane and 1,1-dichloroethane, (> 0.100 for bromoform) Option 1: If CF or RF %RSD <15 or if mean %RSD of all analytes < 15 then use average CF or RF. Alternatively use a cal. curve (see option below). Option 2: If CF or RF %RSD >15 or if the mean %RSD of all analytes > 15, then use a cal. curve: a) linear cal. using least squares regression; b) linear cal. using weighted least squares regression. Requirement: r ≥0.99, not forced through the origin, do not use origin as a cal. point. Option 3: Where instrument response is non-linear over wide working range or above procedures fail acceptance criteria, non-linear cal. may be employed. Requirement: COD ≥0.99, not forced through origin, do not use origin as a cal. point, other requirements exist pending curve fitting model chosen.	Minimum of 3 levels, lowest near but above MDL. If %RSD < 35, linearity assumed and average RF used. Alternatively, use a calibration curve.	Five levels (10, 20, 50, 100, and 200). RRF and RSD criteria listed in Table 5 of Exhibit D/VOA (see page A-13). Primary characteristic ions used for quantitation are listed in Tables 2 (see page A-11) and 4 (see page A-12) of Exhibit D/VOA. Up to 2 compounds in Table 5 of Exhibit D/VOA are permitted to fail RRF and RSD criteria provided RRF ≥0.010 and %RSD ≥40.0%.	Minimum of 5 levels, lowest near but above MDL. %RSD should be <20 for all compounds. If RF %RSD >20, then use a cal. curve: a) linear cal. using least squares regression; b) linear cal. using weighted least squares regression. Requirement: r ≥0.99, not forced through the origin, do not use origin as a cal. point.

Method **Parameter ⇓**	**SW-846 Method 8260B**	**EPA 600 Series Method 624**	**CLP VOA (Organic SOW)**	**EIASOP-VOAGCMS8**
Continuing Calibration/ Calibration Verification	Mid-level calibration standard run every 12 hours. RF for SPCCs same as for initial calibration. RF of CCCs must be <20% difference from initial calibration. Internal standards: RT must be within ± 30 seconds from last mid-point standard level of the initial calibration; area must be -50 to +100%.	QC check standard analyzed each working day. Compare results to Table 5 (see page A-75).	A mid-level calibration standard is analyzed every 12 hours. The % difference criteria is listed in Table 5 of Exhibit D/VOA. Up to 2 compounds in Table 5 of Exhibit D/VOA (see page A-13) permitted to fail criteria if RRF > 0.010 and %D = 40%.	Mid-level calibration standard run every 12 hours. RF must be <30% difference from initial calibration. The absolute areas of quantitation ions of both internal and surrogate standards must not be decreased by more than 30% from the most recent continuing calibration, or by more than 50% from the areas of the initial calibration.
Surrogate Standards	4-Bromofluorobenzene, Dibromofluoromethane, Toluene-d_8, and 1,2-Dichloroethane-d_4 are recommended. Compare %R to laboratory established limits or to Table 8 (see page A-131) if laboratory limits are not available. Laboratory limits must fall within limits specified in Table 8. (See page A-131)	Minimum of 3 from Table 3 (see page A-74). % Recovery limits not specified.	(System Monitoring Compounds) 4-Bromofluorobenzene, 1,2-Dichloroethane-d_4, and Toluene-d_8. Recovery limits in Table 7 of Exhibit D/VOA (see page A-14). RRT must be within 0.06 RRT units of continuing calibration standard.	4-Bromofluorobenzene, 1,2-Dichloroethane-d_4, and Toluene-d_8. Recovery limits established by laboratory.
Internal Standards	Fluorobenzene, Chlorobenzene-d_5, 1,4-Dichlorobenzene-d_4 are recommended. RT must be ±30 seconds from last calibration check (12 hours); area must be -50 to +100%.	Optional. If used, minimum of 3 from Table 3 (see page A-74).	Bromochloromethane, 1,4-Difluorobenzene, and Chlorobenzene-d_5. RT must be ±30 seconds from last calibration; area must be 50 to 100%. See Table 3 of Exhibit D/VOA (see page A-12) for target compound assignments.	Pentafluorobenzene, 1,4_DiflourobenzeneChlorobenzene-d_5, and 1,4-Dichlorobenzene-d_4

Method **Parameter ⇓**	**SW-846 Method 8260B**	**EPA 600 Series Method 624**	**CLP VOA (Organic SOW)**	**EIASOP-VOAGCMS8**
Accuracy/Precision	One MS/MSD per 20 samples or each batch of samples, whichever is more frequent. The MS/MSD percent recovery (R_i) should lie within the QC acceptance criteria determined from the analysis of laboratory control samples during method validation. (See also: **QC Check Standards/Samples**.)	One MS per 20 samples from each site or 1 per month, whichever is more frequent. Compare %R to Table 5 (see page A-75). (See also: **QC Check Standards/Samples**.)	One MS/MSD per each case or 20 samples or each extraction batch or each 14 day period samples received from case, whichever is more frequent (only 5 compounds spiked). Compare results to Table 8 of Exhibit D/VOA (see page A-14).	One MS/MSD per 20 samples or each batch of samples, whichever is more frequent The MS/MSD percent recovery (R_i) should lie within the QC acceptance criteria established by the laboratory.
Method Blanks	One method blank per extraction batch (up to 20 samples) or when there is a change in reagents, whichever is more frequent.	One method blank per day.	One method blank every 12 hours. Concentration = CRQL for all but methylene chloride = 2.5 times CRQL; acetone; 2-butanone = 5 times CRQL.	One method blank per extraction batch (up to 20 samples) or every 12 hours.
Preservation/ Storage Conditions	pH <2 with HCl or H_2SO_4 (aqueous). Sodium thiosulfate if residual chlorine (aqueous). Store at 4°C.	pH <2 with HCl. Sodium thiosulfate if residual chlorine. Store at 4°C.	Protect from light. Store at 4°C. Aqueous: pH of 2 All samples in group should be stored together. Storage blanks required. Samples should be stored for 60 days after the data package has reached the EPA.	pH <2 with HCl (aqueous). Sodium thiosulfate if residual chlorine (aqueous). Store at 4°C.
Holding Time	14 days of sample collection.	14 days of sample collection.	10 days of sample receipt.	14 days of sample collection.
Field Sample Amount Required	40 mL VOA vial in duplicate without headspace (air bubbles) (aqueous) 4 oz. (solid) glass container Teflon lined septa	40 mL VOA vial in duplicate without headspace (air bubbles) glass container Teflon lined septa	40 mL VOA vial in duplicate without headspace (air bubbles) (aqueous) 4 oz. (solid) glass container Teflon lined septa	40 mL VOA vial in quadruplicate without headspace (air bubbles) (aqueous) 40 mL VOA vial in duplicate with water (low soil) Store below 10 degees

Method **Parameter ⇓**	**SW-846 Method 8260B**	**EPA 600 Series Method 624**	**CLP VOA (Organic SOW)**	**EIASOP-VOAGCMS8**
Amount for Extraction	5 mL (aqueous) or 25 mL (aqueous) 5 grams (solid)	5 mL	5 mL (aqueous) 5 grams (solid) 4 grams (medium-level solid)	5 mL (aqueous) 5 or 10 grams (solid)
Other Criteria (Method Specific)	Tuning: 50 ng bromofluorobenzene (BFB) initially and every 12 hours; acceptance criteria in Table 4 (see page A-123). Qualitative ID: The intensities of the characteristic ions of a compound maximize in the same scan or within one scan of each other. RRT of the sample component is within 0.06 RRT units of the RRT of the standard component. The relative intensities of the characteristic ions are within 30% of those ions in the reference spectrum. Tentative ID: All ions >10% intensity must be ±20% of standard, ±0.06 RRT units of standard RRT. Molecular ion must be present. Library searches may be made for the purpose of tentative identification.	Tuning: 50 ng bromofluorobenzene (BFB) initially and every 24 hours; acceptance criteria in Table 2 (see page A-74). Qualitative ID: Three characteristic ions must be ±20% of standard and must maximize within 1 scan.	Tuning: 50 ng bromofluorobenzene (BFB) initially and every 12 hours; acceptance criteria in Table 1 of Exhibit D/VOA (see page A-10). Qualitative ID: All ions > 10% intensity must be present and ±20% of standard; ±0.06 RRT units of standard RRT. Up to 30 compounds not listed in Exhibit C for the volatile organic fraction, with responses > 10% of nearest IS are tentatively identified via a library search. Relative intensities of reference spectrum must be present in sample spectrum and within 20%. Molecular ion must be present.	Tuning: 50 ng bromofluorobenzene (BFB) initially and every 12 hours; acceptance criteria in SOP. Qualitative ID: All ions > 10% intensity must be present and ±20% of standard The retention time should be within three standard deviations of the mean retention time of the compound in the calibration mixture. Up to 10 non-targets compounds with responses twice the level of the low level calibration point. Probability >60% from the reference library.

EPA Region 1

Standard Operating Procedure for Head Space Screening for Volatile Organic Compounds in Aqueous and Soil Samples

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Table of Contents

1.0 Summary of Method

1.1 An aqueous sample is collected in a 40 mL VOA vial. Ten mL is then placed in a 22 mL vial and allowed to equilibrate for 6 to 24 hours at room temperature. A sample of the head space gas is withdrawn with a steel barrel syringe or analyzed by the Tekmar 7000 autosampler.

1.2 A 10g soil sample is collected with a 10 mL plastic syringe with the tip cut off or with a Terra Core sampler and injected into a pre-weighted VOA vial containing 10mL of methanol. The vial is then weighed to calculate the soil wet weight and shaken or vortexed for 30-60 seconds. The extract is diluted 1:50 and analyzed.

1.3 An aliquot of the headspace is injected into a calibrated gas chromatograph. The compounds are separated on a capillary column. Retention times are used for compound identification and peak areas are used to quantitate the identified compounds.

1.4 This method can be used to provide screening data in a timely manner for guidance of ongoing work in the field.

2.0 Purpose

2.1 To ensure that procedures for VOA analysis are consistently followed by all analysts.

3.0 Scope and Application

3.1 The procedure contained herein is applicable to all EPA Region 1 chemists performing screening for volatile organic compounds for soil and water samples.

3.2 This method is applicable for the screening of various volatile organic compounds in water and soil samples. Typical achievable reporting levels using a photoionization detector (PID) and an electron capture detector (ECD) are given below. These reporting levels are based on instrument response and can vary depending upon instrument conditions. For soils, the reported values are on a wet or dry weight basis.

Table 1 – Target Compound List and Reporting Levels

Analyte	Aqueous MDL (μg/L)****		Aqueous RL (μg/L)
	PID	**ECD**	
Benzene *	0.45		1.0
Chlorobenzene *	0.92		1.0
1,1-Dichloroethylene ***	0.72	0.91	1.0
Cis-1,2-Dichloroethylene *	0.33		0.50
Trans-1,2-Dichloroethylene *	0.58		1.0
Ethylbenzene *	0.66		1.0
Tetrachloroethylene ***	1.0	0.66	1.0
Trichloroethylene ***	0.68	0.57	1.0
1,1,1-Trichloroethane **		0.59	1.0
Toluene *	0.32		0.50
m/p-Xylene *	1.4		1.5
o-Xylene *	0.99		1.0

* = PID only
** = ECD only
*** PID and ECD
**** MDL Study June 2009

3.3 This method may be used when the quality assurance objectives are either QA1 or QA2 as defined in Interim Final Guidance for the Quality Assurance/Quality Control Guidance for Removal Activities, April 1990. Briefly, QA1 is a screening objective to afford a quick preliminary assessment of site contamination. QA2 is a verification objective used to verify analytical (field or lab) results. A minimum of 10% of samples screened may be analyzed by a full protocol method for qualitative and quantitative confirmation at the client's request.

4.0 Definitions

4.1 *Field Duplicates (FD1 and FD2)*: Two separate samples collected at the same time and place under identical circumstances and treated exactly the same throughout field and laboratory procedures. Analyses of FD1 and FD2 give a measure of the precision associated with sample collection, preservation, and storage, as well as with laboratory procedures.

4.2 *Headspace*: Vapor above water or solvent in sample vial.

4.3 *Laboratory Duplicate (LD1 and LD2):* Two injections from the same sample. The analyses of LD1 and LD2 give a measure of the precision associated with the laboratory procedure.

4.4 *Laboratory Reagent Blank (LRB):* An aliquot of VOA free reagent water or other blank matrix (i.e. methanol diluted into reagent water for soils) that is treated exactly as a sample including exposure to all glassware, equipment, solvents, and reagents that are used with other samples. The LRB is used to determine if the method analytes or other interferences are present in the laboratory environment, the reagents, or the apparatus.

4.5 *Reagent Water Blank*: An aliquot of VOA free reagent water.

4.6 *Stock Standard Solution*: A concentrated solution containing one or more method analytes (in methanol) prepared in the laboratory using assayed reference materials or purchased from a reputable commercial source.

4.7 *Working Standard Solution*: A solution of several analytes prepared in the laboratory from stock standard solutions and diluted as needed to prepare aqueous calibration solutions and other needed analyte solutions.

4.8 *Secondary Standard*: A standard from another vender or a different lot number that is used to check the primary standard used for quantitation.

5.0 Health and Safety Warnings

5.1 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical should be treated as a potential health hazard. Exposure to these reagents should be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets should be made available to all personnel involved in these analyses. For example, concentrated sulfuric acid presents some hazards and is moderately toxic and extremely irritating to skin and mucous membranes. Use these reagents in a fume hood whenever possible and if eye or skin contact occurs flush with large volumes of water.

5.2 Always wear safety glasses or a shield for eye protection, protective clothing, and observe proper mixing techniques when working with these reagents.

5.3 Some method analytes have been tentatively classified as known or suspected human or mammalian carcinogens. Pure standard materials and stock standard solutions of these compounds should be handled with suitable protection to skin, eyes, etc.

6.0 Cautions

6.1 The methanol stock and secondary standards are replaced every 3 months.

7.0 Personnel Qualifications

7.1 The analyst should have at least a 4 year degree in a physical science.

7.2 The analyst should be trained at least one week and have a working knowledge of this method and quality control before initiating the procedure.

7.3 All personnel shall be responsible for complying with all quality assurance/quality control requirements that pertain to their organizational/technical function.

8.0 Interferences

8.1 Method interferences may be caused by contaminants in solvents, reagents, glassware and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in the chromatograms. All of these materials must routinely be demonstrated to be free from interferences under the conditions of the analysis by running laboratory method blanks.

8.2 Matrix interferences may be caused by contaminants that coelute with the target compounds. The extent of matrix interferences will vary considerably from source to source. A different column or detector may eliminate this interference.

8.3 Contamination by carry-over can occur whenever high level and low level samples are sequentially analyzed. To reduce carry-over, a VOA free water blank should be analyzed following an unusually concentrated sample to assure that the system is clean.

9.0 Apparatus, Materials, Computer Hardware and Software

9.1 Shimadzu GC 2014 portable gas chromatography equipped with a PID, ECD, and a 30m, 0.53 mm DBPS-624 megabore capillary column.

9.2 Tekmar 7000 headspace autosampler.

9.3 Syringes, 5μL – 1mL

9.4 22mL crimp top vials

9.5 GC Software – Totalchrom version 6.3.1

9.6 Processing Software – Totalchrom version 6.3.1

10.0 Reagents

10.1 Methanol – demonstrated to be free of analytes

10.2 Reagent water – VOA free water demonstrated to be free of analytes

10.3 Standard and secondary stock solutions – solutions are either prepared from pure standard materials or purchased by the Region 1 Chemistry Laboratory and are used to prepare aqueous working and secondary standards. The standards used in this procedure include EPA Purgeable A standard and a Custom Mix standard, both of which are diluted with deionized water to a 10ppb concentration.

11.0 Instrument and Method Calibration

11.1 Shimadzu analysis – The Shimadzu instrument must be turned on so that it has ample time to warm up before samples are run. This can take up to 3 hours if the detector is cold.

11.2 A sequence is created using the Totalchrom software and includes the sample name, date, position on the autosampler, the dilution factor and the report format. A new folder should be created for each date samples are run, and contain the date in the folder's name. Each sequence should be saved as the date in MMDDYY format within the corresponding folder. The sequence must also be recorded in the log book.

11.3 The Supelco 10ppb Custom Mix standard (100 ppm) and the Supelco 10ppb Purgeable A (200 ppm) standards are prepared by using a syringe to transfer 10 and 5 μL, respectively, of the stock standards into 2 -100mL volumetric flasks filled with deionized water. Then, 10mL of these working standards are transferred into a 22mL crimp top vial. All standard preparations should be recorded in the standard preparation log book.

11.4 The Sequence should begin with several injections of the 10ppb Custom Mix standard followed by the Purge A Secondary Source Standard and a blank.
A CCV/CCB pair should be run after every 10 samples. Blanks should be run after any samples with high concentrations to prevent carry over into the following samples.

11.5 The method is calibrated by generating calibration factors from a single injection of the 10 ppb standard. Calibration factors are calculated by dividing the peak area by the standard concentration. Open the Method Editor in the Totalchrom software and selecting Edit Components. Select Calibrate using Factors under the Calibration tab and enter the new calibration factors for each compound. Enter factors for both the PID and ECD and save the method files separately in the folder for that day. These new methods can be entered in the sequence by opening the Sequence Editor and selecting the new method in the appropriate columns.

12.0 Sample Collection, Handling, and Preservation

12.1 Aqueous Sample Collection- Fill the 40mL sample vial completely.

12.2 Soil Sample Collection – Place approximately 10 grams of the soil into a 40mL VOA vial containing 10 mL of methanol.

12.3 Samples should be kept refrigerated when not in use and all analysis should be carried out within 2 weeks of the sample collection date.

12.4 All transferring of the samples should be documented on a chain of custody form.

12.5 Samples should be preserved with 1:1 HCl. To pH<2.0

13.0 Sample Preparation and Analysis

13.1 Use pH paper to measure the pH of each sample. All pH levels should be <2.
Measure pH after aliquoting.

13.2 Aqueous Sample Preparation- Use a pipet to transfer 10mL of the sample into a 22mL crimp top vial, label the vial with the sample number and place a cap on the vial. Dilutions may be prepared by using a pipet to transfer the appropriate volume of sample to a vial to result in a 10mL final volume. Record pH and
Dilutions on the VOA Sample Extraction and Dilution Worksheet

13.3 Soil Sample Preparation – Weigh the vial before and after the soil is added to determine the sample weight, then vortex the vial for 30-60 seconds. Allow the solution to settle so that the methanol sits above the soil. Use a pipet to transfer 200μL of the solution to a vial containing 9.8mL dionized water, creating a 50x dilution. Label and cap the vial.

13.4 After filling all VOA vials with samples, standards and blanks, allow all samples to equilibrate for 8-24 hours before running with the autosampler.

13.5 Sample Analysis – Load all samples, standards, and blanks into the autosampler as described in 11.4. Be sure that the position of the vials in the autosampler corresponds with the ordering of the Totalchrom sequence.

13.5 When all samples are in place and the sequence is complete, select Method 1 on the autosampler and select the start and stop position. Press the start button on the instrument.

14.0 Data Acquisition, Calculations and Data Reduction

14.1 Identification of compounds present in a sample is made by matching retention times of peaks in the sample chromatogram to the retention times of standard peaks. After a compound is identified, quantification is done by peak area comparison relative to the calibration factor.

14.2 When a sample is finished running, the results can be processed by entering Batch Reprocessing on the Totalchrom homepage. The sequence and folder for the samples can be selected and the row number of the samples to be processed should also be entered.

14.3 To view the chromatograms, select Results Reprocessing on the Totalchrom homepage and then open the folder containing the samples for that day. There will be a PID and ECD file for each sample that was run.

14.4 After examining the chromatograms, it might be necessary to rerun certain samples using a determined dilution factor. If chromatograms are manually integrated, by sure to print out the chromatogram before and after the manual integration and stamp the final copy with the Manual Integration stamp, checking off the reason for integration.

14.5 Calculations for soil sample analysis

To find the dry weight of a sample, weight out a aliquot of the soil sample (<10 grams) on a aluminum tray. After heating this tray overnight in an oven, remove the tray and re-weigh the sample to find the dry weight.

% Solids = (dry weight/wet weight) *100

Calculations for the reporting levels for soil samples:

$$\text{Conversion to ug/Kg (wet weight)} = \frac{(\text{Extract Volume})(\text{Dilution})(\text{Aq. RL})}{(\text{Sample Wet Weight})}$$

$$\text{Conversion to ug/Kg (dry weight)} = \frac{((\text{Extract Volume})+(\text{ wet Wt } * \%\text{ moisture}))(\text{Dilution})(\text{Aq. RL})}{(\text{Sample dry weight})}$$

Aqueous RL based on most recent MDL study (see table 1)

15.0 Laboratory Documentation

15.1 All standards prepared are recorded in the standard preparation log book. The book should include the Analyst name, the date, and the date on which the standard was received, opened, and will expire. Also included are the vendor, lot number, and the volume created of each standard.

15.2 All sequences run need to be recorded in the Instrument Run Log. Included in this should be the date, project number, sample name, file name, dilution, and position on the autosampler. Any malfunctions during a sequence run should also be recorded in this book.

15.3 All documents pertaining to a project should be kept in the project folder. This should contain the LIMS request form, a print out of the sequence, copies of the instrument log and standard log pages, the VOA Sample Extraction and Dilution Worksheet, printouts of all chromatograms, calibration files and results, along with the project notes and chain of custody form.

16.0 Quality Control

16.1 A reagent water blank and a one point standard are used for instrument's calibration. Initially run 10 μg/L standard to determine retention times and response factors of the instrument. Repeat a second 10 μg/L standard to check the reproducibility. Acceptance criteria: within +/- 15% difference from the first standard.

16.2 Lab reagent blanks are analyzed daily for soils and periodically for aqueous samples to be sure of no reagent interferences and to be sure of no carry over from previous injections. Technical judgment is used to determine frequency. Acceptance criteria: No target compound peaks greater than one-half the reporting level.

16.3 A second source standard containing some compounds of interest is analyzed daily to verify calibration standard. Acceptance criteria: +/- 20% of true value.

16.4 A continuing calibration standard is run at least every 10 samples and at the end of the sample batch to update the instrument's calibration due to changes from temperature fluctuations with respect to retention times and response factors. Acceptance criteria: +/- 20%D agreement with the previous calibration.

16.5 Run field and laboratory duplicates when possible. Acceptance criteria: RPD +/- 20%.

16.6 When possible, GC/MS confirmation of 10% of the field samples analyzed should be performed. This is done, dependent upon the project data quality objective.

17.0 References

17.1 Interim Final Guidance for the Quality Assurance/Quality Control Guidance for Removal Activities, April 1990

Appendix 1 Standard Preparation Log Book Example

Head Space Standard Preparation

Analyst:
Date:

Stock
Lot #
Date Rec'd
Date Opened
Expiration Date

Standard	Volume	Final Volume
10 ppb Custom		
10 ppb Purge A		

Appendix 2 GC Sample Log Book Example

EPA Region 1
GC Sample Log
Instrument: Shimadzu 14B Code J:

P.N.	Survey	Date	Init	Sample ID	File Name	AS No	Rep Dil	Arch Date	Maintenance Comments

Appendix 3 Tekmar 7000 Method 1 Parameters

Platen: 40°C   Platen Equil: 0.00

Smpl Equil: 7.0

Vial Size: 20 mL

Mixer: Off   Mix: -No-

Mix Power: -No-   Stabilize: -No-

Cap Cooldown: -NI- min at –NI-

Press: 0.30   Press Equil: 0.05

Loop: 0.30   Loop Equil: 0.05

Inject: 1.00

Cap Inject: -NI- min at – NI –

Valve: 95°C   Line: 100°C

Capillary Union Htr: -NI-

Inj per vial: 1

GC Cycle Time: 10

Parameter Optimization: Off

--> -No-

By –No-

Appendix 4 GC 2014 Shimadzu Gas Chromatograph Parameters

Column

Temp Monit (°C)	60.0
Temp Program Total (min)	10.0

	Rate (°C/min)	Temp (°C)	Time (min)
Init:	---	60.0	10.00
1st:	end		

Equilibration Time (min)	60.0

Flow

Inlet Press (psi)	12.5
Total Flow (mL/min)	22.0
Split Mode	direct
Control Mode	flow
Carrier Gas Type	N2

Injection Port

	Actual	Setting
Temp (°C)	180.0	180.0

Detector Det #1

PID1	On	
Temp (°C)	209.4	210.0
Flame		Off
Filter Time Constant		200mS
Signal Output Port		Ch 1
Background Sig Save		Off
Background Sig Comp		Off
Det Sig Subtraction		Off
Signal Range		x1
Analog Signal Type		Linear

Detector Det #2

PECD1	On	
Temp (°C)	210.0	210.0
Current (nA)		1.00
Filter Time Constant		200mS
Signal Output Port		Ch 2
Background Sig Save		Off
Background Sig Comp		Off
Det Sig Subtraction		Off
Signal Range		x1
Analog Signal Type		Linear

Appendix 5: Project Review Form

Project Review Form
Head Space VOA Screening Analyses by GC

Project Number__________**Site**_________________**LIMSCode**_________**Matrix**___________

Note: Any omissions or problems with the data require resolution before proceeding to the next review step.

===

REQUESTED ANALYSIS AND DATA FOLDER COMPLETENESS CHECK

( ) Does the LIMS information match the COC requests?- Check LIMS Project Form
( ) Were all samples analyzed and identified correctly?
( ) Have the samples been analyzed according to the referenced method or SOP? Are all deviations approved and documented.
( ) Have holding times been met?
( ) Has sample preservation been checked and documented for all samples?
( ) Is the raw data folder complete?
    ( ) Copy of the Chain-of-Custody form and sample receipt checklist
    ( ) Project notes
    ( ) Soil extraction summary sheet for dry weight calculation
    ( ) Laboratory notebook form
    ( ) Initial and continuing calibrations - summarizations and raw data for all associated calibrations
    ( ) Computer generated sample sequence list, copy of instrument run log
    ( ) Quantitation reports, reprocessed after manual checks (manual integration stamp initialed and dated by analyst)
    ( ) Have manual integrations or other manipulations of computer generated data been performed?
    If Yes, explain here or in the Project Narrative______________________________
    List file names for manual integration:_________________________________

Reviewed by: Date Reviewed:

===

DATA EVALUATION

( ) Have the proper number of QC samples been analyzed?
    ( ) Blanks
    ( ) PE Samples
    ( ) Second source standard
    ( ) Calibration standards (initial, continuing)
    ( ) Duplicates
    ( ) QC check sample
    ( ) Other (specify)
( ) Is the information on the medium level soil extraction bench sheets correct?
( ) Is there documentation of standard preparation and traceability?
( ) Are blank contaminants within limits? If outside limits, is there documented approval to proceed with analysis?
( ) Are QC check sample recoveries within limits?
( ) Are initial and continuing calibrations acceptable?
( ) Have samples been processed with updated calibration factors?
( ) Are manual and computer based calculations correct? Check significant figures and document with a sample calculation from raw data to final concentration (the reviewer initials and dates calculation.)
    ( ) Dry weight calculations
    ( ) Report factors
    ( ) Sample concentrations
    ( ) Other
( ) Are the concentrations of the compounds found within calibration range?
( ) Are duplicate results within QC acceptance windows?
( ) Has the final report been checked for transcription errors?

Reviewed by: Date Reviewed:

==

FINAL REPORT

( ) Check the following information on the report accuracy.
    ( ) Sample IDs- laboratory and field
    ( ) Date sampled (collected) ( ) Date received ( ) Date analyzed
    ( ) Sample weight, % solids
    ( ) Reporting Limit (R.L.), dilution and scaling factor
    ( ) Qualifiers
    ( ) pH
( ) Is the method summary an accurate reflection of all encountered problems? Are observations about the samples noted? Are method blank contaminants mentioned?
( ) Are the reported results consistent with the significant figure policy?
( ) Has the final report been checked for transcription errors?

Reviewed by: Date Reviewed:

Comments:

* = See Comments
NA = Not Applicable
N = No
Y = Yes

GZA
GeoEnvironmental, Inc.
Engineers and Scientists

Boring No.: .
Page: 1 **of** 2
File No.:
Check:

Contractor:
Foreman:
Logged by:
Date Start/Finish:
Boring Location:
GS Elev.: **Datum:**

Rig Type:
Casing I.D.:
Hammer O.D.:
Other:

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Depth (ft)	Sample Information: No.	Yield Test (gpm)	Depth (ft)	Avg. Adv. Rate (Min./Rod)	Field Test Data (ppm)	Sample Description & Classification	Stratum Desc. / Fracture Loc.	Remarks	Equipment Installed
									No Equipment Installed
20									
40									
60									
80									
100									

REMARKS

All depth measurements are approximate. Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: .

GZA
GeoEnvironmental, Inc.
Engineers and Scientists

Boring No.:
Page: 2 **of** 2
File No.:
Check:

Depth (ft)	Sample Information					Sample Description & Classification	Stratum Desc. / Fracture Loc.	Remarks	Equipment Installed
	No.	Yield Test (gpm)	Depth (ft)	Avg. Adv. Rate (Min./Rod)	Field Test Data (ppm)				
							120.0 ft		
140									
160									
180									
200									
220									
240									

REMARKS

All depth measurements are approximate. Stratification lines represent approximate boundary between soil types, transitions may be gradual Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.:

AIR HAMMER AIR HAMMER TEST.GPJ G A_NH.GDT 12/2/09

A-9-2

Field Monitoring: Flame Ionization Detector (TVA-1000)

` FIELD MONITORING: FLAME IONIZATION DETECTOR (TVA-1000)

PURPOSE

This Standard Operating Procedure (SOP) *Field Monitoring: Flame Ionization Detector (TVA-1000)* provides a general framework for field screening drilling cuttings and drilling water for total volatile organic compounds (VOCs) using a Foxboro Company Portable Organic Vapor Analyzer Model TVA-1000 (Flame Ionization Detector [FID]).

In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested, and inspected according to the manufacturer's instructions. The manufacturer’s instruction manuals for field equipment shall be brought to the site for each sampling event.

All instruments will be successfully calibrated once by the sampling team prior to the sampling event. Instruments will be calibrated at the beginning of each sampling day at the site and will be checked again at the end of the day. Instrument calibration may be performed at additional times during the sampling day if instrument readings appear to be significantly different than previously observed.

EQUIPMENT AND MATERIALS

- Foxboro Company Portable Organic Vapor Analyzer Model TVA-1000 and accessories. Accessories include: battery charger, shoulder strap, carrying case, regulator, H_2 refilling plumbing, activated charcoal filter assembly methane cylinder;
- Spare parts (charcoal filter, stainless steel filters for sample intake lines);
- H_2 cylinder, tools (screwdrivers, box-end wrenches, sparkles adjustable wrench, socket wrench, etc.);
- Sample containers (250 ml glass jars, 40 ml septum vials);
- Thermometer; and
- Instruction Manual - Foxboro Company Portable Organic Vapor Analyzer Model TVA-1000B, dated June 1996.

PROCEDURES

1. Preparation for Calibration and Use

   a. Connect the close area sampler to the sample probe nut and sleeve. Manually turn the probe nut until tight. Connect the data transfer cable to the FID via the swage lock fitting adjacent to the hydrogen valve.

b. Ensure the hydrogen tank contains enough hydrogen to complete the intended work scope. The detector uses approximately 150 pounds per square inch (psi) per hour of operation. Refill the hydrogen tank with H_2, if necessary using the refill plumbing and sparkles wrench.

c. Open the red hydrogen valve

d. Press “ON” then “CONTROL” to open the main menu. Press “1” to turn on the pump and Press “3” to ignite. The reading on meter indicates background level of total organic vapors in the ambient air.

2. Calibration

a. Calibrate the detector daily prior to beginning field activities, as well as, following all field activities.

b. At the Main Menu, press “2” Setup, then press “1” to calibrate.

c. Press “3” Zero. Inset the sample probe into the charcoal filter. Press ENTER to start. Wait to stabilize.

d. Press “2” span concentration and enter the concentration of the methane standard. Press ENTER to start. Wait to stabilize then press ENTER to accept.

e. Press EXIT two times to return to the Main Menu.

3. Operation - Air Quality Monitoring for VOCs

a. Turn on the detector following steps 1.a. through 1.d. above. Record the background concentration.

b. The probe should be held in close proximity to the area being monitored to provide a representative reading. Collect an additional reading within the breathing zone and record both readings.

c. Record the detected concentrations in a field book or field summary sheet as ppm above background. Refer to the site specific GZA Health and Safety Plan to determine safe breathing zone concentrations. Use of a respirator may be necessary should concentrations warrant.

4. Operation – Drilling Cuttings and Drilling Water Sample Screening with Survey Mode (Field and Laboratory)

Note: See Mottolo SAP Addendum SOP A-9-1 for guidance on taking drill cuttings and drilling water samples for the EPA Chelmsford, Massachusetts laboratory.

a. Obtain drilling cuttings and drilling water samples for field VOC headspace screening.

        i. Split spoon samples (if used) – Transfer an appropriate volume of soil into a laboratory issued sample container (8 oz glass jar), immediately after opening the spoon.
        ii. Air Rotary Drilling – Drilling soil cuttings / bedrock cuttings and drilling water samples will need to be collect from the drilling operation and headspace tested whenever water bearing fractures are encountered. Transfer an appropriate volume of sample into a laboratory issued sample container (8 oz glass jar).
        iii. Other samples (if used) – For test pits, hand augers, and all other soil samples immediately transfer an appropriate volume of soil into a laboratory issued sample container (8 oz glass jar)..

    b. Cut the aluminum foil into approximately 3-inch by 3-inch squares.
    c. Fill an 8 oz glass jar with soil (or drilling cuttings or drilling water) to be screened, leaving approximately 1 inch of airspace.
    d. Tightly cover the mouth of the jar with an aluminum foil square and tighten the cap. Remove the jar from direct sunlight and allow five minutes (in heated vehicle or room if cold weather exists) for transfer of organic compounds from the sample to the air space. Shake jar for 30 seconds; allow to sit at least 15 minutes (in heated vehicle or room if cold weather exists) but no longer than 2 hours.
    e. Turn on the detector following step 1.a. through 1.d. above. Record the background concentration.
    f. Shake the jar (being careful not to damage the foil) for another 30 seconds prior to taking a reading. Unscrew the cap, and gently insert the sample probe through the foil into the air space above the sample material. Do not allow the probe to contact soil or liquid contained within the jar.
    g. Record the maximum concentration measured by the detector onto a boring log, test pit log, or appropriate field data collection sheet as ppm (and take appropriate actions based on Mottolo SAP Addendum SOP A-9-1).
    h. Periodically collect breathing zone measurements as well as measurements directly above the borehole or excavation. Refer to the site-specific GZA Health and Safety Plan to determine safe breathing zone concentrations. Use of a respirator may be necessary should concentrations warrant.

5. Shut-Down Procedures

    a. Complete an end of the day calibration check.
    b. Close the hydrogen valve supply valve and the H_2 tank valve.
    c. Press “ON” then “CONTROL” to open the main menu. Press “1” to turn off the pump.

d. Unscrew the hydrogen cylinder. Leaving the cylinder in the detector will result in a slow leak of hydrogen until the detector's next use.

e. Clean the instrument and repack into its carrying case for transport.

RECORDS AND DOCUMENTATION

Readings will be recorded on an applicable log sheet for the work being performed in accordance with the approved work plan. Note: Specify lamp energy rating, calibration standard, and special response factors or curves that may be employed.

SPECIAL NOTES

1. A flame ionization detector is not the only air quality monitoring instrument recommended for unknown air spaces. Discuss appropriate monitoring with the project manager and/or office health and safety manager. This instrument should not be used to ascertain whether further personal protective equipment may be necessary.

2. The TVA-1000 contains pressurized hydrogen gas which is extremely flammable. Extreme care should be used when transporting the unit. The instrument cannot be transported aboard airplanes or through certain highway tunnels unless the hydrogen supply tank is emptied.

3. Maintenance procedures, including lamp cleaning are specified in the Instruction Manual.

APPLICABLE STANDARDS AND REFERENCES

Operating and Service Manual for Foxboro TVA-1000B.

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A-9-3

Screening For DNAPL Using Sudan IV Dye Testing

SCREENING FOR DNAPL USING SUDAN IV DYE TESTING METHODS

PURPOSE

This Standard Operating Procedure (SOP) *Screening for DNAPL Using Sudan IV Dye Testing Methods* provides general guidance for the preparation of Sudan IV dye test bottles and the screening of soil and rock samples for the presence or absence of dense non-aqueous phase liquids (DNAPL) using Sudan IV dye. This SOP was developed to be used at the Mottolo Pig Farm Superfund Site, in Raymond, New Hampshire, concurrent with bedrock drilling activities.

The screening of soil and bedrock samples using Sudan IV provides data that may be used to evaluate the potential presence or absence of organics liquids in the form of DNAPL in subsurface soils, bedrock, or groundwater. This screening method is used in conjunction with subsurface soil and bedrock drilling techniques, generally in areas of suspected heavy contamination. Sudan IV is a nonvolatile, hydrophobic dye. It is a reddish-brown powder that dyes organic fluids such as chlorinated solvents and fuels, red upon contact. Sudan IV dye cannot be used to identify or quantify a specific type of NAPL. It does not allow discrimination between fuels, solvents, or mixtures of organic fluids. It is a simple screening tool to indicate the presence or absence of organic fluids and must be used in conjunction with analytical methods to identify specific contaminants and hazards.

Sudan IV sample screening jars may be prepared in the field or office prior to sample collection activities. They do not require refrigeration. The sample screening jar consists of clear wide mouth soil jars with a Teflon (or equivalent) lined cap. The screening jars contain approximately 4 milligrams of Sudan IV powder in deionized water. Soil, bedrock, or groundwater samples retrieved from a borehole are added to the screening jars. The screening jars are shaken and then examined for NAPL, which should be stained bright red.

EQUIPMENT AND SUPPLIES

The following list is not exhaustive, but provides a listing of the minimum equipment required and supplies:

- Sudan IV dye (powder form);
- Pre-weighed 2 oz to 6 oz clear wide mouth jars (or appropriate size) with Teflon (or equivalent) lined lid;
- Deionized water;
- Notebook/field book/logs;
- Digital camera;
- Permanent markers;
- Disposable, plastic, 5 ml syringes (used as a scoop for measuring out Sudan IV powder);
- Stainless steel scoop;
- Stainless steel bowl and spoon;

- Electronic balance (optional);
- Graduated cylinder (50 mL);
- Health and safety protective equipment (i.e., safety glasses with side shields, gloves, etc.).

PROCEDURES

1. Prior to sampling, prepare a clear, 2 oz to 6 oz jar with Teflon (or equivalent) lined cap by adding approximately 4 milligrams of Sudan IV powder to the jar and add approximately 50 ml of DI water. This can be done in advance of sample collection in a controlled environment to avoid adverse conditions in the field.

2. Add the sample (rock fragments, soil and/or groundwater) to the prepared 2 oz to 6 oz jar and tighten cap. Since the screening test is determining gross presence or absence the most heavily contaminated rock or soils should be used for the screening sample.

3. Shake sample for 10 to 30 seconds and examine it for NAPL, which should be stained bright red through contact with the Sudan IV. Rate the presence of NAPL using the following categories:

    a. "A" if NAPL was identified as present based on visual evidence and Sudan IV dye test; or

    b. "B" if NAPL presence was suspected based on visual evidence but not present based on Sudan IV testing; or

    c. "C" if NAPL does not appear to be present at all.

4. Record results in field notebook and on any field data records being used.

5. Photograph field screening results indicating the presence of DNAPL.

HEALTH AND SAFETY WARNINGS

Sudan IV dye is an irritant and possible mutagen. Skin and eye contact will be avoided through the use of personal protective equipment. Latex or nitrile gloves and safety glasses will be required at all times during handling of Sudan IV. The preparation of sample jars will be conducted in a calm environment (no breezes) which may cause the Sudan IV to become airborne. For additional product information, refer to the attached Sudan IV Material Safety Data Sheet.

Attachment: Sudan IV Material Safety Data Sheet

p:\04jobs\0024400s\04.0024466.00\04.0024466.27 - mottolo\sap addendum #1\sap appendix a - sops\sop a-9\sop a-9-3 sudan iv screen.docx

chemists helping chemists in research & industry

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FAX: (414) 273-4979

RECEIVED
JUL 10

ATTN: SAFETY DIRECTOR
JIM WIECK
GOLDBERG/ZOINO & ASSOCIATES INC
380 HARVEY RD
MANCHESTER NH 03103-3347

DATE: 07/03/95
CUST#: 926252
PO#: 46630

MATERIAL SAFETY DATA SHEET

SECTION 1. - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - -

PRODUCT #: 19810-2 NAME: SUDAN IV, CERTIFIED

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

CAS #:85-83-6
MF: C24H20N4O

SYNONYMS

BIEBRICH SCARLET BPC * BIEBRICH SCARLET RED * BIEBRICH SCARLET R MEDICINAL * BRASILAZINA OIL RED B * CALCO OIL RED D * CANDLE SCARLET B * CANDLE SCARLET 2B * CANDLE SCARLET G * CERES RED BB * CEROTINE PONCEAU 3B * CERVEN ROZPOUSTEDLOVA 24 (CZECH) * C.I. 258 * C.I. 26105 * C.I. SOLVENT RED 24 * 2',3-DIMETHYL-4-(2-HYDROXYNAPHTHYLAZO) AZOBENZENE * DISPERSOL RED PP * ENIAL RED IV * FAST OIL RED B * FAST RED BB * FAT PONCEAU R * FAT RED B * FAT RED 2B * FAT RED BB * FAT RED BS * FAT RED TS * GRASAL BRILLIANT RED B * GRASAN BRILLIANT RED B * HIDACO OIL RED * LACQUER RED V * LACQUER RED VS * LIPID CRIMSON * 1-((2-METHYL-4-((2-METHYLPHENYL)AZO)PHENYL)AZO)-2-NAPHTHALENOL * OIL RED IV * OIL RED 3 * OIL RED 7 * OIL RED 47 * OIL RED 282 * OIL RED A * OIL RED APT * OIL RED 2B * OIL RED 3B * OIL RED BB * OIL RED 4B * OIL RED BS * OIL RED O * OIL RED EO * OIL RED F * OIL RED GO * OIL RED PEL * OIL RED RC * OIL RED RR * OIL RED S * OIL RED TAX * OIL RED ZO * OIL SCARLET * OIL SCARLET 48 * OLEAL RED BB * ORGANOL RED B * ORIENT OIL RED RR * PHENOPLASTE ORGANOL RED B * PLASTORESIN RED F * RED 3R SOLUBLE IN GREASE * RESINOL RED 2B * RUBRUM SCARLATINUM * RESOFORM RED G * SARLACH R (CZECH) * SCARLET RED * SCARLET RED, BIEBRICH * SCARLET R (MICHAELIS) * SCHARLACHROT * SCHULTZ NO. 541 * SILOTRAS RED T3B * SOMALIA RED IV * STEARIX RED 4B * STEARIX RED 4S * SUDAN IV * SUDAN P * SUDAN RED IV * SUDAN RED 4BA * SUDAN RED BB * SUDAN RED BBA * TERTROGRAS RED N * O-TOLUENEAZO-O-TOLUENEAZO-BETA-NAPHTHOL * O-TOLUENEAZO-O-TOLUENE-BETA-NAPHTHOL * O-TOLYLAZO-O-TOLYLAZO-BETA-NAPHTHOL * O-TOLYLAZO-O-TOLYLAZO-2-NAPHTHOL * 1-(4-O-TOLYLAZO-O-TOLYLAZO)-2-NAPHTHOL * TOYO OIL RED BB * WAXAKOL RED BL * WAXOLINE RED O * WAXOLINE RED OM * WAXOLINE RED OS *

SECTION 3. - - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS
HARMFUL
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES AND SKIN.
POSSIBLE RISK OF IRREVERSIBLE EFFECTS.

CONTINUED ON NEXT PAGE

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MATERIAL SAFETY DATA SHEET

CUST#: 926252
PO#: 46630

PRODUCT #: 198102 NAME: SUDAN IV, CERTIFIED
MF: $C_{24}H_{20}N_4O$

POSSIBLE MUTAGEN.
TARGET ORGAN(S):
LIVER
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.
DO NOT BREATHE DUST.

SECTION 4. - - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
DISCARD CONTAMINATED CLOTHING AND SHOES.

SECTION 5. - - - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -

EXTINGUISHING MEDIA
WATER SPRAY.
CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
UNUSUAL FIRE AND EXPLOSIONS HAZARDS
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

SECTION 6. - - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - -

EVACUATE AREA.
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
WEAR DISPOSABLE COVERALLS AND DISCARD THEM AFTER USE.

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CUST#: 926252
PO#: 46630

PRODUCT #: 198102 NAME: SUDAN IV, CERTIFIED
MF: $C_{24}H_{20}N_4O$

SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - -

REFER TO SECTION 8.

SECTION 8. - - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
DO NOT BREATHE DUST.
AVOID ALL CONTACT.
AVOID PROLONGED OR REPEATED EXPOSURE.
READILY ABSORBED THROUGH SKIN.
WASH THOROUGHLY AFTER HANDLING.
POSSIBLE MUTAGEN.
IRRITANT.
KEEP TIGHTLY CLOSED.
STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - -

APPEARANCE AND ODOR
RED-BROWN POWDER
MELTING POINT: 199 C (DEC)

SECTION 10. - - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - -

INCOMPATIBILITIES
STRONG OXIDIZING AGENTS
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:
CARBON MONOXIDE, CARBON DIOXIDE
NITROGEN OXIDES

CONTINUED ON NEXT PAGE

MATERIAL SAFETY DATA SHEET

CUST#: 926252
PO#: 46630

PRODUCT #: 198102 NAME: SUDAN IV, CERTIFIED
MF: $C_{24}H_{20}N_4O$

SECTION 11. - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - - -

ACUTE EFFECTS
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
CAUSES EYE AND SKIN IRRITATION.
EXPOSURE CAN CAUSE:
STOMACH PAINS, VOMITING, DIARRHEA.
CHRONIC EFFECTS
LABORATORY EXPERIMENTS HAVE SHOWN MUTAGENIC EFFECTS.
TARGET ORGAN(S):
LIVER
RTECS NO: QL5775000
2-NAPHTHOL, 1-((4-(O-TOLYLAZO)-O-TOLYL)AZO)-
TARGET ORGAN DATA
TUMORIGENIC (EQUIVOCAL TUMORIGENIC AGENT BY RTECS CRITERIA)
TUMORIGENIC (TUMORS AT SITE OF APPLICATION)
ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - -

DISSOLVE OR MIX THE MATERIAL WITH A COMBUSTIBLE SOLVENT AND BURN IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND SCRUBBER. OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - -

CONTACT ALDRICH CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - -

REVIEWS, STANDARDS, AND REGULATIONS
IARC CANCER REVIEW:ANIMAL INADEQUATE EVIDENCE IMEMDT 8,217,75
IARC CANCER REVIEW:HUMAN NO ADEQUATE DATA IMEMDT 8,217,75

CONTINUED ON NEXT PAGE

CUST#: 926252
PO#: 46630

PRODUCT #: 198102 NAME: SUDAN IV, CERTIFIED
MF: $C_{24}H_{20}N_4O$

IARC CANCER REVIEW:GROUP 3 IMSUDL 7,56,87
NOHS 1974: HZD A1356; NIS 6; TNF 212; NOS 13; TNE 2432
NOES 1983: HZD A1356; NIS 15; TNF 1210; NOS 23; TNE 20219; TFE 10256
EPA GENETOX PROGRAM 1988, POSITIVE: CELL TRANSFORM.-SA7/SHE
EPA GENETOX PROGRAM 1988, INCONCLUSIVE: HISTIDINE REVERSION-AMES TEST
EPA TSCA SECTION 8(B) CHEMICAL INVENTORY

SECTION 16. - - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - - -

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. ALDRICH SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

A-10

Bedrock Borehole Groundwater Sampling

BEDROCK BOREHOLE GROUNDWATER SAMPLING

PURPOSE

This Standard Operating Procedure (SOP) *Bedrock Borehole Groundwater Sampling* provides a general framework for collecting screening level groundwater quality samples from an open bedrock borehole at the Mottolo Superfund Site (Mottolo). Sample collection includes bulk and depth sampling. The bulk sample will be collected from the open borehole, and represent average (mixed) water quality estimated over the entire length of the borehole, designed to provide data comparable to residential bedrock drinking water samples. Depth sampling consists of discrete sample collection at select depths within bedrock wells proximate to bedrock features of interest such as fracture zones. The locations of fractures are typically estimated based on drillers observations made during the advancement of the borehole as well as observations made by the field hydrogeologist, and borehole geophysical data if available.

The bulk water sample will be collected using an appropriately sized bladder pump immediately after the well is developed by the drilling subcontractor. Sample collection will follow well development by overpurging per SOP A-9-1. The submersible pump used to develop the well will be placed at a location in the borehole, consistent with placement/design for a residential drinking water supply well (approximately 50 feet above the bottom of the borehole). Bulk water sample data will be used to screen whether there is evidence of site contamination in a well.

The method for collection of discrete depth samples that this SOP covers includes use of a bladder pump at discrete intervals/depths adjacent to fracture zones. A submersible pump used to create groundwater flow from the bedrock fractures into the well. Sample data collected from specific fractures of interest will be used to evaluate whether there is evidence of groundwater entering the well from different fracture zones being contaminated or uncontaminated. Depending upon the drillers observations of groundwater yield at different depths (or from geophysical logging data), the GZA project manager may determine that there is only one fracture zone of interest and in that case the sampling would be conducted only in the sampling zone of interest.

The collection of water quality parameters (temperature, dissolved oxygen, oxidation reduction potential, specific conductance, pH, and turbidity) will be optional and will depend upon the specific rationale for sample collection. If water quality indicator parameters are to be collected, they are to be taken at each sampling interval once the sampling line and the flow-through-cell have been purged of the well water from the previous sampling depth location. All measurements must be obtained using a “flow-through-cell,” except for turbidity. Turbidity must be taken at a point before the flow-through-cell and from an instrument separate from the flow-through-cell apparatus (refer to the attached schematic). A three-way stop cock attached to the tubing before the flow-through-cell will be used for this purpose. Transparent flow-through cells are required to allow field personnel to watch for particulate build-up within the cell, which may affect indicator field parameter values measured within the cell, and have a cell capacity of 250 milliliters (mL) or less. The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times.

If the well contains any equipment such as a well pump or transducers, sampling devices, etc., the equipment shall be removed from the well prior to the sampling event. If the well is a residential well, the well equipment removal will be performed by a licensed well company in New Hampshire and the work performed will be consistent with industry best practices and WD-WSEB-4-11 (Disinfecting a Private Well).

Any modifications to this SOP shall be approved by the New Hampshire Department of Environmental Services (NHDES) in consultation with the Environmental Protection Agency (EPA) in advance, documented in the site logbook, and presented in the final report.

EQUIPMENT AND MATERIALS

The following is a list of equipment and material used in conjunction with bedrock borehole groundwater sampling as described in this SOP:

Equipment and Supplies	
• QED bladder pump, MP-10 controller, air compressor or compressed nitrogen for bladder pump operation, and polyethylene tubing (1/4-inch OD for compressed gas line and waster sample line) for primary sampling approach for water sample from well	• Toolbox
• Ball valve and associated fittings used with poly tubing at discharge end to control flow rate (for optional sampling approach)	• Appropriate health and safety gear and GZA-approved site-specific Health & Safety Plan (HASP)
• Stainless steel Drop Tube Assembly (optional) if the sampling depth is greater than the capability of the bladder pump.	• Poly sheeting
• Polyethylene Drop Tube tubing (optional) if there are no issues with semi-volatiles (use Teflon tubing if there is an issue) (sized for Drop Tube Assembly). Length not to exceed 150 feet. Inflow filter screen (stainless steel) for the Drop Tube Assembly is optional.	• Necessary tent /canopy for protection of the equipment from the weather elements
• Masterflex silicon tubing or equivalent, of varying diameter to connect to the water quality meter	• Sample containers, preserved as necessary
• Grundfos pump (capable of pumping one gpm or less) for creating a low flow rate from bedrock fractures to ensure the well contains representative formation; control box; and power source. In warm weather evaluate the use of marine batteries or other high capacity batteries. In cold weather a generator may be required. If a generator is used, also provide a minimum 100 ft extension cord to locate the generator down-wind at least 100 ft from the sampling location.	• Loose ice, shipping containers and packing materials
• Instruments for measuring water quality parameters, as required (QED MP-20 Micropurge Flow Cell & Three-way stop cock, and separate Hach 2100 P Turbidity Meter, & Hach DR/890)	• Field-data sheets, sample labels, and chain-of-custody records
• Flow measurement supplies (250 ml graduated cylinder, graduated buckets and stop watch, etc.)	• Clear tape – Place clear tape over sample container labels before sampling if it has not been done prior to going into the field in the event the labels are not waterproof labels. Alternative – use plastic water proof labels.
• Appropriate calibration solutions as needed for the QED MP-20 and turbidity meter including; 0 mg/L DO (check), Zobel ORP, 718 µS/cm & 1,413 µS/cm specific conductance, 7, 4, 10 units pH, and <0.1, 20, 100, and 800 NTUs for turbidity	• Logbook, field sheets, pencil/pen/sharpies, calculator, and engineering scale
• Buckets, drums, or other for containerization of liquids (as needed)	• Appropriate health and safety gear as specified in the Site specific HASP (i.e., gloves, safety glasses, steel-toe boots, etc.)
• Water level meter – 300', 1" diameter poly tubing used for water level measurement, if required	• Borehole field log
• Arsenic Speciation Kits, as required; 60mL syringe and Meng filter tip	• Distilled or deionized water
• 0.45 micron inline filters, as required	• 6-foot folding rule, fiberglass surveyors tape
	• Decontamination equipment and supplies

PRELIMINARY PROCEDURES INCLUDING WATER LEVEL MEASUREMENTS

1. In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested, and inspected according to the manufacturer's instructions. The manufacturer's instruction manuals for field equipment shall be brought to the site for each sampling event.

2. All instruments, as applicable, will be successfully calibrated once by the sampling team prior to the sampling event. For those instruments that are factory calibrated only (i.e., Hach DR890), a certificate indicating calibration information (date, standards used to calibrate, successful calibration achieved, etc.) should be obtained and included with field documents. Calibration certifications should be less than one year old.

   Water quality instruments will be calibrated at the beginning of each sampling day at the site and will be checked (in the run mode) in the morning and again at the end of the day. Instrument calibration may be performed at additional times during the sampling day if instrument readings appear to be significantly different than previously observed. **IMPORTANT** – ***Refer to the Calibration SOP A-2 of the SAP for specific calibration information and procedures.***

3. Prior to any sampling, an equipment blank will be collected on the submersible and bladder pumps, and subsections of the associated tubing (refer to **Table 5**). The equipment blank samples will be collected following the submergence and operation of the pump and tubing in DI water. The water, pump, and tubing will be containerized within a minimum 6-inch diameter polyvinyl chloride (PVC) pipe for the submersible pump and a 2-inch-diameter PVC pipe for the bladder pump. The PVC pipe will be sealed at the bottom with a slip cap. The pumps will be operated within the PVC pipe such that water recirculates through the pump, tubing and PVC pipe. A grab sample of the water will be collected directly from the pump and submitted for analysis.

4. Bladder Pump -

   - The pump's bladder capacity should be optimized to ensure a volatile organic compound (VOC) sample can be collected in one bladder cycle or in the "pause-hold-sample" mode of the MP-10. As a result, a minimum bladder capacity of 100 mL is required to ensure that 40 mL can be obtained to fill the VOC VOA vial. This assumes that at least 4 feet of head (water column above the pump intake) is available for the QED bladder pumps and that 6 feet of head is available for the geo-tech bladder pumps.
   - In the event that there is less water above the bladder pump intake, the size of the bladder pump bladder will need to be maximized for the well diameter to ensure that at least 70 mL of sample can be collected at one time (Note – the water head guidance is specific to the QED/Geo-tech bladder pumps. Other brands of bladder

pumps may require more water head above the pump intake to operate correctly). If there is consistently insufficient water head above the pump intake, the sampling procedure will need to be re-evaluated or the well replaced with a new deeper well.

5. Water level measurements will be collected prior to and concurrent with development/purging/sampling measured to 0.01 feet and referenced to the top of casing. Care should be taken to minimize water column disturbance. Use the following procedures to collect water level measurements:

   - If possible, and when applicable, start at those wells that are least contaminated and proceed to those wells that are most contaminated.
   - Measure the groundwater level before beginning well development and after well development. Lower water level meter and graduated measuring tape / cable into the well to the water surface to determine if the well has recharged at least ninety percent before taking a bulk water sample.
   - Record the distance from the water surface (to 0.01 feet), as determined by the audio signal or tone, to the reference measuring point (i.e., top of casing) and record in the field book/field sheet. In addition, note the reference point used.
   - Remove all downhole equipment used for the water level measurement, and replace well cap and locking steel caps.
   - Decontaminate all the equipment entering the well(s) in accordance with SOP A-7 Sampling Equipment Decontamination Procedure.

GROUNDWATER SAMPLING PROCEDURES

SECTION I - BULK WATER SAMPLE

1. There is no purging required with the bladder pump since the driller's submersible pump will be used to develop the well in accordance with SOP A-9-1. The bulk water sample will be taken after the well has been developed and the well has recovered at least 90 percent relative to the water level prior to well development.

2. Review equipment setup diagrams at the end of the SOP. Two setup diagrams are provided (one using a compressed nitrogen source and one using a compressor which is an alternative approach). The preferred approach is the compressed nitrogen source. Set up the equipment according to the appropriate diagram before proceeding with the rest of the procedure.

3. The bladder pump intake within each well should be located at the midpoint of the open bedrock bore hole. In the event that the sampling depth exceeds the capability of the bladder pump to sample, a drop tube assembly with no more than 150 feet of tubing will be used to obtain the groundwater samples (see attached).

4. The QED bladder pump intake should have at least 4 feet of water head to maximize the filling of the individual pump's bladder.

5. Great care must be taken during pump installation and sampling to minimize the disturbance of particulates.

6. Be sure all sampling equipment is properly protected from the weather.

7. Activate the gas source, which activates the pneumatic controller.

8. The PSI of the bladder pump controller setting should be close to the PSI needed to lift water the depth of the pump intake plus ten to twenty PSI to maximize the discharge volume from the bladder. However, be careful not to set the PSI setting too high resulting in a sample stream that shoots out of the tubing during sampling. The water flow out of the bladder pump during sampling needs to be a laminar flow without air bubbles. If air bubbles are observed, they can usually be removed by elevating the discharge tube and pump to allow the air to continue rising until discharged with the water. In the event that it is difficult to remove the captured air bubbles in the sample tubing, use the "pause-hold-sample" mode to flush the air bubbles out of the sample tubing.

   Start with the cycle setting of one cycle per minute. Initially set the discharge setting to 20 seconds and the refill setting to 40 seconds unless the settings used in a previous sampling event (for the same number of cycles per minute) for the well are known (and start with those settings if known).

9. If water quality parameters are being collected, tilt the MP-20 low flow cell with the outflow connection facing upward to eliminate and prevent air bubbles.

10. Prevent sample and air tubing from crimping. All tubing needs to maintain open condition.

11. If the normal pulse volume from a pump cycle is less than 70 mL, the operator needs to place the controller in the "pause-hold-sample mode" to confirm that a pulse volume of 70 mL or greater can be collected. The "pause-hold-sample mode" will empty the bladder. Note that if the pulse volume is 70 mL or greater, there is no need to perform this check as you will be sampling directly from the pump cycle.

    In the event the "pause-hold-sample mode" volume is less than 70 mL, the operator will attempt to change operating conditions to increase the "pause sample mode" volume. If attempts are unsuccessful, an immediate call to the GZA project manager is required to discuss the issue. (Note: the need to fill the VOAs with one pulse volume of water is an NHDES requirement.)

12. In the event that flow from the bladder pump appears to be a water/air mixture during purging/sampling operations, pumping should be discontinued without taking a sample. This may signal that turbulent flow is occurring, the water level in the well is at the pump intake level, or the bladder has been damaged. Contact the GZA project manager if this happens.

13. If the pulse water volume is 70 mL per pulse or greater, the sampler may sample directly from the pump pulse. In the event the pulse water volume is less than 70 mL per pulse, the water samples will need to be collected through the "pause-hold-sample" function of the QED MP-10 controller.

14. Sample Collection:

    a. Measure flow rate and record in field book. Target a flow rate between 70 and 250 milliliters per minute.

    b. Remove the cap from the sample container and place it on the poly sheeting or in a location where it won't become contaminated. Immediately begin sample collection. In general, the order in which samples should be collected from each well includes:

        - Volatile Organic Compounds (see special notes);
        - Total Arsenic and other total metals as required;
        - 1,4 Dioxane, as required; and
        - MNA parameters, as required.

    For the collection of samples for VOC analysis, refer to the Special Notes section at the end of this SOP.

    c. All sample containers should be filled by allowing the discharge to flow gently down the inside of the container with minimal turbulence.

    d. Following bulk water sample collection, connect the discharge line to the water quality meter (QED MP-20) using silicon tubing. The MP-20 will be assembled in accordance with SOP A-1. The water quality parameters will include the following parameters monitored in-line: pH, temperature, specific conductance, ORP, and dissolved oxygen. Turbidity will be monitored separately from those parameters monitored in-line; it will collected through a 3-way stop cock before the flow through cell.

    e. When recording pH and dissolved oxygen data, only use one decimal place (round off to nearest tenth place number). When dissolved oxygen data is less than 0.5 mg/L, data should be recorded as "< 0.5" or "less than 0.5". When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers (round off to the nearest whole number). When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". Once the water quality parameters have been collected shut off the pump. The pump assembly (including the tubing) and water level meter will be removed and pump assembly decontaminated.

f. Refer to SOP A-8 *Chain-of-Custody, Sample Packaging and Shipment Procedures* for documentation requirements and SOP A-7 *Sampling Equipment Decontamination Procedures* for decontamination requirements.

15. Field duplicate samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection and should be in the same priority order as indicated above. Duplicate samples are not intended to be blind duplicate samples. They should be designated with a "DUP" after the well designation (i.e., MOT_MW-100D DUP) as indicated in the SAP.

16. Field matrix spike/matrix spike duplicate (MS/MSD) samples should be collected by filling a separate container for analysis immediately following the actual field sample collection and duplicate sample if required at this location. Refer to **Table 5** included in the SAP for specific QC sampling requirements and appropriate COC notations required for MS/MSD samples.

17. After collection of the samples, disconnect equipment as needed. Tubing will be discarded and disposed of appropriately. New tubing is to be used for each well.

18. Secure the well.

19. All equipment (water level meter) must be decontaminated following SOP A-7.

20. If equipment blank is required, fill the PVC chamber (4-foot PVC riser with end cap to provide well scenario for pump) with DI water. Lower tubing intake into the PVC chamber. Activate pump and purge one tubing volume of water through the setup. Collect an equipment blank sample by filling the appropriate bottles required for samples. Continuously add DI water to the PVC chamber until all the bottles have been filled. Refer to **Table 5** included in the SAP for specific QC sampling requirements.

BULK WATER SAMPLE (OPTIONAL METHOD USING A SUBMERSIBLE PUMP)

Note: In the event that the bladder pump method of collecting the bulk water sample from the well encounters problems due to the cold weather, this optional method (using a submersible pump) would be used to obtain the bulk water sample from a bedrock well.

1. Bulk groundwater sampling is performed immediately following borehole development/purging. The submersible pump is left in place and sample collected directly from the discharge line.

2. Using the ball valve on the sample port (connected to the discharge line), reduce the flow to collect the bulk water sample. The flow must be reduced to laminar flow, reducing the potential for aeration of the sample and potential loss of sample preservative or VOCs.

3. Measure flow rate and record in field book. Remove the cap from the sample container and place it on the poly sheeting or in a location where it won't become contaminated. Immediately begin sample collection. In general, the order in which samples should be collected from each well includes:

   - Volatile Organic Compounds (see special notes);
   - Total Arsenic and other total metals as required;
   - 1,4 Dioxane, as required; and
   - MNA parameters, as required.

   For the collection of samples for VOC analysis, refer to the Special Notes section at the end of this SOP.

4. All sample containers should be filled by allowing the discharge to flow gently down the inside of the container with minimal turbulence.

5. Following bulk water sample collection, if water quality measurements are being collected, connect the discharge line to the water quality meter (QED MP-20) using silicon tubing. The MP-20 will be assembled in accordance with SOP A-1. The water quality parameters will include the following parameters monitored in-line: pH, temperature, specific conductance, ORP, and dissolved oxygen. Turbidity will be monitored separately from those parameters monitored in-line; it will be collected through a three-way stop cock before the flow through cell.

6. When recording pH and dissolved oxygen data, only use one decimal place (round off to nearest tenth place number). When dissolved oxygen data is less than 0.5 mg/L, data should be recorded as “< 0.5” or “less than 0.5”. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers (round off to the nearest whole number). When turbidity data is less than 5 NTU, data should be recorded as “< 5” or “less than 5”. Once the water quality parameters have been collected, shut off the pump. The pump assembly (including the tubing) and water level meter will be removed and pump assembly decontaminated.

7. Once the water quality parameters have been collected, shut off the pump. The pump assembly (including the tubing) and water level meter will be removed and pump assembly decontaminated in accordance with SOP A-7.

8. Refer to SOP A-8 *Chain-of-Custody, Sample Packaging and Shipment Procedures* for documentation requirements and SOP A-7 *Sampling Equipment Decontamination Procedures* for decontamination requirements.

SECTION II – DEPTH SAMPLING OF BEDROCK WELLS

Sampling bedrock boreholes conceptually includes use of a grundfos pump to induce fracture flow into the borehole while simultaneously utilizing a bladder pump to collect a discrete grab sample proximate to bedrock features of interest (i.e., bedrock fractures). The following describes the procedures used:

1. Review equipment setup diagrams at the end of the SOP. Two setup diagrams are provided (one using a compressed nitrogen source and one using a compressor which is an alternative approach). The preferred approach is the compressed nitrogen source. Set up the equipment according to the appropriate diagram before proceeding with the rest of the procedure.

2. Be sure all sampling equipment is properly protected from the weather elements.

3. Installation and positioning of the bladder pump intake: The bladder pump intake within each well should be located at the desired depths for sampling. The sampling depths will be determined one of two ways:

   - If geo-physical logging was performed, the data can be used to determine the depths in the well where the significant bedrock fractures are located. If the geo-physical logging provides information as to whether the groundwater exits or enters the well and whether it flows up or down the well, the sampling location should be adjusted up or down from the fracture zone a distance of up to six inches as determined by the GZA geologist. The sampling depths will be recorded.
   - If the driller determined the well yield at different at depths during drilling, this data can be used to indicate the depths where significant bedrock fractures containing groundwater were encountered.
   - If no information on the bedrock fracture depths is known, as a cost effective sampling approach, the groundwater will be sampled every fifty feet starting 15 feet below the water table to provide screening level data. The sampling depths will be recorded.
   - Note that the QED bladder pump intake should have at least 4 feet of water head to maximize the filling of the individual pump's bladder.
   - In the event that the sampling depth exceeds the capability of the bladder pump to sample, a drop tube assembly with no more than 150 feet of tubing will be used to obtain the groundwater samples (see attached). Sampling without the drop tube assembly is preferred so sampling the well starting at the top and moving down the well will maximize the number of samples taken with just the bladder pump alone. If the drop tube assembly is needed, contact the GZA project manager for instructions.

- Care must be taken during bladder pump installation and sampling to limit the generation of turbulent conditions within the borehole to minimize the disturbance of particulates which would increase the turbidity of the groundwater.
- Attach the groundwater level meter tape/cord (with depth measurements) to the bladder pump and measure the distance from the meter probe to the inlet of the bladder pump so that the depth of the pump inlet will be known for taking groundwater samples.

4. <u>Installation and positioning of the grundfos pump:</u> Install the grundfos pump in the water table in the approximate mid-point of the water column located in the well casing to create a flow of formation water into the well. If using a generator to power the pump, locate the generator downwind at least 100 feet away from the well. Operate the pump at approximately 0.08 gallons per minute. Maintain this pumping during the entire sampling event. Treat the water discharge with a particulate filter and carbon filter, if directed by the GZA project manager. The grundfos pumping is needed to cause movement of water into the well from the bedrock fractures. The flow rate is set low so the pump does not change the movement of groundwater into a fracture if that is its normal flow pattern.

5. <u>Begin Pumping:</u> First turn on the grundfos pump. Once the desired flow rate of the grundfos pump has been achieved (0.08 gallons per minute), activate the gas source, which activates the pneumatic controller associated with the bladder pump to check to see if the controller is operable. Turn on the bladder pump. The bladder pump controller settings will need to be adjusted to achieve a reasonably low flow rate, ranging between 100 and 200 ml per minute. The sampler will need to “fine tune” the operating conditions to achieve the desired flow rate of both the grundfos and bladder pump rates at the different depths.

   The PSI setting of the bladder pump controller should be close to the PSI needed to lift water the depth of the pump intake plus ten to twenty PSI to maximize the discharge volume from the bladder. However, be careful not to set the PSI setting too high resulting in a sample stream that shoots out of the tubing during sampling. The water flow out of the bladder pump during sampling needs to be a laminar flow without air bubbles. If air bubbles are observed they can usually be removed by elevating the discharge tube of the pump to allow the air to continue rising until discharged with the water. In the event that it is difficult to remove the captured air bubbles in the sample tubing, use the “pause-hold-sample” mode to flush the air bubbles out of the sample tubing.

   A bladder pump cycle setting of one cycle per minute should be utilized unless directed differently by the GZA project manager or the GZA QA Officer. Initially set the discharge setting to 20 seconds and the refill setting to 40 seconds unless the settings used in a previous sampling event (for the same number of cycles per minute) for the well are known (and start with those settings if known).

6. Stabilization of water level in the well: Check the water level for the first ten minutes of operation to confirm that the water level in the well is not decreasing. If the water level is observed to be decreasing, slow the pumping rate of the grundfos pump until the groundwater level stabilizes. In the event the groundwater level still does not stabilize and the grundfos pump cannot pump any slower, then decrease the bladder pump rate (but not lower than 100 ml per minute unless the well is a low recharge well). Adjust bladder pump discharge and refill rates (followed by PSI if required) until there is little or no water level drawdown. Keep the refill setting higher than the discharge setting and make sure that the refill setting is greater than 10 seconds. Try to reserve the use of the PSI setting to keep the flow of discharge water laminar. As adjustments are being made, continue to check the water level.

   If the water level keeps decreasing, contact the GZA project manager for instructions.

7. Confirm sufficient volume in one pulse to collect VOC samples: After it has been determined that the water level appears stabilized, if the normal pulse volume from a pump cycle is less than 70 mL, the operator needs to place the controller in the "pause-hold-sample mode" to confirm that a pulse volume of 70 mL or greater can be collected. The "pause-hold-sample mode" will empty the bladder. Note that if the pulse volume is 70 mL or greater, there is no need to perform this check as you will be sampling directly from the pump cycle.

   In the event the "pause-hold-sample mode" volume is less than 70 mL, the operator will attempt to change operating conditions to increase the "pause sample mode" volume. If attempts are unsuccessful, an immediate call to the GZA project manager is required to discuss the issue. (Note: the need to fill the VOAs with one pulse volume of water is a NHDES requirement.)

   In the event it is observed or known that the flow rate for a stabilized groundwater level is below 50 mL per minute, the well will be considered to have insufficient recharge for sampling. Refer to the "Monitoring Wells That Have Insufficient Recharge" section below for instructions as to how to sample the well.

8. Confirm laminar flow and no air bubbles: In the event that flow from the bladder pump appears to be a water/air mixture during sampling operations, pumping should be discontinued without taking a sample. This may signal that turbulent flow is occurring, the water level in the well is at the pump intake level, or the bladder has been damaged. Contact the GZA Project Manager to obtain instructions.

9. Purge Volume and Sample Collection: Prior to sample collection at the desired depth and/or interval, purge one discharge line volume (see below for formula) and the additional volume for the flow-through cell (i.e. 250 ml). Record on field form attached.

   The purge volume of the sampling line is equal to h *3.14(r/12)2 * 7.48 gal/ft3.

One purge volume is equal to (h) * (f) where:
h = length of tubing
f = the volume in gal/foot

Then convert gallons to milliliters (1 gallon = 3785 ml) so that the purge volume can be accurately measured using a graduated cylinder.

Tubing Diameter (inches)	¼ - inch (0.25) OD **(0.17 in ID)***	3/8 - inch (0.375) OD **(0.25 in ID)***	5/8 - inch (0.625) OD **(0.50 in ID)***
Volume (gal/foot)	0.0012	0.0026	0.0102
Volume (ml/foot)	4.5	9.7	38.6

*** Volume calculations based on tubing inside diameter (ID)**

Immediately following the tubing/flow-through-cell purge, begin collecting the sample. In general, the order in which samples should be collected from each well includes:

- Volatile Organic Compounds (see special notes);
- Total Arsenic and other total metals as required;
- 1,4 Dioxane, as required; and
- MNA parameters, as required.

For the collection of samples for VOC analysis, refer to the Special Notes section at the end of this SOP.

10. If water quality parameters are to be collected:

- Following discrete sample collection, connect the discharge line to the water quality meter (QED MP-20) using silicon tubing. The MP-20 will be assembled in accordance with SOP A-1. The water quality parameters will include the following parameters monitored in-line: pH, temperature, specific conductance, ORP, and dissolved oxygen. Turbidity will be monitored separately from those parameters monitored in-line; it will be collected through a 3-way stop cock before the flow through cell.
- When recording pH and dissolved oxygen data, only use one decimal place (round off to nearest tenth place number). When dissolved oxygen data is less than 0.5 mg/L, data should be recorded as "< 0.5" or "less than 0.5". When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers (round off to the nearest whole number). When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". Once the water quality parameters have been collected the pump can be lowered to the next depth, if applicable.

11. Refer to SOP A-8 Chain-of-Custody, Sample Packaging and Shipment Procedures for documentation requirements and SOP A-7 Sampling Equipment Decontamination Procedures for decontamination requirements.

12. Field duplicate samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection and should be in the same priority order as indicated above. Duplicate samples are not intended to be blind duplicate samples. They should be designated with a "DUP" after the well designation (i.e., MOT_MW-100D DUP) as indicated in the SAP.

13. Field matrix spike/matrix spike duplicate (MS/MSD) samples should be collected by filling a separate container immediately following the actual field sample collection and duplicate sample if required at this location. Refer to Table 5 included in the SAP for specific QC sampling requirements and appropriate COC notations required for MS/MSD samples.

14. After collection of the samples, deactivate the gas source and disconnect equipment as needed. Tubing will be discarded and disposed of appropriately. New tubing is to be used for each well.

15. Secure the well.

16. All equipment (water level meter) must be decontaminated following SOP A-7.

17. If equipment blank is required for a bladder pump setup, fill the PVC chamber (4-foot PVC riser with end cap to provide well scenario for pump) with DI water. Lower pump setup including pump and appropriate Teflon tubing into the PVC chamber. Activate bladder pump and purge one tubing volume of water through the setup. Collect an equipment blank sample by filling the appropriate bottles required for samples. Continuously add DI water to the PVC chamber until all the bottles have been filled. Refer to Table 5 included in the SAP for specific QC sampling requirements.

RECORDS AND DOCUMENTATION

Assigned Sample ID for the Chain of Custody (COC)

Because of the labeling restraints in the EMD Database, the depth samples in each borehole will have to be identified by the depth in the comment section only. The sample ID itself (e.g., MOT_MW-100D) will remain the same under the sample ID on the chain of custody. The various depths will be in the comments section only. The laboratory will record the depths on each analysis page.

Field data records must be maintained while performing bedrock borehole groundwater sampling. The GZA Bedrock Borehole Groundwater Sampling Worksheet SOP A-10 is the approved forms for use by staff during sampling. At a minimum, the field log/sampling worksheet should document the following in ink:

- Job name and number;
- Borehole identification;
- Assigned sample ID;
- Name of sample collector(s);
- Date;
- Well depth (to be included in the comments section of the COC);
- Static water level measurement;
- Clock time of all water levels measurements referenced to the casing;
- All in-line water quality readings (i.e., pH, temperature, specific conductance, dissolved oxygen, ORP, and turbidity);
- Brief description of any problems or occurrences; and
- Time of sample completion.

Refer to SOP A-8 Chain-of-Custody, Sample Packaging and Shipment Procedures for documentation requirements and SOP A-7 Sampling Equipment Decontamination Procedures for decontamination requirements.

SPECIAL NOTES

Special Considerations When Using Compressed Gas

When using compressed gas as the compressed air source, be sure to transport tanks upright and properly secured. Always remove regulator when transporting tanks or moving tank to a new sampling location. When using a tank for the first time, connect the regulator valve and shut the regulator valve off, then open the tank valve all the way and then close the tank valve (this seats the valve seal properly). The regulator valve shall use a psi guage that is 150 psi (minimum) to 400 psi (maximum).

Special Considerations for Volatile Organic Compound Sampling

The proper collection of a sample for VOCs requires minimal disturbance of the sample to limit volatilization and therefore a minimal loss of volatiles from the sample. The following VOC procedures should be followed:

- Open the vial, set cap in a protected place, and collect the sample. When collecting duplicates, collect both samples at the same time.
- Do not rinse the vial or excessively overflow it.

- Do not collect the initial 10 mL (approximate) of sample or the last 10 mL (approximate) of sample of the sample pulse volume. The beginning and end of the sample pulse volume has been in contact with air.
- Be sure the sample flow is laminar and there are no air bubbles in the sample flow.
- There should be a convex meniscus on the top of the vial. You can use the cap to create the convex meniscus for VOC samples, if needed.
  - **For methane/ethane/ethene and carbon dioxide, do not use the sample bottle cap to top off the sample vials. Small bubbles are considered normal for these pre-preserved containers.**
- Check that the cap has not been contaminated (splashed) and carefully cap the vial.
- Place the cap directly over the top and screw down firmly. Do not over-tighten and break the cap.
- Invert the vial and tap gently. If an air bubble appears, uncap and attempt to add a small volume of sample to achieve the convex meniscus without excessively overfilling the vial. If there this has to be repeated more than twice, discard the sample and begin again with a new container and preservative. It is imperative that no entrapped air is in the sample vial.
- Immediately place the vial in the protective foam sleeve (if available) and place into the cooler.

ATTACHMENTS

Equipment Setup Diagrams (4)
Drop Tube Assembly
Worksheet

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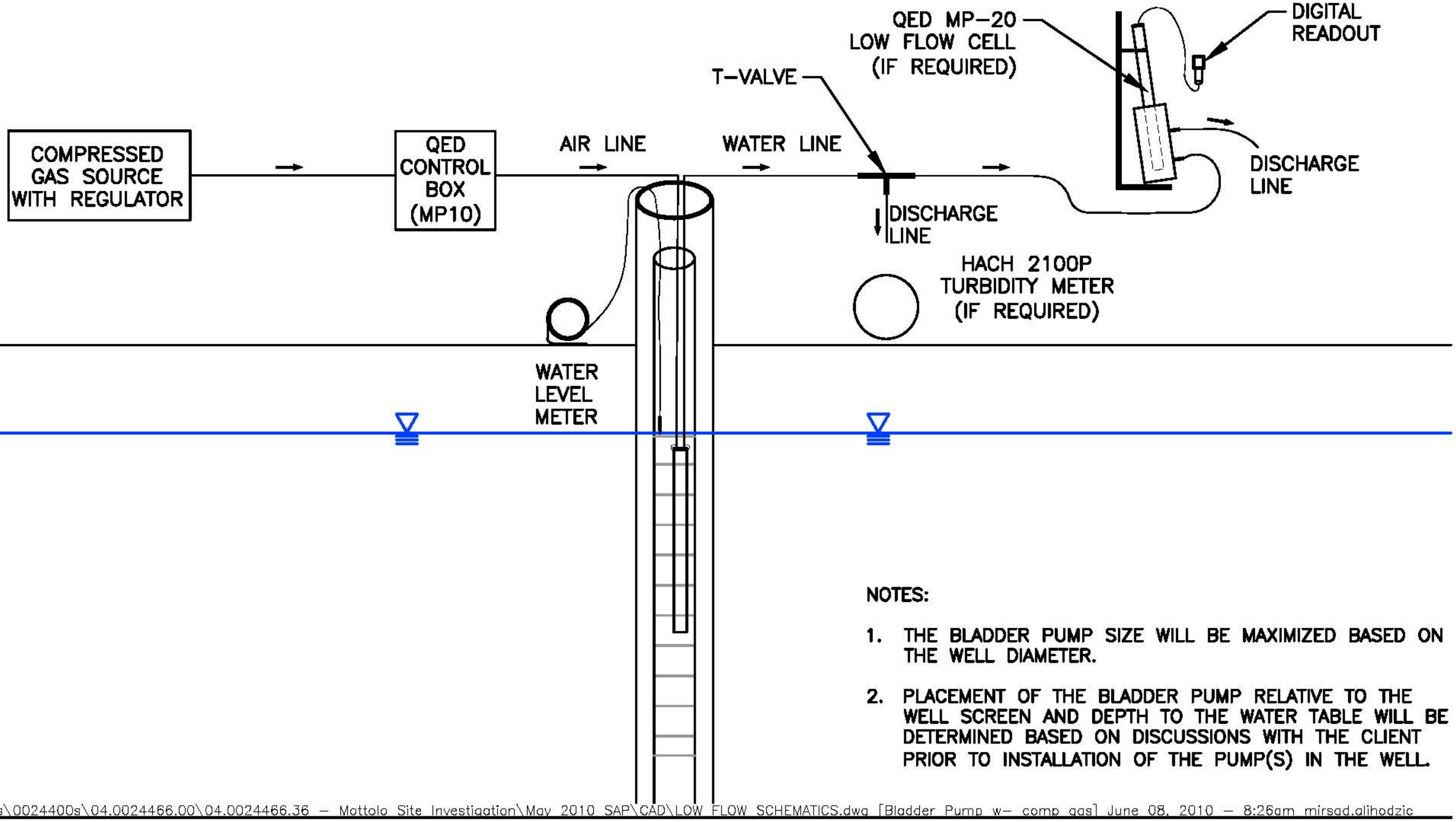
SCHEMATIC OF THE LOW FLOW SET UP USING A BLADDER PUMP WITH COMPRESSED GAS SOURCE

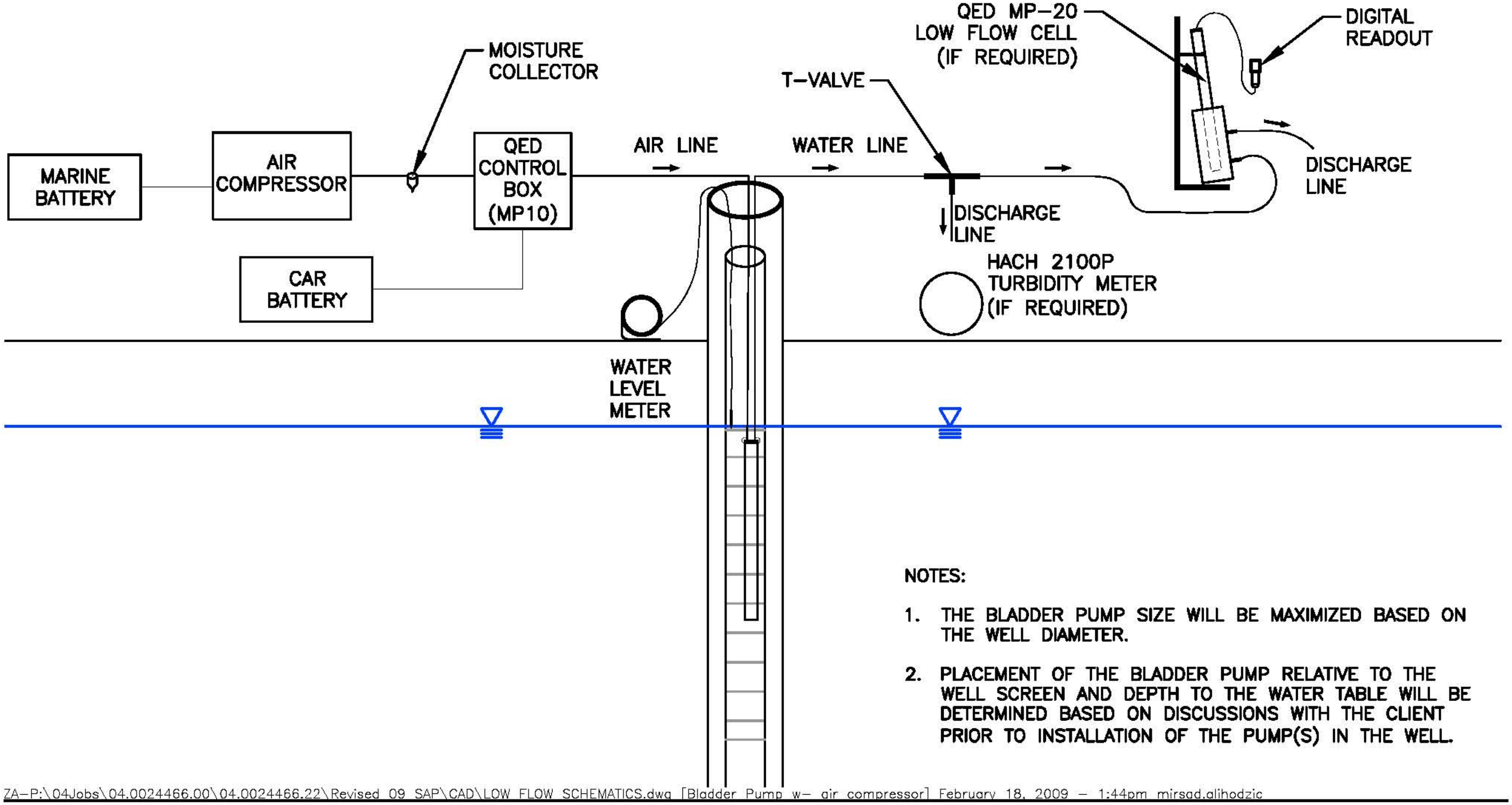


NOTES:

1. THE BLADDER PUMP SIZE WILL BE MAXIMIZED BASED ON THE WELL DIAMETER.
2. PLACEMENT OF THE BLADDER PUMP RELATIVE TO THE WELL SCREEN AND DEPTH TO THE WATER TABLE WILL BE DETERMINED BASED ON DISCUSSIONS WITH THE CLIENT PRIOR TO INSTALLATION OF THE PUMP(S) IN THE WELL.

ZA-P:\04Jobs\0024400s\04.0024466.00\04.0024466.36 – Mottolo Site Investigation\May 2010 SAP\CAD\LOW FLOW SCHEMATICS.dwg [Bladder Pump w- comp gas] June 08, 2010 – 8:26am mirsad.alihodzic

SCHEMATIC OF THE LOW FLOW SET UP USING A BLADDER PUMP WITH COMPRESSOR



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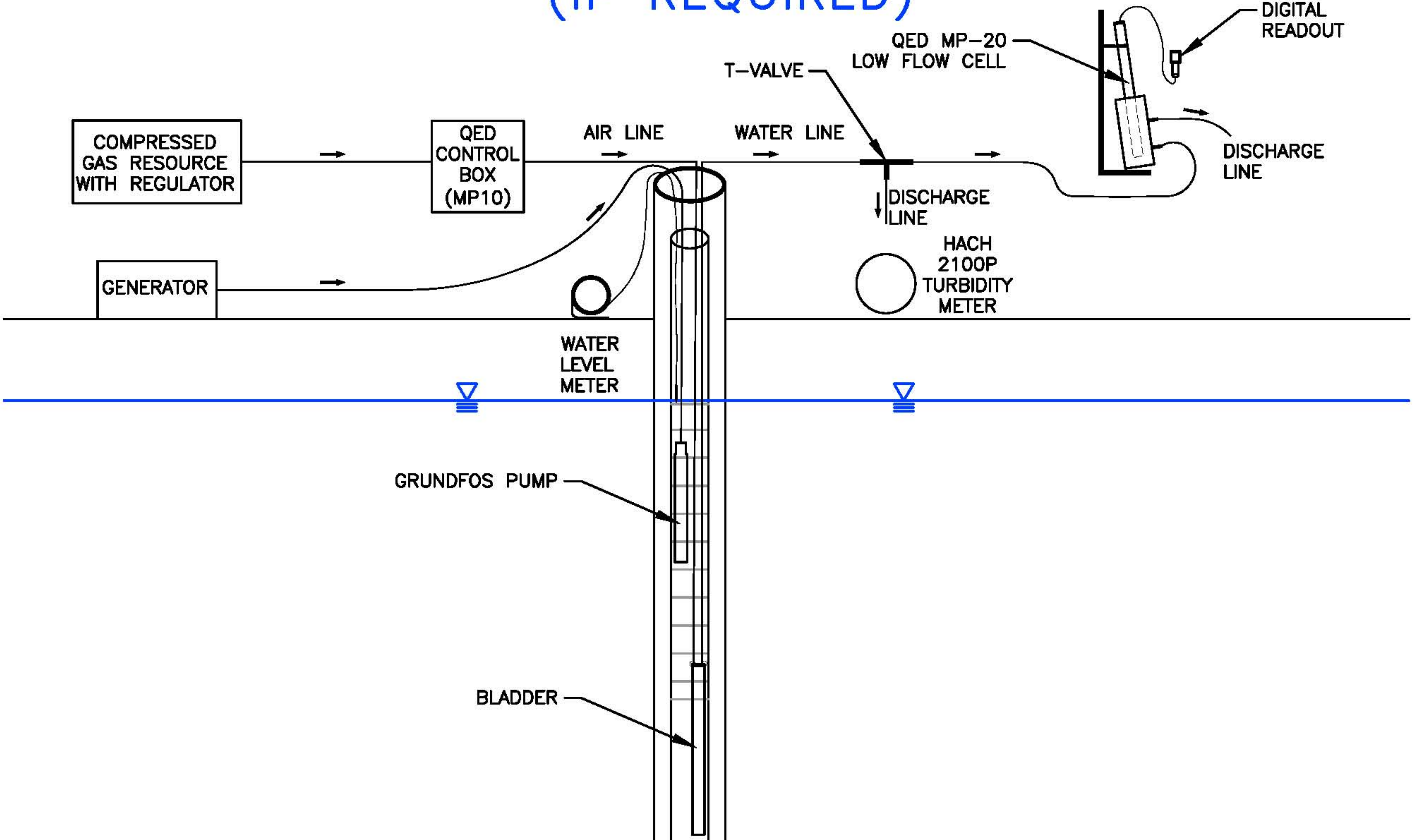
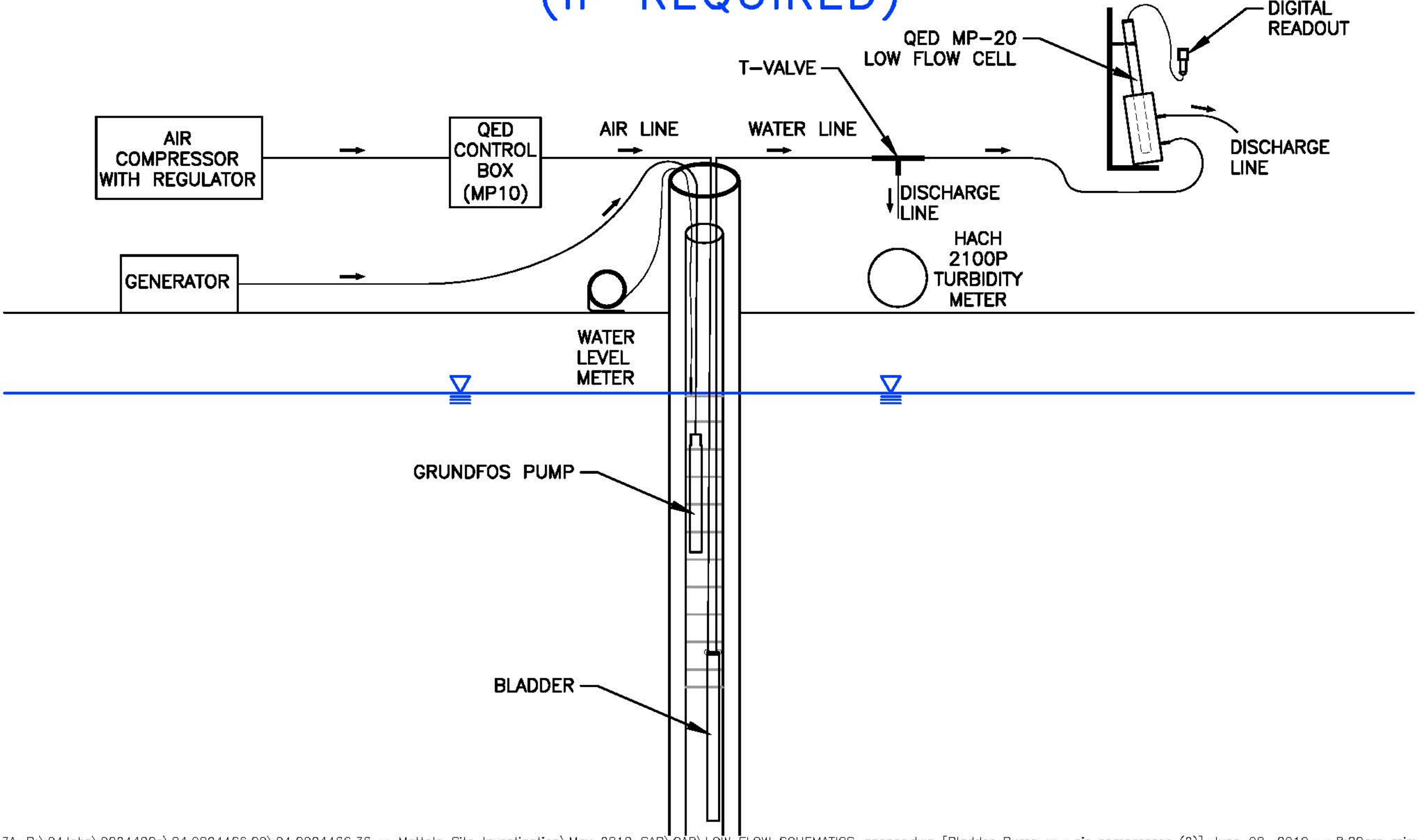
SCHEMATIC OF THE SET UP USING A BLADDER PUMP WITH COMPRESSED GAS SOURCE FOR BULK DEPTH SAMPLING (IF REQUIRED)



SCHEMATIC OF THE SET UP USING A BLADDER PUMP WITH AIR COMPRESSOR SOURCE FOR BULK DEPTH SAMPLING (IF REQUIRED)



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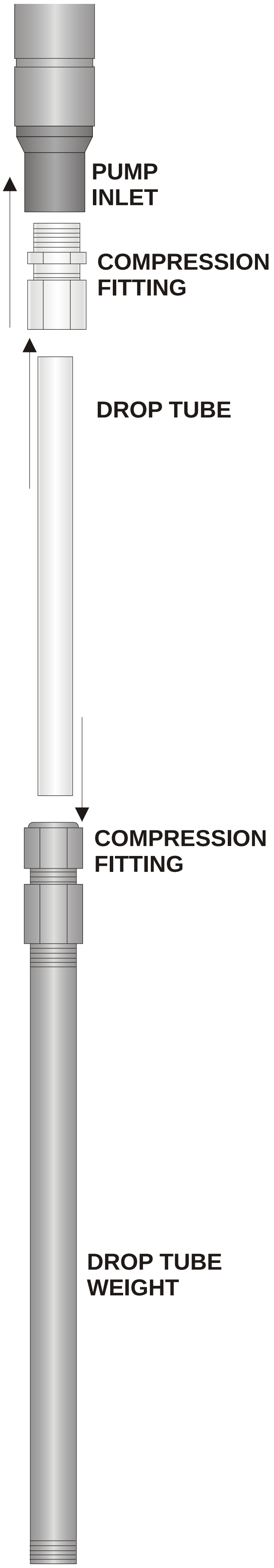
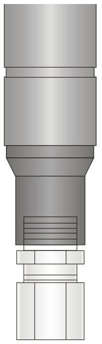
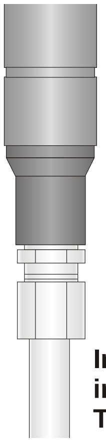
Inlet Drop Tube Assembly





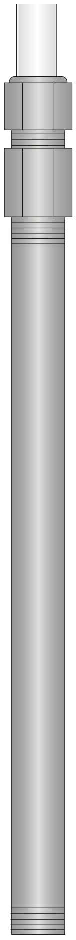
1

Thread compression fitting into pump inlet until tight.



2

Insert drop tube fully into compression fitting. Tighten fitting.

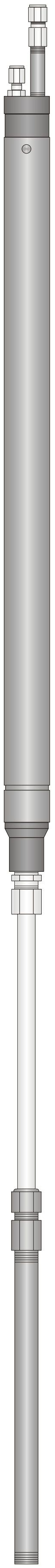


3

Insert drop tube fully into compression fitting on top of drop tube weight. Tighten fitting.

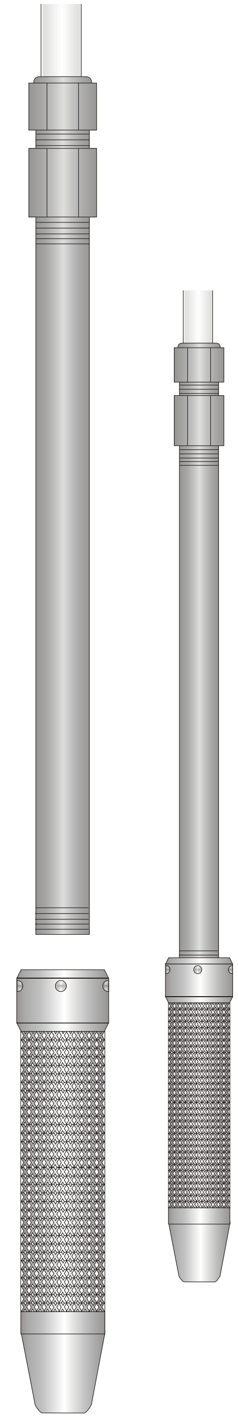
4

Add additional drop tube weights as required if drop tubing lengths exceed 100'



5 **OPTIONAL INLET SCREEN**

Screw inlet screen securely onto the end of the drop tube weight



GZA GeoEnvironmental, Inc.

FIELD WATER QUALITY MEASUREMENT FORM

Depth / Bulk Sampling

Page _____of_____

Site: Mottolo Superfund Site

Date : ______________________
Weather Conditions : ______________________
Field Personnel: ______________________
Purging Device & Serial # (pump type): ______________________
Reference Measuring Point (Top of PVC/Top of Casing): ______________________
Screen Interval (ft, ref. to measuring point): ______________________

Well ID	**Sample Time (24 HR)**	**Depth Interval (ft)**	**Volume Purged (mL)**	**Temp +/- 3% (ºC)**	**Spec. Cond.[1] +/- 3% (µS/cm)**	**pH +/- 0.1 units**	**ORP +/-10 (mV)**	**DO +/- 10% if > 0.5 (mg/L)**	**Turbidity +/- 10% if > 5 (NTU)**	**Comments/Adjustments**

Notes:

1. µSiemens per cm (same as µmhos/cm) at 25 ºC
2. Oxidation reduction potential.
3. All depths in feet below the referenced measuring point, unless specified.
4. When recording pH and dissolved oxygen data, only use one decimal place. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers. When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". When DO data is less than 0.5 mg/L, data should be recorded as "<0.5" or "less than 0.5".
5. "NR" indicates no reading taken.

____
Sampler's Signature

A-11

Water Level Measurements – Select Bedrock Boreholes/Monitoring Wells & Residential Water Supply Wells

WATER LEVEL MEASUREMENTS – SELECT BEDROCK BOREHOLES/MONITORING WELLS & RESIDENTIAL WATER SUPPLY WELLS

PURPOSE

This Standard Operating Procedure (SOP) *Water Level Measurements – Select Bedrock boreholes/Monitoring Wells & Residential Water Supply Wells* is to set guidelines for the manual determination of the depth to water in residential bedrock drinking water wells.

In general, water-level measurements taken in bedrock boreholes, piezometers, or monitoring wells are used to construct water table or potentiometric surface maps and to determine flow direction as well as other aquifer characteristics. Therefore, all water level measurements at a given site should preferably be collected within a 24-hour period.

Taking water level measurements in residential water wells has the inherent issue of water level drawdown by residential water usage and affecting the water level measurement in the residential well. To minimize the water level draw down issue, it is proposed when obtaining site access to question the resident on when the well is not used and to attempt to measure the water level during a period of well inactivity.

In addition, because bacteria may be introduced when inserting foreign objects into existing water supply wells, the New Hampshire Department of Environmental Services (NHDES) recommends evaluating and documenting water quality (ecoli/total coliform) before and after use of a water level meter to ensure that monitoring activities have not adversely impacted water quality. Attached is NHDES' fact sheet (WD-DWGB-22-24 2008 - Sanitary Practices for Monitoring Water Levels in Drinking Water Supply Wells) that provides guidance regarding sanitary practices.

EQUIPMENT AND MATERIALS

- Site-specific plan and boring logs;
- Field book;
- Water level field sheet (see below);
- Electronic water level meter (measures in increments of 0.01 feet);
- Well keys and other applicable field equipment to open water supply wells;
- Appropriate preserved sample containers, coolers, loose ice;
- Indelible black-ink pen (Sharpie);
- Decontamination equipment and supplies including chlorine bleach; and
- Personal protective clothing and gear

METHOD SUMMARY

If water level measurements are being completed for the first time following well installation, a survey mark/physical notch should be placed on the top of the riser or casing as a reference point for future groundwater level measurements. If the top of the riser or casing is not flat, make the reference point the highest point. The measurement reference point should be documented in the site logbook.

All field personnel must be made aware of the measurement reference point (top of casing [TOC] or top of PVC pipe [TOPVC]) being used in order to ensure the collection of comparable data.

Before measurements are made, water levels in piezometers and monitoring wells should be allowed to stabilize for a minimum of 24 hours after well construction and development. In low yield situations, recovery of water levels to equilibrium may take longer. All measurements should be made to an accuracy of 0.01 feet. Water level measuring equipment must be decontaminated and, in general, measurements should proceed from the least to the most contaminated wells.

PRE-MEASUREMENT PROCEDURES

Prior to collection of water level measurements, a water sample must be collected from a tap that receives water from the drinking water well before unsealing the well. The collection procedure for residential water supply well samples shall be in accordance with SOP A-6. Analyses for these samples will include e.coli and total coliform. Refer to **Tables 3** and **5** for bottle requirements and quality assurance sampling requirements.

All equipment shall be decontaminated prior to use in accordance with SOP A-7. Following routine decontamination, all downhole equipment shall be sanitized with chlorine bleach (sodium hypochlorite). Chlorine bleach shall be applied using a low pressure sprayer. After spraying and disinfecting with bleach, thoroughly rinse all monitoring equipment with clean distilled water. All sanitized monitoring equipment should be bagged (if possible) and kept in a dry, sanitized storage area, and not allowed to come into direct contact with the ground surface or any other un-sanitized object before placing the equipment in the well.

WATER LEVEL MEASUREMENT PROCEDURES

Care should be taken to minimize water column disturbance. Use the following procedures to collect water level measurements:

1. Open the well and monitor the headspace with the appropriate air monitoring instrument to determine the presence of volatile organic compounds (if applicable).

2. Lower the electronic water level meter probe and measuring tape into the well until the water surface is reached as indicated by a tone or meter deflection. Record the distance from the reference point to water surface.

3. Record the distance from the water surface (to 0.01 feet), as determined by the audio signal or tone, to the reference measuring point (i.e., top of PVC riser or casing) and record on the field measurement form (see Water Level Measurement Form attached). In addition, note the reference point used (top of PVC riser or casing).

4. In field book/field sheet, note any physical changes to well condition, such as erosion or cracks in protective concrete pad, road box, standpipe, etc.

5. Remove all downhole equipment used for the water level measurement, and replace well cap and locking steel caps.

6. Decontaminate all the equipment entering the well(s) in accordance with GZA's SOP A-7 and sanitize with chlorine bleach as described above.

POST-MEASUREMENT PROCEDURES

Approximately 24 to 48 hours after collection of water level measurements, a sample shall be collected from the same tap where the pre-measurement sample was taken that receives raw water from the drinking water well. The collection procedure for residential water supply well samples shall be in accordance with SOP A-6. Analyses for these samples will include ecoli and total coliform. Refer to **Tables 3** and **5** for bottle requirements and quality assurance sampling requirements.

If data results indicate that bacteria were introduced into the well during monitoring activity, disinfect the well after obtaining the permission and cooperation of the well owner. Prior to disinfecting the well, the well owner should be informed in writing that they should not drink the water after disinfection until the well has completely flushed. Procedures for well disinfection are outlined on the attached DES fact sheet WD-WSEB-4-11.

RECORDS AND DOCUMENTATION

All water level information should be recorded on the attached example Groundwater Level Measurement Form

SPECIAL NOTES

None.

APPLICABLE REFERENCES AND STANDARDS

United States Environmental Protection Agency – Environmental Response Team Standard Operating Procedures "Water Level Measurement" SOP #2043 Revision 0.1, February 11, 2000. USEPA Contract 68-C4-0022

ATTACHMENTS

Water Level Measurement Form

NHDES Fact Sheet WD-DWGB-22-24, Sanitary Practices for Monitoring Water Levels in Drinking Water Supply Wells

NHDES Fact Sheet WD-WSEB-4-11, Disinfecting a Private Well

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Water Level Measurement Form
Mottolo Superfund Site
Raymond, New Hampshire

Date:____________

Field Engineer:____________

Well Designation	**Well Depth**	**Well Type** (2-in, 1.5-in etc)	**Measuring Point**	**Measured Depth To Water** (ft, referenced to measuring point)	**Measuring Device (Sonic or Standard)**

ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

29 Hazen Drive, Concord, New Hampshire 03301 • (603) 271-3503 • www.des.nh.gov

WD-WSEB-4-11 2005

Disinfecting a Private Well

The following provides a detailed, step-by-step outline for emergency disinfection of a private drinking water well. It is possible to have good disinfection even though certain steps are deleted. It is also possible that some water supplies may be prone to bacterial contamination and thus require permanent disinfection.

ACTIONS PRIOR TO DISINFECTION

Well Inspection. Carefully inspect the well to identify potential pathway(s) that allowed bacteria to enter the well. See the DES fact sheets concerning Dug Well Design at www.des.state.nh.us/factsheets/ws/ws1-4.htm or Bedrock Well Design at www.des.state.nh.us/factsheets/ws/ws1-2.htm, which identify good well construction. If there are structural deficiencies in the well that are not addressed, the bacteria **contamination will reoccur**. The vast majority of bacterial occurrences in wells can be linked to easily corrected construction flaws rather than disaster conditions.

Flushing the System. The second step prior to disinfecting is to flush the well and the home's plumbing the system. Chlorine is not able to kill bacteria entrapped within mud, rust or other solids. In order to achieve total bacterial kill, all components of the system must be flushed to a clean condition. Flush this debris through outside hose taps so as to not overload your septic tank or leach field. Also bypass any treatment devices until discussing disinfection with the treatment device installer or manufacturer.

Cleaning/Flushing Dug Wells. Slide open the cover, look for poor construction and repair as necessary, scrub the walls with a long handled brush and wash down using a garden hose. If a "mud sucker construction pump" is available, pump the dirty water out of the well. If only the regular installed pumping system is available, pump the dirty water out of the well using outside sill faucets of the home. During this flushing process, do not use water in the home in order to minimize the amount of dirty water entering the rest of the plumbing system. Flush the well to a clean condition until all discolored water has ceased. Be careful no to overheat the pump.

Cleaning/Flushing Bedrock Wells. It is not possible to physically clean the side walls of a bedrock well. However, the cascading water caused by the "drawdown" in the well will significantly flush the inside of the well. Flush the well by pumping to waste until all discoloration has ended. If the pumped water becomes mixed with air, turn off the pump so as to not to cause overheating and pump damage. Pumping can continue later.

Flushing Pressure Tanks. Settling of dirt may occur in the pressure tank and/or hot water tank of the plumbing system. To clean the pressure tank, first run the well until the water coming out of faucets is crystal clear over a sustained period. Then using the manual off/on switch and automatic pressure switch, create flow in and out of the pressure tank to loosen any sediments that has settled to the bottom of that tank. For cleaning the hot water tanks connect a garden hose to the faucet at the bottom of the tank and flush to waste until clean.

Flushing Plumbing. The plumbing system can be cleaned by creating high flow velocity in the plumbing. This can be accomplished by targeting each leg of the plumbing system separately. Best results are achieved by opening multiple faucets to create the highest flow rates possible. The velocity of flow (i.e., high flow), rather than the flow duration, is the most critical factor in flushing the plumbing. Flush this cleaning water onto the ground, not into your septic system, where possible. Remove faucet aerators before flushing.

WHAT CHEMICALS TO USE TO DISINFECT

Chlorine is the standard chemical used to disinfect all components of a water system except treatment devices. For disinfecting treatment devices call your water conditioning installer or manufacturer. Chlorine comes in two common forms: 5.25-6 percent sodium hypochlorite, a liquid; and 70+ percent HTH calcium hypochlorite, a solid. The liquid form is ordinary household chlorine bleach., however, read the small print on the label to ensure that it is only sodium hypochlorite. The solid HTH can be purchased from swimming pool supply dealers in either tablets or powder form. Do not use modern bleaches made for synthetic fabrics or those with fragrances added for disinfecting a well.

ESTIMITING THE VOLUME OF WATER NEEDING DISINFECTION

To determine the amount of chlorine to use, it is necessary to first estimate the total volume of water to be disinfected. This would include the water in the well, that in surrounding soils, and that in the home's plumbing system. The volume of water in a cylindrical shape can be determined by using the formula below:

Volume (in Gallons) = $n \times R^2 \times H \times 7.48$
Where: $n = 3.14$
R = radius (in feet) of the well.
H = water depth (in feet) from water surface to bottom of the well.

Shown below are volumes for various size cylinders. Bedrock wells are typically 6" in diameter and dug wells are typically 3 feet in diameter.

VOLUME IN WELLS
(Approximate capacity of a well in U.S. Gallons)

Diameter	6"	1'	2'	3'	4'	
Water Depth						
2.5'*	4	15	60	130	230	gallons
5'*	8	30	120	260	460	
10'	15	60	240	520	930	

20'	30	120	470	1060	1880
100'	140	590	2350	-	-
500'	710	2950	-	-	-

* = to achieve minimal filtration of rainfall, the soil backfill around a well should be at least 5 feet above the seasonal high water table.

Water also exists outside of the well hole in the soil and crushed stone or rock fractures surrounding the well. Depending on well type and depth, this amount of water can be large. We suggest doubling or tripling the volume of water determined inside the well casing when considering the amount of well water needing disinfection. Your estimate of the amount of extra water outside the well's "footprint" is a judgment call.

CONCENTRATION OF CHLORINE TO USE

Liquid Chlorine. The chlorine concentration used to disinfect a well can be varied based on the bacterial contamination level expected. If the well is believed to be reasonably clean (no inundation by muddy surface water, no dead animals), then 5-10 parts per million (ppm) is a good disinfecting concentration. If stronger contamination is expected, then a 50 ppm concentration, or higher, should be used. Shown below are amounts of chlorine to achieve the desired concentration of chlorine in water. Chlorine can be hazardous; wear suitable clothing and eye protection.

Desired Chlorine and Water Concentration	5.25-6% Chlorine Store Bleach	Water Volume
1 ppm*	1 gallon of 5.25%	50,000 gallons
5 ppm	1 gallon of 5.25%	10,000 gallons
10 ppm	1 gallon of 5.25%	5,000 gallons
50 ppm	1 gallon of 5.25%	1,000 gallons

*parts per million also equal to milligrams per liter

Example: Assume we have a well 800 feet deep, 6 inches in diameter and static water at 50 feet. Your calculations of the amount of water needing to be disinfected is given below:

Water inside well whole = 1,100 gallons
Water in rock/soils immediately surrounding well hole = 2,200 "
(assume twice as much volume)
Water in home plumbing and pressure tank = 50
———
Total = 3,350 gallons

Now choose the concentration of chlorine to be used, based on assumed contamination level. Since the well has been flushed to a high state of cleanliness, use 10 ppm of hypochlorine for the disinfection solution. Refer to the chart above and select the line, for the desired concentration of 10 ppm, i.e., second line for 10 percent.

Since we only have approximately 3,400 gallons of water to disinfect at a desired concentration of 10 ppm, we will not need a full gallon of bleach. Given 3,400 gallons of water to disinfect, the amount of bleach is given by the ratios of water volumes 3,400/5,000. This would be approximately 3 quarts of bleach solution.

Solid Chlorine

Equivalent Volume of Hypochlorite to Weight of HTH	
Required 5.25-6 % Hypochlorite	**Equivalent 70% HTH**
1 quart	2.2 oz by weight
1 gallon	8.9 oz

In bedrock wells remember there are other homes down hill of your property also using the same rock fractures. Please start with a low concentration chlorine, going to higher amounts if your first disinfection is not successful. Please respect your neighbors.

DISINFECTING WELLS

Pour in the proper volume of chlorine into the well. Mix by running a hose stream from a sill faucet into the well. Circulate the chlorine water solution through the pressure tank, and home plumbing system. Confirm chlorinated water has reached all taps by odor at user taps or by test kit determination. Chlorine test kits may be owned by those neighbors that have backyard swimming pools.

Let chlorinated water remain in the pipes and well overnight. Some water usage can occur but avoid high volume demands that would dilute the chlorine strength. *Do not drink water with high chlorine levels.*

Existing Dug Wells. Remove the cover. Pour in the proper volume of chlorine. Mix using flow from a garden hose and await odor from faucets.

Existing Bedrock Wells. Remove or open well cap. Some well caps have a 1-inch removal plug at the top of the cap. This plug can be removed to gain access to the interior of the well. Otherwise remove the entire cap. With bedrock wells there may be difficulty in dispersing the chlorine throughout the entire well depth. When liquid chlorine is used, add water to the top of the well to force the liquid chlorine deeper into the drill hole. Typically a garden hose would be used for mixing the chlorine. The water would be added to the top of well until the chlorine odor is noted in the running water. This method is often used for a shallower bedrock well, less than 100 feet.

Solid chlorine tablets can also be used. The advantage of chlorine tablets is that they sink to the bottom of the well, fully dispersing the chlorine through the overall well depth. The tablets should be reduced in size by placing in a heavy bag and breaking with a hammer. Pour the dry chlorine pieces into the well. Wash chlorine particles off wires and other well parts of the well interior. Liquid chlorine can also be used in a deeper well.

Let the chlorine set over night, and then proceed as indicated for shallow wells.

HOW TO TIME THE ADDITION OF CHLORINE

As a typical rule of thumb, the chlorine should be in contact with the water system components overnight. The more contact time, the more assured the bacterial kill. Chlorine is normally added to a water system in the early evening. This allows the chlorine ample contact time with the well before being flushed out the next morning. Early the next morning, the excess chlorine should be flushed to waste. DES suggests flushing to waste until the free chlorine level is less than 1.0 mg/l free chlorine. The remaining chlorine will dissipate with time and usage.

Flushing out Chlorine

The next morning flush the heavy chlorine to waste into the woods or on top of the soil. Do not run the chlorine solution into a stream as it will kill fish, frogs, etc. Do not run chlorinated water into leach fields or onto grass. Continue until chlorine has dissipated or is of a very low concentration. Remember no bacterial testing can begin until all chlorine is gone. Chlorine will dissipate on its own with time. Flushing chlorine to waste hastens the process.

WATER QUALITY TESTING

Once all chlorine is purged from the well, a bacterial test can be taken. **Any** chlorine remaining in the well or in the sample bottle will negate the lab test thus requiring collection of another sample. Thus *all chlorine must be purged from the well before a bacterial test can be taken.*

If the bacterial test shows the absence of total coliform bacteria the well should be useable for drinking water. However if there is not a good bacteria sample record for this well it is desirable to take a few more bacterial samples to document the consistency and dependability of the acceptable bacterial condition.

If total coliform is present or occurs irregularly, it may mean that the disinfection needs to be done over or it may mean that new bacteria have entered the well from an unrecognized defect that caused the previous bacterial contamination.

Permanent Disinfection

If bacterial presence continues, a permanent disinfection system should be installed. Such system could be a chlorine feed by a chemical feed pump or an ultraviolet (UV) system as discussed in fact sheet www.des.state.nh.us/factsheet/ws/ws-4-5.htm. Such a system should be preceded by a fine mesh particle filter to insure the disinfectant is not overwhelmed by irregular contaminant levels. If there has been no meaningful bacterial testing on this source in recent years, it may be possible that the well did not have reliable bacterial even before the emergency condition.

FOR MORE INFORMATION

For more information, please call DES at (603) 271-3503. For a complete list of fact sheets please request fact sheet WD-WSEB-15-2. We would appreciate your comments and suggestions pertaining this fact sheet. Drinking water fact sheets are available through the DES web site at: http://www.des.nh.gov/wseb then select fact sheets. Please check with the DES internet site annually for changes to this document. 10/05

ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE
DEPARTMENT OF
Environmental
Services

29 Hazen Drive, Concord, New Hampshire 03301 • (603) 271-3503 • www.des.nh.gov

WD-DWGB-22-24 2008

Sanitary Practices for Monitoring Water Levels in Drinking Water Supply Wells

Withdrawal testing programs associated with community well siting and large groundwater withdrawal permit applications may include monitoring water levels in existing wells that provide drinking water to community water systems or private residences. The New Hampshire Department of Environmental Services provides the following guidelines to ensure that monitoring activities do not adversely impact water quality.

Bacteria may be introduced when inserting foreign objects, including monitoring equipment, into a water well. DES recommends completing the following activities to document existing water quality, and to ensure that monitoring activities have not adversely impacted water quality.

1. Collect a water sample from a tap that receives water from the drinking water well before unsealing the well. The sample should be collected, preserved, and transported per laboratory instructions. DES recommends testing for total coliform and e-coli bacteria. DES also recommends that an analysis be conducted for non-coliform bacteria. The non-coliform test may show a small number of non-coliform organisms in the well. However, when the concentration of non-coliform organisms is high, their presence can hamper the growth of organisms in the coliform family and the non-coliform analysis invalidates the total coliform test.

   If the non-coliform bacteria concentration in the well is high, the water could be insufficiently filtered. Reasons for a lack of adequate filtration include:

   - The well is not properly constructed.
   - The soil/rock is not properly filtering rain water that is percolating down from above.

   A laboratory accredited by the State of New Hampshire should analyze all samples. A list of accredited laboratories can be found at www.des.nh.gov/asp/NHELAP/labsview.asp.

   The applicant may also want to consider conducting other water quality testing in addition to bacteria, depending upon site-specific needs and the level of water quality documentation required to limit liability. Provide the well owner with the results of the laboratory testing, the analysis documentation provided by the laboratory, and a fact sheet or other literature that explains how to interpret the results of the water quality testing. Many laboratories provide this literature with the testing results.

2. Sanitize all monitoring equipment with chlorine. Chlorine comes in two common forms. A liquid, 5.25 percent sodium hypochlorite, better known as household bleach, can be purchased in any supermarket. Read the label to ensure purchase of only sodium hypochlorite. A solid, 70± percent HTH calcium hypochlorite, can be purchased from swimming pool supply dealers in either tablet or powder form. Thoroughly rinse all monitoring equipment (for example, probes, cables, etc.) with clean water after disinfecting with chlorine. All sanitized monitoring equipment should be kept in a dry, sanitized storage area, and not allowed to come into direct contact with the ground surface or any other unsanitized object before placing the equipment in the well.

3. Immediately after resealing the well, repeat the bacteria testing to ensure water quality was not degraded as a result of monitoring activity. Repeat the bacteria testing two to three weeks later to further ensure that bacteria were not introduced into the water system during withdrawal testing.

4. If bacteria were introduced into the well during monitoring activity, disinfect the well after obtaining the permission and cooperation of the well owner. Prior to disinfecting the well, the well owner should be informed in writing that they should not drink or bathe in the water after disinfection until the well has completely flushed. Procedures for well disinfection are outlined in DES fact sheet WD-WSEB-4-11, which may be downloaded at www.des.nh.gov/factsheets/ws/ws-4-11.htm.

The sanitary practices outlined above should be considered as guidance only. The applicant should determine the most effective way to protect the water quality of private wells, as well as its own liability. For example, the applicant or well owner may want to consider testing for additional parameters or collecting samples more frequently, such as during the pumping period of the withdrawal testing program. Furthermore, the applicant must obtain permission from any well owner prior to disclosing the results of their water quality analysis to any other third party.

Please note that this guidance only pertains to placing temporary water level monitoring equipment in a well. Should water level monitoring activities require removing or modifying any permanent well equipment or materials, these activities would have to be conducted in accordance with We 100-1000 Water Well Board Rules, which are available at www.des.nh.gov/rules/desadmin_list.htm#boards.

For more information about the sanitary practices outlined above, please contact Christine Bowman at (603) 271-8866 or Christine.Bowman@des.nh.gov, or Diana Morgan at (603) 271-2947 or Diana.Morgan@des.nh.gov.

For Additional Information

Please contact the Drinking Water and Groundwater Bureau at (603) 271-2513 or dwgbinfo@des.state.nh.us or visit our website at www.des.nh.gov/dwgb/. Copies of fact sheets, rules and other DES publications are available from the DES Public Information Center, (603) 271-2975.

Note: This fact sheet is accurate as of August 2008. Statutory or regulatory changes, or the availability of additional information after this date may render this information inaccurate or incomplete.

A-12

Multi-Level Sampling System Installation
(to be provided once the multi-level sampling system is selected)

A-13

Reserved

A-14

Well Installation: Overburden Wells

WELL INSTALLATIONS: OVERBURDEN WELLS

PURPOSE

Provide procedures for installation of overburden (unconsolidated formation) wells intended to provide access to groundwater for the collection of water quality samples, measurement of depth to groundwater, and perform hydraulic aquifer testing. The activities described in this Standard Operating Procedure (SOP) are typically performed by a test boring drilling contractor, and observed and documented by GZA. Each monitoring well shall be constructed, maintained, and decommissioned only by a New Hampshire-licensed water well contractor holding a valid technical drillers license under RSA 482-B.

Note: Field staff need to check with the principal-in-charge (PIC) and/or the project manager (PM) before conducting field work to confirm the actual field procedure to be followed and to discuss and document any deviations to GZA's SOP.

EQUIPMENT AND MATERIALS

The following equipment shall be provided by the driller:

- Schedule 40 solid polyvinyl chloride (PVC) pipe (riser), two-inch- (2") diameter, flush-joint threaded. Small diameter PVC pipe may be used to allow for installation of multiple well screens (i.e., multi-level wells). However, use of smaller diameter PVC pipe will limit groundwater sampling methodologies which can be uses and hydraulic testing methods. Potential limitations on future well use must be considered when selecting PVC pipe diameter;
- Schedule 40 slotted PVC (wellscreen), two-inch- (2") diameter, typically having one-hundredth-of-an-inch (0.01") slots (a.k.a. 10 slot), flush-joint threaded. Please refer to comment above regarding use of smaller PVC pipe diameters. Additional slot sizes are available and should be selected by the project manager based on the formation grain size distribution prior to installation of the monitoring well;
- Threaded bottom end cap;
- Bentonite clay (pellets or chips);
- Clean silica sand (Sand pack mesh size 20 – 40 for 0.01" wellscreen slot size [10 slot]);
- Portland cement;
- Concrete mix;
- Steel pipe (protective standpipe), four-inch- (4") or larger diameter, five-foot (5') length, threaded one end, with cap and locking device, or protective roadway box; and
- Locking well plug and lock.

Equipment and materials to be provided by the GZA field engineer/geologist may include, but are not limited to the following:

- Personal protective equipment;
- Field notebook and clipboard, boring log forms, any special test documentation forms;
- 6-foot engineer's ruler and measuring tape (minimum 100 feet);
- Water level meter;
- Volatile organic compound (VOC) meter (photoionization detector and/or flame ionization detector);
- Sample containers; and
- Decontamination equipment and supplies.

PROCEDURES

1. Install filter sand below the selected base of the wellscreen approximately one foot (1') thick by pouring sand down the borehole while withdrawing the casing one foot (1'). Measure and record the depth of the sand cushion.

2. Assemble and install the observation well riser, screen, and bottom end cap. Well tip must be fitted with a threaded or slip-on plug (bottom end cap). All pipe sections shall be connected by dry threading of the joints. <u>No glue, solvents, or lubricating compounds shall be used to make up the connections.</u> The well pipe assembly must be carefully lowered into the borehole to ensure centering of the well in the hole. After installation, the GZA field engineer/geologist and the drilling contractor will carefully measure the depth to the well tip and record the measurement on the well log.

3. Install a sand filter around the wellscreen to approximately two feet (2') above the screen. Grain size of the sand shall be appropriate for the slot size of the screen (normally one hundredth [0.01"] of an inch). The sand should be installed and casing simultaneously removed slowly taking care to avoid bridging of filter sand within the casing or withdrawing too much casing and allowing formation material to surround the wellscreen. The depth to the top of filter sand should be confirmed and recorded.

4. A bentonite clay seal approximately two feet (2') thick or greater should be installed above the sand filter. The bentonite pellets or chips should be installed in the same manner as the filter sand. The depth to the top of bentonite seal should be confirmed and recorded.

5. If required based on well design, the remainder of the borehole may be filled with a grout to within approximately 2 feet of the ground surface. This is accomplished by inserting a tremie pipe (typically 1-in inner diameter black water line tubing) to just above the top of the bentonite seal and pumping in grout until it flows at the surface. (Grout should consist of cement-bentonite, high solids bentonite, or expansive cement mixtures to be

selected by the drilling inspector.) The remainder of the casing will be removed during installation of the grout mixture. The level of the grout in the borehole should be confirmed and recorded following removal of the casing.

6. Cut the well pipe approximately two feet (2') above grade.

7. Install a five-foot (5') section of steel pipe (protective standpipe) (four-inch ([4"] diameter or larger) equipped with a threaded, lockable cap, three feet (3') into the borehole. Complete the installation by constructing a concrete surface pad around the steel guard pipe. The concrete pad shall be a minimum of one-half-foot (1/2') thick and one and one-half feet (1-1/2') in diameter, sloped away from the protective casing.

8. If well head completions must be flush with the ground surface, a roadway box may be installed in lieu of the metal pipe. Installation consists of square-cutting the riser pipe two inches (2") below grade and cement grouting the box in place in a manner similar to the protective standpipe. If a roadway box is installed in a paved area or any area that may be plowed to remove snow, care must be taken that the roadway box is flush with the paved surface or ground surface to limit the potential for damage by snow plows. Roadway boxes should not be installed below the paved or ground surface to avoid accumulation of surface water and/or sediment over the roadway box.

9. Should a level elevation survey be required, refer to GZA's SOP D-11 *Elevation Level Survey of Site Features*.

10. Develop the well in accordance with GZA's SOP D-12 *Well Development*.

RECORDS AND DOCUMENTATION

Well installations will be recorded on the drilling log for the hole. Installation details to be recorded include total well depth, screen depth and length, filter and seal depths and thicknesses, well head completion type, well location, and any other details or measurements deemed necessary by the field engineer/geologist. All measurements should be made from ground surface. Well location should be based on taped measurements from up to three site features that can be located on a site plan or sketch. A graphic depiction of the well location should be sketched on the back of the boring log or in the field engineers/geologists field notebook.

SPECIAL NOTES

1. Steel protective pipe or valve gate boxes shall be steam-cleaned or hot water power rinsed prior to installation to remove cutting oil or other residue. To assist in removal for sampling, the cap threads may be lubricated with a small amount of non-petroleum based material (e.g., vegetable oil).

2. If well is to be installed above the base of the borehole, care must be taken to ensure any underlying strata are properly sealed to preclude the possibility of cross-contamination. Seals can be constructed using either grout or bentonite pellets.

3. Grout backfill above bentonite seal may be omitted under certain stratigraphic conditions. In those cases, hole should be backfilled with native materials with occasional thin bentonite seals. Completed installation must have a vertical permeability less than that of the natural strata encountered.

APPLICABLE STANDARDS AND REFERENCES

American Society for Testing and Materials (ASTM) Standard D 5092 (Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers), Reapproved 1995).

United States Environmental Protection Agency (EPA) SOP#: 2048 (Monitor Well Installation), date 03/18/96, Revision #:0.0.

U.S. EPA, "Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities," SW-611, December 1980.

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A-15

Overburden Well Development

OVERBURDEN WELL DEVELOPMENT

PURPOSE

To enhance the hydraulic connection between the wellscreen and the overburden soil by removing fine grained materials (fines) from the vicinity of the well screen, including the filter pack. This allows groundwater to freely flow from the formation into the monitoring well, and reduces turbidity of the water during sampling.

Note: Field staff needs to check with the principal-in-charge (PIC) and/or the project manager (PM) before conducting field work to confirm the actual field procedure to be followed and to discuss and document any deviations to GZA's standard operating procedure (SOP). There are also certain contaminant conditions such as LNAPL or DNAPL where the PIC/PM may elect not to develop the monitoring well.

EQUIPMENT AND MATERIALS

- Personal protective clothing and gear (e.g., gloves, safety glasses, tyvek suit);
- Field book;
- Calculator;
- Boring log with well construction details, including drilling method;
- Centrifugal pump and tubing;
- Container (as appropriate, 5-gallon bucket, 55-gallon drum or truck-mounted tank/roll-off);
- Surge block and stem;
- Bailer, rope and ring; and
- Decontamination equipment and supplies.

PROCEDURES

Well development needs to be completed after well installation as soon as practically possible. It should not occur any sooner than 48 hours for wells that have been grouted. It may be performed by overpumping through the use of pumps, in conjunction with a surge block, or by bailing. Factors that influence well development include: (1) the geologic material; (2) the design and completion of the well; and (3) the drilling method.

Prior to well development, regardless of the method used, determine the depth to the bottom of the well by using a weighted tape or water level meter. Compare the measured well depth to the depth of the well upon installation to assess if any fine material has accumulated in the bottom of the well. Also collect the depth to water measurement. This information, combined with the depth to the bottom of the well and the diameter of the well, will be used to approximate the minimum volume of water to be purged from the well (see below for purge volume estimates for common size wells).

Ultimately well development should continue until all the fines are removed from the water column. This is not always technically feasible given the type of geologic materials are screened in. Assume well development will require the removal of a minimum of three to five times the volume of the screened water column. A greater purge volume may be required, depending on the method of drilling. Record the volume of water purged during development in your field book. Containment of purge water may be required. In many instances it may be appropriate to discharge development water directly to the ground surface. Refer to the PM for guidance. Decontaminate equipment as appropriate prior to development of additional wells.

OVERPUMPING

1. For well locations where static water levels are shallow (less than 20 feet [20'] deep), recharge is sufficiently rapid to prevent drawdown below 20 feet (20'), and groundwater is not significantly contaminated, "overpumping" is an advantageous well development method. For most well locations, centrifugal pumping is the best method; where centrifugal pumping is not feasible (e.g., low recharge), alternate purging methods may be used, such as inertial, gas-driven, or bladder pumps. The following procedure is followed:

    a. Lower clean pump tubing to the bottom of the well. Evacuate the well by pumping at a rate faster than the well would normally be pumped or purged for sample collection. Pump until discharge water, collected in a container, is visually clear of significant suspended sediment, or until the content of suspended sediment appears to stabilize after significant pumping. Tubing should be periodically raised and lowered within the well during pumping.

2. Overpumping should be combined intermittently with mechanical surging through the use of a bailer and/or surge block. The purpose of surging is to free collected sediment from the filter pack and wellscreen. The following procedure is followed:

    a. Slowly lower the surge block or bailer to the bottom of the well, increasing the speed of lowering and retracting near the bottom of the wellscreen. Care should be taken not to compact accumulated sediment or force it out through the wellscreen. Care should also be taken to prevent the surge block from freely falling to the bottom of the well, possibly forcing off or breaking the end cap (well point).

b. Continue to intermittently surge and overpump the well, until a minimum of three to five well volumes have been removed from the well and the purge water is clear. An additional volume may need to be removed depending on the drilling method used. If water is lost to the formation during drilling that volume of will need to be recovered during well development.

BAILING

1. Secure bailer rope to a clean bailer. Tie a bailer ring to the end of the rope to keep the rope from being pulled back into the well. Allow the bailer to free fall down the well until it strikes the surface of the water. The contact of the bailer produces a surge of water forced out the borehole in the formation. Remove the bailer from the well once it fills. As the bailer fills and is rapidly withdrawn from the well, particulate matter flows into the well.

2. Continue bailing until the water is free of suspended sediments. In general, a purge volume of three to five times the well volume is the minimum volume to be removed from the well, regardless of whether the water is free of suspended sediments. It assumes no water was lost to the formation during drilling. The additional volume produced during drilling will also need to be removed during development.

3. If the well is dewatered during bailing, resume bailing once the well has recovered.

4. During bailing, care should be taken to keep the bailer rope off the ground. If it makes contact with the ground surface, any contaminants on the ground may be introduced to the well.

WELL VOLUME CALCULATIONS

The purge volume is equal to $h \times 3.14(r/12)^2 \times 7.48\ \text{gal/ft}^3$

One purge volume is equal to (h) * (f)
where:
h = height of the water column (depth to bottom – depth to water) in feet; and
f = the volume in gal/foot from the above table.

The volume (one purge volume) in gallons/feet for common size monitoring wells are as follows:

Well Diameter (inches)	1	1.5	2	3	4	6
Volume (gal/feet)	0.041	0.032	0.1631	0.3670	0.6524	1.4680

RECORDS AND DOCUMENTATION

All well development information including the purge calculation and resulting volume purged, visible water quality (appearance) and changes of visible water quality, and any odors or other information should be recorded in the field notebook.

SPECIAL NOTES

None.

APPLICABLE REFERENCES AND STANDARDS

Massachusetts Department of Environmental Protection, Standard References, "Well Development" (Section 4.5), March 1989.

United States Environmental Protection Agency – Office of Research and Development, EPA Document #160014-891034, "Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells" (Section 7), March 1991.

United States Environmental Protection Agency – Environmental Response Team Standard Operating Procedures "Well Development" SOP #2044 Revision 0.1, October 23, 2001.

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APPENDIX B

Not applicable to this SAP Addendum

APPENDIX C

GZA SUBCONTRACTOR SOPS

Geophysical Logging SOP

EQUIPMENT AND METHODS

General

Mount Sopris Matrix and MGXII portable digital logging systems were used with a 4MXA-1000 winch for the borehole geophysical logging. Data were recorded along with depth in digital format using a PC. Data were displayed in real time in the field and were processed in the office using WellCAD v. 4.2, commercially licensed software.

Acoustic Televiewer

An ALT ABI-40 acoustic televiewer (ATV) probe was used for this project. The ATV acquires a high resolution, effectively continuous, magnetically oriented, 360° image of the borehole wall using the reflected signal of sound waves in the ultrasonic frequency range. Both amplitude and travel time of the reflected signal are displayed and can be used to detect bedrock structures such as fractures, foliation, and bedding planes. The probe includes a 3-axis magnetometer and three accelerometers to orient the image and to provide borehole deviation data that are used to correct structure orientations from apparent to true orientations.

Acoustic Caliper. ATV travel time data can also be used to calculate an acoustic caliper log. The acoustic caliper log measures the average borehole diameter as a function of depth. The acoustic caliper log is derived from the travel time data and the velocity of the acoustic signal in water. The acoustic caliper log is used to locate possible fractures and to aid in the interpretation of other borehole geophysical logs.

Optical Televiewer

An ALT OBI-40 optical televiewer (OTV) probe was used for this project. The OTV acquires a high resolution, effectively continuous, magnetically oriented, 360° image of the borehole wall. The image can be used to detect bedrock structures such as fractures, foliation, and bedding planes and to provide information about lithology. The probe includes a 3-axis magnetometer and three accelerometers to orient the image and to provide borehole deviation data that are used to correct structure orientations from apparent to true orientations.

Fluid Temperature

A Mount Sopris 2SFB-1000 fluid resistivity/temperature probe was used for the temperature logging. The temperature sensor is a semiconductor device for which the voltage output is linearly related to temperature. Temperature logs record the temperature of formation fluid with depth and are also useful for detecting flow into or out of the borehole via hydraulically transmissive fractures/fracture zones.

Fluid Resistivity/Conductivity

A Mount Sopris 2SFB-1000 fluid resistivity/temperature probe was used for the fluid resistivity logging. The probe uses an electrically shielded Wenner array to measure the capacity of the borehole fluid to transmit electric current with depth and can be an indicator of salinity and water quality. If fluid resistivity contrasts are present between the borehole fluid and individual fractures and fracture zones, the fluid resistivity logs are also useful indicators of flow into or out of the borehole via hydraulically transmissive fractures/fracture zones.

Resistivity is the physical property that relates electric current density to potential gradient and is defined as

$$\tilde{n} = (A / L) * (V / I) \qquad \text{Eq 1}$$

where:	$\tilde{n}$	is resistivity
	A	is cross-sectional area of a homogeneous tube
	L	is length of the tube
	V	is potential
	I	is current

3-Arm Caliper

A Mount Sopris 2PCA-1000 3-arm caliper probe was used for this project. The 3-arm caliper mechanically measures the average borehole diameter as a function of depth. The caliper log is used to locate possible fractures and to help in the interpretation of other logs.

Heat Pulse Flow Meter

A Mount Sopris HFP-2293 heat pulse flow meter (HPFM) was used for the HPFM logging. The HPFM measures the vertical rate and direction of fluid flow in a borehole at discrete depths and is designed to be used for boreholes with flow rates less than one gallon per minute (gpm). A heating grid heats a thin sheet of water in a short time interval (less than 0.05 sec), and, if vertical flow is present, the sheet of water moves along the borehole in the direction of flow. Temperature sensors located at known distances above and below the heating grid monitor the differential temperature of the borehole fluid. The time required for the sheet of heated water to reach one of the sensors is measured, and, based on factory calibrations, the time is used to calculate the vertical flow rate. HPFM measurements can be made under ambient or stressed (injected or pumped) conditions.

Measurement depths are selected based on information provided by other borehole geophysical data such as OTV, ATV, fluid temperature, and fluid resistivity. To make a measurement, the probe is positioned at a selected depth and the probe is stabilized by the friction between the centralizers on the tool and the borehole wall. When the borehole fluid has stabilized after the disturbance caused by the probe being moved to the measurement depth, the heating grid is fired, and a measurement cycle starts.

LIMITATIONS OF THE METHODS

General

With the 4MXA-1000 winch, the logging cable passes over a calibrated wheel, and an encoder counts the revolutions, which are converted to depth. Slippage of the logging cable may occur, resulting in errors in recorded depth. At the beginning and end of a logging run, fiducial depths (commonly ground surface or top of casing) are measured and are compared to determine if slippage occurred.

Acoustic Televiewer

ATV logging requires that liquid be present in the portion of the borehole to be logged. However, the liquid does not need to be optically clear. The ATV probe must be centralized in the borehole to acquire optimal images of the borehole wall. If the borehole wall is rough and/or irregular or the diameter of the open borehole is larger than the diameter of the casing, the probe may not be adequately centralized and the quality of the acoustic images may be compromised.

The ATV logs are used to determine the depth and orientation of fractures and other planar features intersected by a borehole. In some cases, natural planar features in the bedrock, such as mineral veins, bedding, and foliation may appear to be fractures in the ATV logs, but are not actual discontinuities in the bedrock.

The accuracy of the orientation measured by the ABI-40, as stated by the manufacturer, is ±0.5° for the inclination data and ±1° for the azimuth data. The ABI-40 relies on the earth's magnetic field to determine azimuth. Therefore, in areas where the magnetic field may be significantly affected by local magnetic objects, the accuracy of dip azimuths reported in the logs may be reduced. Specifically, the dip azimuth data of bedrock structures and the borehole deviation data within approximately five feet of steel casing are not accurate. However, the depth and dip angle of bedrock structures within approximately five feet of steel casing are accurate.

Acoustic Caliper. The acoustic caliper data is unlikely to indicate the presence of high angle fractures and fractures with small apertures. High angle fractures with large apertures may show small enlargements in the caliper log at both the top and bottom of the intersection of the fracture with the borehole. It also may be difficult to identify fractures in the caliper log located near the bottom of casing where a significant enlargement commonly occurs and may be due to causes other than natural fractures.

Optical Televiewer

The OTV can be acquired in both air and optically clear water-filled boreholes. If the borehole is water-filled, the clarity of the water directly affects the quality of the OTV image. The OTV probe must be centralized in the borehole to acquire optimal images of the borehole wall. If the borehole wall is rough and/or irregular or the diameter of the open borehole is larger than the diameter of the casing, the probe may not be adequately centralized and the quality of the optical images may be compromised.

The OTV logs are used to determine the depth and orientation of fractures and other planar features intersected by a borehole. In some cases, natural planar features in the bedrock, such as mineral veins, bedding, and foliation may appear to be fractures in the OTV logs, but are not actual discontinuities in the bedrock. The OTV images are also used to provide information about lithology.

The accuracy of the orientation measured by the OBI-40, as stated by the manufacturer, is ±0.5° for the inclination data and ±1° for the azimuth data. The OBI-40 relies on the earth's magnetic field to determine azimuth. Therefore, in areas where the magnetic field may be significantly affected by local magnetic objects, the dip azimuths reported in the logs may be compromised. Specifically, the dip azimuth of bedrock structures and the borehole deviation data within approximately five feet of steel casing are not accurate. However, the depth and dip angle of bedrock structures within five feet of steel casing are accurate.

Fluid Temperature

Fluid temperature logging requires that liquid be present in the portion of the borehole to be logged. According to the manufacturer's specifications, the measurement range is -20° C to 80° C, the accuracy is better than ±1%, and the resolution is 0.01° C. Temperature logging is ineffective for accurately measuring the formation fluid temperature unless the borehole fluid is at equilibrium, except for detecting flow into or out of the borehole via hydraulically transmissive fractures. Additionally, a vertical temperature gradient must be present in the borehole in order to detect water movement into or out of the borehole.

Fluid Resistivity and Fluid Conductivity

Fluid resistivity logging requires that liquid be present in the portion of the borehole to be logged. According to the manufacturer's specifications, the measurement range is 0 ohm-m to 100 ohm-m, the accuracy is better than ±1%, and the resolution is 0.05%. A contrast in fluid resistivity must be present between the borehole fluid and fluid in the fractures in order to detect water movement into or out of the borehole.

3-Arm Caliper

The 3-arm caliper data is unlikely to indicate the presence of high angle fractures and fractures with small apertures. High angle fractures with large apertures may show small enlargements in the caliper log at both the top and bottom of the intersection of the fracture with the borehole. It also may be difficult to identify fractures in the caliper log located near the bottom of casing where a significant enlargement commonly occurs and may be due to causes other than natural fractures. .

Heat Pulse Flow Meter

The HPFM requires liquid in the interval to be logged. According to the manufacturer's specifications for the HPFM, the measuring range is 0.03 to 1.0 gpm, the accuracy is ±5% for the mid-range, increasing to ±15% for the extremes of the range, and the resolution is 5%. Data below the stated calibration range are reported when such data are repeatable. Although the accuracy of such data may be low, non-zero values indicate that flow is occurring and indicate the direction of flow. The HPFM probe measures the difference in temperature between the upper and lower temperature sensors. In the absence of flow, the thermal pulse would move symmetrically out from the grid, affecting the two sensors equally as a function of time. Therefore, the conductive or convective dissipation of the heat pulse would yield a zero value in the absence of flow.

STANDARD OPERATING PROCEDURES

Data Acquisition

Data acquisition parameters are provided as follows:

Table 1 – Data Acquisition Parameters

Log	Sampling Interval	Logging Speed	Logging Direction
OTV	0.01 feet	5 feet per minute	down and up
ATV & Acoustic Caliper	0.01 feet	6 - 8 feet per minute	down and up
Fluid Temperature & Fluid Resistivity	0.1 feet	7 - 10 feet per minute	down and up
3-Arm Caliper	0.1 feet	7 - 10 feet per minute	up
Natural Gamma Ray	0.1 feet	7 - 10 feet per minute	down and up
Normal Resistivity, SP, & SPR	0.1 feet	7 - 10 feet per minute	down and up
HPFM	HPFM data were acquired at discrete depths.		

Equipment Decontamination

After each log was completed, the logging probes were decontaminated by washing each with Alconox and rinsing with distilled water. After all logs for a given borehole were completed, the downhole portion of the cable was similarly cleaned.

Equipment Calibration and Standardization

Depth Encoder. Adequate tension was maintained between the depth encoder wheel and the logging cable. The depth encoder was cleaned after each logging run. Repeat sections for each log were acquired to verify depth consistency and to correct any depth inconsistency. In addition, at the beginning and end of a logging run, a fiducial depth (top of casing) was measured and checked for consistency. Recorded depths of fixed features in the borehole (i.e. reported casing lengths, reported borehole depth, reported structure depths based on core logs provided by JCO, etc.) were checked for consistency. Additionally, water level depths measured using the ATV probe were checked against measurements made with a water level indicator. After correcting the data using repeat log sections, comparing different logs for each borehole, and comparing fiducial depths, the depth error due to slippage was generally less than 0.2 ft and, in most cases, less than 0.1 ft.

ATV. To verify consistency, repeat logs were acquired for the full length of the fluid-filled open hole, and borehole orientation data were compared with OTV logs. Acoustic caliper data were compared to known casing and borehole diameters.

OTV. The OTV orientation was checked using a Brunton compass and a calibration tube on 04/23/06 prior to logging the first borehole of the project and on 05/18/06 on the final day of field work. According to manufacturer's specifications, recalibration of the OTV and ATV tools is unnecessary. Based on field checks of orientation and comparison of the OTV and ATV logs, instrument drift was not observed.

Temperature, Fluid Resistivity, and Fluid Conductivity. The temperature and fluid resistivity/conductivity probe was factory calibrated to the following standards, 15.2 ^{o}C to 23.5 ^{o}C, and 8.41 ohm-m to 70.3 ohm-m, immediately before use for the project.

3-Arm Caliper. The 3-arm caliper probe was calibrated before each log using two calibration rings of known inner diameter of 3.51 inch and 10.19 inch.

Heat Pulse Flow Meter. To verify consistency, multiple measurements were made at each sample depth. The HPFM was factory calibrated. Multiple performance checks on the heating grid were conducted during data acquisition at each borehole. To ensure consistent injection/pumping rates during HPFM data acquisition, injection/pumping rates were monitored a minimum of four times per hour.

Data Processing

The processing consists mainly of selecting scales, filters, and the layout of the tracks. In addition, the OTV and ATV data require determining the depth, orientation, and category of the bedrock structures detected. To increase the quality of the images, the brightness and contrast of the OTV images were adjusted and the ATV travel time images were digitally centralized. The ATV amplitude images can be normalized, although normalization was not applied to the ATV amplitude data for this project.

Data Interpretation

Fractures can be identified on the basis of the OTV images, ATV amplitude images, and/or the ATV travel time images. Some, if not most, of the criteria for identifying fractures require a judgment call, and different log analysts will not necessarily make the same call. Hence, some of the bedrock structures identified as fractures may not be fractures. Bedding, foliation, veins, and other planar geologic features in the rock may appear similar to fractures in the borehole geophysical data. Depths where water enters and leaves the borehole can be inferred based on changes in the fluid temperature and/or fluid resistivity data. Depths where water enters and leaves the borehole can also be identified based on changes in the vertical flow rate or direction in the HPFM data.

The WellCAD software program reports the orientation of bedrock structures (fractures, bedding, foliation, veins, and other planar geologic features) as the dip azimuth (dip direction) and dip angle of each structure. The dip azimuth is perpendicular to the strike as used commonly by geologists. The dip azimuth data are referenced to magnetic north and the dip angle data are reported as the bedrock structure's angle from horizontal. The datum for depths in this report is the top of the 6-inch steel casing. The WellCAD software program reports the depth of a bedrock structure as the average of the depth of the top and bottom intersections of the bedrock structure and the borehole wall.

Bedrock structures detected in the televiewer logs are grouped into three categories: Fracture Rank 1, Fracture Rank 2, and Fracture Rank 3. The categories are shown as color-coded lines and symbols on the structure projection plots, tadpole plots, and on the structure statistics plots. Figure 3 explains the bedrock structure categories, and Figure 4 explains how to read the tadpole plots.

Fracture Rank 1 describes minor fractures that are not distinct and may not be continuous around the borehole. Fracture Rank 2 describes intermediate fractures that are distinct and continuous around the borehole with little or no apparent aperture. Fracture Rank 3 describes major fractures that are distinct and continuous around the borehole with apparent aperture.

The structure projection plots display the structural interpretation of the televiewer data and displays the bedrock structures as they appear in the televiewer images. The depth, orientation, and category of the bedrock structures can be read from the structure projection plots. The data in the structure projection plots are apparent data and are not corrected from apparent to true dip azimuth and dip angle.

The tadpole plots are created from the structure projection plots after the data are corrected from apparent to true dip azimuth and dip angle. The tadpole plots graphically display the depth, orientation, and category of the bedrock structures interpreted from the televiewer images. The orientation of bedrock structures are graphically displayed on the tadpole plots by a tadpole made up of a circle, the head, and a line, the tail. The position of the head, left to right on the tadpole plot, gives the dip angle of the bedrock structure. The left side of the track indicates a dip angle of 0° and the right side of the track indicates a dip angle of 90° from horizontal. The position of the tail gives the dip azimuth of the fracture and can be read like a compass. The tail pointing directly up is 0°, magnetic north. We note explicitly that the dip azimuth is perpendicular to the strike as the term is used by geologists.

Level Elevation Survey SOP

GROUND SURVEY OF WELL LOCATIONS

PURPOSE

To provide methods and calculations necessary to conduct and report results of an on the ground field survey for well locations including the transfer of horizontal and vertical control on NAD83 – NAVD88 datum to the site.

EQUIPMENT AND MATERIALS

- Field Book
- Pencil
- 5" Total Station (robotic and/or conventional) & Data Collector
- Topcon GR-3 survey grade sub-centimeter, dual-frequency, dual constellation GPS/GLONASS units and corresponding data collectors
- 32X Auto level
- Tripods, tribrachs, prisms for backsight/foresight setup
- Prism pole
- 25' pocket tape
- Level Rod
- 2-way radios
- Nails, stakes, flagging, permanent marker & paint
- Calculator
- Socket set, tools
- Gloves

PROCEDURES

1. Site control preparation
    a. Recon site and set nails, spikes, or stakes for control stations in optimal locations to allow for maximum side shot locations and/or optimal GPS base station positioning.
    b. Road side stations shall be properly coned off and appropriate temporary signage shall be set up.
    c. Stations shall be marked and painted.
2. Conducting the survey
    a. Establish primary site control with GPS. Setup two units on site and transfer datum from known published survey control on NAD83 – NAVD88. Primary site control shall be established in static mode.
    b. For total station work, establish the appropriate additional control with static GPS as necessary for tie-ins and checks for conventional traverse control.

c. Run appropriate traverse(s) with doubled H & V angles using stationary backsights and foresights and incorporating established base control. Repeat EDM distance measurement. Side shots to wells shall also have doubled H & V angles and repeated distance measurement with EDM.

d. For GPS static and RTK work, establish a temporary base station on a clear and unobstructed setup.

e. RTK solutions for well locations shall be fixed. Observe each well site for minimal obstructions and monitor readings to ensure accurate H & V data. For wells where RTK data is not optimal due to obstructions, a total station shall be used from established network control.

f. Establish a minimum of two temporary bench marks on site with the auto level from established site control, check and balance as necessary.

g. For each well location, survey the center location of the well and elevations of the ground surface, top of well casing and top of cap. Well caps will need to be removed to access the casing using appropriate tools and shall be reset as found when location of well is completed. Data and appropriate notes shall be recorded.

h. Depending on each individual well site conditions, either GPS or total station instrumentation will be used as deemed appropriate to ensure accurate data collection.

FIELD RESULTS

Field data will be checked and post processed in the office. Resulting data will be tabulated and issued. Results will be recorded and shown to the nearest 0.01'. Any discrepancies shall be field verified prior to being issued.

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