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SRSNE Site Group

Remedial Design Project Operations Plan Attachment B

Field Sampling Plan

Solvents Recovery Service of New England, Inc.
(SRSNE) Superfund Site
Southington, Connecticut

May 2010

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Operations Plan Attachment B

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Superfund Site
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SRSNE Site Group

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Tables

Figures

Appendices

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
ASTM	ASTM International
BBL	Blasland, Bouck & Lee, Inc.
bgs	below ground surface
CD	Consent Decree
COC	constituent of concern
CTDEP	Connecticut Department of Environmental Protection
DNAPL	dense, non-aqueous phase liquid
DO	dissolved oxygen
DQOs	Data Quality Objectives
ELUR	Environmental Land Use Restriction
FID	flame ionization detector
FS	Feasibility Study
FSP	Field Sampling Plan
HCTS	Hydraulic Containment and Treatment System
HDPE	high-density polyethylene
ID	inside diameter
IDW	investigation-derived waste
ISTR	in-situ thermal remediation
MCL	Maximum Contaminant Level
mg/kg	milligram per kilogram
mg/L	milligram per liter
mL	milliliter
MNA	monitored natural attenuation
MS	matrix spike

MSD	matrix spike duplicate
NAPL	non-aqueous phase liquid
ND	not detected
NGVD	National Geodetic Vertical Datum
NPL	National Priorities List
NTCRA	Non-Time-Critical Removal Action
NTUs	Nephelometric Turbidity Units
ORP	oxidation/reduction potential
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCDDs	polychlorinated dibenzo-p-dioxins
PCDFs	polychlorinated dibenzofurans
PDA	personal digital assistant
PID	photoionization detector
PIPP	Pre-ISTR Preparation Plan
PMC	GA Pollutant Mobility Criteria
PPE	personal protective equipment
ppb	part per billion
ppm	part per million
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
R^2	coefficient of determination
RCRA	Resource Conservation and Recovery Act
RD POP	Remedial Design Project Operations Plan

RD/RA	Remedial Design/Remedial Action
RDEC	Residential Direct Exposure Criteria
RDWP	Remedial Design Work Plan
RI	Remedial Investigation
ROD	Record of Decision
RSRs	Remediation Standard Regulations
SAP	Sampling and Analysis Plan
SOPs	Standard Operating Procedures
SOW	Statement of Work
SPLP	Synthetic Precipitation Leaching Procedure
SPT	Standard Penetration Test
SRSNE	Solvents Recovery Service of New England, Inc.
SVOCs	semi-volatile organic compounds
TAL	Target Analyte List
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalence Quotient
ug/L	microgram per liter
UPS	United Parcel Service
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds
WHO	World Health Organization

1. Introduction

1.1 Purpose and Scope

On September 30, 2005, the United States Environmental Protection Agency (USEPA) issued a Record of Decision (ROD) (USEPA 2005) for the Solvents Recovery Service of New England, Inc. (SRSNE) Superfund Site in Southington, Connecticut (Site) (Figure B-1). A Consent Decree (CD) and Statement of Work (SOW) were subsequently prepared for the Remedial Design/Remedial Action (RD/RA) at the Site. The CD was negotiated between the USEPA and the SRSNE Site Group (an unincorporated association of Settling Defendants to the CD), and lodged on October 30, 2008 with the United States District Court for the District of Connecticut in connection with Civil Actions No. 3:08cv1509 (SRU) and No. 3:08cv1504 (WWE). The CD was entered by the Court on March 26, 2009. The CD and the SOW define the response activities and deliverable obligations that the SRSNE Site Group is to perform to implement RD/RA activities at the Site.

This *Field Sampling Plan* (FSP) establishes sample collection and field monitoring methods and procedures to be followed to ensure that sampling and investigatory activities at the Site are conducted in a consistent manner in accordance with technically acceptable protocols. Sample collection and field monitoring methods and procedures presented in this FSP are consistent with prior work conducted by the SRSNE Site Group. The objective of the FSP is to facilitate the collection of environmental monitoring data that meets Data Quality Objectives (DQOs) established in the Quality Assurance Project Plan (QAPP) (Attachment C to the *Remedial Design Project Operations Plan* [RD POP]). The QAPP and this FSP collectively represent the *Sampling and Analysis Plan* (SAP) for the RD activities at the Site.

The RD POP, and specifically the SAP components, is intended to supplement the field investigations identified in the *Remedial Design Work Plan* (RDWP), which was a SOW-required deliverable submitted concurrent with the April 2009 version of the RD POP. The RDWP includes several work plans that describe the scope of planned field investigations to support the RD phase of the project. In consideration of the nature of the planned investigation activities, this FSP provides Standard Operating Procedures (SOPs) for environmental monitoring activities expected or likely to be conducted during the RD phase of the work (see Appendix B-1). The QAPP presents the organization, objectives, functional activities, and specific quality assurance/quality control (QA/QC) activities associated with the RD activities.

The QAPP also describes the specific protocols that will be followed for the laboratory and field analyses.

The initial draft version of this FSP was submitted to the USEPA in April 2009 as a component of the RD POP. This revised version has been prepared to address USEPA comments and the SRSNE Site Group's associated responses that have been provided in the interim. This includes the following:

- USEPA comments received via electronic mail on June 5, 2009; associated responses were provided on June 17, 2009.

- USEPA comments received via electronic mail on August 18, 2009; associated responses were provided on October 15, 2009.

- USEPA comments received via electronic mail on November 5, 8 and 12, 2009; associated responses were provided on January 5, 2010.

- USEPA comments received via electronic mail on February 11, 2010; initial responses were provided on February 23, 2010, with final USEPA approval on March 23, 2010.

1.2 Project Setting

The SRSNE Site is located in the Town of Southington, Connecticut, in Hartford County, approximately 15 miles southwest of the City of Hartford. It is located on Lazy Lane, just off Route 10 (Queen Street), and adjacent to the Quinnipiac River. The SRSNE Site, generally depicted on Figure B-2, consists of the SRSNE Operations Area (4 acres), the Cianci Property (10 acres), a railroad right-of-way, and those areas where the SRSNE-related plume in groundwater has come to be located, including Southington's Curtiss Street Well Field (the Town Well Field Property). The Town Well Field Property is a 28-acre parcel of undeveloped land containing two municipal drinking water wells (Production Wells No. 4 and No. 6). The wells were closed in 1979 when they were found to contain volatile organic compounds (VOCs). The Site was listed on the National Priorities List (NPL) in September 1983.

Additional information regarding the site location and setting is provided in the RDWP.

1.3 Remedial Design/Remedial Action Overview

The RD/RA SOW outlines the activities and deliverable obligations required to implement the work required under the CD and the selected remedy as outlined in the ROD (USEPA 2005). The RD will consist of the following phases:

- An initial remedial steps phase
- A design initiation phase
- A conceptual design phase
- A design completion phase

The selected remedy, developed by combining components of different alternatives for source control and management of migration to obtain a comprehensive approach for Site remediation, was described in the ROD. Key elements are summarized as follows:

- Treat waste oil and solvents – where present as non-aqueous phase liquid (NAPL) in the subsurface in the overburden aquifer (i.e., the Overburden NAPL Area) – using in-situ thermal treatment.

- Following in-situ thermal treatment, cap the former SRSNE Operations Area and the railroad right-of-way. The cap will be low-permeability and multi-layered and is to be designed, constructed, and maintained to meet the requirements of Resource Conservation and Recovery Act (RCRA) Subtitle C type cap (“RCRA C”).

- Excavate soils exceeding cleanup levels from certain discrete portions of the former Cianci Property. The estimated limits of soil removal on the former Cianci Property (five discrete excavation areas) are shown on Figure G-1 of the Post-Excavation Confirmatory Sampling Plan (Attachment G to the RDWP); these limits are subject to modification based on additional sampling proposed as part of remedial design. Provided that concentrations of polychlorinated biphenyls (PCBs) do not warrant off-site disposal, soils excavated from the former Cianci Property (and from other areas excavated outside the cap limits as part of other RD/RA activities) may be relocated to the former SRSNE Operations Area for placement beneath the cap.

- Capture and treat (on site) groundwater in both the overburden and bedrock aquifers that exceeds applicable federal drinking water standards and risk-based levels. This will be achieved through continued operation, maintenance, and modification (as needed) of the Hydraulic Containment and Treatment System (HCTS).

- Monitored natural attenuation (MNA) of the groundwater plume outside the capture zones (i.e., the severed plume, shown on Figure 3A of the RDWP) that exceeds cleanup levels.

- MNA of constituents in the groundwater plume inside the capture zones and within the Bedrock NAPL Area (shown on Figure 3B of the RDWP).

- Implement institutional controls (i.e., Environmental Land Use Restrictions [ELURs]) to minimize the potential for human exposure to Site-related constituents in the subsurface soils and impacted groundwater and to prohibit activities that might affect the performance or integrity of the cap.

- Monitor groundwater and maintain the cap over the long term.

1.4 Document Organization

The remainder of the report is organized into three sections, each of which is identified and briefly described as follows:

- **Section 2 – Sampling and Field Procedures:** Specifies the procedures to be followed during monitoring well modifications (e.g., installation, abandonment, etc.), groundwater and soil sampling, and NAPL monitoring activities.

- **Section 3 – Sample Quality Assurance/Quality Control Procedures:** Discusses sample handling procedures, custody requirements, equipment calibration techniques and decontamination procedures, and the management of investigation-derived waste (IDW).

- **Section 4 – References:** Lists the references that are cited throughout the text of this plan.

Several attachments, including Standard Operating procedures and field activity forms, are provided with this FSP and referenced within the text as appropriate.

2. Sampling and Field Procedures

2.1 Sampling Objectives

Environmental sampling at the SRSNE Site will be performed to support the remedial design. DQOs are established in the QAPP (Attachment C to the RD POP).

The following subsections describe sample collection and handling methods and procedures pertaining to the following general sampling categories:

- Groundwater
- Soil and wetland soil
- Post-excavation confirmation

The HCTS consists of the groundwater extraction and treatment systems formerly referred to as the Non-Time Critical Removal Action (NTCRA) 1 and NTCRA 2 systems. While the system nomenclature was modified with entry of the CD (per Section II.D of the SOW), the HCTS is the same system that has been operating at the Site for several years. Procedures associated with continued operation of this system are provided in the *Groundwater Containment and Treatment System Operations Plan* (Handex 2001).

SOPs for sampling activities associated with other elements of the RD are provided in Appendix B-1. This includes ancillary procedures for equipment cleaning, field measurements, and calibration and maintenance of field instruments. Sample handling, packing, and shipping procedures, together with field QA/QC requirements, are discussed in Section 3. Table B-1 provides a list of the SOPs contained in this FSP.

2.2 Groundwater Monitoring Network Modification

The following subsections describe the activities associated with modifying and maintaining the groundwater monitoring well network at the Site. This includes provisions for well maintenance, abandonment, installation, development, and testing. Such activities are required to establish and maintain the well network proposed in the *Monitoring Well Network Evaluation and Groundwater Monitoring Program* (Attachment N to the RDWP).

2.2.1 Well Maintenance Program

This section describes the activities to be conducted to ensure that the wells used for groundwater monitoring are suitable for collecting representative groundwater samples and gauging of water levels. The well maintenance program includes the following:

- Inspection
- Continued maintenance
- Repair
- Abandonment, if necessary

Each of these components of the well maintenance program is discussed below.

2.2.1.1 Inspection

Prior to their use in groundwater monitoring, each pre-existing monitoring well proposed for use as part of the RD groundwater monitoring program will be inspected to verify that it is in suitable condition. Well inspections, including the assessment of the external and internal condition of the wells, will be performed and recorded on a Well Integrity Assessment Form, which is included in the SOP for Monitoring Well Integrity Survey (Appendix B-1-1).

As indicated in Appendix B-1-1, inspection will include visual inspection of the well condition (e.g., presence of cover and lock, condition of surface seal, presence of a marked measuring point, etc.). It will also include gauging of the wells and comparison of the gauged depth to the recorded well construction depth reported on the construction log. In any case, the pre-existing wells and piezometers that are intended for sampling (i.e., not solely used for water-level measurements) during the monitoring program will be purged/developed using one or a combination of the methods listed below until the bottom of the well feels “solid” and the purge water is relatively free of sediment. Prior to development, each well intended for future sampling will be gently brushed with a weighted brush to assist in removing loose debris, silt or floc attached to the inside wall of the well riser and/or screen prior to development. If turbidity remains above 50 Nephelometric Turbidity Units (NTUs) after sediment removal has been achieved through purging, development will continue until the turbidity is below 50 NTUs or for up to 30 additional minutes, whichever occurs first. The final turbidity will be recorded and redevelopment will be discontinued at that point. Development methods include:

- Bailing the bottom of the well using a bottom-loading stainless steel bailer, bouncing the bailer gently on the bottom of the well, and periodically removing the bailer to decant the collected sediment

- Pumping the bottom of the well using a submersible pump capable of pumping highly turbid groundwater

- Pumping the bottom of the well with an inertia pump (e.g., WaTerra or similar) with optional surge block

This process will help reduce, to the extent practicable, the turbidity of groundwater samples obtained using either low-flow or no-purge (i.e., HydraSleeve™) methods. Disposal requirements for purge water generated during this process are discussed in Section 3-6. Equipment decontamination is discussed in Section 3-7.

If gauging indicates a possible well obstruction, efforts will be made to clear the obstruction to provide for continued use of the well. If a monitoring well that is to be used solely for water level monitoring appears to be obstructed and efforts to clear the obstruction are unsuccessful, a qualitative “slug test” will be performed to confirm that the screened interval of the well is still hydraulically connected to the formation. If the “slug test” confirms that it is still hydraulically connected to the formation, the well will be used for water-level measurement only.

If a monitoring well that is to be used for groundwater sampling and water level monitoring appears to be obstructed, and efforts to clear the obstruction are unsuccessful, the well will be slug tested to assess its suitability for water-level measurements. If suitable for water-level measurement, the well may be retained for that purpose. Obstructed wells will not be used for sampling; wells unsuitable for sampling will either be abandoned and replaced (using the procedures described below), or another appropriate well in that vicinity in the appropriate hydrostratigraphic zone (if available) will be substituted as a sampling location.

As part of the initial well integrity assessment, the measuring point elevations of wells to be used for gauging will be resurveyed to verify this reference elevation. For wells requiring maintenance, the survey will be performed after the maintenance is completed to reflect any modifications made to the well as part of the maintenance activity.

Observations and recommendations resulting from the monitoring well integrity survey will be provided to the USEPA and CTDEP upon completion of the work.

2.2.1.2 Continued Maintenance

During each sampling event at a given well/piezometer, the general condition of the well/piezometer will be evaluated and any observations of compromised well integrity will be noted and corrected.

In addition, during the comprehensive groundwater elevation measurement events that will occur every five years, the depth to the bottom of each well used for water level measurements will also be measured. This will provide backup information to allow an assessment of any sediment accumulation. If it is determined that over 0.2 feet of sediment has accumulated since removing the sediment as described above, the sediment will be removed from the well using the same processes described above.

2.2.1.3 Repair

If any component of a well/piezometer is found to be broken, bent or otherwise inoperable, it will be repaired or replaced, as appropriate. For example, if a steel protective casing or flush-mount curb box is broken and cannot be locked, secured or repaired, it will be removed and replaced, and a new concrete pad would be installed at ground surface. Any well cap that is determined to be inoperable or missing will be replaced. If a well lock for a protective casing or bolt for a flush-mount curb box is inoperable or missing, it will be replaced. If the cement surface completion of a well/piezometer is found to be loose or absent, it will be replaced. Although this section describes some typical examples of repairs that may be required, this should not be considered a complete list. Any condition that compromises the security or integrity of a well/piezometer will be reported to the Project Coordinator and expediently corrected.

2.2.1.4 Abandonment

Monitoring wells targeted for abandonment in the *Monitoring Well Network Evaluation and Groundwater Monitoring Program* (Attachment N to the RDWP), located in the thermal treatment area, or otherwise determined to be unsuitable for use will be abandoned. A total of 40 wells/piezometers are currently proposed for abandonment as detailed in Table B-2.

For all wells that are to be abandoned in the thermal treatment area and/or inside the NTCRA 1 sheet pile wall, the following procedures will be followed:

1. Tremie grout the bedrock portions of the bedrock wells with neat cement grout to approximately 5 feet above the top of rock (allow grout to set for 12 hours, or as otherwise specified by the manufacturer).

2. Remove the surface completion of the well.

3. Overdrill with hollow-stem augers to the top of bedrock.

4. Remove the well materials to the extent practicable using the winch on the drill rig.

5. Ream out any materials that were not removed with the winch, using a roller bit that closely fits the inside of the augers (water rotary), to the originally installed depth of overburden wells or the top of rock for bedrock wells.

6. Tremie grout the borehole with neat cement grout upon removal of the augers to ground surface (allow grout to set for 12 hours, or as otherwise specified by the manufacturer).

7. Top off grout, if necessary.

8. Cover with soil or asphalt patch (to match surrounding grade) after the grout has been allowed to set.

The overburden and bedrock wells to be abandoned in other areas will be abandoned using the following approach:

1. Tremie grout the well with neat cement grout to ground surface.

2. Remove the surface completion of the well.

3. Top off the grout to ground surface.

4. Cover with soil after the grout has been allowed to set.

All of the wells to be abandoned are two-inch monitoring wells, except:

- NTCRA 1 extraction/recovery wells RW-5 and RW-6, which are 8-inch-diameter – in and near the thermal treatment area

- Wells PW-406 and PW-407, which are 4-inch-diameter – inside the NTCRA 1 sheet pile wall

2.2.2 Well Installation

Monitoring wells are proposed for installation in the overburden and bedrock. Five groundwater zones are currently monitored at the SRSNE Site:

- *Shallow, middle, and deep overburden*, which represent the upper, middle, and lower thirds of the saturated overburden deposits, respectively

- *Shallow and deep bedrock*, which represent approximately the upper 30 feet of bedrock and the portion of the bedrock that is more than 30 feet below the top of rock, respectively

These five zones were established based on geology (overburden versus bedrock) and on the desire for vertical resolution of the plume.

Monitoring wells are proposed for installation in the shallow, middle and deep overburden. In addition, a shallow or deep bedrock monitoring well and a deep or shallow bedrock piezometer are proposed for installation in separate boreholes at each of the three new bedrock well cluster locations (MW-903, MW-906, and MW-907).The depth of each new bedrock well or piezometer at these locations will be selected based on the results of vertical profiling to be conducted during drilling.

Additional details regarding drilling and well installation are provided below.

2.2.2.1 Drilling and Characterization of Monitoring Well Boreholes

This subsection describes the activities to be performed during the drilling of boreholes for monitoring well installations. The SOP for monitoring well installation is provided in Appendix B-1-2.

Soil Boring and Characterization

Twenty-three monitoring wells are proposed for installation to assist in delineating and monitoring the SRSNE-related constituent of concern (COC) plume and provide additional wells for hydraulic head measurements (see Table B-2). Soil borings drilled during the installation of these wells will be advanced using hollow-stem augers for the overburden wells and hollow-stem augers and/or air rotary for the bedrock wells. Rotosonic drilling methods may also be employed. During the advancement of soil borings using hollow-stem augers, soil and/or in-situ groundwater samples may be obtained, as described below.

Other wells may also be installed, either because of unrepairable conditions or in the event that proposed wells do not achieve delineation/investigation objectives. For replacement wells, the wells would be installed to match the screen interval and location of the well they replace. New overburden well boreholes will be characterized following the procedures described below.

<u>Soil Sampling</u>

Soil samples will be obtained from soil borings using a split-spoon sampler (Appendix B-1-3: Soil Drilling and Soil Sample Collection SOP and B-1-4 Extraction/Preservation of Soil/Sediment for VOCs). If rotosonic drilling is used, soils will be characterized using the rotosonic soil core samples. Soil samples will be obtained continuously at wells MW-902M, MW-902D and TW-08D, which are proposed for installation in the NTCRA 1 Containment Area where NAPL could be present. These continuous soil samples will be field-screened for the potential presence of NAPL, as described in the dense, non-aqueous phase liquid (DNAPL) Contingency Plan (Appendix B-1-5). Soil borings at the other proposed well locations will be sampled approximately every five feet through the overburden. Where multiple new wells are to be installed in a cluster, only the deepest overburden well borehole (which will be installed first) will be sampled using split-spoon samplers. Soil samples will be described in terms of grain size, color, moisture, sorting, rounding, plasticity and/or density, etc., and screened for the presence of detectable organic vapors using a photoionization detector (PID) or flame ionization detector (FID) (Appendix B-1-6: Soil Description). As described in the DNAPL Contingency Plan, if a PID or FID soil screening value for a given sample is above 100 parts per million (ppm), the sample will undergo further detailed evaluation for visible NAPL. The soil boring description from the deepest overburden borehole will be referenced on the boring logs and considered representative of the conditions for the shallower wells of the cluster.

As described below, in-situ groundwater sampling is proposed during overburden drilling at some well cluster locations. If soil conditions preclude the effective use of the in-situ groundwater sampler at a particular depth interval, then a saturated soil sample will be obtained (in lieu of an in-situ groundwater sample) for laboratory analysis of VOCs.

Vertical Profiling in Overburden

Vertical profiling during drilling in the overburden will provide a cost-effective means to identify appropriate screen depths for proposed overburden groundwater monitoring wells where the saturated overburden is relatively thick (greater than 30 feet). This condition applies to the following well cluster locations: MW-121, MW-903, MW-904, MW-906, MW-907 and PZO-4. The SOP for HydroPunch™ Groundwater Sampling is provided in Appendix B-1-7.

During installation of the initial (deepest proposed) overburden well at these cluster locations, in-situ groundwater samples or saturated soil samples will be obtained at 10-foot depth intervals in the saturated overburden using a HydroPunch™ or similar sampling device. Where the soil characteristics (e.g., fine grain size, high density) preclude effective HydroPunch™ use, a split-spoon sample of saturated soil will be obtained. In either case, these samples will be obtained at 10-foot depth intervals and submitted for VOCs by analytical Method SW 846 8260B, with rapid (24-hour, if possible) turnaround.

Where saturated soil samples are obtained in lieu of in-situ groundwater samples, the analytical results will be converted to equilibrium pore-water concentrations using site-specific partitioning parameters presented in the Remedial Investigation (RI) Report (Blasland, Bouck & Lee, Inc. [BBL] June 1998).

Bedrock Drilling

Two bedrock borings will be drilled during bedrock well installation activities at each of the following well clusters: MW-903, MW-906 and MW-907. The first bedrock boring at each location will be drilled into the deep bedrock and completed with a shallow or deep bedrock monitoring well, depending on the results of vertical profiling described below. A bedrock piezometer will be installed in the second bedrock boring at each location to provide additional resolution of the vertical hydraulic gradient in the bedrock at these locations; the second bedrock borehole at each of these three clusters will be drilled to the appropriate depth – either deeper or shallower than the bedrock monitoring well – to assess vertical gradients in consideration of the selected screen interval for the monitoring well.

The bedrock borings will be advanced through unconsolidated materials and bedrock using hollow-stem auger and, if necessary, air rotary or rotosonic drilling methods. Soil cuttings will not be logged because the proposed bedrock wells will be clustered with overburden monitoring wells that will be logged and characterized from ground surface to the top of bedrock. Hollow-stem augers having an inner diameter of at least 8¼ inches, and if necessary a nominal 8-inch diameter air rotary bit (or similar diameter rotosonic core barrel and outer casing), will be used to drill through the unconsolidated materials to the top of bedrock. An 8-inch nominal diameter air rotary bit (or similar rotosonic casing) will then be used to drill 5 feet into competent bedrock. A 6-inch-diameter permanent black steel casing will then be installed to the bottom of the 5-foot socket in the top of bedrock. The 6-inch casing will then be grouted in place using neat cement grout by the tremie method until the grout is observed at ground surface.

After the grout has cured a minimum of 12 hours, or as otherwise specified by the manufacturer, a nominal 4-inch-diameter or 6-inch-diameter, or similar air rotary bit rotosonic casing, or diamond-bit rotary core barrel will be used to drill to an eventual total depth of approximately 200 feet below ground surface. During drilling in rock, the rate of penetration (number of minutes per 5-foot interval), general lithology of rock cuttings, and qualitative observations regarding water production or loss will be recorded in the field book and/or personal digital assistant (PDA). After drilling each 20-foot interval, the new portion of the borehole (bottom 20 feet) will undergo extraction packer testing using a single-packer assembly, as discussed below. Alternatively, the borehole may be drilled to the target total depth and be packer tested using a dual-packer assembly. Rock cuttings will be described in terms of color, lithology, etc.; screened using a PID; and these observations will be recorded as appropriate.

<u>Vertical Profiling in Bedrock</u>

During or shortly after drilling of the first bedrock boring at each location, vertical profiling will be conducted to measure bedrock hydraulic conductivity, identify the predominant flow zone(s) intersected by the borehole, and collect groundwater samples for rapid laboratory analysis of VOCs. Vertical profiling will be conducted by means of extraction packer testing at 20-foot intervals.

If the borehole is drilled and packer tested incrementally, the borehole will be advanced to 20 feet below the bottom of the casing, drilling equipment will be retrieved from the borehole, and the bottom 20 feet of the borehole will be isolated using a single-packer assembly. The isolated section will then be pumped to allow hydraulic conductivity testing and screening-level groundwater sampling using one of the two methods described below.

If the borehole is drilled to total target depth (200 feet below ground surface [bgs]) prior to packer testing, drilling equipment will be retrieved from the borehole. The borehole will then be packer tested in 20-foot increments using a dual-packer assembly. The isolated section of borehole during each packer test will then be pumped to allow hydraulic conductivity testing and screening-level groundwater sampling using one of the two methods described below.

Option 1: Standpipe Method

A packer assembly with one or two inflatable packers at the bottom of a steel or polyvinyl chloride (PVC) standpipe will be installed to isolate a 20-foot section of the borehole. A submersible pump with foot valve and dedicated polyethylene tubing will be installed into the standpipe, and a specific capacity test will be performed as described in the Specific Capacity Testing and Data Reduction SOP (Appendix B-1-8). However, the test will continue until at least two packer-interval volumes plus two pre-pumping standpipe water column volumes have been removed, or the water has been pumped down to the bottom of the borehole. Groundwater levels inside and outside of the standpipe will be monitored to verify the effectiveness of the packer seal. After purging is complete, a groundwater sample will be obtained from the discharge end of the pump tubing. Efforts will be made to prevent pumping the packer/standpipe assembly dry. However, if the assembly is pumped dry, even with a very low pumping rate, the recovery of the water level will be monitored for a period of 30 minutes using a decontaminated electronic water level probe. Recovery will continue until sufficient groundwater is present to allow sampling using a new, disposable polyethylene bailer. Water level data obtained during the borehole recovery may be used to estimate K of the bedrock interval using a rising head test should an insufficient amount of data be collected to use the specific capacity method.

Option 2: Sealed Transducer Method

A single-packer or dual-packer assembly, with submersible pump and transducer below the packer, will be installed to a 20-foot section of the borehole. The assembly will be lowered into the borehole on a length of flexible polyethylene tubing. The transducer cable will extend through the (upper) packer with a sealed fitting. The transducer will be used to obtain pre-pumping and during-pumping potentiometric data within the isolated zone below the packer. The submersible pump will be turned on, and a specific capacity test will be performed as generally described in the Specific Capacity Testing and Data Reduction SOP (Appendix B-1- 8). However, the water level data for the zone below the packer will be obtained using the transducer, and the test will continue until at least two packer-interval volumes plus two polyethylene-tubing volumes have been removed, or the water level has been pumped down to the intake of the pump. The groundwater level outside of the polyethylene tubing will be monitored to verify the effectiveness of the packer seal. After purging is complete, a groundwater sample will be obtained from the discharge end of the pump tubing. Efforts will be made to prevent pumping the packer/standpipe assembly dry. However, if the assembly is pumped dry, even with a very low pumping rate, the recovery of the water level will be monitored for a period of 30 minutes using a decontaminated electronic water level probe. Recovery will continue until sufficient groundwater is present to allow sampling using the submersible pump.

If drilling and packer testing are performed incrementally, after screening-level groundwater sampling using one of the two methods described above, the packer will be deflated and drilling will commence again until the next targeted sampling interval depth is achieved.

Alternative Method to Identify Purging Volume Using Fluorescein Dye

Another alternative to identify whether sufficient purging has been performed prior to packer-test sampling is to use fluorescein dye in the drilling water, and then purge each packer test interval until the dye is removed to a negligible remaining concentration. The target concentration of dye in the drill water should be approximately 20 milligrams per liter (mg/L), which is greater than two orders of magnitude above its visual threshold (approximately 0.1 mg/L) and over five orders of magnitude above its typical laboratory detection limit (less than 0.001 mg/L). The dyed drilled water can be prepared by mixing 38 grams of fluorescein into every 500 gallons of drill water. In open sunlight, fluorescein photodegrades rapidly; thus, the drill water batch tank should be covered (e.g., with black, 1 millimeter plastic or other opaque material) during the day to minimize photodegradation of the dye. After removing the drilling tools, the borehole may be purged prior to performing packer testing to assist in removing dyed drill water.

A visual standard indicating 95 percent dilution of the drill water will be prepared by mixing 1 part dyed drilling water with 19 parts potable water. This standard should be kept in the dark to minimize photodegradation of the dye. The goal of packer-test purging will be to reach at least the clarity of a prepared visual standard, indicating that the discharge water is composed of at least 95 percent formation water and less than 5 percent drilling water. A purge water sample and visual standard can then be photo-documented, and the screening-level groundwater sample collected for VOC analysis.

If the visual standard is still not reached after a reasonable period and volume of purging, then VOC sampling can still be performed, provided that samples of the dyed drilling water and screening level groundwater sample are also sent for fluorescein analysis. The fluorescein data can then be used to calculate a quantitative correction factor to be applied to COC analytical results. Representative COC concentrations in groundwater (C_{gw}) can then be calculated as:

$$C_{gw} = C_m \, [F_d / (F_d - F_s)]$$

where: C_m = measured COC concentration, as reported by the lab

F_d = fluorescein concentration in drilling water

F_s = fluorescein concentration in groundwater sample

Screening-Level Groundwater Sample Analysis and Data Evaluation

Groundwater samples obtained by packer testing will be placed in laboratory-supplied containers, packed on ice, cooled to approximately 4°C, and shipped under appropriate chain-of-custody protocols to the laboratory for analysis of VOCs by analytical Method SW 846 8260B, with rapid (24-hour, if possible) turnaround.

2.2.2.2 Monitoring Well Construction

Groundwater monitoring wells will be installed in overburden soil borings or in bedrock boreholes to provide groundwater elevation and groundwater quality information. Overburden monitoring wells will be installed through hollow-stem augers; bedrock wells and piezometers) will be installed through permanent steel casings into open bedrock boreholes (Appendix B-1-2).

Overburden monitoring wells will be constructed using 2-inch-diameter, schedule 40, 0.010-inch slotted screens and riser pipes. Bedrock monitoring wells and piezometers will be installed with 2-inch inside diameter (ID), 0.010-inch slotted schedule 80 PVC screens and riser pipes. However, if NAPL is encountered at a given borehole during drilling, the well/piezometer will be installed using stainless steel well materials and a grouted bottom sump, as discussed below. Morie #0 or equivalent sand packs will be placed along the screened interval of each well or bedrock piezometer to a height of approximately 2 to 5 feet above the top of screen.

At the overburden well locations, a 3-foot thick minimum bentonite seal will be placed above the sand pack and the remainder of the borehole will be filled with neat cement grout to within approximately 2 feet of ground surface. At deep overburden boreholes where vertical profiling is performed, the portion of the borehole below the selected monitoring well screened interval (if any) will be filled with bentonite, following by 2 feet of sand pack material, prior to constructing the well.

At the bedrock boreholes, after selection of the screened interval for the monitoring well and piezometer, the portion of the borehole below the screened interval will be grouted using neat cement grout, as appropriate. After allowing the grout to set for a minimum of 12 hours, or as otherwise specified by the manufacturer, two feet of sand pack will be placed below the screen. After the screen and riser are installed, a sand pack will be added to a height of 2 to 5 feet above the top of the screen. A 3-foot thick minimum bentonite seal will be placed above the sand pack and the remainder of the borehole will be filled with neat cement grout to within approximately 2 feet of ground surface. The wells and piezometers will be completed at ground surface with locking steel protective casings or bolt-down curb boxes, set in concrete surface pads.

The bedrock wells will be constructed of 2” ID schedule 80 PVC screens and risers. The overburden wells will be constructed of schedule 40 PVC screens and risers. All new and replacement wells installed in the NTCRA 1 Containment Area will be constructed of No. 304 stainless steel well screens and risers, as discussed further below.

Contingency for Constructing Wells or Piezometers Where NAPL is Encountered

If NAPL is encountered during drilling, borehole purging or packer testing, the monitoring well or piezometer installed in the borehole will be installed with a No. 304 stainless steel screen and blank sump below the screen. The entire length of the sump below the screen will be grouted in place using neat cement grout, such that the bottom of the sand pack is at the bottom of the screen.

Modified Well Design in NTCRA 1 Containment Area ("N" Wells)

The proposed "N" wells in the NTCRA 1 Containment Area may be installed using stainless steel well materials and they will be installed with 1-foot long sumps grouted in place below the screen and sand pack, as discussed below.

TerraTherm, the thermal remediation contractor, will perform calculations to predict the potential increase in groundwater temperatures that may occur downgradient of the thermal treatment area. The results of that analysis will ultimately be presented with the Conceptual Design for the thermal remedy. Based on the results of those calculations, the proposed "N" wells may be installed using No. 304 stainless steel screens and risers. Any wells to be located in areas where the calculations suggest possible groundwater temperatures above 70 ºC will be constructed of stainless steel.

Each of the new "N" wells, as well as replacement well TW-08B, will have a 1-foot-long sump below the screen. The entire length of the sump below the screen will be grouted in place using neat cement grout, such that the bottom of the sand pack is at the bottom of the screen. The annulus surrounding the screen and extending to approximately three feet above the screen will be filled with appropriately silica sand pack material. A three-foot bentonite seal (minimum) will be placed above the sand pack and neat cement grout will fill the remainder of the annulus within approximately 2 feet of the ground surface. These wells will be completed above grade with locking steel protective casings set in a concrete surface pad. In addition, if visual evidence of NAPL is observed during drilling of these three wells, the well material will consist of No. 304 stainless steel rather than PVC. To accommodate the sump at deep overburden wells MW-902D and TW-08D, the hollow-stem augers will be advanced 1 foot into the top of the weathered bedrock at these two boreholes.

Monitoring Well Screen Lengths and Depths

The following procedures will be used to select monitoring well screen lengths and depth intervals.

- Shallow overburden wells (MW-903S and MW-904S) will have 10-foot long screens, with approximately 8 feet below the water table and 2 feet in the vadose zone.

- Where the saturated overburden is less than 30 feet thick, the new middle and deep overburden wells will have screen lengths approximately equal to the thickness of the zone in which they are installed (i.e., 1/3 of the saturated overburden thickness). The saturated overburden thickness will be determined based on the depth of the water table and the top of bedrock as observed during drilling of the new boreholes, and/or prior geologic data from wells in the same cluster, if any.

- Where the saturated overburden is at least 30 feet thick, middle and deep overburden wells will be installed with a 10-foot long screen centered vertically at the depth where VOCs were detected at the highest concentrations, if any, during vertical profiling in the appropriate overburden zone (i.e., middle or deep overburden). If VOCs are not detected, or are detected at similar concentrations in all the vertical profiling samples in a given overburden zone at a given cluster location, then the well will be installed with the screen vertically centered at the depth(s) of the coarsest-grained material observed during soil sampling within that overburden zone.

- Bedrock wells will be constructed with a 15-foot long screen installed in an approximately 20-foot long sand pack at the depth interval where VOCs were detected at the highest concentrations, if any, during vertical profiling in the bedrock. If VOCs are not detected, or are detected at similar concentrations in all the vertical profiling samples in a given bedrock borehole, then the well will be installed in the interval that had the highest estimated hydraulic conductivity value calculated based on packer-test data.

- Bedrock piezometers will also be constructed with 15-foot long screens in 20-foot long sand packs. The bedrock piezometer will be installed at a different depth than the adjacent monitoring well, with at least a 20-foot vertical separation between screen intervals. In general, greater vertical separation will be preferred between the well and piezometer to improve the resolution of vertical hydraulic gradients in bedrock at the three bedrock drilling locations. However, piezometers will also be installed in zones that have relatively high VOC concentrations or calculated packer-test hydraulic conductivity values, if possible.

Horizontal and vertical survey control will be established for each new well, including the top of the PVC riser, the top of the protective casing or curb box, and the ground surface adjacent the well, based on the existing baseline for the SRSNE Site and the National Geodetic Vertical Datum (NGVD) of 1929.

2.2.3 Well Development and Specific Capacity Testing

Each newly installed monitoring well and bedrock piezometer will be developed to remove fine sediment from the well and enhance the hydraulic connection between the well and the surrounding formation as described in the Monitoring Well Development SOP (Appendix B-1-9). Well development will be performed by gently surging the well using either a surge block or bailer, and purging using either a bailer or pump. Development at each well will be complete when the visible turbidity of the purged water has been reduced to the extent practicable, and a minimum of three well volumes has been removed.

To characterize the hydraulic conductivity at each newly installed monitoring well, specific capacity tests will be performed at the end of the development process as described in the Specific Capacity Testing and Data Reduction SOP (Appendix B-1-8).

2.3 Groundwater Sampling from Wells and Piezometers

Following the completion of well inspection, maintenance and repair activities for pre-existing wells/piezometers, and the installation and development of new proposed monitoring wells, the monitoring network will be allowed to equilibrate for a period of a least two weeks prior to performing groundwater sampling.

The following subsections describe the purposes for groundwater sampling and the sampling methods.

2.3.1 Groundwater Sampling Purposes

The proposed monitoring network consists of 124 monitoring wells to be used for sampling and water level measurements, and 36 additional wells to be used for water-level measurements only, as summarized in Tables B-2 and B-3 and further described in the *Monitoring Well Network Evaluation and Groundwater Monitoring Program*. The data obtained from this monitoring network will be used to characterize the SRSNE-related COC plume in terms of:

- Plume extent in all five hydrostratigraphic zones (shallow middle and deep overburden, and shallow and deep bedrock; in all three dimensions)
- Temporal and spatial variations in plume chemistry and geometry
- Progress in meeting the long-term remedial goal of groundwater restoration

- Effectiveness of institutional controls

These monitoring purposes are listed in SOW Section VII.A.1. The general timing of sampling events and lists of analytical parameters are summarized in Table B-3.

2.3.2 Groundwater Sampling Methods

Groundwater sampling will be performed using low-flow and/or no-purge (HydraSleeve™) methods, as described below. Low-flow sampling will be performed with the pump intake at the approximate mid-point of the saturated screened interval of the monitoring well. Similarly, HydraSleeve™ samples will be approximately centered at the midpoint of the saturated screened interval of the monitoring well. Sampling at the midpoint of the saturated screened interval of a monitoring well is consistent with conventional practices for low-flow sampling (Puls and Barcelona, USEPA/540/S-95/504, April 1996; USEPA Region 1, January 19, 2010). This approach minimizes the potential for confusion regarding sampling depths, decreases monitoring event complexity, and improves sample repeatability. It is proposed that midpoint sampling be performed consistently for all monitoring wells during the RD/RA process, unless an unforeseen factor necessitates sampling at a different depth. If so, the need for modifying the sampling depth will be discussed with USEPA prior to implementation.

2.3.2.1 Low-Flow Sampling

The initial comprehensive groundwater sampling event will entail sampling of 124 wells for various lists of analytical parameters, as detailed in Table B-3. These wells will be sampled using either the USEPA Region 1 Low-Flow procedure (Appendix B-1-10-A) or the SOP for sampling wells and piezometers with saturated screen lengths greater than 10 feet (Appendix B-1-10-B). Laboratory analytical methods are specified in the QAPP (Attachment C to the RD POP).

At the wells selected for field demonstration of low-flow versus no-purge sampling (described below), a supplemental measurement of turbidity will also be obtained during low-flow sampling. The same model of turbidity meter will also be used during subsequent no-purge sampling at the same wells selected for the field demonstration. The supplemental turbidity data, obtained with the same model of turbidity instrument via low-flow and no-purge (HydraSleeve™) sampling, will be used to:

- Compare low-flow and no-purge sample turbidity as directly as practicable
- Allow an assessment of whether sample turbidity may have affected the analytical results for sorptive analytes such as metals

The supplemental turbidity measurements will be made immediately prior to filling bottles for filtered or unfiltered Target Analyte List (TAL) metals analysis using a Hach 2100P or Lamotte 2020 turbidity meter, calibrated and used according to the manufacturer's specifications (with two-point calibration).

TAL metals analysis will be performed for total metals using unfiltered groundwater samples, and dissolved metals using field-filtered groundwater samples. The groundwater samples that will be analyzed for total metals will not be filtered, but will be acidified to pH<2. The groundwater samples that will be analyzed for dissolved metals will be field-filtered using a 0.45 micron filter. Field filtration of low-flow groundwater samples will be performed by connecting the discharge tubing (prior to the flow-through cell) to the tip of a new 0.45 micron filter, and pumping the water through the filter into an appropriate pre-preserved bottle provided by the analytical laboratory.

Following filtration, dissolved metals samples will be preserved by acidification to pH<2. One filter blank will be obtained per shipment (or per "lot") of 0.45 micron filters by filling a new disposable syringe with distilled or deionized water, connecting a new filter to the tip of the syringe, and pushing the water through the filter into an appropriate pre-preserved bottle provided by the analytical laboratory. A minimum of one filter blank will be obtained for each model of filter used, per groundwater sampling event for TAL metals.

The speciation of iron [Fe (III)/Fe(II)] and manganese [Mn(II)] for MNA evaluation will be evaluated based on the total (unfiltered) and dissolved (field-filtered) metals analytical results. As recommended by Dr. Guy Sewell of the USEPA's Robert S. Kerr Laboratory in a July 16, 1996 telephone discussion with Michael Gefell of BBL during the development of the RI Work Plan, the relative speciation of Fe (III)/Fe(II) and Mn(II) will be estimated based on the total and dissolved concentrations of these metals in groundwater. It is assumed that the dissolved fraction of Fe and Mn represent predominantly the Fe(II) and Mn(II) valence states, respectively. The Fe(III) concentration will be calculated by subtracting the dissolved Fe concentration from the total Fe concentration. Based on the July 16, 1996 discussion with Dr. Sewell, minimizing contact with atmospheric oxygen is not critical to sample quality when samples are preserved by acidification. However, as an added precaution, ARCADIS will minimize agitation of the groundwater samples obtained for analysis of total or dissolved Fe and Mn, minimize the headspace in the sample bottles, and perform field filtration as quickly as practicable.

2.3.2.2 HydraSleeve™ Sampling

A field demonstration is proposed during the first comprehensive groundwater sampling event to compare no-purge groundwater sampling (HydraSleeve™ samplers) to low-flow purging and sampling. Assuming that the results of both methods are similar, HydraSleeve™ will be proposed for use during subsequent sampling during the RD/RA process. USEPA will review the HydraSleeve™ proposal and will determine which, if any, sampling events may be conducted using HydraSleeve™ in place of USEPA Region 1's approved low-flow procedures. HydraSleeve™ sampling procedures are described in detail in the Groundwater Sampling with HydraSleeves™ SOP (Appendix B-1-11).

Field filtration of no-purge (HydraSleeve™) groundwater samples will be performed using a new disposable or decontaminated plastic syringe, with a new 0.45 micron disc-style filter on the end of the syringe. The HydraSleeve™ discharge tube will be connected to the tip of the syringe, and the syringe will be filled by drawing back the plunger. After the syringe is filled and is disconnected from the discharge tube, the filter will be attached to the tip of the syringe. Finally, the plunger will be pushed into the syringe, 10-15 milliliters (mL) of groundwater will be pushed through the filter, and then the sample water will be collected from the filter discharge directly into an appropriate pre-preserved bottle provided by the analytical laboratory. Following filtration, dissolved metals samples will be preserved by acidification to pH<2.

Wells Selected for Field Demonstration

To demonstrate the effectiveness of no-purge sampling, a comparative field demonstration between HydraSleeve™ and low-flow sampling will be performed at 7 overburden and 4 bedrock monitoring wells with total VOC concentrations less than 1,000 ug/L during the most recent sampling. The specific wells proposed for the field demonstration, the hydrogeologic units they are installed in, and the total VOC concentration during the most recent sampling event are as follows:

- Shallow overburden monitoring wells: P-101C (100 ug/L) and P-13 (2.4 ug/L)

- Middle overburden wells: P-101B (920 ug/L), MW-704M (46 ug/L) and MW-3 (18 ug/L)

- Deep overburden wells: MW-704D (28 ug/L) and MW-707D (Not Detected [ND])

- Shallow bedrock wells: MW-704R (730 ug/L), P-11A (270 ug/L) and MW-127C (41 ug/L)

- Deep bedrock well: MW-707DR (15 ug/L)

These monitoring wells are distributed at various locations and depths within and immediately downgradient of the SRSNE-related VOC plume. In addition, based on hydraulic conductivity data measured during the RI, these wells cover a hydraulic conductivity range of nearly four orders of magnitude.

Comparative Sampling

The selected monitoring wells will be sampled using the USEPA Region 1 low-flow method as described above. HydraSleeve™ samplers will also be deployed in the well before and after low-flow sampling, allowed to equilibrate for 24 hours or more, and retrieved to obtain two separate no-purge samples. HydraSleeve™ sampling procedures are described in Appendix B-1-11. Sampling of these wells will be performed in approximate increasing order of total VOC concentrations based on their most recent sampling results.

The samples obtained using either method will be analyzed for the parameters that are proposed to be sampled as part of subsequent groundwater sampling events, namely:

- VOCs

- 1,4-dioxane

- MNA parameters

- TAL metals

Immediately before filling bottles for filtered or unfiltered TAL metals analysis during the field demonstration, a supplemental turbidity measurement of the water from the HydraSleeve™ sampler will be obtained using either a Hach 2100P or Lamotte 2020 turbidity meter (calibrated and used according to the manufacturer's specifications). The same model turbidity meter will be used for supplemental turbidity measurements for comparative low-flow samples during the field demonstration, as discussed above.

After HydraSleeve™ sampling, a down-hole water-quality instrument will be used to measure field parameters used in the MNA assessment: dissolved oxygen (DO), oxidation/reduction potential (ORP), pH and temperature. Standard field parameter measurements will be completed as described in the Down-Hole Groundwater Field Parameter Measurement SOP (Appendix B-1-12).

During subsequent sampling events, after HydraSleeve™ sampling at each well where MNA parameters are analyzed for, MNA field parameters will continue to be measured using a down-hole instrument.

2.3.2.3 Low-Flow/HydraSleeve™ Data Comparison

The groundwater analytical results obtained using low-flow and HydraSleeve™ methods at the tested wells will be tabulated and compared graphically using standard X-Y charts (with arithmetic axes), similar to the RI field demonstration comparing low-flow to traditional purge sampling. Screening criteria will be applied prior to data tabulation and evaluation, and include the following:

1. Preliminary data will not be included in this comparison; only data validated in accordance with the procedures outlined in the QAPP (Attachment C to the RD POP) will be used.

2. If multiple concentrations are available for comparison (i.e., primary and duplicate samples from the sample sampling method), then the average value will be used in the statistical analysis.

3. Only site-related VOCs (per Table L-1 of the ROD, plus 1,4-dioxane), metals and MNA parameters will be subject to comparison.

4. Analytical parameters that were reported as not detected in non-diluted samples will be assigned a value of one-half the detection limit.

5. If an analytical parameter in a diluted sample was reported as not detected, that analyte will not be included.

After data validation is complete, the results will be tabulated and pared down in consideration of the above screening steps. The data will then be plotted graphically on an X-Y chart for each of the parameter groups listed in Section

2.3.2.2 (Comparative Sampling), with low-flow results appearing along the X-axis and HydraSleeve™ results along the Y-axis. The coefficient of determination (R^2) will be calculated for the plotted "best-fit" linear regression trend line. The R^2 value will be calculated separately for each parameter group (i.e., VOCs, TAL metals, and MNA parameters). If the R^2 value is greater than or equal to 0.85, then for the purposes of this analysis, the two data groups will be deemed comparable. In this scenario, HydraSleeve™ will be selected for subsequent groundwater sampling events during the RD/RA process until site closure is nearly achieved, at which point the final sampling events will be performed using a different method, at the discretion of the USEPA and the Connecticut Department of Environmental Protection (CTDEP).

If, however, the R^2 value is less than 0.85, the dataset will undergo further evaluation to understand the variables that resulted in the lower value before selecting sampling methods for subsequent events. For instance, certain constituents (e.g., individual metals) may have been detected that are not Site-related, and may have impacted the results. Similarly, if the metals data have an R^2 value less than 0.85, then the sample turbidity data will be evaluated to determine whether sample turbidity could have affected the results.

2.4 Groundwater Elevation and NAPL Thickness Monitoring

Water levels will be measured in accordance with procedures described in the SOP for Water-Level and NAPL Thickness Measurements (Appendix B-1-13).

2.4.1 Groundwater Elevation Monitoring

Groundwater elevation measurements will be collected during each groundwater sampling event with a water level probe or an oil/water interface probe, and measured to the nearest 0.01 foot. As part of each comprehensive groundwater sampling event, a synoptic round of measurements will be obtained in as short a timeframe as practicable at all of the wells and piezometers in the monitoring program, and at select surface-water measurement locations. The total depth of each well or piezometer will be measured during these synoptic measurement events. The measured total depth will be compared to previous readings to check for siltation or other potential problems with the well's integrity and to confirm well identity.

Surface water elevation measurements will be obtained at measurement points that will be established, marked and surveyed on the bridges where Lazy Lane and Curtiss Street cross the Quinnipiac River. Water levels will be converted to elevations using the surveyed measurement point (i.e., top of casing) elevations. Water levels will also be obtained immediately prior to sampling at any well/piezometer.

Groundwater elevations will also be measured at key pairs of wells and piezometers as part of monitoring of the HCTS to verify that groundwater is flowing in the direction of the extraction wells and the hydraulic gradient has been reversed in the area formerly downgradient of the extraction wells.

2.4.2 NAPL Thickness Monitoring

Monitoring wells in the NTCRA 1 Containment Area will be monitored for the presence of NAPL using an oil/water interface probe or bottom loading bailer once every two weeks throughout the implementation of the thermal treatment remedy as described in the SOP for Water-Level and NAPL Thickness Measurements (Appendix B-1-13).

NTCRA 1 Containment Area wells (designated "N" on the well network maps [Figure N-2 through N-6] of the *Monitoring Well Network Evaluation and Groundwater Monitoring Program* [Attachment N to the RDWP]) include:

- Shallow overburden wells MWL-304 and MWL-307
- Middle overburden wells MW-415, MW-902M and TW-08A
- Deep overburden wells MW-413, MW-902D and TW-08D
- Shallow bedrock wells MW-416 and TW-08B

2.5 Soil Sampling

Soil sampling will be completed to address Section V.C.1 of the SOW, which requires soil investigations to:

- Sample walls of excavations to confirm that material exceeding soil and wetland soil cleanup levels has been removed (SOW Section V.C.1.g). (Refer to sampling proposed in the *Post-Excavation Confirmatory Sampling Plan* [Attachment G to the RDWP].)
- Re-assess the extent of the area to be capped following implementation of the in-situ thermal remediation (ISTR) component of the remedy (SOW Section V.C.1.i). (Refer to sampling proposed in the *Soil Investigation Plan* [Attachment I to the RDWP].)

- Determine background concentrations for dioxin[1] in soil (SOW Section V.C.1.i). (Refer to sampling proposed in the *Soil Investigation Plan* [Attachment I to the RDWP].)

In addition, soil sampling is proposed to further assess the potential presence of dioxin in soils at and beyond the proposed RCRA C cap limits, and to further delineate planned soil excavation areas on the Cianci Property (refer to sampling proposed in the *Soil Investigation Plan* [Attachment I to the RDWP]). Finally, soil sampling is proposed to characterize soils and assess cap limits along the railroad right-of-way north of the former Operations Area (refer to sampling proposed in the *Pre-ISTR Preparation Plan* [Attachment M to the RDWP]).

2.5.1 Pre-Design Sampling of Cianci Property Removal Areas

The remedial approach for the site includes removal of soils from five discrete areas on the Cianci Property (see Figure I-3 of the *Soil Investigation Plan* [Attachment I to the RDWP]). The purpose of removal in these areas is to address soils in the vicinity of prior sample locations where concentrations of one or more constituents exceeded the cleanup levels for soil and wetland soil. Note that, in each case, the constituents targeted for analysis are those that exceeded the cleanup levels in the original sample(s) around which each removal area was established.

Table I-1 of the *Soil Investigation Plan* (Attachment I to the RDWP) summarizes the sample location(s), depth interval(s), and constituents that exceeded cleanup goals and, therefore, triggered the planned soil removal activities in each of the five targeted removal areas. The sample locations and preliminary removal limits (based on the ROD) and also depicted on Figure I-3. Soil samples will be collected as described in the SOP for Surface and Subsurface Soil Sampling using Manual Methods (Appendix B-1-14).

For excavation areas that surround a single prior sample location that exceeds cleanup levels (i.e., Excavation Areas 1 through 4), four pre-design sample locations surround the prior sample location at a distance of approximately 20 feet from the prior location. For Excavation Area 5, which encompasses several prior sample locations, six pre-design sample locations surround the

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[1] The term “dioxin” is used herein for consistency with the SOW; it refers to the family of organic compounds known as polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs/PCDFs).

group of prior samples. In general, the proposed pre-design sample locations are slightly within the preliminary removal limits indicated in the ROD.

In the event that preliminary delineation samples contain constituents that remain above cleanup levels, step-out samples will be collected and analyzed to delineate the extent of impact. It is anticipated that step-out samples will be collected between 10 and 25 feet outward (i.e., away from the center of the removal area) from the initial delineation location.

2.5.2 Post Excavation Confirmation Sampling

In general, post-excavation confirmatory samples will be collected from the bottom and/or sidewalls of each excavation area targeted for removal per the ROD and SOW. The purpose of these samples is to confirm that soils impacted above ROD/SOW-specified cleanup levels have been removed following excavation to targeted limits. Table G-1 of the *Post-Excavation Confirmatory Sampling Plan* (Attachment G to the RDWP) summarizes for each area the COCs exceeding cleanup levels, the estimated size (i.e., area and depth) of each excavation, and the anticipated number of confirmatory sidewall and bottom samples. If necessary, based on the initial samples, further excavation and confirmatory sampling will be conducted until cleanup levels are achieved. This approach is further discussed below. Soil samples will be collected as described in the Surface and Subsurface Soil Sampling SOP using Manual Methods (Appendix B-1-14).

As indicated above, confirmatory sampling may include sidewall sampling and/or bottom sampling. The need for each type of sampling will depend on the nature of the pre-excavation dataset, the basis for the cleanup level that triggered the excavation, and the depth of removal. These factors, and their implication on the nature of the sidewall and bottom sampling, are further discussed below. The approach for identifying the specific constituents to be analyzed for in post-excavation confirmatory samples is also discussed below.

2.5.2.1 Sidewall Sampling

For each excavation area, sidewall samples will be collected as needed to provide at least one sample per 50 linear feet of excavated perimeter, with a minimum of three perimeter samples for each individual excavation area. To the extent possible, existing samples (including pre-design samples; see Attachment I to the RDWP) will be used to delineate an excavation area if (1) the location of the sample is such that it would serve as an excavation boundary, (2) the analyzed constituents in the sample include the constituents that initially triggered the excavation, and (3) the target constituents are below cleanup levels. In the absence of existing data, sidewall samples will be collected from the perimeter of the excavation at a depth of 0-2 feet or less below the surrounding ground surface. Specifically, post-excavation sidewall samples would be collected from 0-2 feet if the excavation extends to 2 feet or more, but only to the depth of the excavation if less than 2 feet. The perimeter sidewall samples will be located in a manner that encompasses the original sample location that triggered removal in each specific area. Data obtained from bottom verification samples will be used to confirm the vertical extent of removal.

2.5.2.2 Bottom Sampling

The need for post-excavation bottom sampling will be determined based on the type of regulatory exceedance that prompted the excavation. For areas excavated to address an exceedance of a cleanup level that is based on Residential Direct Exposure Criteria (RDEC) of the Connecticut Remediation Standard Regulations (RSRs), bottom verification sampling will not be required if the bottom of the excavation extends to at least four feet bgs. This is based on the fact that excavation areas are expected to be backfilled with clean soil to re-establish the original grade, and an ELUR is a planned component of the final remedy. Under these conditions, soil located below four feet is considered inaccessible per 22a-133k-2(b)(3) of the RSRs, and RDEC standards do not apply to inaccessible soils. For areas excavated to address an exceedance of a cleanup level that is based on the GA Pollutant Mobility Criteria (PMC), bottom sampling is not required if soil is excavated to the depth of the seasonal low water table [per 22a-133k-2(c)(1)(A)].

In the event that bottom verification samples are required, samples will be collected at a frequency of one sample per 1,000 square feet of excavated area. Bottom samples will be collected from a depth of 0- to 1-foot below the bottom of the excavation.

2.5.2.3 Laboratory Analyses

For each area, confirmatory sampling will focus on the specific constituent(s) that triggered the need for excavation in that area. If an area is targeted for soil removal based on an exceedance of lead, then the sidewall and bottom samples will be analyzed for lead only. In areas where removal is based on exceedance of PMC-based standards, and the excavation does not extend below the seasonal low water table, the verification samples will initially be analyzed for total concentrations of the target constituents. If the total concentration (measured in milligrams per kilogram [mg/kg]) exceeds the applicable cleanup level for a PMC-based standard (measured in mg/L), by a factor of more than 20, the verification sample will be analyzed for the target constituent(s) using the Synthetic Precipitation Leaching Procedure (SPLP) method. If the total concentration (mg/kg) is less than 20 times greater than the PMC-based standard (mg/L), the sample will be deemed to meet the PMC-based cleanup level. The "factor of 20 rule" is based on the volume of fluid relative to soil that used to generate leachate in the SPLP method. Unless the total concentration (mg/kg) is at least 20 times greater than the SPLP-based standard (mg/L), it is mathematically not possible to exceed the standard in the leachate extracted from the sample.

In the case of PCBs, if the mass result is less than 1 mg/kg, SPLP analyses are not required to comply with the PMC [RSRs, Fundamental Review, CTLEP-005 (rev.), March 2006].

2.5.3 Soil Sampling to Define Capping Limits

Surface capping was a component of the selected remedial approach for portions of the former Operations Area and railroad right-of-way. The estimated extent of capping in these areas is depicted on Figure 8 in the ROD, as well as on Figure I-2 of the *Soil Investigation Plan* (Attachment I to the RDWP). Consistent with Sections IV.A.2 and V.C.1.i, the extent of the cap is subject to further evaluation to meet the SOW-specified Performance Standards for soil. Accordingly, soil sampling will be performed for the purpose of defining the extent of the former Operations Area and railroad right-of-way subject to capping.

Soil sampling to further define the cap limits will be performed using a two-phased approach. The first phase will be performed as part of initial pre-design investigations (i.e., following USEPA approval of the RDWP), and is intended to provide an initial assessment of the presence and extent of dioxin at and near the proposed in the cap limits in the former Operations Area. This focused initial assessment of dioxin concentrations is proposed due to the limited available dataset for dioxin in soils, the extremely low cleanup levels associated with dioxins (i.e., potentially 1 part per billion [ppb] or lower), the recalcitrance of dioxins relative to other site-related organics, and the potential for airborne distribution as a result of the former operation of the open pit incinerator. Considering these factors, this first phase of sampling is intended to assess the extent to which the presence of dioxins may substantially affect the determination of cap limits. Conducting this assessment early in the remedial design process will allow for further evaluation of remedial design options in the event that dioxin concentrations above the cleanup goals are present substantially beyond the preliminary cap limits indicated in the ROD.

The initial sampling phase includes collection of 6 surface soil samples (0- to 1-foot deep) for analysis of dioxins and furans using Method 8290. As shown on Figure I-2, the majority of the samples will be collected from the southern portion of the former operations area and in the primary downwind direction from the former open-pit incinerator. These samples will likely be collected at the same time as the background dioxin samples (Section 2.6.4) and prior to any surface grading or site preparation activities associated with the ISTR component of the remedy.

Based on the results of the initial sampling and evaluation of the results relative to the findings of the background sampling, additional samples may be collected as part of the first phase of cap delineation sampling to further delineate the presence and extent of dioxins in soil. The additional sample locations would be established by stepping outward from the initial sample locations with the objective of delineating the extent of dioxin in surface soils at levels exceeding the cleanup level.

The second phase of cap delineation sampling will be conducted following implementation of the ISTR component of the remedy. This phase will specifically address the requirement of Section V.C.1.i of the SOW, which requires soil sampling after implementation of the in-situ thermal component to re-assess the cap limits. Soil sampling after ISTR implementation will provide data representative of the conditions at the time, including site modifications that may occur as a result of grading, operation, and staging of support equipment associated with ISTR implementation.

It is anticipated that the second phase of cap delineation sampling will include sampling at approximately 22 locations around the perimeter of the proposed cap limit. Figure I-2 of the *Soil Investigation Plan* (Attachment I to the RDWP) identifies target locations for this sampling that reflect the preliminary cap limits indicated in the ROD. The actual locations are subject to change based on several factors, including:

- Modifications to the Site made for the purposes of implementing the ISTR component, including grading, fill, and drainage modifications described in the *Pre-ISTR Preparation Plan* (PIPP; Attachment M to the RDWP).

- Analytical data for samples to be collected as part of the PIPP, and any resulting modifications to the scope of work made as a result of those data.

- Grading and modifications of the former Operations Area to provide sufficient access, staging, and support for the ISTR implementation.

- The findings of the initial dioxin investigations to be performed as the initial phase of the cap delineation sampling, including any further sampling that may be necessary to determine the extent of dioxin in soils.

The second phase of delineation samples will be collected from the 0- to 1-foot depth interval and analyzed for dioxins. Similar to the first phase of this approach, additional samples may be warranted to further refine the final cap limits for the purposes of detailed cap design. To the extent that such they are available, other data generated by remedial design activities (e.g., soil sampling proposed as part of the PIPP) will be used to support the cap delineation.

2.5.4 Investigation of Background Dioxin Concentrations

As indicated above, soil sampling is required to assess the background concentrations of dioxin because background concentrations have a bearing on the soil cleanup levels for this constituent group. To address this requirement, samples will be collected from four locations shown on Figure I-1 of the *Soil Investigation Plan* (Attachment I to the RDWP). These locations were identified in consideration of the presumed primary source of dioxins at the Site (i.e., the former open pit incinerator in the southeast corner of the former Operations Area; Figure I-1), topography, primary wind direction, and accessibility. Specific factors associated with selection of the individual samples are summarized as follows:

Sample Location	Rationale
BDS-01 through -03	Topographically upgradient of the former Operations Area and upwind[2] relative to the former open pit incinerator
BDS-04	Accessible location for sampling that is not hydraulically downgradient of the former Operations Area and is side-gradient relative to primary wind direction.

[2] "Upwind is relative to the primary average annual wind direction for the Southington, Connecticut area, which is from the west-southwest based on data from nearby weather stations reported at Weather Underground (www.wunderground.com).

At each location, samples will be collected from the 0- to 1-foot depth increment and analyzed for dioxins and furans using SW-846 Method 8290. The resulting data will be used to calculate a 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) Toxic Equivalence Quotient (TEQ) using the World Health Organization (WHO) 2005 Toxic Equivalency Factors (TEFs). Soil samples will be collected as described in the Surface and Subsurface Soil Sampling using Manual Methods (Appendix B-1-14).

2.5.5 Pre-ISTR Soil Characterization

Installation of the relocated culvert will require excavation and handling of soils from the existing ditch in the western portion of the railroad right-of way to create a new culvert inlet and facilitate flow into that inlet. It will also require excavation of soils and existing concrete pipe along the path of the relocated culvert. Due to proximity to the former operations area and associated potential for impacts, soils in the vicinity of the proposed culvert inlet will be sampled as part of a pre-design investigation. Specifically, 20 samples will be collected from 10 locations in the ditch and adjacent areas, as shown on Figure M-9 of the PIPP (Attachment M to the RDWP). The purpose of these samples will be to characterize the soils so that appropriate health and safety and grading design considerations can be incorporated into the detailed design. The resulting data will also support future delineation of the required extent of the RCRA C cap (refer to the *Soil Investigation Plan* provided as Attachment I to the RDWP), as well as the planned relocation of the fiber optic line (discussed in Section 6 of the PIPP).

The soil samples will be collected from depths of 0 to 2 feet and 2 to 4 feet. The surficial interval (0 to 2 feet) represents soils most likely to be excavated or regraded in the course of modifying the culvert inlet area. These samples will also facilitate evaluation of the cap limits and re-routing of the fiber optic line. Samples from the 2- to 4-foot depth interval will be collected to assess the potential for deeper impacts that may affect design-related decisions regarding the RCRA C cap limits and the fiber optic cable relocation. All samples will be analyzed for VOCs, semi-volatile organic compounds (SVOCs), PCBs, and metals. The results will be presented in the final design plan for the pre-ISTR activities, and will be considered, as appropriate, in development of the final design of the culvert relocation approach.

2.6 Soil Gas and Indoor Air Sampling

The *Vapor Intrusion Study Work Plan* (Attachment K to the RDWP) includes provisions for sampling of soil gas and/or indoor air. Such sampling may be performed in the event that groundwater sampling and/or modeling indoor air concentrations are not sufficient to conclude a lack of unacceptable risk associated with the vapor intrusion (VI) pathway. If determined to be necessary, an iterative process of soil gas sampling (adjacent to buildings subject to investigation), subslab soil gas sampling (beneath the buildings subject to investigation), and indoor air sampling may be performed to further assess potential risks associated with the VI pathway. The need for these measures would be further assess following evaluation of the proposed VI-related groundwater sampling, and a report summarizing the evaluation of VI-related groundwater data would include further details regarding the need for and scope of soil gas, subslab, and/or indoor air sampling.

If determined necessary, soil gas samples will be collected outside, but adjacent to, existing buildings requiring further VI assessment. Soil gas samples will be installed as temporary points using the methodology described in the SOP described in Appendix B-1-15. Soil gas samples will be collected in either 1-liter or 6-liter SUMMA® canisters for the analysis of site-specific VOCs using USEPA Method TO-15. The list of site-specific VOCs will be identified based on the constituents previously detected in groundwater in or near the specific investigation area. Prior to collecting any samples, a helium test will be conducted to ensure the integrity of the seal around the probe point. The helium SOP is also provided in Appendix B-1-16. The location and number of soil gas samples will be determined based on the delineation of COCs within the shallow overburden groundwater plume, accessibility, and the proximity of occupied structures.

Sub-slab soil gas samples may be collected from buildings, if determined necessary based on (or in lieu of) soil gas results. In preparation for sub-slab soil gas sampling, a reconnaissance will be conducted to evaluate the condition of the building slab and identify subsurface utilities, basements, and other structures that may act as preferential vapor migration pathways within the building(s) subject to investigation. The building reconnaissance will include the following tasks:

- Completion of a building survey that identifies building construction and uses.

- Creation of a photograph library that documents current building conditions and potential chemical background sources.

- Identification of potential background chemical sources (i.e., VOCs). A hand-held photoionization detector (PID) may be used to characterize overall VOC concentrations.

- Identification of the heating, ventilation, and cooling system(s) and their operating parameters including the number of units, percent fresh air intake, and flow rates.

- A qualitative assessment of ambient air flows between various areas of the building.

The need for, location and number of subslab soil gas samples will be determined based on the delineation of COCs within the shallow overburden groundwater plume and evaluation of soil gas samples (if utilized). Sub-slab soil gas samples would be collected in either 1-liter or 6-liter SUMMA® canisters for the analysis of site-specific VOCs using USEPA Method TO-15. The list of site-specific VOCs will be identified based on the constituents previously detected in groundwater or soil gas in the vicinity of the structure(s) being investigated. All sub-slab soil gas samples will be collected as temporary points unless soil gas data indicate that more than one round of sampling may be necessary (e.g., soil gas concentrations are higher than screening benchmarks). Under these conditions permanent sampling points may be established to allow for additional sub-slab samples to be collected. Sub-slab soil gas samples will be collected using the SOP for temporary sub-slab sampling points (Appendix B-1-15). If sub-slab soil gas samples are collected from permanent sampling points, the SOP for permanent sub-slab sampling points will be followed instead (Appendix B-1-17). Prior to collecting any samples, a helium test (Appendix B-1-16) will be conducted to ensure the integrity of the seal around the probe point. Once subslab soil gas sampling is completed and prior to closing any temporary sample ports, a pressure differential reading will be collected at each sample location using a micro-manometer. All measurements will be collected consistent with the manufacturer's instructions.

The need for, location and number of indoor air samples will be determined based on the delineation of COCs within the shallow overburden groundwater plume and evaluation of soil gas and/or subslab soil gas sampling. Indoor air samples would be collected within target buildings using 6-liter SUMMA® canisters and analyzed for site-specific VOCs using USEPA Method TO-15. The list of site-specific VOCs will be identified based on the constituents previously detected in either groundwater or soil gas in the vicinity of the structure(s) being investigated. Prior to the collection of indoor air samples, a building inventory will be conducted to identify the presence of items or materials that may produce or emit constituents of concern (i.e., background sources) and therefore contribute to indoor air concentrations. Indoor air samples will be collected from the breathing zone (i.e., 3 to 5 feet above ground surface) from the lowest level of the building (i.e., basement or first floor for slab-on-grade buildings). Samples will be collected for a duration of 24 hours for residential buildings and 8 hours for commercial/industrial buildings. Attempts will be made to collect indoor air samples during the heating season (i.e., November 15 to March 31) because this represents the period of greatest VI potential. Indoor air samples may be collected coincident with sub-slab soil gas samples and multiple sampling events may be employed if indoor air concentrations are above screening benchmarks. The SOP for indoor air sampling is presented in Appendix B-1-18.

3. Sample Quality Assurance/Quality Control Procedures

3.1 Introduction

This section includes methods for sample management and field management that will be used during the RD/RA activities at the SRSNE Site.

3.2 Sample Handling

3.2.1 Sample Designation System

Samples will be identified with a unique designation system that will facilitate sample tracking. The sample designation system to be employed during the sampling activities will be consistent, yet flexible enough to accommodate unforeseen sampling events and conditions. An alpha-numeric system is considered appropriate and will be used by field personnel to assign each sample with a unique sample identification number.

Groundwater Samples from Wells and Piezometers

Multiple groundwater samples will be obtained from monitoring wells and piezometers that are fixed, surveyed, and potentially recurring sampling locations. Groundwater samples will be assigned sample identifications that consist of the well name and sampling date (8 digits). For example, a groundwater sample collected from well MW-903S on May 8, 2010 would be identified as “MW-903S-05082010”.

For groundwater samples collected as part of the HydraSleeve™ investigation, the groundwater sample identification will be the same, except an extension will be added as follows:

- -HS1 for the first HydraSleeve™ sample (i.e., collected prior to low-flow sampling)
- -HS2 for the second HydraSleeve™ sample (collected after low-flow sampling)

Field duplicates, trip blanks, and rinse blanks collected during groundwater sampling will be identified by the sample type, date of collection, and sequential number for the day (in the event more than one type of sample is collected in a given day to meet required QA/QC frequencies). For example:

- DUP-GW-05152010-#2 (i.e., the second blind duplicate for groundwater collected on May 15, 2010)

- TB-05082010-#1 (i.e., the first Trip Blank collected on May 8, 2010)

- RB-GW-05212010-#1 (i.e., the first Rinse Blank for groundwater collected on May 21, 2010)

Additional sample volumes collected for matrix spike (MS) and matrix spike duplicate (MSD) analysis will be noted on the chain of custody forms, and the associated additional sample containers will be labeled with the appropriate suffix (MS or MSD).

Single-Event and Solid-Matrix Samples

Solid matrix samples such as soil and sediment are typically obtained at a single, unique location during one event – repeat sampling of solid matrices at the exact same location is uncommon. Therefore, to clearly identify these sampling locations via sample identifications, the following procedure will be used. This procedure will also apply in the event a groundwater sample is collected from a non-well location (e.g., from a non-well borehole or open excavation) for a site characterization purpose.[3]

The first letter prefix will indicate the area of the site where the sample was collected: Operations Area (O), former Cianci Property (C), railroad right-of-way (R), Town Well Field (W), or other locations on the perimeter of the Study Area (P), followed by sample location ID, followed by two letters indicating the sample type and two digits indicating the sequential sample number collected from the location. The following is an example of the sample ID formula to be followed for the first surface soil sample collected from location “CSB-1” located in the Operations Area: Site Area-sample location ID-sample type-sequential sample number (O-CSB-1-SS-01). Note the sequential number in the sample ID will not apply to groundwater samples.

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[3] Non-well-based groundwater sampling is not presently proposed for any RD/RA purpose, but this provision is included in the event that the need for such sampling is identified in the course of the work.

The samples types will be designated using the following codes:

- Surface Soil – “SS”
- Subsurface Soil – “SB”
- Sediment – “SD”
- Soil Gas – “SG”
- Equipment Blank – “EB”
- Filter Blank – “FB”
- Excavation Bottom – “BT”
- Groundwater – “GW”
- Excavation Sidewall – “ES”
- Rinse Blank – “RB”
- Trip Blank – “TB”

A two-digit sample number beginning with “01” will be assigned in the field to the first sample; subsequent samples will be assigned numbers following in sequence. Where necessary, the code system will be supplemented to accommodate additional sample identification information. For example, the code for soil and sediment samples will include a qualifier to identify the section increment (e.g., 0 to 0.5 feet).

Additional sample volumes collected for matrix spike (MS) and matrix spike duplicate (MSD) analysis will be noted on the chain of custody forms, and the associated additional sample containers will be labeled with the appropriate suffix (MS or MSD).

Rinse blanks will use the same coding scheme noted above for groundwater (e.g., the first rinse blank associated with soil sample collection on May 12, 2010 would be named RB-SS-05122010-#1). Field duplicates will be labeled as ordinary field samples with a unique identification number (e.g., the first field duplicate associated with soil sample collection on May 12, 2010 would be named DUP-SS-05122010-#1). Duplicate samples will not be identified, and the laboratory will analyze them as “blind” quality control samples.

3.2.2 Sample Containers and Preservation

Sample collection, preservation and handling must be in accordance with the analytical method. If preservative is added to the bottles prior to shipment to the field, care must be taken not to overfill the containers. Preservation is required for aqueous samples submitted for VOC (see Appendix B-1-4) or metals analyses. Samples will be handled as described in the Chain of Custody, Handling, Packing and Shipping SOP (Appendix B-1-19).

Table B-4 lists the sample matrices, analytical parameters, required containers and specified preservatives for samples collected for analysis at off-site laboratories.

3.2.3 Sample Packing and Shipping Requirements

All samples must be labeled and packed correctly before transport for laboratory testing. Sample containers will be obtained from the analytical laboratory. Each container will be labeled appropriately with all relevant information, including at a minimum:

- Sample type
- Project number and site name
- Date
- Time
- Sampler's initials
- Sample number

Samples will be stored and shipped in a properly packed container at 4ºC. All samples will be delivered to the laboratory within 48 hours of the time of collection, with the possible exception of some samples collected on Friday or Saturday. In those cases, the samples will be stored at 4ºC and shipped at the earliest allowable time.

3.3 Chain of Custody/Sample Control

A paramount component of data collection is the ability to demonstrate that the samples were obtained from the locations stated and that they reached the laboratory or archive without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal or archive must be properly documented. Documentation will be accomplished through a chain of custody record that documents each sample and identifies the individuals responsible for sample collection, shipment, and receipt, and the analysis that will be completed for each sample. A sample is considered in custody if at least one of the following criteria is met:

- The sample is in a person's actual possession.
- The sample is in unobstructed view, after being in the person's actual possession.
- The sample is locked and only accessible by the custodian after having been in the person's actual possession.
- The sample is in a secured area, restricted to authorized personnel (e.g., laboratory).

A laboratory typically will not accept samples for analysis without a correctly prepared chain of custody form. The chain of custody must be signed by each individual who has had the sample(s) in his/her custody. A chain of custody is to be prepared for each sample shipped to a laboratory for analysis. Information on this form will correlate with other supporting documentation, including sample labels and sample collection logs.

The chain of custody accounts for the elapsed time and custodians of the sample from the time of its collection to the time of receipt by the laboratory. The individuals who have physically handled the sample or witnessed initial sample collection and packaging (e.g., a sample team member) must be identified on the form. A sample team member relinquishes the sample by signing the chain of custody. Individuals who either relinquish or receive samples must include their complete names, company affiliation, and the date and time the samples were relinquished. The times that the samples are relinquished and received by the next custodian should coincide, with the exception of transfer by commercial carriers. Commercial carriers will not be required to sign the chain of custody.

If a sample is to be stored for a period of time (e.g., overnight), measures are to be taken to secure the sample container in a manner that provides only the custodian of record with access. If samples are relinquished to a commercial carrier (i.e., United Parcel Service [UPS], Federal Express, etc.), the carrier waybill number is recorded, and a copy of the waybill is attached to the chain of custody. These documents are maintained with other field documentation. The original chain of custody is sealed inside the shipping container with the samples. If a laboratory- or project-based courier is used, that individual will be required to execute the chain of custody.

If a correction is made to the chain of custody, the correction should be made by the originator of the change, who will draw a single line through the error, initial and date the correction, and, if necessary, provide an explanation of the change. The documentation should have sufficient detail to clearly document the change to a third-party reviewer.

1,4-dioxane, while analyzed by Method 8260C, has a different sample preparation method (5030C) than the other volatiles. Therefore, the COC must indicate the following for groundwater samples that are to be analyzed for 1,4-dioxane:

> “Preparation Method 5030C – lab to adjust pH prior to analysis and provide documentation with the report”

All chain of custody activities will be performed in accordance with the Chain of Custody, Packing, Handling, and Shipping SOP (Appendix B-1-19).

Sample Control

Field personnel are responsible for maintaining control of samples. Samples shall be maintained in the possession of the sampler until transferred to a representative of the laboratory. The date, time and signatures for transfer of sample possession will be documented on the chain of custody.

3.4 Documentation

Field activities and samples must be properly documented during the sampling process. The primary means of documentation is a series of dedicated, project-specific, bound field log books. Additionally, where appropriate, specific activities (e.g., well integrity assessment and groundwater sampling) will be logged on field activity log sheets.

Documentation of field activities provides an accurate and comprehensive record of the work performed sufficient for a technical peer to reconstruct the day's activities and provide certification that all or necessary client, regulatory, contract, and work plan requirements were met. General requirements include:

- Use of bound field books as the primary source for information collection and recording. Field books should be dedicated to the project and appropriately labeled.
- Appropriate header information documented on each page, including project title, project number, date, weather conditions, changes in weather conditions, other persons (if any) in the field party, and author. The specific information requested depends on the nature of work being performed and on the form being used. Information fields that are not applicable should be noted "N/A" or with other appropriate notations.
- Field documentation entries using indelible ink.
- Legible data entries. A single line should be drawn through incorrect entries and the corrected entry should be written next to the original strikeout. Strikeouts are to be initialed and dated by the originator, with an explanation of the change, if necessary.
- Applicable units of measurement with entry values.

- Field records maintained in project files.
- Use of field activity logs, as appropriate, to formally document activities and events as a supplement to bound field books. The field activity log can be a standard or project-specific form. Preprinted standard forms are available for many activities and should be used whenever possible. These forms will provide prompts and request additional information that may be useful and/or needed that the author is not aware of at the time. Example forms are provided in Appendix B-2.

3.4.1 Sample Collection

Sample collection data are documented in a bound field book and/or on a Field Activity Log. Where both are being used, information contained in one is cross-referenced to the other. Entries include:

- Sample identification number, location taken, depth interval, sample media, sample preservative, collection time, and date
- Sample collection method and protocol
- Physical description of the sample (standard classification system for soil will be followed as described in the Appendix B-1-6)
- If a composite sample, the sample's make-up, including number and location of grab samples incorporated
- Quality control-related samples collected (e.g., duplicates, blinds, trip blanks, field blanks)
- Container description and sample volume
- Pertinent technical data, such as pH, conductivity, temperature, and headspace reading
- Pertinent technical comments
- Identification of personnel collecting the sample

3.4.2 Subsurface Logs

Soil borings are to be recorded in bound field books and may be supplemented with prepared forms. Personnel completing the log are to supply the following information:

- Names(s) of personnel logging boring
- Administrative and technical information included in the header
- Types of equipment used (e.g., drill rig type, drilling tools used, backhoe model)
- Subcontractor/driller used
- Descriptions of subsurface materials encountered and the number and type of samples collected, if any
- Subsurface exploration depth and units of measure
- For drilling, length of recovery
- Sample type and sample number for geotechnical or analytical samples collected; these data are also to be entered on the sample collection log (if used) and the sample label
- Classification standard protocol used, if any (e.g., ASTM International [ASTM] Standard Penetration Test [SPT])
- Narrative description of the soil (using standard classification system) and other pertinent information
- Description of consistency of cohesive soils
- Additional data such as (but not limited to) background and sample vapor/gas readings, observation of sheens, presence of NAPL, depth to water (if encountered), odors, and changes in drilling conditions

3.5 Calibration

Calibration will be performed on field parameter probes at the beginning of each day of intended use in accordance with USEPA's *Calibration of Field Instruments* SOP (January 2010; provided as Appendix B-1-20) and the QAPP (Attachment C to the RD POP). Subsequent calibration during the day will be performed, if needed (e.g., if an instrument malfunctions). The calibration will be checked at the end of each day of instrument use to determine if the instrument remained in calibration throughout the day. This check will be performed with the instrument in measurement mode. The standards that will be used to calibrate the instruments will be as follows:

- Turbidity: 0, 1 and 10 NTU calibration solutions

- pH: 4, 7 and 10 buffers
- Specific Conductance: 10 µS/cm and 10 mS/cm calibration solutions
- DO: Zero DO solution
- ORP: Zobell ORP and Light's Solution ORP calibration standards
- Temperature: Comparison to ASTM certified thermometer

Records must be maintained (in the project files of the firm who generated them) for each piece of calibrated measuring and test equipment and each piece of reference equipment. The records must indicate that established calibration procedures have been followed and that the accuracy of reference chemical and radioactive standards has been verified.

Records for periodically calibrated equipment must include the following minimum information:

- Type and identification number of equipment
- Calibration frequency and acceptance tolerances
- Calibration dates
- The individual and organization performing the calibration
- Reference equipment and/or standards used for calibration (listed above)
- Calibration data
- Certificates or statements of calibration provided by manufacturers and external organizations
- Documentation of calibration acceptance or failure and of repair of failed equipment

An individual file folder should be established to maintain records for each piece of measuring and test equipment. Equipment periodic calibration files should contain an equipment calibration and maintenance record, calibration data forms and/or certification of calibration provided by manufacturers or external organizations, and notice of equipment calibration failure.

Measuring and test equipment used for field investigations will typically be calibrated as part of operational use. For this equipment, records of the calibrations or checks will be documented as part of the test data (e.g., in the field notebook or on an appropriate field activity log). Equipment-specific forms may also be developed. These records should include information similar to that required for periodically calibrated equipment. Documentation related to malfunctioning equipment or equipment that fails calibration should also be included in the individual equipment file.

Calibration files for equipment requiring periodic calibration should be sent with equipment that is transferred to allow a continuously updated record to be maintained. Recalibration of sensitive equipment should be performed following the transfer. When measuring and test equipment is rented or leased, procurement documents must specify that a current certificate of calibration must accompany the equipment. This certificate must be maintained with the project documentation calibration records.

3.6 Management of Investigation-Derived Materials and Wastes

3.6.1 Drill Cuttings

Consistent with the field procedures employed during the RI and Feasibility Study (FS; BBL and USEPA 2005), soil and rock cuttings from drilling activities east of the Quinnipiac River will be containerized and transported to the NTCRA 1 Containment Area. These cuttings will be screened with a PID and, if the PID reading is less than 5 ppm above background, they will be spread over the ground inside the NTCRA 1 sheet pile wall. Drill cuttings from locations west of the Quinnipiac River will be screened with a PID at the drilling location and, if the PID reading is less than 5 ppm above background, the cuttings will be spread over the ground adjacent to the drilling location. Drill cuttings that exhibit a PID reading higher than 5 ppm over background will be containerized and transported to the NTCRA 1 Containment Area for additional screening, and characterization, as needed. Depending on the status of the work, such materials may also be temporarily staged in the Operations Area for subsequent use as grading/fill as part of the pre-ISTR preparation activities or subgrade preparation for the RCRA C cap. Containers used to transport and store drill cuttings will be labeled in terms of contents, location and date filled (Appendix B-1-21).

Background for drill cuttings will be obtained by measuring the organic vapor concentration of clean air, upwind from the drilling location using the calibrated PID, prior to PID screening of soils produced from the boreholes.

3.6.2 Water from Drilling Activities

Groundwater generated during bedrock drilling and packer testing east of the Quinnipiac River, or west of the river within the estimated VOC regulatory plume above drinking water standards in bedrock, will be containerized and transported to the existing on-site groundwater treatment system (the HCTS). After allowing sediment to settle, the drilling and packer-test purge water from these locations will be processed through the HCTS.

Drilling water and packer-test purge water generated at bedrock drilling locations that do not meet these criteria will be discharged to ground surface at the drilling location.

3.6.3 NAPL

NAPL will be containerized and temporarily stored on site pending proper off-site disposal.

3.6.4 Disposable Equipment and Debris

Disposable equipment and debris, such as health and safety equipment, polyethylene plastic sheeting, sampling equipment, and other equipment and/or sampling debris not reused in the investigation, will be collected in plastic bags during the sampling events and then placed into appropriately-labeled containers and temporarily stored in a secure on-site area pending proper disposal.

3.6.5 Groundwater from New Wells

Groundwater produced during development, specific capacity testing, and purging and sampling at all new wells where prior sampling data are not available will be containerized and transferred to the HCTS for treatment. After allowing sediment to settle, the water from these locations will be treated using the HCTS.

3.6.6 Groundwater from Pre-Existing Wells

Groundwater produced during redevelopment (to remove accumulated silt from wells to be sampled) and sampling of all wells where the most recent sampling indicated Maximum Contaminant Level (MCL) exceedances will be containerized and transferred to the HCTS for treatment. After allowing sediment to settle, the water will be treated by the treatment system.

Groundwater from the remaining pre-existing wells (i.e., those with no MCL exceedances in the most recent sampling round) will be decanted at ground surface adjacent to the well.

3.7 Equipment Decontamination

To ensure accurate sampling and to minimize cross-contamination from one sample location to the next, proper decontamination techniques must be followed in the field. These techniques apply to small sampling equipment, heavy-drilling and field-dedicated equipment, disposable equipment, and personal protective clothing and personal protective equipment (PPE). Different techniques apply to different types of equipment.

Reusable equipment, such as personal protective clothing, must be washed with non-phosphate detergent and rinsed with tap water.

Decontamination of small sampling equipment such as spoons, bowls, and mixing devices will be performed in accordance with the Field Equipment Cleaning SOP (Appendix B-1-22). For small sampling equipment, the following decontamination procedure will be followed:

- Wash with non-phosphate detergent
- Rinse with tap water
- Rinse with deionized water
- Allow to air dry

Field sampling equipment will not be decontaminated with solvents (e.g., methanol) unless free-phase petroleum product comes in contact with the equipment. If this occurs, a methanol rinse step will be added after the tap water rinse. Citra-Solve®, or a similar cleaning solution, is a suitable alternate for cleaning equipment surfaces impacted by petroleum-based NAPL.

Decontamination for drilling equipment such as drill rigs, well casings, and auger flights will follow the Heavy Equipment Cleaning SOP (Appendix B-1-23). These pieces of equipment could contain potential sources of interference to environmental samples. The sampling equipment may have come in contact with the materials adjacent to the matrix being sampled or media may be attached to the actual sampling equipment. Heavy equipment may also retain contaminants from other sources such as roadways and storage areas or material from previous job sites that was not adequately removed. For these reasons, it is important that the sampling equipment be cleaned prior to use.

Two methods are used for cleaning heavy equipment: steam cleaning and manual scrubbing. Steam cleaning can remove visible debris. Since steam cleaners provide a high-pressure medium, they are very effective for solids removal. They are also easy to handle and generate low volumes of wash solutions. A second method involves manual scrubbing of equipment using brushes. This procedure can be as effective as steam cleaning and is preferred in situations where steam cleaning fails to remove visible materials. Disadvantages to manual scrubbing are that it is labor-intensive and generates large volumes of wash and rinse solutions.

Heavy equipment will be thoroughly steam-cleaned or manually scrubbed upon arrival and when moved between sampling locations. Drill rig items (e.g., auger flights, drill rods, and drill bits) will be cleaned before changing sample locations (Appendix B-1-23).

Water generated by equipment cleaning activities will be containerized using decontamination pads and treated by the HCTS. The decontamination pad waste plastic will be collected in plastic bags and placed into appropriately-labeled containers and temporarily stored in a secure on-site area pending proper disposal.

<u>Field QA/QC Requirements</u>

Field QA/QC will include field duplicate samples, MS/MSD samples, and rinse blank samples. Field duplicate samples and MS/MSD samples will be collected on a frequency of 1:20 samples. Trip blanks will also be included with every cooler that contains samples subject to VOC analysis. Refer to the QAPP (Attachment C to the RD POP) for a complete list of QA/QC sampling methods.

3.8 Corrective Measures

Corrective actions are required when field or analytical data are not within the objectives specified in the QAPP. Corrective actions include procedures to promptly investigate, document, evaluate, and correct data collection and/or analytical procedures. Field corrective action procedures for the actions are described below.

When conducting the field work, if a condition is noted by the field crew that would have an adverse effect on data quality, corrective action will be taken so as not to repeat this condition. In addition, sample collection will be repeated in the event that the action jeopardized the sample quality or integrity. Condition identification, cause, and corrective action implemented by the Field Manager or a designee will be documented in the project file and reported to the appropriate ARCADIS Task Manager, the Project Manager, and the Project Coordinator.

Examples of situations that would require corrective actions are provided below:

- Protocols as defined by the QAPP have not been followed.
- Equipment is not in proper working order or is not properly calibrated.
- QC requirements have not been met.
- Issues resulting from performance or systems audits have not been resolved.

Project personnel will continuously monitor ongoing work performance in the normal course of daily responsibilities.

4. References

BBL. 1998. *Remedial Investigation Report*. June 1998.

BBL and USEPA. 2005. *Feasibility Study Report*. Solvents Recovery Service of New England, Inc. Superfund Site, Southington, Connecticut. May 2005.

CTDEP. 2006. RSRs, Fundamental Review, CTLEP-005 (rev.). March 2006.

Handex. 2001. *Groundwater Containment and Treatment System Operations Plan*. October 2001.

Parsons, 2005. *Results Report for the Demonstration of No-Purge Groundwater Sampling Devices at Former McClellan Air Force Base, California*. October 2005.

USEPA. 2005. Record of Decision Summary, Solvents Recovery Service of New England, Inc. (SRSNE) Site, Southington, Connecticut. September 2005.

Weather Underground. 2009. Yearly Summary for 2009 – Southington, CT. http://www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=MC7403&day=12&year=2009&month=2&graphspan=year. 2009.

World Health Organization. 2005. The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds. June 2005.

ARCADIS

Tables

Table B-1.
List of Standard Operating Procedures
SRSNE Superfund Site, Southington, CT

Appendix B-1 Reference	SOP	SOP #
B-1-1	Monitoring Well Integrity Survey	SOP #298782
B-1-2	Monitoring Well Installation	SOP #1723199
B-1-3	Soil Drilling and Sample Collection	SOP #3153199
B-1-4	Extraction/Preservation of Soil/Sediment for VOCs	SOP #2853199
B-1-5	DNAPL Contingency Plan	SOP #1593199
B-1-6	Soil Description	SOP #00188782
B-1-7	Groundwater Sampling Using HydroPunch™	SOP #1834199
B-1-8	Specific Capacity Testing and Data Reduction	SOP #1793199
B-1-9	Monitoring Well Development	SOP #1713199
B-1-10	Groundwater Purging and Sampling Procedures for Monitoring Wells and Piezometers	SOP #2003199
B-1-11	Groundwater Sampling with HydraSleeves™	SOP #1098782
B-1-12	Down-Hole Groundwater Field Parameter Measurement	SOP #1343199
B-1-13	Water-Level and NAPL Thickness Measurement Procedures	SOP #1643199
B-1-14	Surface and Subsurface Soil Sampling using Manual Methods	SOP #3053199
B-1-15	Sub-Slab Soil Gas Sampling - Temporary Points	SOP #427199
B-1-16	Administering Helium Tracer Gas for Leak Checks of Soil Gas or Sub-Slab Sampling Points	SOP #416199
B-1-17	Sub-Slab Soil Gas Sampling and Analysis Method TO-15 - Permanent Probe	SOP #425199
B-1-18	Indoor Air Sampling Analysis Method TO-15	SOP #765199
B-1-19	Chain of Custody, Handling, Packing, and Shipping	SOP #1663199
B-1-20	Draft Calibration of Field Instruments (USEPA 2010)	--
B-1-21	Investigation-Derived Waste Handling and Storage	SOP #1523199
B-1-22	Field Equipment Decontamination	SOP #1613199
B-1-23	Heavy Equipment Decontamination	SOP #1623199

Table B-2.
Well Construction Information and Network Modifications
SRSNE Superfund Site, Southington, CT

Location	Easting (X)	Northing (Y)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Well Fm.	NTCRA 1 Area (N)	Bkgd. Metals and MNA (M)	Bkgd. Metals (B)	Routine Plume Monitoring (R)	Compreh. Rounds Only (C)	WL Only (W)	Install	Dormant (Retain)	Abandon (X)	Targeted Sampling Depth (ft bgs)
CPZ-1	565212	286107	4.6	19.6	O					1					12.1
CPZ-2	565216	286045	9.6	19.6	O								1		14.6
CPZ-3	565290	286163	9.2	24.2	O					1					16.7
CPZ-4	565322	286092	8.7	23.7	O								1		16.2
CPZ-5	565376	286312	9.1	24.1	O					1					16.6
CPZ-6	565480	286325	10.2	25.2	O					1					17.7
CPZ-7	565343	286467	3.9	23.9	O					1					13.9
CPZ-8	565397	286529	10.5	20.5	O					1					15.5
CPZ-9	565229	286575	9.7	19.7	O									1	14.7
CPZ-10	565237	286643	9.1	19.1	O					1					14.1
CPZ-1R	565209	286103	41.1	61.1	R					1					51.1
CPZ-2R	565217	286039	40.1	60.1	R					1					50.1
CPZ-3R	565286	286158	43.2	63.2	R					1					53.2
CPZ-4R	565322	286085	45.9	65.9	R					1					55.9
CPZ-5R	565374	286319	42.0	62.0	R					1					52.0
CPZ-6R	565480	286318	50.1	70.1	R					1					60.1
CPZ-7R	565338	286472	41.0	61.0	R					1					51.0
CPZ-8R	565395	286533	41.7	61.7	R				1						51.7
CPZ-9R	565244	286575	34.2	54.2	R									1	44.2
CPZ-10R	565233	286642	40.3	60.3	R					1					50.3
CPZ-2A	565219	286090	7.3	22.3	O					1					14.8
CPZ-4A	565300	286147	8.3	23.3	O				1						15.8
CPZ-6A	565396	286321	9.1	24.1	O					1					16.6
CW-1-78	565213	285075	35.0	40.0	O						1				37.5
CW-2-78	565073	285036	22.0	27.0	O								1		24.5
CW-3-75	565678	285115	27.5	32.5	O								1		30.0
CW-3-78	565162	284652	15.0	20.0	O								1		17.5
CW-4-75	565312	285355	30.0	35.0	O						1				32.5
CW-4-78	565155	284650	55.0	60.0	O								1		57.5
CW-5-75	565286	285030	32.0	37.0	O								1		34.5
CW-5-78	565251	284543	67.0	72.0	O								1		69.5
CW-6-75	565222	284832	40.0	45.0	O								1		42.5
CW-6-78	565396	284625	78.0	83.0	O								1		80.5
CW-B-77	565310	285711	18.0	23.0	O						1				20.5
DN-3	565128	286040	8.8	21.8	O					1					15.3
DP-1	565620	286146	0.6	3.1	O								1		1.8
DP-2	565597	286323	1.5	6.5	O								1		4.0
DP-3	565578	286481	1.2	6.2	O								1		3.7

See Notes on Page 7.

Table B-2.
Well Construction Information and Network Modifications
SRSNE Superfund Site, Southington, CT

Location	Easting (X)	Northing (Y)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Well Fm.	NTCRA 1 Area (N)	Bkgd. Metals and MNA (M)	Bkgd. Metals (B)	Routine Plume Monitoring (R)	Compreh. Rounds Only (C)	WL Only (W)	Install	Dormant (Retain)	Abandon (X)	Targeted Sampling Depth (ft bgs)
DP-4	565524	286655	1.2	6.2	O								1		3.7
DP-5	565602	287100	1.2	6.2	O								1		3.7
DP-6	565599	286886	0.9	5.9	O								1		3.4
DP-7	565520	286887	2.1	7.1	O								1		4.6
DP-8	565523	287085	7.1	12.1	O								1		9.6
MW-01	565281	285950	23.5	48.5	OR									1	36.0
MW-02	565307	285338	39.0	69.0	OR									1	54.0
MW-03	565509	285065	52.5	82.5	O				1						67.5
MW-04	565622	285470	46.0	76.0	OR									1	61.0
MW-05	565651	286030	66.5	76.5	R					1					71.5
MW-06	565660	286017	24.0	64.0	O								1		44.0
MW-07	565646	286028	14.5	44.5	O								1		29.5
MW-08	565654	286015	5.0	25.0	O								1		15.0
MW-121A	565539	285834	74.0	95.0	R					1					84.5
MW-121B	565532	285817	42.0	52.0	O				1						47.0
MW-121C	565535	285826	58.7	68.7	R				1						63.7
MW-121M	565540	285810	21.0	31.0	O				1			1			26.0
MW-123A	565280	286128	55.0	85.0	R								1		70.0
MW-123C	565274	286126	10.0	15.0	O								1		12.5
MW-124C	565238	285852	35.9	45.9	R				1						40.9
MW-125A	565403	286393	60.0	65.0	R								1		62.5
MW-125C	565402	286382	40.5	50.5	R					1					45.5
MW-126B	565124	287008	7.5	12.5	O		1								10.0
MW-126C	565123	287011	24.0	34.0	R			1							29.0
MW-127B	565403	285087	37.0	47.0	O					1					42.0
MW-127C	565404	285081	91.5	101.5	R				1						96.5
MW-128	565211	285319	55.0	65.0	R					1					60.0
MW-129	563866	286975	13.9	23.9	R								1		18.9
MW-201A	565732	287690	54.0	64.0	R								1		59.0
MW-201B	565737	287694	10.0	20.0	O								1		15.0
MW-202A	566031	287225	119.0	129.0	R						1				124.0
MW-202B	566037	287225	82.5	92.5	O						1				87.5
MW-203A	566355	285360	150.0	160.0	R								1		155.0
MW-203B	566351	285359	95.0	105.0	O								1		100.0
MW-204A	565669	285566	89.0	114.0	R					1					101.5
MW-204B	565652	285569	68.0	78.0	O					1					73.0
MW-205A	565559	284997	123.5	133.5	R						1				128.5
MW-205B	565551	284992	39.0	49.0	O					1					44.0

See Notes on Page 7.

Table B-2.
Well Construction Information and Network Modifications
SRSNE Superfund Site, Southington, CT

Location	Easting (X)	Northing (Y)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Well Fm.	NTCRA 1 Area (N)	Bkgd. Metals and MNA (M)	Bkgd. Metals (B)	Routine Plume Monitoring (R)	Compreh. Rounds Only (C)	WL Only (W)	Install	Dormant (Retain)	Abandon (X)	Targeted Sampling Depth (ft bgs)
MW-206A	565732	284158	115.5	125.5	R								1		120.5
MW-206B	565726	284159	79.0	89.0	O								1		84.0
MW-207A	565484	284175	103.0	113.0	R								1		108.0
MW-208A	565678	283622	111.0	121.0	R								1		116.0
MW-209A	564582	286263	18.0	38.0	R			1							28.0
MW-209B	564582	286258	12.0	15.0	O			1							13.5
MW-408	565318	286324	31.6	51.2	R									1	41.4
MW-409	565320	286332	6.7	16.3	O									1	11.5
MW-410	565305	286329	7.1	11.7	O									1	9.4
MW-411	565299	286341	31.3	50.9	R									1	41.1
MW-412	565302	286335	16.0	21.0	O									1	18.5
MW-413	565278	286350	14.8	19.8	O	1									17.3
MW-414	565273	286339	30.2	49.8	R									1	40.0
MW-415	565275	286346	6.8	11.8	O	1									9.3
MW-416	565264	286291	29.4	49.4	R	1									39.4
MW-501A	565838	286346	86.0	91.0	R					1					88.5
MW-501B	565837	286343	55.0	65.0	O					1					60.0
MW-501C	565838	286350	20.0	30.0	O					1					25.0
MW-502	565495	286270	15.0	35.0	O				1						25.0
MW-701DR	564579	286254	93.3	107.8	R		1								100.6
MW-702DR	564912	286075	80.3	110.3	R						1				95.3
MW-703D	565300	285097	74.0	84.0	O					1					79.0
MW-703DR	565299	285073	144.3	174.3	R					1					159.3
MW-703S	565299	285087	25.0	35.0	O					1					30.0
MW-704D	565540	285591	53.0	63.0	O				1						58.0
MW-704DR	565552	285565	102.0	132.0	R				1						117.0
MW-704M	565557	285574	37.0	47.0	O				1						42.0
MW-704R	565568	285583	79.0	89.0	R					1					84.0
MW-704S	565557	285583	4.0	19.0	O					1					11.5
MW-705D	565421	286754	25.0	35.0	O					1					30.0
MW-705DR	565429	286750	90.0	100.0	R				1						95.0
MW-705R	565422	286744	44.0	54.0	R					1					49.0
MW-706DR	565668	286216	116.5	126.5	R				1						121.5
MW-707D	565599	285102	84.9	94.9	O					1					89.9
MW-707DR	565567	285124	162.0	192.0	R				1						177.0
MW-707M	565605	285109	58.0	68.0	O					1					63.0
MW-707R	565599	285115	115.0	125.0	R					1					120.0
MW-707S	565608	285116	20.0	30.0	O					1					25.0

See Notes on Page 7.

Table B-2.
Well Construction Information and Network Modifications
SRSNE Superfund Site, Southington, CT

Location	Easting (X)	Northing (Y)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Well Fm.	NTCRA 1 Area (N)	Bkgd. Metals and MNA (M)	Bkgd. Metals (B)	Routine Plume Monitoring (R)	Compreh. Rounds Only (C)	WL Only (W)	Install	Dormant (Retain)	Abandon (X)	Targeted Sampling Depth (ft bgs)
MW-708S	566241	286418	83	93	O						1				88.0
MW-708M	566245	286405	116	126	O						1				121.0
MW-708R	566254	286408	179.4	189.4	R						1				184.4
MW-708DR	566251	286424	236.1	266.1	R						1				251.1
MW-709R	565403	287092	50	70	R					1					60.0
MW-709DR	565403	287092	120	134	R					1					127.0
MW-710S	566112	284847	32.2	42.2	O						1				37.2
MW-710R	566110	284836	133.5	143.5	R					1					138.5
MW-710DR	566113	284857	186.5	206.5	R					1					196.5
MW-801S	565124	285425	8.0	18.0	O						1				13.0
MW-801R	565126	285430	35.0	45.0	R						1				40.0
MW-901D	564832	286257	8	13	O		1					1			10.5
MW-901R	564831	286263	25	40	R		1					1			32.5
MW-902M	565213	286256	12.5	17.5	O	1						1			15.0
MW-902D	565215	286258	19	24	O	1						1			21.5
MW-903S	565732	286084	19	29	O					1		1			24.0
MW-903M	565838	285910	70.6	80.6	O					1		1			75.6
MW-903D	565844	285903	93	103	O					1		1			98.0
MW-903R or DR	565850	285890	180	195	R					1		1			TBD
PZ-903R or DR	565850	285890	130	145	R						1	1			TBD
MW-904S	565785	286237	5	15	O					1		1			10.0
MW-904D	565848	286365	69	79	O					1		1			74.0
MW-905M	565262	285851	17	26	O					1		1			21.5
MW-906M	565710	286741	30	40	O					1		1			TBD
MW-906D	565708	286745	50	60	O					1		1			TBD
MW-906R or DR	565706	286743	165	180	R					1		1			TBD
PZ-906R or DR	565706	286743	98	113	R						1	1			TBD
MW-907M	565540	285997	28.1	38.1	O				1			1			33.1
MW-907D	565548	285990	40	50	O				1			1			45.0
MW-907DR	565530	285980	159	174	R				1			1			166.5
PZ-907R	565530	285980	108	123	R						1	1			115.5
MW-908D	565300	286107	24.9	29.9	O					1		1			27.4
MW-909D	565347	286539	22.7	27.7	O					1		1			25.2
MWD-601	565228	286572	21.4	26.4	O									1	23.9
MWL-301	565261	286598	1.0	11.0	O									1	6.0
MWL-302	565359	286603	1.0	11.0	O								1		6.0
MWL-303	565457	286604	1.0	11.0	O					1					6.0
MWL-304	565265	286466	1.0	11.0	O	1									6.0
MWL-305	565354	286450	1.0	11.0	O								1		6.0
MWL-306	565502	286450	1.0	11.0	O								1		6.0
MWL-307	565259	286297	1.0	11.0	O	1									6.0

See Notes on Page 7.

Table B-2.
Well Construction Information and Network Modifications
SRSNE Superfund Site, Southington, CT

Location	Easting (X)	Northing (Y)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Well Fm.	NTCRA 1 Area (N)	Bkgd. Metals and MNA (M)	Bkgd. Metals (B)	Routine Plume Monitoring (R)	Compreh. Rounds Only (C)	WL Only (W)	Install	Dormant (Retain)	Abandon (X)	Targeted Sampling Depth (ft bgs)
MWL-308	565354	286304	1.0	11.0	O								1		6.0
MWL-309	565505	286302	1.0	11.0	O				1						6.0
MWL-310	565251	286147	0.5	10.5	O									1	5.5
MWL-311	565351	286149	1.0	11.0	O								1		6.0
MWL-312	565509	286154	1.0	11.0	O					1					6.0
MWL-313	565352	285992	1.0	11.0	O					1					6.0
MWL-314	565502	286001	1.0	11.0	O						1				6.0
P-10	565316	286803	9.0	14.0	O								1		11.5
P-101A	565674	286226	66.0	96.0	R					1					81.0
P-101B	565675	286232	34.0	44.0	O				1						39.0
P-101C	565676	286238	3.0	13.0	O				1						8.0
P-102A	565702	286458	81.0	91.0	R					1					86.0
P-102B	565702	286465	29.0	39.0	O					1					34.0
P-102C	565702	286472	3.0	13.0	O					1					8.0
P-11A	565583	286220	58.0	68.0	R				1						63.0
P-11B	565583	286220	9.0	14.0	O					1					11.5
P-12	565321	287115	9.0	14.0	O		1								11.5
P-12A	565321	287105	30.0	50.0	R								1		40.0
P-13	565242	285851	4.9	14.9	O				1						9.9
P-14	565582	286212	79.0	89.0	R								1		84.0
P-15	564917	285631	24.0	34.0	R									1	29.0
P-16	565129	286518	7.5	12.5	O									1	10.0
P-1A	565124	286367	26.0	36.0	R									1	31.0
P-1B	565125	286372	10.8	15.8	O									1	13.3
P-2A	565118	286221	22.0	32.0	R									1	27.0
P-2B	565116	286223	11.0	16.0	O									1	13.5
P-3A	565576	286459	54.5	64.5	R					1					59.5
P-3B	565570	286457	13.0	17.0	O					1					15.0
P-4A	565008	286294	20.0	30.0	R									1	25.0
P-4B	565011	286294	9.8	14.8	O									1	12.3
P-5A	565394	286291	42.5	52.5	R								1		47.5
P-5B	565391	286283	4.0	9.0	O					1					6.5
P-6	565500	286294	47.5	57.5	R					1					52.5
P-7	565439	286805	11.5	16.5	O								1		14.0
P-8	564918	286064	14.9	19.9	O						1				17.4
P-8A	564921	286067	58.0	70.0	R						1				64.0
P-9	565412	286584	8.0	13.0	O								1		10.5
PW-406	565291	286337	29.8	49.8	R									1	39.8

See Notes on Page 7.

Table B-2.
Well Construction Information and Network Modifications
SRSNE Superfund Site, Southington, CT

Location	Easting (X)	Northing (Y)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Well Fm.	NTCRA 1 Area (N)	Bkgd. Metals and MNA (M)	Bkgd. Metals (B)	Routine Plume Monitoring (R)	Compreh. Rounds Only (C)	WL Only (W)	Install	Dormant (Retain)	Abandon (X)	Targeted Sampling Depth (ft bgs)
PW-407	565291	286331	5.7	17.7	O									1	11.7
PZO-1	565335	286384	11.0	16.0	O									1	13.5
PZO-2	565351	286370	11.0	16.0	O									1	13.5
PZO-2D	565578	285340	75.0	85.0	O				1						80.0
PZO-2M	565586	285328	46.0	56.0	O				1						51.0
PZO-3	565313	286507	12.6	17.6	O									1	15.1
PZO-3D	565726	285210	88.0	98.0	O					1					93.0
PZO-3M	565736	285211	46.0	56.0	O					1					51.0
PZO-4	565395	286243	12.5	17.5	O									1	15.0
PZO-4M	565369	285471	29	39	O					1		1			34.0
PZO-4D	565367	285473	46	56	O					1		1			51.0
PZO-5	564621	287042	7.7	12.7	O								1		10.2
PZO-6	564176	285978	5.6	9.6	O								1		7.6
PZO-6S	565487	285569	12.0	22.0	O								1		17.0
PZO-7	564951	286483	4.1	6.1	O									1	5.1
PZO-121S	565547	285820	1.7	11.7	O						1				6.7
PZO-204M	565658	285562	45.7	55.7	O					1					50.7
PZO-204S	565649	285565	2.7	12.7	O								1		7.7
PZR-1	565331	286383	29.5	34.5	R									1	32.0
PZR-1R*	565722	285404	103.0	123.0	R						1				113.0
PZR-2	565349	286365	29.0	34.0	R									1	31.5
PZR-2DR*	565579	285319	184.0	204.0	R					1					194.0
PZR-2R*	565562	285330	120.5	140.5	R				1						130.5
PZR-3	565264	286622	30.0	35.0	R									1	32.5
PZR-3R*	565745	285220	120.3	140.3	R					1					130.3
PZR-4	565355	286289	33.0	38.0	R									1	35.5
PZR-4R*	565369	285471	69.7	89.7	R					1					79.7
PZR-4DR*	565388	285464	135.0	155.0	R					1					145.0
PZR-5	564616	287042	31.2	46.2	R								1		38.7
PZR-5R*	565280	285532	53.0	73.0	R					1					63.0
PZR-6	564177	285975	27.3	42.3	R								1		34.8
PZR-7	564948	286483	26.8	41.8	R									1	34.3
RW-1	565265	286133	14.5	27	O						1				20.8
RW-1R*	565571	285561	82	172	R						1				127.0
RW-2	565377	286288	19	31.5	O						1				25.3
RW-3	565365	286384	18	28	O						1				23.0
RW-4	565314	286498	9.9	21	O						1				15.5
RW-5	565250	286570	10.21	20.21	O									1	15.2

See Notes on Page 7.

Table B-2.
Well Construction Information and Network Modifications
SRSNE Superfund Site, Southington, CT

Location	Easting (X)	Northing (Y)	Screen Top Depth (feet bgs)	Screen Bottom Depth (feet bgs)	Well Fm.	NTCRA 1 Area (N)	Bkgd. Metals and MNA (M)	Bkgd. Metals (B)	Routine Plume Monitoring (R)	Compreh. Rounds Only (C)	WL Only (W)	Install	Dormant (Retain)	Abandon (X)	Targeted Sampling Depth (ft bgs)
RW-6	565225	286413	10.14	20.14	O						1				15.1
RW-7	565223	286113	8.58	18.58	O						1				13.6
RW-8	565304	286179	11	26	O						1				18.5
RW-9	565344	286238	10.81	30.81	O						1				20.8
RW-10	565370	286333	8.27	33.27	O						1				20.8
RW-11	565354	286446	8.84	23.84	O						1				16.3
RW-12	565281	286161	12.5	27.5	O						1				20.0
RW-13	565560	285602	35	75	O						1				55.0
RW-14	565534	285573	31	71	O						1				51.0
SRS-1	565194	285871	17	22	O					1					19.5
SRS-2	565200	285871	5.5	10.5	O								1		8.0
SRS-3	565394	285864	31	41	O					1					36.0
SRS-4	565392	285868	5	15	O								1		10.0
SRS-5	565530	285997	7	37	O								1		22.0
SRS-6	565578	286010	30.09	69.84	O								1		50.0
TW-07A	565393	286384	15.8	25.8	O								1		20.8
TW-08A	565213	286406	4	14	O	1									9.0
TW-08B	565213	286406	21.5	31.5	R	1									26.5
TW-08D	565213	286406	17	22	O	1						1			19.5
TW-09	564984	286593	19.5	29.5	R									1	24.5
TW-10	564882	286403	25.5	35.5	R									1	30.5
TW-11	565282	285956	5.5	15.5	O								1		10.5
WE-1	565220	286787	27	41.5	R								1		34.3
WE-2	565220	286808	3	13.5	O								1		8.3
WE-3	565140	286142	28	31	R									1	29.5
WE-5	565139	286144	1.5	11.5	O									1	6.5
WE-6	564936	286481	4.8	5.8	R									1	5.3
						10	5	3	26	80	36	26	58	40	
						Total Wells Proposed for Sampling:					124				

Notes:
1) Shading indicates proposed wells, installation locations and depth intervals are estimates only, and will be verified in the field based on actual geologic conditions, water table depth, and/or site accessibility constraints.
2) Fm. = Formation
OVB = overburden
TOR = top of rock
MW = monitoring well
WL = water level
bgs = below ground surface
TBD = to be determined
3) Wells listed as "Dormant" are not currently proposed for monitoring during the RD/RA Program, but will be retained for potential future use (as appropriate).
4) Targeted sampling depths at the proposed monitoring wells will be the midpoint of the screened interval; specific depths to be determined based on final well construction details.

Table B-3.
Groundwater Monitoring Network and Sampling Events
SRSNE Superfund Site, Southington, CT

Well Group	# Wells	Sampling Period	Sampling Frequency	Analytical Parameters
"C" wells	80	first comprehensive event	1 event	VOCs, alcohols, 1,4-dioxane, TAL metals, PAHs, PCBs
"R" wells	26			VOCs, alcohols, 1,4-dioxane, TAL metals, PAHs, PCBs, MNA parameters
"N" wells	10			VOCs, alcohols, 1,4-dioxane, TAL metals, PAHs, PCBs, MNA parameters
"M" wells	5			TAL metals, MNA parameters (background)
"B" wells	3			TAL metals (background)
"C" wells	80	subsequent comprehensive events	every 5 years	VOCs, 1,4-dioxane, TAL metals
"R" wells	26			VOCs, 1,4-dioxane, TAL metals, MNA parameters
"N" wells	10			VOCs, 1,4-dioxane, TAL metals, MNA parameters
"M" wells	5			TAL metals, MNA parameters
"B" wells	3			TAL metals
"R" wells	26	after first comprehensive event	annual	VOCs
			biennial	MNA parameters
"M" wells	5	after first comprehensive event	annual	TAL metals (background)
			biennial	MNA parameters (background)
"B" wells	3	after first comprehensive event	annual	TAL metals (background)
"N" wells - overburden	8	before thermal treatment	biennial	VOCs, MNA parameters
		during thermal treatment	annual	VOCs, MNA parameters
		after thermal, before equilibrium	3x / year	VOCs, MNA parameters
		after equilibrium	annual	VOCs
			biennial	MNA parameters
"N" wells - bedrock	2	before thermal treatment	annual	VOCs, MNA parameters
		during thermal treatment	annual	VOCs, MNA parameters
		after thermal, before equilibrium	3x / year	VOCs, MNA parameters
		after equilibrium	annual	VOCs
			biennial	MNA parameters
"W" wells	36	all comprehensive events	every 5 years	Water levels only - during all comprehensive events

Notes:
1) biennial = once every two years.
VOCs = Volatile Organic Compounds.
TAL = Target Analyte List.
PAHs = Polycyclic Aromatic Hydrocarbons.
PCBs = Polychlorinated Biphenyls.
MNA = Monitored Natural Attenuation.

Table B-4.
Sample Containers, Preservation and Holding Times
SRSNE Superfund Site, Southington, CT

Parameter	Analytical and Preparation Method[9]/SOP Reference	Method[9]	Bottle Type[6]	Minimum Required Sample Volume[7]	Preservation	Holding Time[5]
Groundwater; Initial Comprehensive Sampling						
VOCs	SW846 8260B/TACT-1	8260B [2]	2 x 40-ml glass vials	NA [8]	HCl to pH<2, Cool to 4°C±2°C	14 days to analysis
1,4-Dioxane	SW846 8260B/TAT-24	8260B [2]	2 x 40-ml glass vials	NA [8]	Cool to 4°C±2°C	7 days to analysis
SVOCs	SW846 8270/TACT-2, TACT-4	8270 [2]	2 x 1-L amber glass bottles with Teflon®-lined lid	NA [8]	Cool to 4°C±2°C	7 days to extraction 40 days to analysis
PCB	SW846 8082/TACT-6, TACT-7	8082 [2]	2 x 1-L amber glass bottles with Teflon®-lined lid	NA [8]	Cool to 4°C±2°C	7 days to extraction 40 days to analysis
Alcohols	SW846 8015/TAW-9	8015 [2]	2 x 40-ml glass vials	NA [8]	Cool to 4°C±2°C	14 days to analysis
Dissolved Gases	AM20GAx/MS-5	AM20GAx	2 x 40-ml glass vials	NA [8]	Trisodium Phosphate, Cool to 4°C±2°C	14 days to analysis
TAL Metals - Total	SW846 6010/7470/TACT-10, TACT-11 and TACT-13	6010/7470 [2]	1 x 500ml plastic bottle	NA [8]	HNO_3 to pH<2	180 days to analysis
						Mercury - 28 days to analysis
TAL Metals - Dissolved	SW846 6010/7470/TACT-10, TACT-11 and TACT-13	6010/7470 [2]	1 x 500ml plastic bottle		HNO_3 to pH<2 after field filtering	180 days to analysis
						Mercury - 28 days to analysis
Alkalinity	SM2320B/TACT-16	SM2320B [3]	1 x 1-L plastic bottle	NA [8]	Cool to 4°C±2°C	14 days to analysis
Chloride	EPA 300.0/TACT-15	300.0 [1]		NA [8]		28 days to analysis
Sulfate						28 days to analysis
Nitrate-N						48 hours to analysis
Nitrite-N						48 hours to analysis
Sulfide	SM4500 S2D/TAN-18	SM4500 S2D [3]	1 x 125 ml plastic bottle	NA [8]	Zinc acetate + NaOH pH>9	7 days to analysis
Dissolved Iron & Manganese	SW846 6010/TACT-10, TACT-11	6010 [2]	1 x 125 ml plastic bottle	NA [8]	HNO_3 to pH<2 after field filtering	180 days to analysis
TOC	SW846 9060/TACT-20	9060 [2]	2 x 40-ml glass vials	NA [8]	H_2SO_4 to pH<2, Cool to 4°C	28 days to analysis
Groundwater; Pre-Thermal and Post-Thermal Treatment						
VOCs	SW846 8260B/TACT-1	8260B [2]	2 x 40-ml glass vials	80 ml	HCl to pH<2, Cool to 4°C±2°C	14 days to analysis
Dissolved Gases	AM20GAx/MS-5	AM20GAx	1 x 40-ml glass vial	40 ml	Trisodium Phosphate, Cool to 4°C±2°C	14 days to analysis
Alkalinity	SM2320B/TACT-16	SM2320B [3]	1 x 125 ml plastic bottle	75 ml	Cool to 4°C±2°C	14 days to analysis
Chloride	EPA 300.0/TACT-15	300.0 [1]				28 days to analysis
Sulfate						28 days to analysis
Nitrate-N						48 hours to analysis
Nitrite-N						48 hours to analysis
Sulfide	SM4500 S2D/TAN-18	SM4500 S2D [3]	1 x 60 ml plastic bottle	60 ml	Zinc acetate + NaOH pH>9	7 days to analysis
Total Iron & Manganese	SW846 6010/TACT-10, TACT-11	6010 [2]	1 x 125 ml plastic bottle	100 ml	HNO_3 to pH<2	180 days to analysis
Dissolved Iron & Manganese	SW846 6010/TACT-10, TACT-11	6010 [2]	1 x 125 ml plastic bottle	100 ml	HNO_3 to pH<2 after field filtering	180 days to analysis
TOC	SW846 9060/TACT-20	9060 [2]	1 x 40-ml glass vial	40 ml	H_2SO_4 to pH<2, Cool to 4°C	28 days to analysis

Table B-4.
Sample Containers, Preservation and Holding Times
SRSNE Superfund Site, Southington, CT

Parameter	Analytical and Preparation Method[9]/SOP Reference	Method[9]	Bottle Type[6]	Minimum Required Sample Volume[7]	Preservation	Holding Time[5]
Groundwater; Annual VOC Sampling						
VOCs	SW846 8260B/TACT-1	8260B[2]	2 x 40-ml glass vials	80 ml	HCl to pH<2, Cool to 4°C±2°C	14 days to analysis
Groundwater; Biennial MNA Sampling						
Dissolved Gases	AM20GAx/MS-5	AM20GAx	1 x 40-ml glass vial	40 ml	Trisodium Phosphate, Cool to 4°C±2°C	14 days to analysis
Alkalinity	SM2320B/TACT-16	SM2320B[3]	1 x 125 ml plastic bottle	75 ml	Cool to 4°C±2°C	28 days to analysis
Chloride	EPA 300.0/TACT-15	300.0[1]				28 days to analysis
Sulfate						28 days to analysis
Nitrate-N						48 hours to analysis
Nitrite-N						48 hours to analysis
Sulfide	SM4500 S2D/TAN-18	SM4500 S2D[3]	1 x 60 ml plastic bottle	60 ml	Zinc acetate + NaOH pH>9	7 days to analysis
Total Iron & Manganese	SW846 6010/TACT-10, TACT-11	6010[2]	1 x 125 ml plastic bottle	100 ml	HNO_3 to pH<2	180 days to analysis
Dissolved Iron & Manganese	SW846 6010/TACT-10, TACT-11	6010[2]	1 x 125 ml plastic bottle	100 ml	HNO_3 to pH<2 after field filtering	180 days to analysis
TOC	SW846 9060/TACT-20	9060[2]	1 x 40-ml glass vial	40 ml	H_2SO_4 to pH<2, Cool to 4°C	28 days to analysis
Groundwater; Five Year Review Sampling of 7 BG Wells						
TAL Metals - Total	SW846 6010/7470/TACT-10, TACT-11 and TACT-13	6010/7470[2]	1 x 125 ml plastic bottle	75 ml	HNO_3 to pH<2	180 days to analysis
						Mercury - 28 days to analysis
TAL Metals - Dissolved	SW846 6010/7470/TACT-10, TACT-11 and TACT-13	6010/7470[2]	1 x 125 ml plastic bottle	75 ml	HNO_3 to pH<2 after field filtering	180 days to analysis
						Mercury - 28 days to analysis
Groundwater; Five Year Review Sampling of 132 Wells						
VOCs	SW846 8260B/TACT-1	8260B[2]	2 x 40-ml glass vials	80 ml	HCl to pH<2, Cool to 4°C±2°C	14 days to analysis
1,4-Dioxane	SW846 8260B/TAT-24	8260B[2]	2 x 40-ml glass vials	80 ml	Cool to 4°C±2°C	7 days to analysis
TAL Metals - Total	SW846 6010/7470/TACT-10, TACT-11 and TACT-13	6010/7470[2]	1 x 125 ml plastic bottle	75 ml	HNO_3 to pH<2	180 days to analysis
						Mercury - 28 days to analysis
TAL Metals - Dissolved	SW846 6010/7470/TACT-10, TACT-11 and TACT-13	6010/7470[2]	1 x 125 ml plastic bottle	75 ml	HNO_3 to pH<2 after field filtering	180 days to analysis
						Mercury - 28 days to analysis
Dissolved Gases	AM20GAx/MS-5	AM20GAx	1 x 40-ml glass vial	40 ml	Trisodium Phosphate, Cool to 4°C±2°C	14 days to analysis
Alkalinity	SM2320B/TACT-16	SM2320B[3]	1 x 125 ml plastic bottle	75 ml	Cool to 4°C±2°C	14 days to analysis
Chloride	EPA 300.0/TACT-15	300.0[1]				28 days to analysis
Sulfate						28 days to analysis
Nitrate-N						48 hours to analysis
Nitrite-N						48 hours to analysis
Sulfide	SM4500 S2D/TAN-18	SM4500 S2D[3]	1 x 60 ml plastic bottle	60 ml	Zinc acetate + NaOH pH>9	7 days to analysis
Dissolved Iron & Manganese	SW846 6010/TACT-10, TACT-11	6010[2]	1 x 125 ml plastic bottle	100 ml	HNO_3 to pH<2 after field filtering	180 days to analysis
TOC	SW846 9060/TACT-20	9060[2]	1 x 40-ml glass vial	40 ml	H_2SO_4 to pH<2, Cool to 4°C	28 days to analysis

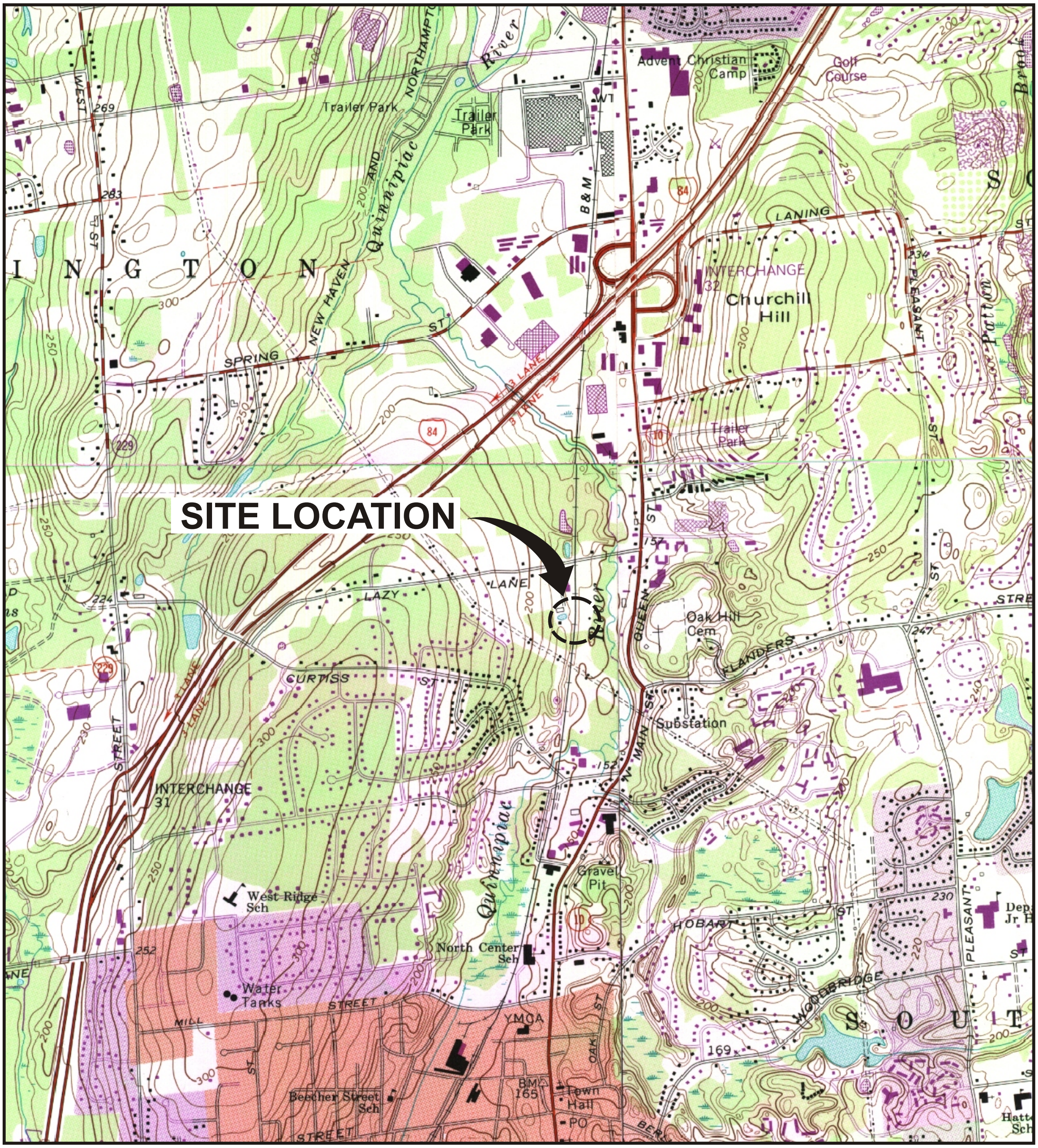
Table B-4.
Sample Containers, Preservation and Holding Times
SRSNE Superfund Site, Southington, CT

Parameter	Analytical and Preparation Method[9]/SOP Reference	Method[9]	Bottle Type [6]	Minimum Required Sample Volume [7]	Preservation	Holding Time [5]
Soil						
VOCs	SW846 8260B/TACT-1	8260B [2]	3-EnCore™ samplers One 60 ml plastic bottle	NA	Cool to 4°C$\pm$2°C	48 hours to preservation 14 days to analysis
SVOCs	SW846 8270/TACT-2, TACT-3	8270 [2]	1 x 8-oz glass jar with Teflon®-lined lid	NA	Cool to 4°C$\pm$2°C	14 days to extraction
PCB	SW846 8082/TACT-7, TACT-8	8082 [2]				40 days to analysis
Dioxins	SW846 8290/TAWS-21, TAWS-22	8290 [2]	1 x 4-oz glass jar with Teflon®-lined lid	NA	Cool to < 4°C	30 days to extraction 45 days to analysis
Metals	SW846 6010/7471/TACT-10, TACT-12 and TACT-14	6010/7471 [2]	1 x 4-oz glass jar with Teflon®-lined lid	NA	Cool to 4°C$\pm$2°C	180 days to analysis Mercury - 28 days to analysis
Air Monitoring						
VOCs	EPA TO-15/TABR-23	TO-15 [4]	Canister	NA	NA	14 days to analysis

Notes:
1. USEPA. *Methods for Chemical Analysis of Water and Wastes*. EPA/600/4-79/020. EMSL-Cincinnati. 1983.
2. USEPA. Office of Solid Waste and Emergency Response. *Test Methods for Evaluating Solid Waste SW-846.* 3rd ed. Washington, DC. 1996.
3. Standard Methods for the Examination of Water and Wastewater
4. USEPA. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. 2nd Edition. EPA/625/R-96/010b. January 1999
5. All holding times are measured from date of collection.
6. Bottle types for initial comprehensive groundwater sampling event based on low-flow sampling methods. Bottle types for subsequent groundwater sampling events based on no-purge sampling with HydraSleeves™. If low-flow methods are employed for subsequent groundwater sampling events, then bottle types consistent with those used during the initial comprehensive sampling event will be used.
7. Applicable to subsequent sampling events in which HydraSleeve™ is the sample collection method.
8. During low-flow sampling, all specified bottles should be filled completely.
9. Laboratories are required to run the latest State-certified, industry-standard version of the specified method.

°C = Degrees Celsius.
PCB = Polychlorinated biphenyl.
TOC = Total organic carbon.

Figures



REFERENCE: SOUTHINGTON, CONN. USGS QUAD. 1968 PR 1992, MERIDEN, CONN. USGS QUAD. 1966 PR 1984, NEW BRITAIN, CONN. USGS QUAD. 1966 PR 1984, & BRISTOL, CONN. USGS QUAD 1967 PR 1984.

2000' 0 2000'

Approximate Scale: 1" = 2000'

Area Location

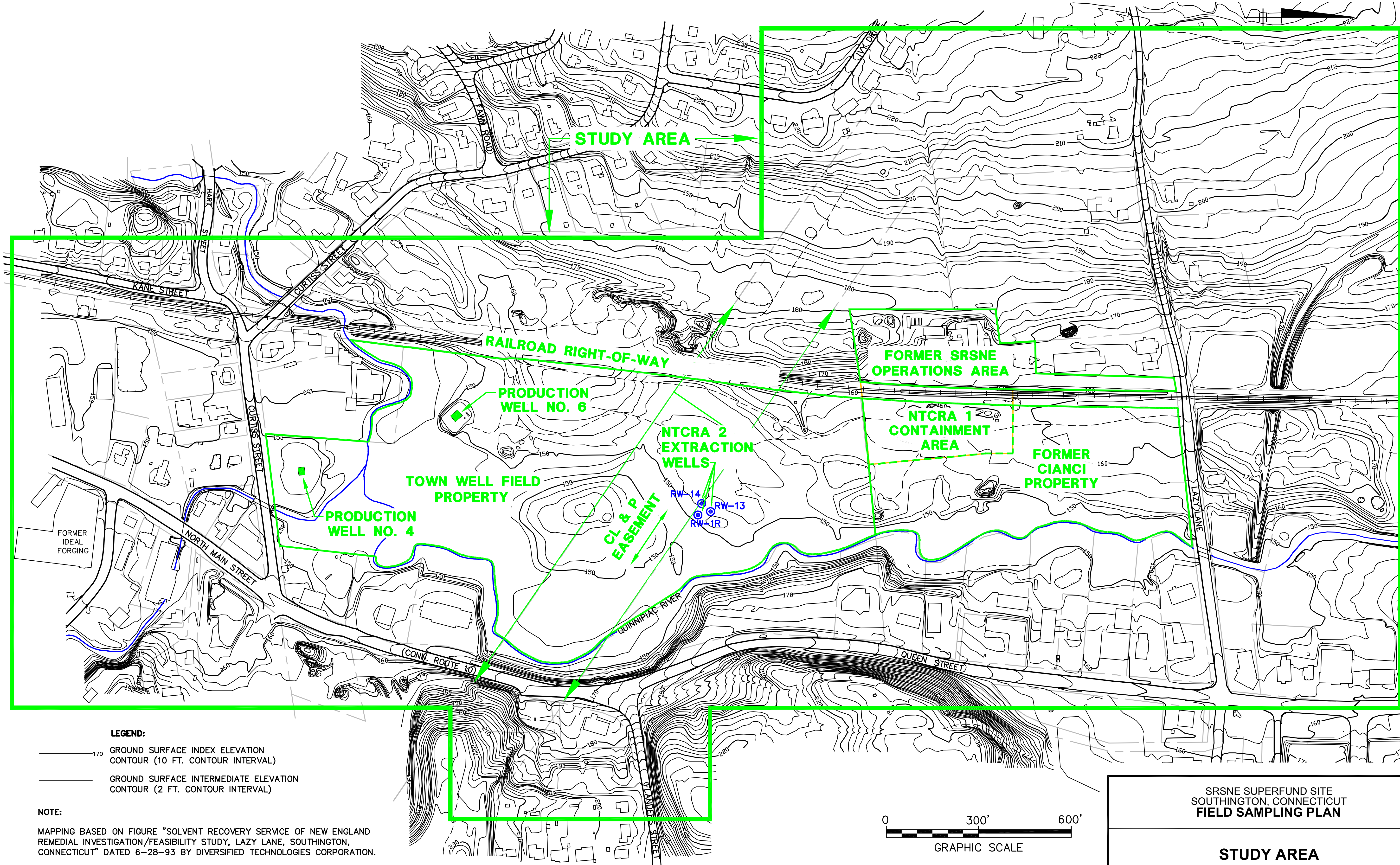
SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
FIELD SAMPLING PLAN

SITE LOCATION MAP

ARCADIS

FIGURE
B-1

04/03/09 SYRACUSE, NY-ENV/CAD-DJH
B0054634/0000/20003/CDR/54634N02.CDR



LEGEND:

170 GROUND SURFACE INDEX ELEVATION CONTOUR (10 FT. CONTOUR INTERVAL)

GROUND SURFACE INTERMEDIATE ELEVATION CONTOUR (2 FT. CONTOUR INTERVAL)

NOTE:

MAPPING BASED ON FIGURE "SOLVENT RECOVERY SERVICE OF NEW ENGLAND REMEDIAL INVESTIGATION/FEASIBILITY STUDY, LAZY LANE, SOUTHINGTON, CONNECTICUT" DATED 6-28-93 BY DIVERSIFIED TECHNOLOGIES CORPORATION.

SRSNE SUPERFUND SITE
SOUTHINGTON, CONNECTICUT
FIELD SAMPLING PLAN

STUDY AREA

ARCADIS

FIGURE
B-2

ARCADIS

Appendices

ARCADIS

Appendix B-1

Standard Operating Procedures

ARCADIS

Appendix B-1-1

Monitoring Well Integrity Survey

ARCADIS
Infrastructure, environment, buildings

Imagine the result

Monitoring Well Integrity Survey

Rev. #: 0

Rev Date: February 24, 2009

Approval Signatures

Prepared by: ______________________ Date: 2/24/09
Raymond A. Stevenson

Reviewed by: ______________________ Date: 2/24/09
Michael Gefell (Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) specifies the procedures for performing inventories of existing monitoring wells. This SOP also applies to piezometers that are constructed analogous to monitoring wells. For simplicity, such piezometers are also referred to as monitoring wells for the remainder of this document.

Monitoring well inventories are periodically conducted to assess the integrity of existing monitoring wells and to identify the need for repairs, replacement of parts, or replacement of wells that are determined to no longer be usable. A well inventory involves an inspection of the overall condition of the well, comparison of measurable quantities (e.g., riser stickup relative to grade and total depth), general verification of survey coordinates and elevation, and measurement of depth to water in the well.

II. Personnel Qualifications

All personnel shall meet the requirements of the site-specific Health and Safety Plan (HASP).

The Project Manager is responsible for ensuring that the activities described herein are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

The Field Manager is responsible for periodic observation of field activities and review of field generated documentation associated with this SOP. The Field Manager is also responsible for implementation of corrective action if well conditions necessitate them.

III. Equipment List

The following materials will be available, as required, during performance of a monitoring well inventory:

- Health and safety equipment (as required by the site-specific Health and Safety Plan)
- Ruler or tape measure
- Water level indicator and/or interface probe
- Indelible pen

- Paint pen
- Well keys
- Wrenches for accessing flush-mount well covers
- Cleaning equipment
- Well construction information
- Field notebook or Personal Digital Assistant (PDA)

If feasible, a supply of typical replacement parts (e.g., locks, bolts, and well caps) should be available to enable immediate usage as necessary.

IV. Cautions

It is important to confirm the correct identity of wells, particularly when they are installed in a cluster. In these cases, however, the wells usually differ significantly in terms of depth below grade. During the well integrity survey, verify that all wells are properly labeled by comparing their measured depth to the reported depth as installed. If the well identity is incorrectly labeled or not labeled, provide a clear, correct label using an indelible pen on the inside of the steel protective cover for the well, or on the outside of the steel protective cover using a paint pen.

V. Health and Safety Considerations

Field activities associated with monitoring well installation will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Care should be taken using tools to access flush-mount curb boxes. Wells in or near roadways must not be accessed without proper traffic cones and flagging. Access to wells containing chemicals of concern may pose a hazard of chemical exposure.

VI. Procedure

The typical procedure for assessing the integrity of a monitoring well is outlined below.

Step 1. Prior to mobilizing in the field, obtain a list of wells/piezometers to be inventoried and available information concerning their location and physical characteristics.

Step 2. Identify site and well identification number on the Well Integrity Assessment Form (Attachment 1). Record all observations on this form, supplemented by notes in the field notebook if necessary.

Step 3. Examine the well for the presence of an identification label. If absent, label the well with the appropriate well number after measuring the total depth of the well to verify that the depth matches the well number (see Step 8 below). If the well identity is incorrectly labeled or not labeled, provide a clear, correct label using an indelible pen on the inside of the steel protective cover for the well, and on the outside of the steel protective cover using a paint pen.

Step 4. Examine the surface condition of the well. Record the type of well (i.e., flush mount or above-grade stickup), condition of the well cover and surface seal. Confirm the protective casing is not bent, the PVC casing is not broken or chipped, and there is no evidence of frost heaving.

Step 5. Unlock and open the well. Record the type (e.g., PVC or stainless steel), dimensions (i.e., casing diameter and stickup relative to grade), condition of the well casing, and type of well cap. If well cap is missing, replace with available parts or record the type of cap required.

Step 6. Measure the above-grade portion of the well riser stickup and compare to the known length of the stickup measured during well installation (surveyed top of inner casing elevation minus ground surface elevation). If the difference between the observed stickup length and the known stickup length is greater than 0.1 foot, the monitoring well location and elevation should be re-surveyed.

Step 7. Locate the marked measuring point along the top of the well casing. If no mark is visible, add a mark at the highest point of the casing using an indelible pen

Step 8. Measure the depth to water and total depth of the well. For total depth measurements, account for any difference in calibration of the measuring tape on the probe (i.e., distance from part of probe that measures depth to water and the physical bottom of the probe which will measure total depth of the well). Record any obstructions encountered and a description of the feel of the well bottom (i.e., soft due to sediment or hard).

Step 9. Compare all observations concerning the measured dimensions of the well with the listed values. Based on these results, as well as other observations concerning the condition of the well, record any appropriate recommendations on the Monitoring Well Integrity Assessment form (Attachment 1). Perform any recommended maintenance activities that can be accomplished with available equipment.

Step 10. Remove all equipment from the well. If no additional maintenance activities are to be performed, close the well and collect all personal protection equipment (PPE) and other wastes generated for disposal (see Section V below).

VII. Follow-up Activities

Depending on the results of the well inventory, several additional activities may be warranted prior to future usage of the well. Typical follow-up activities include replacement of missing parts, removal of sediment from the base of the well, re-surveying of the well, or complete replacement if the well is determined to be unusable. These activities are briefly discussed below.

As stated above, a supply of locks, bolts, and well caps should be available for immediate usage during performance of the well inventories. However, it may not be feasible to maintain a supply of all potential replacement parts due to the variety of well types in use. Therefore, a list of required replacement parts should be compiled during the performance of a well inventory event. At the conclusion of the event, the necessary replacement parts for all wells should be obtained and installed.

Sediment accumulation occurs to some degree in all monitoring wells, particularly those that are not pumped on a routine basis. If a sufficient quantity of sediment which may adversely impact future groundwater sampling activities is observed during a well inventory (i.e., a sediment accumulation of greater than one-half foot above the bottom of the well screen), activities should be taken to remove the sediment. These activities will involve the removal of sediment by either pumping or bailing the well, followed by re-measurement of the total depth of the well to confirm that the total depth is near the reported values. The removed sediment should be inspected for the presence of filter pack materials which may indicate that the well screen has been damaged. If initial efforts are unsuccessful in clearing the sediment accumulations, the well may need to be re-developed or replaced.

The measuring points marked on the well risers are utilized as a base datum in the determination of groundwater elevations. The distance of these markers from the ground surface are verified against listed values during well inventory activities. Minor variations between listed and measured values may be attributed to an uneven ground surface around the well or to enhancements to the ground surface such as paving or grading activities which may have been performed since installation of the well. Therefore, minor variations (i.e., less than 3 inches) will be discounted and existing survey information for the measuring point on the well will be assumed to be accurate. Greater discrepancies may be attributed to damage or modifications to the well, such as cutting or lengthening the well riser. In these situations, the well should be re-surveyed to establish a new datum for future groundwater elevation measurements.

Replacement or decommissioning of a well may be warranted if the well is broken, obstructed, or otherwise compromised. If the well cannot be adequately repaired and is required for future monitoring purposes, a replacement well should be installed if no suitable alternate wells are located in the vicinity.

VII. Waste Management

Materials generated during well inventory activities, including disposable equipment, will be disposed of in appropriate containers.

VIII. Data Recording and Management

Field observations will be recorded on the Well Integrity Assessment Form (Attachment A), and/or in an appropriate Field Notebook or PDA. Well integrity inventory results will be retained in the project file.

IX. Quality Assurance

To verify accurate measurements of well stickup, depth to bottom, depth to groundwater, etc., measurements must be double-checked periodically (e.g., at least one of these measurements per well should be repeated to verify accuracy).

X. References

No references apply to this SOP.

XI. Attachments

A. Well Integrity Assessment Form

WELL INTEGRITY ASSESSMENT FORM

Site Name:________________________________
Well I.D.:_____ _________ _________________
Date: ___________________________________

(For each item, circle the appropriate response or fill in the blank)

Well I.D. Clearly Marked: YES NO
Well Completion: FLUSH MOUNT ABOVE-GRADE STANDPIPE
Lockable Cover: YES NO DAMAGED *(Describe below)*
Lock Present: YES NO ADDED Key Brand/Number:______________________________
Measuring Point Marked: YES NO ADDED
Well Riser Diameter (inches): ____________________
Well Riser Type: PVC Stainless Steel Other *(Describe)* ______ _______________

Surface Condition

Cement Intact: YES NO *(Describe below)*
Curb Box/Well Cover Present: YES NO DAMAGED *(Describe below)*
All Bolts Present: YES NO *(Describe below)* NOT APPLICABLE
Ground Surface Slopes
Away from Well YES NO *(Describe below)*

Well Condition

Well Cap: PVC Slip Cap Pressure-fit Cap None
Well Vent: Slot Cut in Riser Vent Hole in Cap None Not Applicable *(Flush Mount Well)*
Reported Well Riser Stickup (feet): _____________*(use negative number if below grade)*
Measured Well Riser Stickup (feet): _____________ *(use negative number if below grade)*

Depth to Water (feet from Top of Well Riser): ______ ___________ -*or*- DRY

Reported Total Depth of Well (feet below grade): ________________
Measured Total Depth of Well (feet below grade): ______ ________ __
Well Obstructed: YES NO If yes, list depth in feet from Top of Well Riser: ____________________
Well Bottom: SOFT *(contains sediment)* FIRM *(no sediment)*

Recommendations

Repair Concrete/Surface Completion: YES NO If yes, list date performed:______________________
Re-Survey Well: YES NO If yes, list date performed:______________________
Remove Sediment, Redevelop & Re-Measure Depth: YES NO If yes, list date performed:______________________
Replace Well Cap: YES NO If yes, list date performed:______________________
Replace Bolts: YES NO If yes, list date performed:_______________
Replace Lock: YES NO If yes, list date performed:______________________
Other/Miscellaneous Observations:

____

____

Inspector(s):____

WELL INTEGRITY ASSESSMENT FORM

Photograph of Well:

Date of Photograph: ______________________________

Additional Comments:

ARCADIS

Appendix B-1-2

Monitoring Well Installation

Infrastructure, environment, facilities

Imagine the result

Monitoring Well Installation

Rev. #: 2

Rev Date: August 22, 2008

Approval Signatures

Prepared by: Sonya A Cadle Date: 8/25/08

Reviewed by: Michael J Gefell Date: 8/25/08
(Technical Expert)

I. Scope and Application

The procedures set out herein are designed to produce standard groundwater monitoring wells suitable for: (1) groundwater sampling, (2) water level measurement, (3) bulk hydraulic conductivity testing of formations adjacent to the open interval of the well.

Monitoring well boreholes in unconsolidated (overburden) materials are typically drilled using the hollow-stem auger drilling method. Other drilling methods that are also suitable for installing overburden monitoring wells, and are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, Rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and driven well points may also be used in some cases within the overburden. Monitoring wells within consolidated materials such as bedrock are commonly drilled using water-rotary (coring or tri-cone roller bit), air rotary or Rotasonic methods. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling/well depths, site or regional geologic knowledge, type of monitoring to be conducted using the installed well, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No coated bentonite pellets will be used in the well drilling or construction process. Specifications of materials to be installed in the well will be obtained prior to mobilizing onsite, including:

- well casing;
- bentonite;
- sand; and
- grout.

Well materials will be inspected and, if needed, cleaned prior to installation.

II. Personnel Qualifications

Monitoring well installation activities will be performed by persons who have been trained in proper well installation procedures under the guidance of an experienced field geologist, engineer, or technician. Where field sampling is performed for soil or bedrock characterization, field personnel will have undergone in-field training in soil or bedrock description methods, as described in the appropriate SOP(s) for those activities.

III. Equipment List

The following materials will be available during soil boring and monitoring well installation activities, as required:

- Site Plan with proposed soil boring/well locations;
- Work Plan or Field Sampling Plan (FSP), and site Health and Safety Plan (HASP);
- personal protective equipment (PPE), as required by the HASP;
- traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if such are not provided by drillers;
- appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);
- soil and/or bedrock logging equipment as specified in the appropriate SOPs;
- appropriate sample containers and labels;
- drum labels as required for investigation derived waste handling;
- chain-of-custody forms;
- insulated coolers with ice, when collecting samples requiring preservation by chilling;
- photoionization detector (PID) or flame ionization detector (FID);
- ziplock style bags;
- water level or oil/water interface meter;
- locks and keys for securing the well after installation;
- decontamination equipment (bucket, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels);

- field notebook.

Prior to mobilizing to the site, ARCADIS personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary by project, and so communication with the driller will be necessary to ensure that the materials provided will meet the project objectives. Equipment typically provided by the driller could include:

- drilling equipment required by the American Society of Testing and Materials (ASTM) D 1586, when performing split-spoon sampling;
- disposable plastic liners, when drilling with direct-push equipment;
- drums for investigation derived waste;
- drilling and sampling equipment decontamination materials;
- decontamination pad materials, if required; and
- well construction materials.

IV. Cautions

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be delineated by the drilling contractor or an independent underground utility locator service. See separate SOP for utility clearance.

Some regulatory agencies require a minimum annular space between the well or permanent casing and the borehole wall. When specified, the minimum clearance is typically 2 inches on all sides (e.g., a 2-inch diameter well requires a 6-inch diameter borehole). In addition, some regulatory agencies have specific requirements regarding grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling and well installation plan.

If dense non-aqueous phase liquids (DNAPL) are known or expected to exist at the site, refer to the DNAPL Contingency Plan SOP for additional details regarding drilling and well installation to reduce the potential for inadvertent DNAPL remobilization.

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Similarly, consider the material compatibility between the well materials and the surrounding environment. For example, PVC well materials are not preferred when DNAPL is present. In addition, some groundwater conditions leach metals from stainless steel.

Water used for drilling and sampling of soil or bedrock, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply should be considered.

Specifications of materials used for backfilling bore hole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPLs are likely to be present. In these situations, neat cement grout is preferred.

No coated bentonite pellets will be used in monitoring well construction, as the coating could impact the water quality in the completed well.

Monitoring wells may be installed with Schedule 40 polyvinyl chloride (PVC) to a maximum depth of 200 feet below ground surface (bgs). PVC monitoring wells between 200 and 400 feet total depth will be constructed using Schedule 80 PVC. Monitoring wells deeper than 400 feet will be constructed using steel.

V. Health and Safety Considerations

Field activities associated with monitoring well installation will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedures

The procedures for installing groundwater monitoring wells are presented below:

Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods

1. Locate boring/well location, establish work zone, and set up sampling equipment decontamination area.

2. Advance boring to desired depth. Collect soil and/or bedrock samples at appropriate interval as specified in the Work Plan and/or FSP. Collect, document, and store samples for laboratory analysis as specified in the Work Plan and/or FSP. Decontaminate equipment between samples in accordance with the Work Plan and/or FSP. A common sampling method that produces

high-quality soil samples with relatively little soil disturbance is the ASTM D 1586 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils. Split-spoon samples are obtained during drilling using hollow-stem auger, drive-and-wash, spun casing, and fluid/mud rotary. Rotasonic drilling produces large-diameter soil cores that tend to be more disturbed than split-spoon samples due to the vibratory action of the drill casing. Dual-rotary removes cuttings by compressed air and allows only a general assessment of geology. High-quality bedrock samples can be obtained by coring.

3. Describe each soil or bedrock sample as outlined in the appropriate SOP. Record descriptions in the field notebook and/or personal digital assistant (PDA). It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data. During soil boring advancement, document all drilling events in field notebook, including blow counts (number of blows required to advance split-spoon sampler in 6-inch increments) and work stoppages. Blow counts will not be available if Rotasonic, dual-rotary, or direct-push methods are used. When drilling in bedrock, the rate of penetration (minutes per foot) is recorded.

4. If it is necessary to install a monitor well into a permeable zone below a confining layer, particularly if the deeper zone is believed to have water quality that differs significantly from the zone above the confining layer, then a telescopic well construction should be considered. In this case, the borehole is advanced approximately 3 to 5 feet into the top of the confining layer, and a permanent casing (typically PVC, black steel or stainless steel) is installed into the socket drilled into the top of the confining layer. The casing is then grouted in place. The preferred methods of grouting telescoping casings include: pressure-injection grouting using an inflatable packer installed temporarily into the base of the casing, such that grout is injected out the bottom of the casing until it is observed at ground surface outside the casing; displacement-method grouting (also known as the Halliburton method), which entails filling the casing with grout and displacing the grout out the bottom of the casing by pushing a drillable plug, typically made of wood to the bottom of the casing, following by tremie grouting the remainder of the annulus outside the casing; or tremie grouting the annulus surrounding the casing using a tremie pipe installed to the base of the borehole. In all three cases, the casing is grouted to the ground surface, and the grout is allowed to set prior to drilling deeper through the casing. Site-specific criteria and work plans should be created for the completion of non-standard monitoring wells, including telescopic wells.

5. In consolidated formations such as competent bedrock, a monitoring well may be completed with an open borehole interval without a screen and sandpack. In these cases, the borehole is advanced to the targeted depth of the top of the open interval. A permanent casing is then grouted in place following the procedures described in Step 4 above. After the grout sets, the borehole is advanced by drilling through the permanent casing to the targeted bottom depth of the open interval, which then serves as the monitoring interval for the well. If open-borehole interval stability is found to be questionable or if a specific depth interval is later selected for monitoring, a screened monitoring well may later be installed within the open-borehole interval, depending on the annular space and well diameter requirements.

6. Prior to screened well installation or after the completion of an open-bedrock well, the water level or oil/water interface probe should be used to determine the static water level in the borehole in relation to the proposed well screen or open-interval location. If necessary, an open-bedrock well may be drilled deeper to intersect the water table or a permeable water-bearing zone.

7. Upon completing the borehole to the desired depth, if a screened well construction is desired, install the monitoring well by lowering the screen and casing assembly with sump through the augers or casing. Monitoring wells typically will be constructed of 2-inch-diameter, flush-threaded PVC or stainless steel slotted well screen and blank riser casing. Smaller diameters may be used if wells are installed using direct-push methodology or if multiple wells are to be installed in a single borehole. The screen length will be specified in the Work Plan or FSP based on regulatory requirements and specific monitoring objectives. Monitoring well screens are usually 5 to 10 feet long, but may be up to 25 feet long in very low permeability, thick geologic formations. The screen length will depend on the purpose for the well and the objectives of the groundwater investigation. Typically, the slot size will be 0.010 inch and the sand pack will be 20-40, Morie No. 0, or equivalent. In very fine-grained formations where sample turbidity needs to be minimized, it may be preferred to use a 0.006-inch slot size and 30-65, Morie No. 00, or equivalent sand pack. Alternatively, where monitoring wells are installed in coarse-grained deposits and higher well yield is required, a 0.020-inch slot size and 10-20, Morie No. 1, or equivalent sand pack may be preferred. To the extent practicable, the slot size and sand pack gradation may be predetermined in the Work Plan or FSP based on site-specific grain-size analysis or other geologic considerations or monitoring objectives. A blank sump may be attached below the well screen if the well is being installed for DNAPL recovery/monitoring purposes. If so, the annular space around the sump will be backfilled with neat cement grout to the bottom of the well screen prior to placing the sand pack around the screen. A

blank riser will extend from the top of the screen to approximately 2.5 feet above grade or, if necessary, just below grade where conditions warrant a flush-mounted monitoring well. For wells greater than 50 feet deep, centralizers may be desired to assist in centralizing the monitoring well in the borehole during construction.

8. When the monitoring well assembly has been set in place and the grout has been placed around the sump (if any), place a washed silica sand pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen. The sand pack is placed and drilling equipment extracted in increments until the top of the sand pack is at the appropriate depth. The sand pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan or FSP. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack. If non-hydrated bentonite is used, the bentonite should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. No coated bentonite pellets will be used in monitoring well drilling or construction. Potable water may be added to hydrate the bentonite if the seal is above the water table. Monitor the placement of the sand pack and bentonite with a weighted tape measure. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 feet bgs.

9. Place a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing and secure with a neat cement seal. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing and secure with a neat cement seal. In either case, the cement seal will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing, and should slope gently away to promote drainage away from the well. Monitoring wells will be labeled with the appropriate designation on both the inner and outer well casings or inside of the curb box lid.

   When an above-grade completion is used, the PVC riser will be sealed using an expandable locking plug and the top of the well will be vented by drilling a small-diameter (1/8 inch) hole near the top of the well casing or through the locking plug, or by cutting a vertical slot in the top of the well casing. When a flush-mount installation is used, the PVC riser will be sealed using an unvented, expandable locking plug.

10. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook.

11. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Direct-Push Method

The direct-push drilling method may also be used to complete soil borings and install monitoring wells. Examples of this technique include the Diedrich ESP vibratory probe system, GeoProbe®, or AMS Power Probe® dual-tube system. Environmental probe systems typically use a hydraulically operated percussion hammer. Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff/medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual-tube liner for sampling soil. The outside diameter (OD) of the outer casing ranges from 1.75 to 2.4 inches and the OD of the inner sampling tube ranges from 1.1 to 1.8 inches. The outer casing isolates shallow layers and permits the unit to continue to probe at depth. The double-rod system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, the inside diameter (ID) of the steel casing provides clearance for the installation of small-diameter (e.g., 0.75- to 1-inch ID) micro-wells. The procedures for installing monitoring wells in soil using the direct-push method are described below.

1. Locate boring/well location, establish work zone, and set up sample equipment decontamination area.

2. Advance soil boring to designated depth, collecting samples at intervals specified in the Work Plan. Samples will be collected using dedicated, disposable, plastic liners. Describe samples in accordance with the procedures outlined in Step 3 above. Collect samples for laboratory analysis as specified in the Work Plan and/or FSP.

3. Upon advancing the borehole to the desired depth, install the micro-well through the inner drill casing. The micro-well will consist of approximately 1-inch ID PVC or stainless steel slotted screen and blank riser. The sand pack, bentonite seal, and cement/bentonite grout will be installed as described, where applicable, in Step 7 and 8 above.

4. Install protective steel casing or flush-mount, as appropriate, as described in Step 9 above. During well installation, record construction details and tabulate materials used.

5. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Driven Well Point Installation

Well points will be installed by pushing or driving using a drilling rig or direct-push rig, or hand-driven where possible. The well point construction materials will consist of a 1- to 2-inch-diameter threaded steel casing with either 0.010- or 0.020-inch slotted stainless steel screen. The screen length will vary depending on the hydrogeologic conditions of the site. The casings will be joined together with threaded couplings and the terminal end will consist of a steel well point. Because they are driven or pushed to the desired depth, well points do not have annular backfill materials such as sand pack or grout.

VII. Waste Management

Investigation-derived wastes (IDW), including soil cuttings and excess drilling fluids (if used), decontamination liquids, and disposable materials (well material packages, PPE, etc.), will be placed in clearly labeled, appropriate containers, or managed as otherwise specified in the Work Plan, FSP, and/or IDW management SOP.

VIII. Data Recording and Management

Drilling activities will be documented in a field notebook. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of well installation activities, soil descriptions, well construction specifications (screen and riser material and diameter, sump length, screen length and slot size, riser length, sand pack type), and quantities of materials used. In addition, the locations of newly-installed wells will be documented photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

The well or piezometer location, ground surface elevation, and inner and outer casing elevations will be surveyed using the method specified in the site Work Plan. Generally, a local baseline control will be set up. This local baseline control can then be tied into the appropriate vertical and horizontal datum, such as the National Geodetic Vertical Datum of 1929 or 1988 and the State Plane Coordinate System. At a minimum, the elevation of the top of the inner casing used for water-level measurements should be measured to the nearest 0.01 foot. Elevations will be established in relation to the National Geodetic Vertical Datum of 1929. A permanent mark will be placed on top of the inner casing to mark the point for water-level measurements.

IX. Quality Assurance

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate SOP. Well materials will also be cleaned prior to well installation.

X. References

American Society of Testing and Materials (ASTM) D 1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*.

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Appendix B-1-3

Soil Drilling and Sample Collection

Infrastructure, environment, facilities

Imagine the result

Soil Drilling and Sample Collection

Rev. #: 1

Rev Date: March 3, 2009

Approval Signatures

Prepared by: ______________________ Date: 3/3/09

Reviewed by: ______________________ Date: 3/3/09
(Technical Expert)

I. Scope and Application

Overburden drilling is commonly performed using the hollow-stem auger drilling method. Other drilling methods suitable for overburden drilling, which are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, Rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary. Direct-push techniques (e.g., Geoprobe or cone penetrometer) may also be used. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling depths, site or regional geologic knowledge, types of sampling to be conducted, required sample quality and volume, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools).

II. Personnel Qualifications

The Project Manager (a qualified geologist, environmental scientist, or engineer) will identify the appropriate soil boring locations, depth and soil sample intervals in a written plan.

Personnel responsible for overseeing drilling operations must have at least 16 hours of prior training overseeing drilling activities with an experienced geologist, environmental scientist, or engineer with at least 2 years of prior experience.

III. Equipment List

The following materials will be available during soil boring and sampling activities, as required:

- Site Plan with proposed soil boring/well locations;
- Work Plan or Field Sampling Plan (FSP), and site Health and Safety Plan (HASP);
- personal protective equipment (PPE), as required by the HASP;
- drilling equipment required by the American Society for Testing and Materials (ASTM) D 1586, when performing split-spoon sampling;
- disposable plastic liners, when drilling with direct-push equipment;
- appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);

- equipment cleaning materials;
- appropriate sample containers and labels;
- chain-of-custody forms;
- insulated coolers with ice, when collecting samples requiring preservation by chilling;
- photoionization detector (PID) or flame ionization detector (FID); and
- field notebook and/or personal digital assistant (PDA).

IV. Cautions

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be identified by one of the following three actions (lines of evidence):

- Contact the State One Call
- Obtain a detailed site utility plan drawn to scale, preferably an “as-built” plan
- Conduct a detailed visual site inspection

In the event that one or more of the above lines of evidence cannot be conducted, or if the accuracy of utility location is questionable, a minimum of one additional line of evidence will be utilized as appropriate or suitable to the conditions. Examples of additional lines of evidence include but are not limited to:

- Private utility locating service
- Research of state, county or municipal utility records and maps including computer drawn maps or geographical information systems (GIS)
- Contact with the utility provider to obtain their utility location records
- Hand augering or digging
- Hydro-knife
- Air-knife

- Radio Frequency Detector (RFD)
- Ground Penetrating Radar (GPR)
- Any other method that may give ample evidence of the presence or location of subgrade utilities.

Overhead power lines also present risks and the following safe clearance must be maintained from them.

Power Line Voltage Phase to Phase (kV)	Minimum Safe Clearance (feet)
50 or below	10
Above 50 to 200	15
Above 200 to 350	20
Above 350 to 500	25
Above 500 to 750	35
Above 750 to 1,000	35

ANSI Standard B30.5-1994, 5-3.4.5

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Water used for drilling and sampling of soil or bedrock, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply should be considered.

Specifications of materials used for backfilling borehole will be obtained, reviewed and approved to meet project quality objectives.

V. Health and Safety Considerations

Field activities associated with overburden drilling and soil sampling will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedure

Drilling Procedures

The drilling contractor will be responsible for obtaining accurate and representative samples; informing the supervising geologist of changes in drilling pressure; and keeping a separate general log of soils encountered, including blow counts (i.e., the number of blows from a soil sampling drive weight [140 pounds] required to drive the split-barrel sampler in 6-inch increments). Records will also be kept of occurrences of premature refusal due to boulders or construction materials that may have been used as fill. Where a boring cannot be advanced to the desired depth, the boring will be abandoned and an additional boring will be advanced at an adjacent location to obtain the required sample. Where it is desirable to avoid leaving vertical connections between depth intervals, the borehole will be sealed using cement and/or bentonite. Multiple refusals may lead to a decision by the supervising geologist to abandon that sampling location.

Soil Sampling Procedures

Samples of subsurface materials encountered while drilling soil borings will be collected using one of the following methods:

- 2-inch split-barrel (split-spoon) sampler, if using the ASTM D 1586 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils

- Plastic internal soil sample sleeves if using direct-push drilling.

Soil samples are typically field screened with an FID or PID at sites where volatile organic compounds are present in the subsurface. Field screening is performed using one of the following methods:

- Upon opening the sampler, the soil is split open and the PID or FID probe is placed in the opening and covered with a gloved hand. Such readings should be obtained at several locations along the length of the sample

- A portion of the collected sample is placed in a jar, which is covered with aluminum foil, sealed, and allowed to warm to room temperature. After warming, the cover is removed, the foil is pieced with the FID or PID probe, and a reading is obtained.

Samples selected for laboratory analysis will be handled, packed, and shipped in accordance with the procedures outlined in the Work Plan, FSP, or Chain-of-Custody, Handling, Packing, and Shipping SOP.

A geologist will be onsite during drilling and sampling operations to describe each soil sample on the soil boring log, including:

- percent recovery;
- structure and degree of sample disturbance;
- soil type;
- color;
- moisture condition;
- density;
- grain-size;
- consistency; and
- other observations, particularly relating to the presence of waste materials

Further details regarding geologic description of soil samples are presented in the Soil Description SOP.

Particular care will be taken to fully describe any sheens observed, oil saturation, staining, discoloration, evidence of chemical impacts, or unnatural materials.

VII. Waste Management

Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal.

PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures and soil sampling/handling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. Once full, the material will be analyzed to determine the appropriate disposal method.

VIII. Data Recording and Management

The supervising geologist or scientist will be responsible for documenting drilling events using a bound field notebook and/or PDA to record all relevant information in a clear and concise format. The record of drilling events will include:

- start and finish dates of drilling;
- name and location of project;
- project number, client, and site location;
- sample number and depths;
- blow counts and recovery;
- depth to water;
- type of drilling method;
- drilling equipment specifications, including the diameter of drilling tools;
- documentation of any elevated organic vapor readings;
- names of drillers, inspectors, or other people onsite; and
- weather conditions.

IX. Quality Assurance

Equipment will be cleaned prior to use onsite, between each drilling location, and prior to leaving the site. Drilling equipment and associated tools, including augers, drill rods, sampling equipment, wrenches, and other equipment or tools that may have come in contact with soils and/or waste materials will be cleaned with high-pressure steam-cleaning equipment using a potable water source. The drilling equipment will be cleaned in an area designated by the supervising engineer or geologist that is located outside of the work zone. More elaborate cleaning procedures may be required for reusable soil samplers (split-spoons) when soil samples are obtained for laboratory analysis of chemical constituents.

X. References

American Society of Testing and Materials (ASTM) D 1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*.

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Appendix B-1-4

Extraction/Preservation of Soil/Sediment for VOCs

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Extraction/Preservation of Soil/Sediment for VOCs

Rev. #: 1

Rev Date: April 9, 2008

Approval Signatures

Prepared by: Caron Koll Date: 4/9/08

Reviewed by: Dennis K. Capria Date: 4/9/08
(Technical Expert)

I. Scope and Application

Soil or sediment samples collected for volatile organic compound (VOC) analysis must be handled in a manner which will minimize the loss of contaminants due to volatilization and biodegradation. Based on experience and open literature, it has been concluded that field extraction and preservation must be conducted in a manner to ensure that contaminants do not degrade or volatilize during sample handling and transport. The following equipment and procedures summarize the method of field preservation of soil samples.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervision training, and site-specific health and safety training. At least one person on the sampling team must be trained per Department of Transportation (DOT) and (International Air Transportation Administration (IATA) requirements to prepare and offer shipments of samples by a commercial carrier and training in Materials of Trade when transporting this material in ARCADIS or private vehicles for work-related purposes. Trained personnel will use the following shipping guides:

- ARCADIS Hazardous Materials (aka Dangerous Goods) using Shipping Guide No. US-002 - Environmental Samples-Solids Known or Suspected of Being Hazardous per DOT Definition

- ARCADIS Hazardous Materials (aka Dangerous Goods) using Shipping Guide No. US-012 – Environmental Samples solid containing Methanol and or Sodium Bisulfate Preservative (collected using TeraCore® Encore®, EazyDraw® Syringe Samplers).

In addition, ARCADIS personnel overseeing, directing, or supervising soil collection will be versed in the applicable standard operating procedures (SOPs) to successfully complete the sample activities.

III. Equipment List

- portable balance, small electronic or manual scale calibrated with an appropriate certified weight;

- analyte-free water;

- Site specific Health and Safety Plan (HASP);

- personal protective equipment (PPE), per the HASP;
- 1¾ cm inside-diameter disposable soil coring device syringes (supplied by laboratory);
- coolers or transport containers with contained ice;
- large soil sampling device (e.g., split-spoon sampler);
- indelible ink pens;
- field logbook;
- duct tape;
- 1-gallon freezer bags;
- appropriate forms;
- preservative-free empty sample containers;
- Encore™ (or equivalent, e.g. TeraCore®, EazyDraw®) samplers and cut plastic syringes; and/or
- sampling containers provided by the laboratory (dependent on the type of purge and trap unit that will be used to analyze the samples):
  - low-concentration containers with a magnetic stir bar and a solution of 1 gram of sodium bisulfate dissolved in 5 milliliter (mL) of organic-free water. Tare weight of container and contents should be recorded on the label.
  - high-concentration [greater than 200 micrograms per kilogram (ug/kg)] containers will contain 10 mL of methanol and also have the tare weight recorded on the label. Tare weight of the container and contents should be recorded on the label.

IV. Cautions

Once the proper weight has been contained within the syringe, the piston of the syringe is used to push the soil into the 40-mL sample vial. Care must be taken so as not to spill or splash the preservative already in the vials. Caution must also be used when recapping the vial, as even a small amount of soil on the rim of the vial may cause improper sealing and subsequently lead to loss of the preservative and surrogates. The samples must be placed in coolers and maintained at approximately 4°C. The soil sample vials will be weighed by the laboratory before extractions are completed. For this reason, extra labels or tape are not to be added to the vials. Containers or syringes that differ from the tare weight by more than 0.01 gram should not be used.

Avoid over tightening sample vials lids. Over tightened lids may damage the Teflon seal and integrity of the sample.

Samples unpreserved at 4°C have a holding time of 48-hours, from the time of collection and analysis or preservation. If samples are to be shipped unpreserved, plan to express mail via air and to shipment on the same day as collection, unless performance data can be provided to support longer holding times. The 40 mL vials are unacceptable as unpreserved sample containers due to VOC loss via volatilization and biodegradation.

Freezing unpreserved samples in proper containers may be considered to extend holding times to 5 days.

Soils are to be collected and contained in the least amount of time possible to minimize the loss of VOCs. Trimming of outer layer of the exposed the soil sample should be considered, if the sample has been exposed to the atmosphere for more than a couple of minutes,

V. Health and Safety Considerations

Care must be taken so as not to spill or splash the preservative already in the vials, when applicable. Sodium bisulfate is a strong acid and can cause severe burns. If the preservative makes contact, immediately flush with potable water. Immediately consult with a medical professional if any burning, pain, or irritation persists.

The 40-mL sample vials can shatter while tightening. Amber vials are more prone to breakage. Use appropriate cut resistant gloves to avoid possible laceration while tightening vials.

Refer to the site specific health and safety plan (HASP) for further health and safety considerations.

VI. Procedure

Container Preparation

Container preservation may be done either in the field or in the laboratory. Procedures for both methods are provided in this SOP. Standard sample containers for laboratory preservation will include either TeraCore® Encore®, EazyDraw®.

Field preservation will depend on the soil concentration, if known.

For high concentration soils (greater than 200 ug/kg), laboratory-prepared 40-mL VOA vials filled with 5 mL to 10 mL of analyte-free purge and trap grade methanol (at a minimum of 5 mL methanol) to 5 gram soil/sediment. The sample container size may be dependent on the type of purge and trap unit that will be used to analyze the samples.

Containers for low VOC concentrations will include 1 gram of sodium bisulfate dissolved in 5 mL of organic-free water.

The analytical laboratory also adds the appropriate surrogate compounds to the methanol based on the analytical method quality assurance [e.g. 8015, 8021, 8260b, Massachusetts Compendium of Analytical Methods for Volatile Petroleum Hydrocarbons (VPH), or 8260b, USEPA, 2002; DEQE, 2000; MADEP, 2003]. The laboratory records the weight of each vial to the nearest 0.1 gram after both methanol and surrogates have been added. These containers must be stored in coolers and maintained at approximately $4^{o}C \pm 2^{o}$.

Sampling

Selection of a soil/sediment sampling interval will be determined based on a site-specific sampling plan and collected either via TeraCore® Encore®, EazyDraw® or by preservation in the field with methanol and/or sodium bisulfate in containers pre-measured by the laboratory.

<u>Preservation in the Field (laboratory pre-filled sample containers)</u>

Soil/sediment is collected in-situ or from a larger sampling device (e.g., split-spoon, auger, or other sampling device) with a disposable coring device (syringe), also supplied by the laboratory, as soon as possible upon sample retrieval to avoid exposure to air and VOC loss. A coring device that may be used of amendable to soil/sediment type consists of a plastic syringe with the tip removed. It is essential that the diameter be suitable for injection into the sample container. A small electronic or manual balance is needed for weighing the syringe and soil.

1. Once the tare weight of the syringe is determined and a sample interval is selected, soil sample collection is accomplished by manually pushing a syringe into the soil/sediment with the piston withdrawn or collection with a stainless steel spoon.

2. The soil sample weight is determined by subtracting the tared weight from the total weight of the soil and syringe.

3. Acceptable soil sample weight is 5 grams for a 40-mL vial sample container. However, the laboratory may supply larger sized sample containers and require a laboratory-specific weight of soil/sediment.

   - If a syringe is used and the sample weight is less than 5 grams, the syringe may be pushed into the soil again, with the piston withdrawn to gather additional soil.

   - If the sample weight is greater than 5 grams, a portion of soil may be extruded and removed from the syringe.

4. Weigh the containers in the field. Record the weight of each sample. Subtract the tare weight of the container and preservative to obtain the weight of sample. Record the weights on the sample labels and in the field notebook.

5. If the volatile concentrations of the sample are not known, two low-concentration vials and one high-concentration vial should be prepared, as discussed in Section III. Additional vials are needed for samples to be used for laboratory quality control purposes. Note: Samples that contain carbonate minerals may effervesce upon contact with the acidic low-concentration preservative. If the effervescence is small, the loss of volatiles will be limited by quickly capping the vial. If large amounts of gas are generated, target analytes may be lost and the vials may shatter. If this occurs, document the issue in the field notebook and collect another sample using a fresh container prepared with 5 mL (1 mL of water is equivalent to 1 gram of water) of analyte-free water and no preservative.

6. (Place samples on ice immediately after collection and ship or deliver to the laboratory as soon as possible.

7. An additional sample fraction should be placed in a clean glass jar with no preservative for laboratory use to determine percent solids. Moisture content determination is required to report the sample results on a dry weight basis. Moisture content determination is required to report the sample results on a dry weight basis. If soil samples will be analyzed for other parameters, the moisture content can usually be taken from the other sample containers. However, when sampling for VOCs only, a small separate laboratory-supplied container must be filled.

<u>Laboratory Preservation (Encore™ or equivalent)</u>

1. Collect an approximate 5-gram sample using an Encore™ sampler or cut plastic syringe.

2. Place samples on ice immediately after collection and ship or deliver to the laboratory as soon as possible. Samples in capped Encore™ samplers should be delivered within 24 hours of collection to allow the sample to be persevered within 48 hours from collection and meet holding time.

3. In addition to the soil sample collected for VOC analysis, soil must be collected and placed into an empty container for moisture content analysis. Moisture content determination is required to report the sample results on a dry weight basis. If soil samples will be analyzed for other parameters, the moisture content can usually be taken from the other sample containers. However, when sampling for VOCs only, a small separate laboratory-supplied container must be filled.

Shipping Container Preparation

Use ARCADIS Hazardous Materials (aka Dangerous Goods) using Shipping Guide No. US-012 – Environmental Samples solid containing Methanol and or Sodium Bisulfate Preservative (collected using TeraCore® Encore®, EazyDraw® Syringe Samplers) for sample container preparation. Among other requirements depending on whether the samples are shipped by air verse by ground shipping containers must be marked with <u>**"This package conforms to 49 CFR 173.4."**</u> <u>Note</u>: in order to comply with 49 CFR 173.4, the total volume of methanol mixture per shipping container must be less than 30 grams. In addition, other pertinent requirements of this reference are as follows:

- Each inner receptacle is securely packed in an inside packaging with cushioning and absorbent material. The inside packaging cannot react chemically with the material and needs to be capable of absorbing the entire contents of the receptacle. (Note: a foam container for the vials meets these requirements.)

- The inside packaging is securely packed in a strong outside packaging. (Note: a cooler meets this requirement.)

- The gross mass of the completed package does not exceed 64 pounds.

Consult ARCADIS Hazardous Materials (aka Dangerous Goods) using Shipping Guide No. US-012 – Environmental Samples, Solid Containing Methanol and/or Sodium Bisulfate Preservative (collected using TeraCore® Encore®, EazyDraw® Syringe Samplers) for appropriate packing and labeling for shipments via air and ground. In addition, consult the Chain-of-Custody SOP.

VII. Waste Management

Used methanol or sodium bisulfate, if any, will be contained in an airtight drum or container. Containers will be labeled with the project name, date, and contents. Appropriate client specified personnel will be notified for the transport of container to the appropriate on-site storage area for disposal at an appropriate facility. Any unused sample containers with methanol or sodium bisulfate will be shipped back to the laboratory using original packaging material per DOT or IATA procedures.

VIII. Data Recording and Management

Sampling activities, (i.e. location, depth, soil/sediment type, sample identification, sample container tare weight, sample weights, effervescence) will be recorded in the field logbook. Chain of custody (COC) will be prepared per the approved SOP and copies of the COC will be transmitted to the project manager and maintained in project files.

IX. Quality Assurance

Quality assurance activities will be completed to comply with the site specific sampling plan and/or quality assurance project plan.

A methanol trip blank should accompany the sample containers at all times in the field and during transport. This consists of a sample container prepared in a similar manner as the soil sample containers. One trip blank should accompany each sample delivery group.

Field blanks and ambient air blanks are optional when sampling via the methanol preservation method.

Discrete blind duplicate samples may be collected in separate soil/sediment sample containers. Compositing or homogenizing multiple soil/sediment samples into one sample container is not acceptable.

Site-specific matrix spike and matrix spike duplicate (MS/MSD) analyses, if required, may be collected from a single soil/sediment sample container; no additional sample volume is required.

X. References

Arizona Department of Environmental Quality (ADEQ), 2000. Implementation of EPA Method 5035-Soil Preparation of EPA Method 8015B, 8121B and 8260B, Arizona Revised Statues (A.R.S.) 49-104 (A). April 19, 2000.

Massachusetts Department of Environmental Protection (MADEP), 2003. Method for the Determination of Volatile Petroleum Hydrocarbons, MADEP-VPH-03-1.1, Revision 1.1. December 2003.

USEPA, 2002. *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition, Method 5035A – Closed System Purge and Trap for Volatile Organics in Soils and Waste Samples. July 2002.

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Appendix B-1-5

DNAPL Contingency Plan

Imagine the result

DNAPL Contingency Plan

Rev. #: 3

Rev Date: May 1, 2010

Approval Signatures

Prepared by: ______________________ Date: 5/1/10
David Lipson

Reviewed by: ______________________ Date: 5/1/10
Michael Gefell (Technical Expert)

I. Scope and Application

This document has been prepared to guide drilling activities at sites where there is a reasonable expectation that dense, non-aqueous phase liquid (DNAPL) may be present, and provide procedures to be implemented in the event that DNAPL is encountered during subsurface investigations. These procedures are proposed to limit the potential of remobilizing DNAPL, if any, in response to drilling and sampling activities. In addition, the procedures are designed to optimize the recovery of encountered DNAPL (if any) in a safe and efficient manner. This DNAPL Contingency Plan was developed based on a similar document prepared by DNAPL expert Bernard H. Kueper, Ph.D., P.Eng., of Queens University, for an EPA Region 1 Superfund Site (Kueper, May 1995).

Downward DNAPL mobilization may occur in response to drilling activities (short-circuiting along drill stem and/or completed well screen) and groundwater extraction (creation of downward hydraulic gradient in excess of previously measured downward gradients). This DNAPL Contingency Plan addresses drilling-related issues.

II. Personnel Qualifications

DNAPL contingency field activities will be performed by persons who have been trained in proper drilling and well installation procedures under the guidance of an experienced field geologist, engineer, or technician.

III. Equipment List

The following materials will be available during soil boring and monitoring well installation activities, as required:

- Work Plan, Field Sampling Plan (FSP), and site Health and Safety Plan (HASP);
- personal protective equipment (PPE), as required by the HASP;
- equipment specified under drilling and well installation SOPs;
- photo-ionization detector (PID) or flame ionization detector (FID)
- hydrophobic dye (Oil Red O or Sudan IV), pertinent at chlorinated solvent sites;
- disposable pans for performing soil-water pan tests; and

- clean, empty jars for performing soil-water shake tests.
- field notebooks and/or personal digital assistant (PDA)

IV. Cautions

Downward Mobilization

DNAPL can migrate downward during drilling and well installation processes, or via the sand pack or screen of a monitoring well. This caution is applicable to all DNAPL sites, but may be especially important at solvent sites, where DNAPL is likely to have relatively high density and low viscosity; also, pure solvents may be clear and colorless, and therefore difficult to detect visually. Other DNAPLs such as coal tar and creosote, or waste solvents that have been used in degreasing operations, commonly have a dark color and are readily visible in soil or water samples.

Direct-Push Drilling

DNAPL can be indirectly detected in the soil using direct-push instruments such as TarGost (which detects coal tar or creosote DNAPL due to fluorescence) or membrane interface probe (also known as MIP, which detects volatile organic compounds). These types of devices can also be used with a cone-penetration tool (CPT) to rapidly characterize stratigraphy in addition to potential DNAPL presence. However, currently-available direct push tools do not allow the borehole to be grouted as the direct-push tool is extracted from the subsurface. Therefore, use of direct-push tools within zones that are known or likely to contain DNAPL should be limited to one or more the following situations: 1) each direct-push boring is terminated at the first indication of potential DNAPL; 2) direct-push is used for lateral DNAPL delineation above a widespread, thick capillary barrier that has been previously characterized using standard soil borings; 3) a direct-push tool is advanced inside of an outer casing, such that the boring can be tremie-grouted from the bottom upward during removal of the outer casing. Wherever possible, direct-push detectors (e.g., MIP or TarGOST) should be “calibrated” in terms of their response using a series of standards prepared using site soil and DNAPL – this process can significantly improve the reliability of interpretations regarding DNAPL presence.

Other Considerations

The presence or absence of DNAPL at a site can have significant implications in terms of site management, health and safety, and the feasibility of potential remedial alternatives. Therefore, field personnel must be attentive to the potential for DNAPL, recognize when DNAPL is encountered during drilling, and accurately document field observations indicating the presence of DNAPL and interpreted DNAPL depth. In addition, opportunities to characterize DNAPL, when present, may be rare. When practicable, DNAPL samples should be collected and analyzed for physical and chemical characteristics.

Shipping

A Shipping Determination must be performed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

V. Health and Safety Considerations

Field activities associated with this DNAPL Contingency Plan will be performed in accordance with the site HASP, a copy of which will be present on site during such activities.

VI. Procedure

DNAPL Screening During Overburden Drilling

To screen for the potential presence of DNAPL in soil, drilling procedures must allow for high-quality porous media samples to be taken. Split-spoon samples or direct-push samplers should be taken continuously in 2-foot intervals ahead of the auger or drill casing. Upon opening each split-spoon sampler or direct-push plastic liner sleeve, the soil will immediately be evaluated for the presence of visible non-aqueous phase liquid (NAPL), screened for the presence of organic vapors using a portable photo-ionization detector (PID) or flame ionization detector (FID). During screening, the soil will be split open using a clean spatula or knife and the PID or FID probe will be placed in the opening and covered with a gloved hand. Such readings will be obtained along the entire length of the sample. If NAPL is immediately visible in the sample, its depth should be noted and the sampling team should skip to the fourth bullet below.

If the PID or FID examination reveals the presence of organic vapors above 100 parts per million (ppm), the sample will undergo further detailed evaluation for visible non-aqueous phase liquid (NAPL). The assessment for NAPL will include a combination of the following tests/observations:

- Evaluation for Visible NAPL Sheen or Free-Phase NAPL in Soil Sampler – The NAPL sheen will be a colorful iridescent appearance on the soil sample. NAPL may also appear as droplets or continuous accumulations of liquid with a color typically ranging from yellow to brown to black, depending on the type of NAPL. Creosote DNAPL (associated with wood-treating sites) and coal-tar DNAPL (associated with manufactured gas plant [MGP] sites) are typically black and have a characteristic, pungent odor. Pure chlorinated solvents may be colorless in the absence of hydrophobic dye. Solvents mixed with oils may appear brown.

- Soil-Water Pan Test – A portion of the selected soil interval with the highest PID or FID reading > 100 ppm will be placed in a disposable polyethylene dish along with a small volume of potable or distilled water. The dish will be gently tilted back and forth to mix the soil and water, and the surface of the water will be viewed in natural light to observe the development of a sheen, if any. A small quantity of Oil Red O or Sudan IV hydrophobic dye powder will be added and the soil and dye will be manually mixed for approximately 30 to 60 seconds and smeared in the dish to create a paste-like consistency using a new nitrile glove-covered hand. A positive test result will be indicated by a sheen on the surface of the water and/or a bright red color imparted to the soil following mixing with dye.

- Soil-Water Shake Test – A small quantity of soil (up to 15 cc) will be placed in a clear, colorless, jar containing an equal volume of potable or distilled water (40-mL vials are well suited to this purpose, but not required). After the soil settles into the water, the surface of the water will be evaluated for a visible sheen under natural light. The jar will be closed and gently shaken for approximately 10 to 20 seconds. Again, the surface of the water will be evaluated for a visible sheen or a temporary layer of foam. A small quantity (approximately 0.5 to 1 cc) of Oil Red O or Sudan IV powder will be placed in the jar. The sheen layer, if present, will be evaluated for a reaction to the dye (change to bright red color). The jar will be closed and gently shaken for approximately 10 to 20 seconds. The contents in the closed jar will be examined under natural light for visible bright red dyed liquid inside the jar. A positive test result will be indicated by the presence of a visible sheen or foam on the surface of water, a reaction between the dye and the sheen layer upon first addition of the dye powder, a bright red coating on the inside of the vial (particularly above the water line), or red-dyed droplets within the soil.

- Estimation of Relative Degree of NAPL Saturation – When NAPL is interpreted as present in a particular portion of soil, the field geologist should attempt to estimate the relative degree of NAPL saturation in the soil. Specifically, based on the apparent, visible continuity of NAPL within the soil, an interpretation should be made as to whether the observed NAPL is: apparently pooled (continuous interval of soil across entire diameter of soil sample in which the pore spaces are filled with a mixture of NAPL and water); apparently residual (isolated droplets or blebs of NAPL, surrounded by pore spaces containing only water); or inconclusive (unclear whether pooled or residual). If NAPL freely drains out of a soil sample, that indicates that the NAPL is in the form of a pool – however, pooled NAPL may not always freely drain out of soil samples.

As mentioned previously, if NAPL is obviously present upon opening the soil sampler or evaluating the soil sample within the split-spoon sampler or direct-push liner sleeve, it is not necessary to perform a soil-water pan test or soil-water shake test. In addition, it is not necessary to perform both a soil-water pan test and a soil-water shake test; either test method is acceptable. The pan test may be preferred in some circumstances because the presence of a sheen may be easier to see on a wider surface.

When using hydrophobic dye in the tests above, color will be assessed outdoors under natural light during the period between sunrise and sunset, regardless of the degree of cloud cover.

The results of each test or observation will be recorded in the field notebook and/or PDA.

DNAPL Screening During Bedrock Drilling

To screen for the potential presence of DNAPL in bedrock, drilling fluids, rock cuttings, and/or core samples are monitored for the presence of sheens. During drilling using rotary methods (coring or roller bit drilling with water or drilling mud), the return fluid will be screened with a PID or FID and evaluated continuously for the presence of a sheen in the recirculation tub. Where core samples are obtained, they will be carefully evaluated for the presence of a sheen on fracture surfaces. During drilling using air-rotary methods, rock cuttings will be continuously screened using a PID or FID and evaluated for the presence of a sheen. During drilling with rotary methods, the positive head level at the borehole will reduce the potential for DNAPL short-circuiting via the borehole.

If a sheen is observed with any of these methods, drilling will be temporarily discontinued and an evaluation will be undertaken to determine whether pooled DNAPL is present. The drill stem will be retracted to a few feet above the apparent depth where the sheen was first encountered. Groundwater will be extracted from the borehole to produce a drawdown of approximately 5 feet below the approximate static, non-pumping water level for a period of 20 minutes to test for the presence of pooled, mobilizable DNAPL in the fractures surrounding the open borehole. The bottom of the borehole will then be evaluated for the presence of DNAPL using an interface probe or bottom-loading bailer. If no DNAPL is observed, the interpretation will be made that the sheen was not produced by pooled DNAPL. In this case, if drilling by the rotary method, the recirculation water will be replaced by clean water and drilling will continue. Replacing the recirculation water reduces the potential for cross-contamination and facilitates observation of a newly created sheen, if any, at a deeper interval. Accumulation of DNAPL in the bottom of the borehole, however, indicates that the boring has encountered pooled DNAPL. If DNAPL has accumulated, it will be removed using a bottom-loading bailer or pump.

Data Collection Below Zone Containing Pooled DNAPL

If pooled DNAPL is encountered in a borehole and deeper drilling is required to collect data below the zone containing pooled DNAPL, one of the following actions will be taken.

1. Adjustment of Drilling Location - The boring where pooled DNAPL was encountered will be abandoned by tremie grouting using neat cement grout and a replacement boring will be re-attempted at a nearby location.

2. DNAPL Sump Installation - A DNAPL collection well will be installed with a blank sump properly grouted in place below the screen and the boring will be re-attempted at a nearby location. In this case, after removing the DNAPL in the borehole, the boring may be advanced an additional 1 to 2 feet to accommodate a blank sump below the interval with apparent pooled DNAPL.

3. Casing Off DNAPL Layers - If pooled DNAPL is found to be present throughout an area where deeper drilling is essential, a permanent, grouted casing should be installed. The bottom of the pooled DNAPL likely coincides with the top of a relatively fine-grained, low permeability, stratum (capillary barrier). Permanent casing will be installed to the bottom of the borehole and grouted in place using the displacement method prior to advancing the borehole any further. Via the displacement method (also known as the Halliburton Method or the packer-injection method), grout is displaced out the bottom of the casing and fills the annulus outside the casing from the bottom upward. In this case, after removing any DNAPL that may have accumulated in the borehole, the boring may be advanced a few feet into the top of the underlying confining layer or up to 5 feet in bedrock prior to grouting the casing to assist in isolating the zone containing apparently pooled DNAPL. The bottom of the borehole should be checked for the DNAPL accumulation prior to installing and grouting the casing in the drilled "socket". When the casing is grouted in place and the grout has set, the drilling recirculation water will be replaced with clean water to prevent cross-

contamination and facilitate observation of a newly created sheen (if any) at a deeper interval, and drilling will continue.

DNAPL Monitoring

New wells installed in borings where DNAPL was encountered during drilling will be monitored for DNAPL accumulation in the DNAPL sump using an oil-water interface probe or bottom-loading bailer within approximately one day following initial installation. If DNAPL is encountered, a bottom-loading bailer or pump will be used to remove the DNAPL, the final DNAPL thickness will be recorded, and the DNAPL thickness will be reassessed after another day of accumulation (if any). This process will be repeated until DNAPL no longer accumulates overnight, at which point the accumulation monitoring and removal period will extend to one-week intervals. If no DNAPL accumulation is observed over a period of one week, further DNAPL monitoring may be continued with a longer period between monitoring events.

Any DNAPL recovered during drilling and monitoring activities should be analyzed for chemical composition, DNAPL-water interfacial tension, density, and viscosity. The physical tests should be performed at the approximate groundwater temperature at the site where the DNAPL sample was obtained, typically between 10ºC and 20ºC. These parameters will allow for correlation of groundwater chemistry with suspected DNAPL locations and will allow an estimate to be made of the volume and potential mobility of DNAPL, if any, in the formation.

VII. Waste Management

DNAPL removed from wells will be temporarily stored on-site in metal drums for subsequent appropriate off-site disposal. The locations and volumes of recovered DNAPL will be noted.

VIII. Data Recording and Management

Any occurrence of DNAPL encountered during subsurface investigations will be documented in an appropriate field notebook in terms of the drilling location (boring or well identification), depth below surface, type of geologic material in which DNAPL was observed, field screening and testing results, and apparent degree of DNAPL saturation (pooled or residual), and visual characteristics of DNAPL (e.g., color or qualitative viscosity). DNAPL locations and depths will be recorded in a field book and/or on subsurface log forms, as appropriate.

ARCADIS

Appendix B-1-6

Soil Description

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Soil Description

Rev. #: 0

Rev Date: May 20, 2008

Approval Signatures

Prepared by: ______________________ Date: 5/22/08

Reviewed by: ______________________ Date: 5/22/08
(Technical Expert)

Reviewed by ______________________ Date: 5/22/08
(Technical Expert)

I. Scope and Application

This ARCADIS standard operating procedure (SOP) describes proper soil description procedures. This SOP should be followed for all unconsolidated material unless there is an established client-required specific SOP or regulatory-required specific SOP. In cases where there is a required specific SOP, it should be followed and should be referenced and/or provided as an appendix to reports that include soil classifications and/or boring logs. When following a required non-ARCADIS SOP, additional information required by this SOP should be included in field notes with client approval.

This SOP has been developed to emphasize field observation and documentation of details required to:

- make hydrostratigraphic interpretations guided by depositional environment/geologic settings;

- provide information needed to understand the distribution of constituents of concern; properly design wells, piezometers, and/or additional field investigations; and develop appropriate remedial strategies.

This SOP incorporates elements from various standard systems such as ASTM D2488-06, Unified Soil Classification System, Burmister and Wentworth. However, none of these standard systems focus specifically on contaminant hydrogeology and remedial design. Therefore, although each of these systems contain valuable guidance and information related to correct descriptions, strict application of these systems can omit information critical to our clients and the projects that we perform.

This SOP does not address details of health and safety; drilling method selection; boring log preparation; sample collection; or laboratory analysis. Refer to other ARCADIS SOPS, the project work plans including the quality assurance project plan, sampling plan, and health and safety plan (HASP), as appropriate.

II. Personnel Qualifications

Soil descriptions will be completed only by persons who have been trained in ARCADIS soil description procedures. Field personnel will complete training on the ARCADIS soil description SOP in the office and/or in the field under the guidance of an experienced field geologist. For sites where soil descriptions have not previously been well documented, soil descriptions should be performed only by trained persons with a degree in geology or a geology-related discipline.

III. Equipment List

The following equipment should be taken to the field to facilitate soil descriptions:

- field book, field forms or PDA to record soil descriptions;
- field book for supplemental notes;
- this SOP for Soil Descriptions and any project-specific SOP (if required);
- field card showing Wentworth scale;
- Munsell® soil color chart;
- tape measure divided into tenths of a foot;
- stainless steel knife or spatula;
- hand lens;
- water squirt bottle;
- jar with lid;
- personal protective equipment (PPE), as required by the HASP; and
- digital camera.

IV. Cautions

Drilling and drilling-related hazards including subsurface utilities are discussed in other SOPs and site-specific HASPs and are not discussed herein.

Soil samples may contain hazardous substances that can result in exposure to persons describing soils. Routes for exposure may include dermal contact, inhalation and ingestion. Refer to the project specific HASP for guidance in these situations.

V. Health and Safety Considerations

Field activities associated with soil sampling and description will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Know what hazardous substances may be present in the soil and understand their hazards. Always avoid the temptation to touch soils with bare hands, detect odors by placing soils close to your nose, or tasting soils.

VI. Procedure

1. Select the appropriate sampling method to obtain representative samples in accordance with the selected sub-surface exploration method, e.g. split-spoon or Shelby sample for hollow-stem drilling, Lexan or acetate sleeves for dual-tube direct push, etc.

2. Proceed with field activities in required sequence. Although completion of soil descriptions is often not the first activity after opening sampler, identification of stratigraphic changes is often necessary to select appropriate intervals for field screening and/or selection of laboratory samples.

3. Examine all of each individual soil sample (this is different than examining each sample selected for laboratory analysis), and record the following for each stratum:

- depth interval;
- principal component with descriptors, as appropriate;
- amount and identification of minor component(s) with descriptors as appropriate;
- moisture;
- consistency/density;
- color; and
- additional description or comments (recorded as notes).

The above is described more fully below.

DEPTH

To measure and record the depth below ground level (bgl) of top and bottom of each stratum, the following information should be recorded.

1. Measured depth to the top and bottom of sampled interval. Use starting depth of sample based upon measured tool length information and the length of sample interval.

2. Length of sample recovered, not including slough (material that has fallen into hole from previous interval), expressed as fraction with length of recovered sample as numerator over length of sampled interval as denominator (e.g. 14/24 for 14 inches recovered from 24-inch sampling interval that had 2 inches of slough discarded).

3. Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.

4. Any observations of sample condition or drilling activity that would help identify whether there was loss from the top of the sampling interval, loss from the bottom of the sampling interval, or compression of the sampling interval. Examples: 14/24, gravel in nose of spoon; or 10/18 bottom 6 inches of spoon empty.

DETERMINATION OF COMPONENTS

Obtain a representative sample of soil from a single stratum. If multiple strata are present in a single sample interval, each stratum should be described separately. More specifically, if the sample is from a 2-foot long split-spoon where strata of coarse sand, fine sand and clay are present, then the resultant description should be of the three individual strata unless a combined description can clearly describe the interbedded nature of the three strata. Example: Fine Sand with interbedded lenses of Silt and Clay, ranging between 1 and 3 inches thick.

Identify principal component and express volume estimates for minor components on logs using the following standard modifiers.

Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

Determination of components is based on using the Udden-Wentworth particle size classification (see below) and measurement of the average grain size diameter. Each size grade or class differs from the next larger grade or class by a constant ratio of ½. Due to visual limitations, the finer classifications of Wentworth's scale cannot be distinguished in the field and the subgroups are not included. Visual determinations in the field should be made carefully by comparing the sample to the field gauge card that shows Udden-Wentworth scale or by measuring with a ruler. Use of field sieves s recommended to assist in estimating percentage of coarse grain sizes. Settling test or wash method (Appendix X4 of ASTM D2488) is recommended for determining presence and estimating percentage of clay and silt.

Udden-Wenworth Scale Modified ARCADIS, 2008			
Size Class	Millimeters	Inches	Standard Sieve #
Boulder	256 – 4096	10.08+	
Large cobble	128 - 256	5.04 -10.08	
Small cobble	64 - 128	2.52 – 5.04	
Very large pebble	32 – 64	0.16 - 2.52	
Large pebble	16 – 32	0.63 – 1.26	
Medium pebble	8 – 16	0.31 – 0.63	
Small pebble	4 – 8	0.16 – 0.31	No. 5 +
Granule	2 – 4	0.08 – 0.16	No.5 – No.10
Very coarse sand	1 -2	0.04 – 0.08	No.10 – No.18
Coarse sand	½ - 1	0.02 – 0.04	No.18 - No.35
Medium sand	¼ - ½	0.01 – 0.02	No.35 - No.60
Fine sand	1/8 -¼	0.005 – 0.1	No.60 - No.120
Very fine sand	1/16 – 1/8	0.002 – 0.005	No. 120 – No. 230
Silt (subgroups not included)	1/256 – 1/16	0.0002 – 0.002	Not applicable (analyze by pipette or hydrometer)
Clay (subgroups not included	1/2048 – 1/256	.00002 – 0.0002	

Identify components as follows. Remove particles greater than very large pebbles (64-mm diameter) from the soil sample. Record the volume estimate of the greater than very large pebbles. Examine the sample fraction of very large pebbles and smaller particles and estimate the volume percentage of the pebbles, granules, sand, silt and clay. Use the jar method, visual method, and/or wash method (Appendix X4 of ASTM D2488) to estimate the volume percentages of each category.

Determination of actual dry weight of each Udden-Wentworth fraction requires laboratory grain-size analysis using sieve sizes corresponding to Udden-Wentworth fractions and is highly recommended to determine grain-size distributions for each hydrostratigraphic unit.

Lab or field sieve analysis is advisable to characterize the variability and facies trends within each hydrostratigraphic unit. Field sieve-analysis can be performed on selected samples to estimate dry weight fraction of each category using ASTM D2488 Standard Practice for Classification of Soils for Engineering Purposes as guidance, but replace required sieve sizes with the following Udden-Wentworth set: U.S. Standard sieve mesh sizes 6; 12; 20; 40; 70; 140; and 270 to retain pebbles; granules; very coarse sand; coarse sand; medium sand; fine sand; and very fine sand, respectively.

PRINCIPAL COMPONENT

The principal component is the size fraction or range of size fractions containing the majority of the volume. Examples: the principal component in a sample that contained 55% pebbles would be “Pebbles”; or the principal component in a sample that was 20% fine sand, 30% medium sand and 25% coarse sand would be “Fine to coarse Sand” or for a sample that was 40% silt and 45% clay the principal component would be “Clay and Silt”.

Include appropriate descriptors with the principal component. These descriptors vary for different particle sizes as follows.

Angularity – Describe the angularity for very coarse sand and larger particles in accordance with the table below (ASTM D-2488-06). Figures showing examples of angularity are available in ASTM D-2488-06 and the ARCADIS Soil Description Field Guide.

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Plasticity – Describe the plasticity for silt and clay based on observations made during the following test method (ASTM D-2488-06).

- As in the dilatancy test below, select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

- Shape the test specimen into an elongated pat and roll by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble when the soil is near the plastic limit.

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

Dilatancy – Describe the dilatancy for silt and silt-sand mixtures using the following field test method (ASTM D-2488-06).

- From the specimen select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material adding water if necessary, until it has a soft, but not sticky, consistency.
- Smooth the ball in the palm of one hand with a small spatula.
- Shake horizontally, striking the side of the hand vigorously with the other hand several times.
- Note the reaction of water appearing on the surface of the soil.
- Squeeze the sample by closing the hand or pinching the soil between the fingers, and not the reaction as none, slow, or rapid in accordance with the table below. The reaction is the speed with which water appears while shaking and disappears while squeezing.

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

MINOR COMPONENT(S)

The minor component(s) are the size fraction(s) containing less than 50% volume. Example: the identified components are estimated to be 60% medium sand to granules, 25 % silt and clay; 15 % pebbles – there are two identified minor components: silt and clay; and pebbles.

Include a standard modifier to indicate percentage of minor components (see Table on Page 5) and the same descriptors that would be used for a principal component. Plasticity should be provided as a descriptor for the silt and clay. Dilatancy should be provided for silt and silt-sand mixtures. Angularity should be provided as a descriptor for pebbles and coarse sand. For the example above, the minor constituents with modifiers could be: some silt and clay, low plasticity; little medium to large pebbles, sub-round.

SORTING

Sorting is the opposite of grading, which is a commonly used term in the USCS or ASTM methods to describe the uniformity of the particle size distribution in a sample. Well-sorted samples are poorly graded and poorly sorted samples are well graded. ARCADIS prefers the use of sorting for particle size distributions and grading to describe particle size distribution trends in the vertical profile of a sample or hydrostratigraphic unit because of the relationship between sorting and the energy of the depositional process. For soils with sand-sized or larger particles, sorting should be determined as follows:

- Well sorted – the range of particle sizes is limited (e.g. the sample is comprised of predominantly one or two grain sizes)
- Poorly sorted – a wide range of particle sizes are present

You can also use sieve analysis to estimate sorting from a sedimentological perspective; sorting is the statistical equivalent of standard deviation. Smaller standard deviations correspond to higher degree of sorting (see Remediation Hydraulics, 2008).

MOISTURE

Moisture content should be described for every sample since increases or decreases in water content is critical information. Moisture should be described in accordance with the table below (percentages should not be used unless determined in the laboratory).

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet (Saturated)	Visible free water, soil is usually below the water table.

CONSISTENCY or DENSITY

This can be determined by standard penetration test (SPT) blow counts (ASTM D-1586) or field tests in accordance with the tables below. For SPT blow counts the N-value is used. The N-value is the blows per foot for the 6" to 18" interval. Example: for 24-inch spoon, recorded blows per 6-inch interval are: 4/6/9/22. Since the second interval is 6" to12", the third interval is 12" to 18", the N value is 6+9, or 15. Fifty blow counts for less than 6 inches is considered refusal.

Fine-grained soil – Consistency

Description	Criteria
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated one inch by thumb.
Medium stiff	N-value 9-15 or indented about ¼ inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty

Coarse-grained soil – Density

Description	Criteria
Very loose	N-value 1- 4
Loose	N-value 5-10
Medium dense	N-value 11-30
Dense	N-value 31- 50
Very dense	N-value >50

COLOR

Color should be described using simple basic terminology and modifiers based on the Munsell system. Munsell alpha-numeric codes are required for all samples. If the sample contains layers or patches of varying colors this should be noted and all representative colors should be described. The colors should be described for moist samples. If the sample is dry it should be wetted prior to comparing the sample to the Munsell chart.

ADDITIONAL COMMENTS (NOTES)

Additional comments should be made where observed and should be presented as notes with reference to a specific depth interval(s) to which they apply. Some of the significant information that may be observed includes the following.

- **Odor** - You should not make an effort to smell samples by placing near your nose since this can result in unnecessary exposure to hazardous materials. However, odors should be noted if they are detected during the normal sampling procedures. Odors should be based upon descriptors such as those used in NIOSH “Pocket Guide to Chemical Hazards”, e.g. “pungent” or “sweet” and should not indicate specific chemicals such as “phenol-like” odor or “BTEX” odor.

- Structure

- Bedding planes (laminated, banded, geologic contacts)

- Presence of roots, root holes, organic material, man-made materials, minerals, etc.

- Mineralogy

- Cementation

- NAPL presence/characteristics, including sheen (based on client-specific guidance)

- Reaction with HCl (typically used only for special soil conditions)

- Origin, if known (capital letters: LACUSTRINE; FILL; etc.)

EXAMPLE DESCRIPTIONS

51.4 to 54.0' Clay, some silt, medium to high plasticity; trace small to large pebbles, subround to subangular up to 2" diameter; moist; stiff; dark grayish brown (10YR 4/2) NOTE: Lacustrine; laminated 0.01 to 0.02 feet thick, laminations brownish yellow (10 YR 4/3).

32.5 to 38.0' Sand, medium to Pebbles, coarse; sub-round to sub-angular; trace silt; poorly sorted; wet; grayish brown (10YR5/2). NOTE: sedimentary, igneous and metamorphic particles.

Unlike the first example where a density of cohesive soils could be estimated, this rotosonic sand and pebble sample was disturbed during drilling (due to vibrations in a loose Sand and Pebble matrix) so no density description could be provided. Neither sample had noticeable odor so odor comments were not included.

The standard generic description order is presented below.

- Depth

- Principal Components
  - Angularity for very coarse sand and larger particles
  - Plasticity for silt and clay
  - Dilatancy for silt and silt-sand mixtures
- Minor Components
- Sorting
- Moisture
- Consistency or Density
- Color
- Additional Comments

VII. Waste Management

Project-specific requirements should be identified and followed. The following procedures, or similar waste management procedures are generally required.

Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal. PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures and soil sampling/handling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. Once full, the material will be analyzed to determine the appropriate disposal method.

VIII. Data Recording and Management

Upon collection of soil samples, the soil sample should be logged on a standard boring log and/or in the field log book depending on Data Quality Objectives (DQOs) for the task/project. Two examples of standard boring logs are presented below.

The general scheme for soil logging entries is presented above; however, depending on task/project DQOs, specific logging entries that are not applicable to task/project goals may be omitted at the project manager's discretion. In any case, use of a consistent logging procedure is required.

Completed logs and/or logbook will be maintained in the task/project field records file. Digital photographs of typical soil types observed at the site and any unusual features should be obtained whenever possible. All photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or log book and a label showing this information in the photo is useful.

ARCADIS Page _____ of _____

Sample Log

Well/Boring ________________ Project Name and No. ________________

Site Location ________________ Drilling Started ________________ Drilling Completed ________________

Total Depth Drilled ________ feet Hole Diameter ______ inches Sampling Interval ________________ feet

Length and Diameter of Sampling Device ________________ Type of Sampling Device ________________

Drilling Method ________________ Drilling Fluid Used ________________

Drilling Contractor ________________ Driller ________________ Helper ________________

Prepared By ________________ Hammer Weight ________________ Hammer Drop ________ inches

Sample Depth (feet below land surface) From	To	Sample Recovery (feet)	Time/Hydraulic Pressure or Blows per 6 inches	Sample Description	PID (ppm)

http://team/Sites/Offices/North/Northeast Area/Northeast Area Geoscience Forms/Sample Core Log XLS - Sheet1

IX. Quality Assurance

Soil descriptions should be completed only by appropriately trained personnel. Descriptions should be reviewed by an experienced field geologist for content, format and consistency. Edited boring logs should be reviewed by the original author to assure that content has not changed.

X. References

ARCADIS Soil Description Field Guide, 2008 (in progress)

Munsell® Color Chart – available from Forestry Suppliers, Inc.- Item 77341 "Munsell® Color Soil Color Charts

Field Gauge Card that Shows Udden-Wentworth scale – available from Forestry Suppliers, Inc. – Item 77332 "Sand Grain Sizing Folder"

ASTM D-1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils

ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

United States Bureau of Reclamation. Engineering Geology Field Manual. United States Department of Interior, Bureau of Reclamation. http://www.usbr.gov/pmts/geology/fieldmap.htm

Petrology of Sedimentary Rocks, Robert L. Folk, 1980, p. 1-48

NIOSH Pocket Guide to Chemical Hazards

Remediation Hydraulics, Fred C. Payne, Joseph A. Quinnan, and Scott T. Potter, 2008, p 59-63

ARCADIS

Appendix B-1-7

Groundwater Sampling Using HydroPunch^{TM}

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Groundwater Sampling Using HydroPunch™

Rev. #: 01

Rev Date: March 3, 2009

Approval Signatures

Prepared by: Andrew Kamik Date: 3/3/09

Reviewed by: Michael J Gefell Date: 3/3/09
(Technical Expert)

I. Scope and Application

This document describes procedures for collecting discrete-depth groundwater samples using the HydroPunch™ sampling device (QED Environmental Services, Inc.), or equivalent, during drilling in unconsolidated materials. HydroPunch™ can be used to collect a single sample from a selected depth, or multiple samples from a single borehole to produce a profile of groundwater quality data versus depth. The HydroPunch™ sampler is typically driven through open-ended drill casing or hollow-stem augers.

HydroPunch™ consists of a drive point, a stainless steel screen section, a sample reservoir integral within the tool body, and assorted O-rings and check valves to create watertight seals within the various components. Two models of HydroPunch™ have been developed, having slightly different designs and/or component parts as shown on the attached HydroPunch™ schematic drawings. All components are made of stainless steel, Teflon, or other relatively inert materials. The tool can be disassembled easily for cleaning between samples.

Although this document refers to groundwater sample collection, HydroPunch™ is also capable of obtaining samples of light or dense non-aqueous phase liquid (LNAPL or DNAPL, respectively), if present at sufficient saturation and pressure head at the depth of the ampler during deployment.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading groundwater sample collection activities using HydroPunch™ should have a minimum of 2 years of previous groundwater sampling experience and current health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and CPR, as needed. Field personnel will also be compliant with client-specific training requirements. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following materials are required for the collection of discrete-depth groundwater samples using HydroPunch™.

- HydroPunch™ sampling device provided by drilling subcontractor

- Drill casing or augers having an effective inside diameter of at least 1.25 inches (to be provided by drilling subcontractor)
- Electronic water-level probe
- Groundwater sample containers provided by the testing laboratory
- Health and safety monitoring equipment and personal protective equipment
- Materials for decontamination of the sampler between samples

IV. Cautions

Because the HydroPunch™ sampler is a groundwater sampling device, it must be used in saturated soils. Positive hydraulic head is required to fill the sampler, and the sampler may fill slowly or not at all at depths just below the water table. HydroPunch™ I and HydroPunch™ II in the "groundwater mode" cannot be used at sampling depths less than 5 feet below the water table. HydroPunch™ II in the "hydrocarbon mode" is preferred for sampling at the water table.

Some types of geologic materials may not allow effective use of the HydroPunch™ sampler, even at significant depth below the water table. For example, extremely dense soils or those containing cobbles or boulders may resist penetration of the sampler, precluding its use. Low permeability soil such as silt and clay may not produce groundwater at a sufficient rate to fill the HydroPunch™ sampler within a practicable timeframe. For these types of situations, an alternative approach should be considered, such as collecting a sample of saturated soil for analysis.

Groundwater samples collected using HydroPunch™ should be considered screening-level data, suitable for obtaining a general understanding of groundwater quality and selecting depths for monitoring well screens. Samples obtained using HydroPunch™ are commonly more turbid than those produced from installed, developed monitoring wells. Higher turbidity could affect sample quality if samples are to be analyzed for sorptive analytes such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), pesticides or metals. For these types of analytes, unfiltered HydroPunch™ samples could produce concentrations that are higher than those of sediment-free aquifer water. Field or laboratory filtering of the samples obtained for these types of constituents should be considered. For less-sorptive analytes (volatile organic compounds, anions such as chloride, etc.), sample turbidity is unlikely to adversely impact the direct usability of unfiltered samples.

V. Health and Safety Considerations

- Sample collection will be performed using procedures consistent with the project Health and Safety Plan.
- Appropriate personal protective equipment must be worn by ARCADIS field personnel

VI. Procedure

The following steps will be followed during the collection of discrete-depth groundwater Samples using HydroPunch™:

1. Select the desired groundwater sampling depth.
2. The drilling subcontractor will advance the borehole to approximately 2 feet above the depth from which a discrete water sample is to be obtained.
3. The drilling subcontractor will disassemble the HydroPunch™ sampling device according to the manufacturer's instructions to allow the sampler to be decontaminated. The sampler should be completely disassembled, including O-rings and/or check valves.
4. Decontaminate the sampler as appropriate for the range of groundwater analytes to be sampled for, by washing with laboratory-grade detergent and potable water wash, followed by solvent rinse (if sampling for organics) and final rinse with deionized or distilled water. Check the condition of the O-rings during each cleaning, and replace if necessary.
5. The drilling subcontractor will reassemble the decontaminated HydroPunch™ sampling device according to the manufacturer's instructions and lower the device to the bottom of the borehole.
6. The drilling subcontractor will push or drive the HydroPunch™ 5 feet below the bottom of the casing or augers, then retract the sampler 3 feet upward. Subsurface friction will retain the drive point in place, exposing the screen and allowing groundwater to enter the sampling tool.
7. Allow sufficient time to allow the sampler to fill with water. Typically 30 minutes is sufficient, except in low permeability materials.
8. Collect a groundwater sample by:

- Retracting the sampler to ground surface – the drilling subcontractor will then open the sampler allowing collection of the groundwater sample [if using the HydroPunch™ I or else the HydroPunch™ II in groundwater mode (see Attachment A)]

- Lowering a bailer or a peristaltic or inertia pump tube through the rods and body of the sampler, and retrieving the bailer or operating the pump to collect the groundwater sample [if using the HydroPunch™ II in hydrocarbon mode (see Attachment A)]

9. Perform field filtering of samples if required by the work plan, FSP and/or QAPP.

10. Obtain field water quality measurements if required by the work plan, FSP and/or QAPP.

11. Label the sample containers at the time of sampling with the following information.

    - Project name and number
    - Sample location
    - Sample number
    - Date and time of collection
    - Sampler initials
    - Analyses required

12. Preserve, store, handle, and ship samples to the analytical laboratory under chain of custody procedures as described in by the work plan, FSP and/or QAPP.

VII. Waste Management

Investigation-derived waste will be managed as described in the Investigation-Derived Waste Handling and Storage SOP.

VIII. Data Recording and Management

Borehole identification, sample depth, sample date and time will be recorded in the field notebook, the boring log, and/or the personal digital assistant (PDA). The sample will also be identified on an appropriate chain of custody form, as appropriate for submittal to an analytical laboratory for analysis, if required. Consider digital photography to record unusual field conditions or to document compliance.

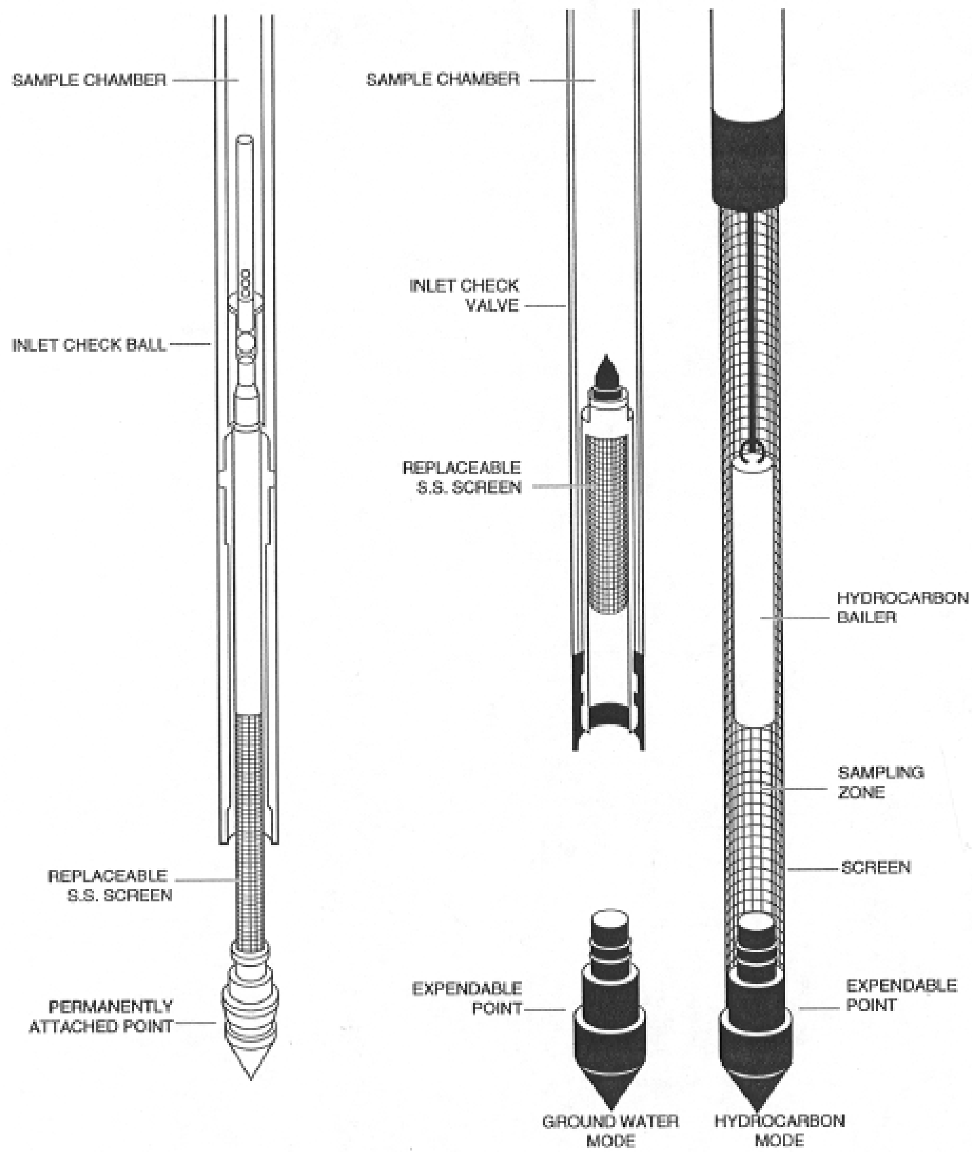
IX. Quality Assurance

The HydroPunch™ sampling device will be decontaminated as appropriate for the list of analytical parameters for which the groundwater samples are collected.

X. References

No references are required to accompany this SOP.

Attachment A - Hydropunch® Schematics



HydroPunch® I

- Collects ground water samples only (not floating layer)
- Permanently-attached drive cone and screen (leaves nothing in the ground)
- Can be used with cone penetrometer or drill rig

HydroPunch® II

- Collects floating layer and ground water
- Replaceable cones and screens are left in ground (note: screens may be retrievable)
- Stronger for tough duty; used with drill ring

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Appendix B-1-8

Specific Capacity Testing and Data Reduction

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Specific Capacity Testing and Data Reduction

Rev. #: 2

Rev Date: February 3, 2006

Approval Signatures

Prepared by: ______________________ Date: 2/27/09
Michael Gefell

Reviewed by: ______________________ Date: 2/27/09
Jerry Shi (Technical Expert)

I. Scope and Application

Specific-capacity testing is a field method used to estimate the transmissivity of a saturated geologic medium surrounding the screened or open interval of a well. A specific-capacity test involves pumping groundwater from a well at a constant rate and quantifying the pumping rate and magnitude of drawdown inside the tested well after a known duration of pumping. Specific-capacity tests are also referred to as single-well pumping tests or constant-rate tests.

The transmissivity is calculated based on the pumping rate and drawdown measured inside the pumped well. Time-drawdown analysis can be performed with a semilog data plot to estimated transmissivity (Driscoll, 1986). Alternatively, an iterative calculation can be performed based on the pumping duration, the effective radius of the well, and storativity of the formation.

If the thickness of the effective water-bearing zone transmitting groundwater to the well intake is assumed to be approximately equal to the length of the intake, the hydraulic conductivity (K) can be estimated by dividing the transmissivity by the length of the intake.

II. Personnel Qualifications

Specific-capacity tests will be performed by persons who have been trained in the proper usage of pumping and water-level measurement equipment under the guidance of an experienced field geologist, engineer, or technician.

III. Equipment List

The equipment needed for specific-capacity testing includes:

- health and safety equipment, as required in the site Health and Safety Plan (HASP);
- cleaning equipment;
- pump (preferably submersible) capable of pumping at a controlled rate between a fraction of one gallon per minute (gpm) and several gpm, equipped with discharge line;
- power source for the pump;
- calibrated in-line totalizing flow meter or two calibrated buckets;

- stopwatch;
- electronic water-level indicator; and
- field notebook.

IV. Cautions

Wells and piezometers have different water-yielding characteristics as a function of their screen lengths, depth below the water table, and geologic materials in which they are installed. During the first minute of pumping, the water level should be continuously monitored and the pumping rate adjusted to avoid pumping the well dry. Additional cautionary statements pertinent to data reduction are included in Section I. Allowing discharge water to infiltrate next to the well can impact the test results and should be avoided.

V. Health and Safety Considerations

Field activities associated with specific-capacity testing will be performed in accordance with a site-specific HASP, a copy of which will be present on-site during such activities.

VI. Procedures

Pre-Test Set-Up

Prior to installing the pump into the well to be tested, the static water level inside the well is measured to the nearest 0.01 foot relative to a specified datum at the top of the well using the electronic water-level indicator. The water level and the time of measurement are recorded in the field notebook. The water level is measured again several minutes after the initial measurement. This measurement and time are also recorded. This procedure is repeated until two consecutive measurements are identical, indicating approximately static conditions. The static depth-to-water is recorded.

The pump is installed inserted into the well to at least 10 feet below the static water level, or within approximately 1 foot of the bottom of the well if the initial water column in the well is less than 11 feet. The depth of the pump intake below the static water level (indicating the length of the pre-test water column above the pump) is recorded. After the pump is installed inserted (but prior to pumping), the water level in the well is monitored until it has returned to within 0.01 foot of the static water level.

Test Procedures

The specific-capacity test is performed as follows:

1. Hold the water-level probe in the well just above the static water level. If an in-line totalizing flow meter is used, record the pre-test volume measurement in the field notebook. If no in-line flow meter is available, place the end of the discharge line into one of the two calibrated buckets. Record the total volumetric capacity of each bucket.

2. Simultaneously start the pump and stopwatch. Record the start time.

3. Immediately begin monitoring the water level in the well. If the water level inside the test well declines rapidly, quickly reduce the pumping rate to a slower, constant rate. To avoid pumping the well "dry" during the test, the drawdown after one minute of pumping should be less than or equal to 20% of the height of the pre-pumping water column above the pump. All pumping rate adjustments should be completed within 1 or 2 minutes of the start of pumping, after which no adjustment should be made other than minor adjustments that may be necessary to maintain a steady pumping rate.

4. Continue to pump for at least 20 minutes, recording the water level in the well at least once every 3 minutes during pumping. If an in-line flow meter is used, record the volume measurement on the totalizer gauge approximately every 2 minutes during the test. If calibrated buckets are used to measure the pumping rate, record the time at which the bucket reaches the known volumetric capacity of the bucket. Transfer the discharge line to the other (empty) calibrated bucket and record the time when it becomes full. Repeat this procedure for the duration of the test.

5. The specific-capacity test is complete after at least 20 minutes of pumping have elapsed. A longer pumping period is not necessary to estimate transmissivity from the test. However, increasing the length of the test may further increase the reliability of the resulting transmissivity estimate. Immediately before termination of pumping, record the final water-level measurement plus the time of the measurement.

6. Recovery data may be collected following pumping. Such data are highly recommended if the test well is in a location that may be tidally influenced. Also, recovery data provide backup data that may be used to estimate transmissivity. To collect recovery data, measure and record water level data according to the same schedule as used during pumping.

7. Calculate and record the total volume of groundwater removed from the well during the test and the total duration of the test. Divide the total volume (in gallons) by the total pumping duration (in minutes) to calculate and record the average test pumping rate (in gpm).

VII. Waste Management

Water generated during specific capacity testing will be placed in containers, if required per State or local regulations. Containerized waste will be managed and disposed of properly.

VIII. Data Recording and Management

Data from a specific-capacity test are reduced to a transmissivity estimate for the water-bearing formation surrounding the intake of the tested well. The transmissivity may be estimated using a single-well time-drawdown method with multiple drawdown measurements, or else using a specific-capacity procedure with one drawdown measurement. These options are described below.

Time-Drawdown Method

The time-drawdown method of analyzing transmissivity requires graphical data evaluation, but has several advantages. The method does not require an estimate of the formation storativity and the results are not influenced by well efficiency.

Plot the measured drawdown data (measurements in feet on Y-axis) versus the pumping time (minutes, logarithmic scale on X-axis). The semilog data plot typically shows an abrupt initial drawdown at early time, followed by a straight-line trend of data points. Draw a line through the straight-line trend of data points and extend the line through at least one complete log cycle (e.g., 10 to 100 minutes). The data points need not extend through the entire interval of the drawn line. The drawn line is extended to cover at least one complete log cycle for ease in data analysis. Determine the drawdown change (•s) over one log cycle of time for the line drawdown through the straight-line trend in the data points. The value of transmissivity can be solved using the following equation (Driscoll, 1986):

$$T = 264\, Q / \triangle s,$$

where:

T = transmissivity of the water-bearing zone surrounding the intake of the tested well (gallons per day per foot);

Q = pumping rate during the period of the straight-line trend in data points (gpm); and

$\triangle s$ = drawdown change over one log cycle (ft).

Single Drawdown Measurement Method

This method is relatively easy to use, but it requires an estimate of the formation storativity and the results can be influenced by well efficiency. The transmissivity can be estimated using a single drawdown measurement via the following equation (Walton, 1962):

$$\frac{Q}{s} = \frac{T}{\left[264 \log\left(\frac{Tt}{2{,}693 r_w{}^2 S}\right) - 65.5\right]}$$

Q/s = specific capacity of the well in gpm per foot

Q = average test pumping rate (gpm)

s = drawdown measured inside of tested well after a known duration of pumping (ft)

T = transmissivity of the water-bearing zone surrounding the intake of the tested well (gallons per day per foot)

S = estimated storativity of the aquifer

r_w = effective radius of the well (ft)

t = time between the start of pumping and the time when the drawdown was measured (minutes)

The value of T can be solved iteratively using a specific-capacity test data reduction computer program. If the well screen is surrounded by a sand pack that may be assumed to be substantially more permeable than the formation, the effective radius of the well is taken to be that of the borehole.

The value of S may be estimated without introducing serious error into the results. For confined aquifers, S should be estimated as 0.0001. For unconfined aquifers, the short-term storativity may be comparable to that of a confined aquifer. Only after a protracted pumping duration (several hours or more) does the storativity begin to approximate the aquifer-specific yield of approximately 0.2 to 0.3 (Nwankwor et al., 1984). In the calculation of transmissivity from a specific-capacity test of less than several hours duration, an estimated storativity value of 0.01 can be used.

To obtain an estimate of the K of the water-bearing zone that transmits groundwater to the well, the calculated transmissivity value may be divided by the estimated thickness of the water-bearing zone. In a stratified formation in which the horizontal K may be expected to greatly exceed the vertical K, the thickness of the water-bearing zone may be estimated as the length of the well intake to obtain an estimate of the K immediately surrounding the well intake.

Cautionary Considerations

It should be noted that the above-listed methods are based on the modified non-equilibrium equation. According to Kruseman and de Ridder (1990), these methods are useful provided that:

$$u = \frac{r^2 s}{4Tt}$$

r = effective well radius
S = storativity
T = transmissivity of the test zone (formation interval adjacent to saturated sand pack)
t = the pumping duration

Following data analysis, the value of u should be calculated to confirm that the above condition is satisfied. If u > 0.15, then a different K test method should be employed. These cases are rare when using drawdown data from the pumped well, because the radius is a small number. The S value used in this calculation can be selected on previous site-specific pumping test results using observation well data, or else estimated as described in the previous subsection.

In circumstances when the pumping rate is low (e.g., less than 1 gpm) and the drawdown is high or occurs within the sand pack, the water removed from the well and sand pack storage should be calculated and subtracted from the pumped volume to estimate the volume of water produced by the formation. The volume of water produced by the formation should be divided by the pumping duration to obtain an effective pumping rate for use in calculating T and K.

In situations where the water level in the test well may be influenced by tidal fluctuations, drawdown and recovery data should both be measured and recorded on the same schedule. In these cases, to correct for potential tidal influence, calculate the average magnitude of the drawdown and recovery measured for the same duration during either pumping or drawdown. For example, if the pumping period lasted 30 minutes, calculate the average of the drawdown at 30 minutes and the magnitude of recovery that occurred during the first 30 minutes after shutting off the pump. This average value accounts for the tidal influence assuming that the rate of tidal change was approximately equal during the drawdown and recovery periods, and it should be considered the “effective drawdown” for use in the specific capacity method of Walton (1962). This correction should be useful in many situations, but may not adequately address tidal impacts if the drawdown due to pumping is small compared to the magnitude of the tidal influence. In these cases, it may be necessary to induce more drawdown during the test and/or time the test to coincide with slack tide conditions.

IX. Quality Assurance

QA Quality assurance calculations must be reviewed by a qualified hydrogeologist. Calculations will be provided with backup documentation, such as raw data and graphs of the data.

X. References

Driscoll, F.G., Groundwater and Wells. Johnson Filtration Systems, Inc., St. Paul, Minnesota, 1089 p. 1986.

Kruseman, G.P., and N.A. de Ridder. 1990. *Analysis and Evaluation of Pumping Test Data. International Institute for Land Reclamation and Improvement, Wageningen, The Netherland*s. Second Edition, Publication 47, 377 p. 1990.

Nwankwor, G.I., Cherry, J.A., and R.W. Gillham. 1985. *A Comparative Study of Specific Yield Determinations for a Shallow Sand Aquifer, Ground Water*, Vol. 22, No. 6, pp. 764-772.

Walton, W.C., 1962. *Selected Analytical Methods for Well and Aquifer Evaluation, Illinois State Water Survey* Bulletin 19.

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Appendix B-1-9

Monitoring Well Development

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Monitoring Well Development

Rev. #: 2.1

Rev Date: October 20, 2009

Approval Signatures

Prepared by: ______________________ Date: 10/20/09
David Lipson

Reviewed by: ______________________ Date: 10/20/09
Michael Gefell (Technical Expert)

I. Scope and Application

Monitoring wells (or piezometers, well points, or micro-wells) will be developed to clear them of fine-grained sediment and any drilling fluids that may have been used during well installation, and enhance the hydraulic connection between the well and the surrounding geologic formation. Development will be accomplished by evacuating well water by either pumping or bailing. Prior to pumping or bailing, the screened interval can be gently surged using a surge block, bailer, or inertia pump with optional surge-block fitting. In addition, sediment accumulated in the bottom of the well can be removed by bailing with a bottom-loading bailer or pumping using a submersible or inertia pump with optional surge-block fitting. Previously-installed wells will also be gently brushed with a weighted brush to assist in removing loose debris, silt or flock attached to the inside of the well riser and/or screen prior to development.

Pumping methods will be selected based on site-specific geologic conditions, anticipated well yield, water table depth, and groundwater monitoring objectives, and may include one or more of the following.

- submersible pump
- inertial pump (Waterra™ pump or equivalent)
- bladder pump
- peristaltic pump
- centrifugal pump

When developing a well using the pumping method, the pump (or, with inertial pumps, the tubing) is lowered to the screened portion of the well. During purging, the pump or tubing is moved up and down the screened interval until the well yields relatively clear water.

Submersible pumps have a motor-driven impeller that pushes the groundwater through discharge tubing to the ground surface. Inertial pumps have a check valve at the bottom of stiff tubing which, when operated up and down, lifts water to the ground surface. Bladder pumps have a bottom check valve and a flexible internal bladder that fills from below and is then compressed using pressurized air to force water out the top of the bladder through the discharge tubing to the ground surface. These three types of pumps have a wide range of applicability in terms of well depth and water depth. Centrifugal and peristaltic pumps use atmospheric pressure to lift water from the well, and therefore can only be practically used where the depth to water is less than 25 feet.

II. Personnel Qualifications

Monitoring well development activities will be performed by persons who have been trained in proper well development procedures under the guidance of an experienced field geologist, engineer, or technician.

III. Equipment List

Materials for monitoring well development using a pump include the following

- health and safety equipment, as required by the site Health and Safety Plan (HASP)
- cleaning equipment
- photoionization detector (PID) to measure headspace vapors
- pump
- polyethylene pump discharge tubing
- plastic sheeting
- power source (generator or battery)
- field notebook and/or personal digital assistant (PDA)
- graduated pails
- appropriate containers
- monitoring well keys
- water level indicator

Materials for monitoring well development using a bailer include the following.

- personal protective equipment (PPE) as required by the HASP

- cleaning equipment
- PID to measure headspace vapors
- bottom-loading bailer, sand bailer
- polypropylene or nylon rope
- plastic sheeting
- graduated pails
- appropriate containers
- keys to wells
- field notebook and/or PDA
- water level indicator
- weighted brush for well brushing

IV. Cautions

Where surging is performed to assist in removing fine-grained material from the sand pack, surging must be performed in a gentle manner. Excessive suction could promote fine-grained sediment entry into the outside of the sand pack from the formation.

Avoid using development fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

In some cases it may be necessary to add potable water to a well to allow surging and development, especially for new monitoring wells installed in low permeability formations. Before adding potable water to a well, the Project Manager (PM) must be notified and the PM shall make the decision regarding the appropriateness and applicability of adding potable water to a well during well development procedures. If potable water is to be added to a well as part of development, the potable water source should be sampled and analyzed for constituents of concern, and the results evaluated by the PM prior to adding the potable water to the well. If potable water is added to a well for development purposes, at the end of development the well will be purged dry to remove the potable water, or if the well no longer goes dry then the well will be purged to remove at least three times the volume of potable water that was added.

V. Health and Safety Considerations

Field activities associated with monitoring well development will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedure

1. The procedures for monitoring well development are described below. (Note: Steps 8, 9, and 11 can be performed contemporaneously using an inertial pump with a surge-block fitting.)

2. Don appropriate PPE (as required by the HASP).

3. Place plastic sheeting around the well.

4. Clean all equipment entering each monitoring well, except for new, disposable materials that have not been previously used.

5. Open the well cover while standing upwind of the well, remove well cap. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field notebook. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the PID reading in the breathing zone is below 5 PID units, proceed. If the PID reading is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don the appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

6. Obtain an initial measurement of the depth to water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

7. Prior to redeveloping wells that were installed prior to 2009 and are proposed for groundwater sampling as part of the RD/RA groundwater monitoring program, gently lower and raise a weighted brush along the entire length of the well

screen and riser to free and assist in removing loose debris, silt or flock. Perform a minimum of 4 “passes” along the screened and cased intervals of the well below the static water level in the well. Allow the resulting suspended material to settle for a minimum of 7 days prior to continuing with redevelopment activities. [This step is not initially required for wells installed during the RD/RA program, but may be used later in the monitoring program, as appropriate.]

8. Lower a surge block or bailer into the screened portion of the well. Gently raise and lower the surge block or bailer within the screened interval of the well to force water in and out of the screen slots and sand pack. Continue surging for 15 to 30 minutes. Note that this step is optional but recommended for all new wells/piezometers, particularly in formations with a relatively high content of fine-grained material.

9. Lower a bottom-loading bailer, submersible pump, or inertia pump tubing with check valve to the bottom of the well and gently bounce the bailer, pump, pr pump tubing on the bottom of the well to collect/remove accumulated sediment, if any. Remove and empty the bailer, if used. Repeat until the bailed/pumped water is free of excessive sediment and the bottom of the well feels solid. Alternatively, measurement of the well depth with a water level indicator can be used to verify that sediment and/or silt has been removed to the extent practicable, based on a comparison with the well installation log or previous measurement of total well depth.

10. After surging the well and removing excess accumulated sediment from the bottom of the well, re-measure the depth-to-water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

11. Remove formation water by pumping or bailing. Where pumping is used, measure and record the pre-pumping water level. Operate the pump at a relatively constant rate. Measure the pumping rate using a calibrated container and stop watch, and record the pumping rate in the field log book. Measure and record the water level in the well at least once every 5 minutes during pumping. Note any relevant observations in terms of water color, visual level of turbidity, sheen, odors, etc. Pump or bail until termination criteria specified in the Field Sampling Plan (FSP) are reached. Record the total volume of water purged from the well.

12. If the well goes dry, stop pumping or bailing and allow well to recover. Resume pumping or bailing when sufficient water has recharged the well.

13. Contain all water in appropriate containers.

14. When complete, secure the lid back on the well.

15. Place disposable materials in plastic bags for appropriate disposal and decontaminate reusable, downhole pump components and/or bailer.

VII. Waste Management

Materials generated during monitoring well installation and development will be placed in appropriate labeled containers and disposed of as described in the Work Plan or Field Sampling Plan.

VIII. Data Recording and Management

Well development activities will be documented in a proper field notebook and/or PDA. Pertinent information will include personnel present on site; times of arrival and departure; significant weather conditions; timing of well development activities; development method(s); observations of purge water color, turbidity, odor, sheen, etc.; purge rate; and water levels before and during pumping.

IX. Quality Assurance

All reused, non-disposable, downhole well development equipment will be cleaned in accordance with the procedures outlined in the Field Equipment Cleaning-Decontamination SOP.

X. References

Not Applicable.

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Appendix B-1-10

Groundwater Purging and Sampling Procedures for Monitoring Wells and Piezometers

Appendices Note:

Appendix B-1-10 contains two different field procedures for collecting groundwater samples from monitoring wells and piezometers.

Appendix B-1-10-A is to be used at wells and piezometers with saturated screen lengths no longer than 10 feet.

Appendix B-1-10-B is to be used at wells and piezometers with saturated screen lengths greater than 10 feet.

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Appendix B-1-10-A

Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples From Monitoring Wells (USEPA 2010)

U.S. ENVIRONMENTAL PROTECTION AGENCY REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

Quality Assurance Unit
U.S. Environmental Protection Agency – Region 1
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Prepared by: Charles Porfert 1/19/10
(Charles Porfert, Quality Assurance Unit) Date

Approved by: Gerard Sotolongo 1-19-10
(Gerard Sotolongo, Quality Assurance Unit) Date

Revision Page

Date	Rev #	Summary of changes	Sections
7/30/96	2	Finalized	
01/19/10	3	Updated	All sections

TABLE OF CONTENTS **Page**

USE OF TERMS

Equipment blank: The equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank needs only to include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after sampling from contaminated wells and not after background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation/reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates: Used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Poteniometric Surface: The level to which water rises in a tightly cased well constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan

SOP: Standard operating procedure

Stabilization: A condition that is achieved when all indicator field parameter measurements are sufficiently stable (as described in the "Monitoring Indicator Field Parameters" section) to allow sample collection to begin.

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): Trip blank is a sample of analyte-free water taken to the sampling site and returned to the laboratory. The trip blanks (one pair) are added to each sample cooler that contains VOC samples.

SCOPE & APPLICATION

The goal of this groundwater sampling procedure is to collect water samples that reflect the total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions, with minimal physical and chemical alterations from sampling operations. This standard operating procedure (SOP) for collecting groundwater samples will help ensure that the project's data quality objectives (DQOs) are met under certain low-flow conditions.

The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations. Indicator field parameters (e.g., dissolved oxygen, pH, etc.) are monitored during purging in order to determine when sample collection may begin. Samples properly collected using this SOP are suitable for analysis of groundwater contaminants (volatile and semi-volatile organic analytes, dissolved gases, pesticides, PCBs, metals and other inorganics), or naturally occurring analytes. This SOP is based on Puls, and Barcelona (1996).

This procedure is designed for monitoring wells with an inside diameter (1.5-inches or greater) that can accommodate a positive lift pump with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval (Hereafter, the "screen or open interval" will be referred to only as "screen interval"). This SOP is not applicable to other well-sampling conditions.

While the use of dedicated sampling equipment is not mandatory, dedicated pumps and tubing can reduce sampling costs significantly by streamlining sampling activities and thereby reducing the overall field costs.

The goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help to minimize sampling variability.

This procedure describes a general framework for groundwater sampling. Other site specific information (hydrogeological context, conceptual site model (CSM), DQOs, etc.) coupled with systematic planning must be added to the procedure in order to develop an appropriate site specific SAP/QAPP. In addition, the site specific SAP/QAPP must identify the specific equipment that will be used to collect the groundwater samples.

This procedure does not address the collection of water or free product samples from wells containing free phase LNAPLs and/or DNAPLs (light or dense non-aqueous phase liquids). For this type of situation, the reader may wish to check: Cohen, and Mercer (1993) or other pertinent documents.

This SOP is to be used when collecting groundwater samples from monitoring wells at all Superfund, Federal Facility and RCRA sites in Region 1 under the conditions described herein. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. All changes and modifications must be approved and included in a revised SAP/QAPP before implementation in field.

BACKGROUND FOR IMPLEMENTATION

It is expected that the monitoring well screen has been properly located (both laterally and vertically) to intercept existing contaminant plume(s) or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, and operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable, for all wells to be sampled, efforts to build a sampling history should commence with the next sampling event.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. For new wells, or for wells without pump intake depth information, the site's SAP/QAPP must provide clear reasons and instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected. If the depths to top and bottom of the well screen are not known, the SAP/QAPP will need to describe how the sampling depth will be determined and how the data can be used.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU, and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the indicator field parameter criteria in this procedure are met. If after 2 hours of purging indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event).

It is recommended that low-flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the data quality objectives, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be developed. Ice formation in the flow-through-cell will cause the monitoring probes to act erratically. A transparent flow-through-cell needs to be used to observe if ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All proper personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples should be handled with suitable protection to skin, eyes, etc.

CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the below conditions occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethene, ethane, dissolved oxygen, etc.) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem when using a centrifugal pump or peristaltic pump.

Direct sun light and hot ambient air temperatures may cause the groundwater in the tubing and flow-through-cell to heat up. This may cause the groundwater to degas which will result in loss of VOCs and dissolved gases. When sampling under these conditions, the sampler will need to shade the equipment from the sunlight (e.g., umbrella, tent, etc.). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sun light or ambient air from heating up the groundwater.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water which is denser than warm water sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convention cell. "During low-flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low-flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., dissolved oxygen meter, etc.) can result in faulty data being collected.

Interferences may result from using contaminated equipment, cleaning materials, sample containers, or uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning to avoid ambient air interferences. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely checked to be free from contaminants and equipment blanks collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected and they are a concern, then a more vigorous cleaning procedure will be needed.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. OSHA regulations may require the sampler to take the 40 hour OSHA health and safety training course and a refresher course prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team needs to read, and be familiar with, the site Health and Safety Plan, all relevant SOPs, and SAP/QAPP (and the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest to the understanding of these site documents and that it is recorded.

EQUIPMENT AND SUPPLIES

A. Informational materials for sampling event

A copy of the current Health and Safety Plan, SAP/QAPP, monitoring well construction data, location map(s), field data from last sampling event, manuals for sampling, and the monitoring instruments' operation, maintenance, and calibration manuals should be brought to the site.

B. Well keys.

C. Extraction device

Adjustable rate, submersible pumps (e.g., centrifugal, bladder, etc.) which are constructed of stainless steel or Teflon are preferred. Note: if extraction devices constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. This is not mandatory, but is considered a "best practice". For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence value should be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

Adjustable rate, peristaltic pumps (suction) are to be used with caution when collecting samples for VOCs and dissolved gases (e.g., methane, carbon dioxide, etc.) analyses. Additional information on the use of peristaltic pumps can be found in Appendix A. If peristaltic pumps are used, the inside diameter of the rotor head tubing needs to match the inside diameter of the tubing installed in the monitoring well.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling, and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

D. Tubing

Teflon or Teflon-lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. Note: if tubing constructed of other materials is to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for metal and other inorganics analyses.

The use of 1/4 inch or 3/8 inch (inside diameter) tubing is recommended. This will help ensure that the tubing remains liquid filled when operating at very low pumping rates when using centrifugal and peristaltic pumps.

Silastic tubing should be used for the section around the rotor head of a peristaltic pump. It should be less than a foot in length. The inside diameter of the tubing used at the pump rotor head must be the same as the inside diameter of tubing placed in the well. A tubing connector is used to connect the pump rotor head tubing to the well tubing. Alternatively, the two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing. The tubing must not be reused.

E. The water level measuring device

Electronic "tape", pressure transducer, water level sounder/level indicator, etc. should be capable of measuring to 0.01 foot accuracy. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each sampling event.

F. Flow measurement supplies

Graduated cylinder (size according to flow rate) and stopwatch usually will suffice.

Large graduated bucket used to record total water purged from the well.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL, or DNAPL) before purging begins (as needed).

H. Power source (generator, nitrogen tank, battery, etc.)

When a gasoline generator is used, locate it downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate samples.

I. Indicator field parameter monitoring instruments

Use of a multi-parameter instrument capable of measuring pH, oxidation/reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and coupled with a flow-through-cell is required when measuring all indicator field parameters, except turbidity. Turbidity is collected using a separate instrument. Record equipment/instrument identification (manufacturer, and model number).

Transparent, small volume flow-through-cells (e.g., 250 mLs or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.

Turbidity samples are collected before the flow-through-cell. A "T" connector coupled with a valve is connected between the pump's tubing and flow-through-cell. When a turbidity measurement is required, the valve is opened to allow the groundwater to flow into a container. The valve is closed and the container sample is then placed in the turbidimeter.

Standards are necessary to perform field calibration of instruments. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP which use a Zobell solution as a standard. For dissolved oxygen, a wet sponge used for the 100% saturation and a zero dissolved oxygen solution are used for the calibration.

Barometer (used in the calibration of the Dissolved Oxygen probe) and the conversion formula to convert the barometric pressure into the units of measure used by the Dissolved Oxygen meter are needed.

J. Decontamination supplies

Includes (for example) non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.

K. Record keeping supplies

Logbook(s), well purging forms, chain-of-custody forms, field instrument calibration forms, etc.

L. Sample bottles

M. Sample preservation supplies (as required by the analytical methods)

N. Sample tags or labels

O. PID or FID instrument

If appropriate, to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

P. Miscellaneous Equipment

Equipment to keep the sampling apparatus shaded in the summer (e.g., umbrella) and from freezing in the winter. If the pump's tubing is allowed to heat up in the warm weather, the cold groundwater may degas as it is warmed in the tubing.

EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field.

Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments are calibrated using U.S Environmental Protection Agency Region 1 *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* January 19, 2010, or latest version or from one of the methods listed in 40CFR136, 40CFR141 and SW-846.

The instruments shall be calibrated at the beginning of each day. If the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is highly recommended to ensure that the instruments did not drift out of calibration. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be qualified or rejected.

PRELIMINARY SITE ACTIVITIES (as applicable)

Check the well for security (damage, evidence of tampering, missing lock, etc.) and record pertinent observations (include photograph as warranted).

If needed lay out sheet of clean polyethylene for monitoring and sampling equipment, unless equipment is elevated above the ground (e.g., on a table, etc.).

Remove well cap and if appropriate measure VOCs at the rim of the well with a PID or FID instrument and record reading in field logbook or on the well purge form.

If the well casing does not have an established reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the altitude of this point should be determined using techniques that are appropriate to site's DQOs.

If water-table or potentiometric surface map(s) are to be constructed for the sampling event, perform synoptic water level measurement round (in the shortest possible time) before any purging and sampling activities begin. If possible, measure water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) the day before sampling begins, in order to allow for re-settlement of any particulates in the water column. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made the day before, it should be measured after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe may not be necessary unless analytical data or field analysis signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternate sampling method. All project modifications must be approved and documented prior to implementation.

If available check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the intake depth or extraction rate(s) used during previous sampling event(s), for either portable or dedicated extraction devices, record new values, and explain reasons for the changes in the field logbook.

PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) are preferred.

The use of dedicated pumps is recommended to minimize artificial mobilization and entrainment of particulates each time the well is sampled. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

A. Initial Water Level

Measure the water level in the well before installing the pump if a non-dedicated pump is being used. The initial water level is recorded on the purge form or in the field logbook.

B. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the appropriate depth (may not be the mid-point of the screen/open interval). The Sampling and Analysis Plan/Quality Assurance Project Plan should specify the sampling depth (used previously), or provide criteria for selection of intake depth for each new well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Pump tubing lengths, above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

C. Measure Water Level

Before starting pump, measure water level. Install recording pressure transducer, if used to track drawdowns, to initialize starting condition.

D. Purge Well

From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged. This information is recorded on the purge form or in the field logbook.

Start the pump at low speed and slowly increase the speed until discharge occurs. Check water level. Check equipment for water leaks and if present fix or replace the affected equipment. Try to match pumping rate used during previous sampling event(s). Otherwise, adjust pump speed until there is little or no water level drawdown. If the minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging.

Monitor and record the water level and pumping rate every five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" somewhat as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. If the initial water level is above the top of the screen do not allow the water level to fall into the well screen. The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.

Note: the flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (e.g., bladder, peristaltic), and/or the use of dedicated equipment. For new monitoring wells, or wells where the following situation has not occurred before, if the recovery rate to the well is less than 50 mL/min., or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. The project manager or field team leader will need to make the decision when samples should be collected, how the sample is to be collected, and the reasons recorded on the purge form or in the field logbook. A water level measurement needs to be performed and recorded before samples are collected. If the project manager decides to collect the samples using the pump, it is best during this recovery period that the pump intake tubing not be removed, since this will aggravate any turbidity problems. Samples in this specific situation may be collected without stabilization of indicator field parameters. Note that field conditions and efforts to overcome problematic situations must be recorded in order to support field decisions to deviate from normal procedures described in this SOP. If this type of problematic situation persists in a well, then water sample collection should be changed to a passive or no-purge method, if consistent with the site's DQOs, or have a new well installed.

E. Monitor Indicator Field Parameters

After the water level has stabilized, connect the "T" connector with a valve and the flow-through-cell to monitor the indicator field parameters. If excessive turbidity is anticipated or encountered with the pump startup, the well may be purged for a while without connecting up the flow-through-cell, in order to minimize particulate buildup in the cell (This is a judgment call made by the sampler). Water level drawdown measurements should be made as usual. If possible, the pump may be installed the day before purging to allow particulates that were disturbed during pump insertion to settle.

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, ORP, DO) at a frequency of five minute intervals or greater. The pump's flow rate must be able to "turn over" at least one flow-through-cell volume between measurements (for a 250 mL flow-through-cell with a flow rate of 50 mLs/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through-cell it would be every ten minutes). If the cell volume cannot be replaced in the five minute interval, then the time between measurements must be increased accordingly. Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments followed by stabilization of indicator parameters. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings are within the following limits:

Turbidity (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Samples for turbidity measurements are obtained before water enters the flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities. Record start and stop times and give a brief description of cleaning activities.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45 degree angle with the port facing upward can help remove bubbles from the flow-through-cell (see Appendix B Low-Flow Setup Diagram). All during the measurement process, the flow-through-cell must remain free of any gas bubbles. Otherwise, the monitoring probes may act erratically. 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 remain submerged in water at all times.

F. Collect Water Samples

When samples are collected for laboratory analyses, the pump's tubing is disconnected from the "T" connector with a valve and the flow-through-cell. The samples are collected directly from the pump's tubing. Samples must not be collected from the flow-through-cell or from the "T" connector with a valve.

VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the pump's flow rate is too high to collect the VOC/dissolved gases samples, collect the other samples first. Lower the pump's flow rate to a reasonable rate and collect the VOC/dissolved gases samples and record the new flow rate.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use the following procedure to collect samples: collect non-VOC/dissolved gases samples first, then increase flow rate slightly until the water completely fills the tubing, collect the VOC/dissolved gases samples, and record new drawdown depth and flow rate.

For bladder pumps that will be used to collect VOC or dissolved gas samples, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL VOC vial.

Use pre-preserved sample containers or add preservative, as required by analytical methods, to the samples immediately after they are collected. Check the analytical methods (e.g. EPA SW-846, 40 CFR 136, water supply, etc.) for additional information on preservation.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter (transparent housing preferred) is required, and the filter size (0.45 μm is commonly used) should be based on the sampling objective. Pre-rinse the filter with groundwater prior to sample collection. Make sure the filter is free of air bubbles before samples are collected. Preserve the filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

Label each sample as collected. Samples requiring cooling will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

G. Post Sampling Activities

If a recording pressure transducer is used to track drawdown, re-measure water level with tape.

After collection of samples, the pump tubing may be dedicated to the well for re-sampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth annually is usually sufficient after the initial low stress sampling event. However, a greater frequency may be needed if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and then following sampling of each well. Pumps should not be removed between purging and sampling operations. The pump, tubing, support cable and electrical wires which were in contact with the well should be decontaminated by one of the procedures listed below.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps and tubing are used, only the initial sampling event will require decontamination of the pump and tubing.

Note if the previous equipment blank data showed that contaminant(s) were present after using the below procedure or the one described in the SAP/QAPP, a more vigorous procedure may be needed.

Procedure 1

Decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump and tubing. The pump may be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Optional - flush with isopropyl alcohol (pesticide grade; must be free of ketones {e.g., acetone}) or with methanol. This step may be required if the well is highly contaminated or if the equipment blank data from the previous sampling event show that the level of contaminants is significant.

Flush with distilled/deionized water. This step must remove all traces of alcohol (if used) from the equipment. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, matrix spike/matrix spike duplicates, trip blanks (VOCs), and temperature blanks.

FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities (see Appendix C, example table), and record the following for each well:

Site name, municipality, state.

Well identifier, latitude-longitude or state grid coordinates.

Measuring point description (e.g., north side of PVC pipe).

Well depth, and measurement technique.

Well screen length.

Pump depth.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, calculated or measured total volume pumped, and clock time of each set of measurements.

Type of tubing used and its length.

Type of pump used.

Clock time of start and end of purging and sampling activity.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analyses.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions, including approximate ambient air temperature.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling/monitoring equipment used, including trade names, model number, instrument identification number, diameters, material composition, etc.

DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, field indicator parameters measured during purging, field instrument calibration information, and whatever other field logbook information is needed to allow for a full evaluation of data usability.

Note: the use of trade, product, or firm names in this sampling procedure is for descriptive purposes only and does not constitute endorsement by the U.S. EPA.

REFERENCES

Cohen, R.M. and J.W. Mercer, 1993, *DNAPL Site Evaluation*; C.K. Smoley (CRC Press), Boca Raton, Florida.

Robert W. Puls and Michael J. Barcelona, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, April 1996 (EPA/540/S-95/504).

U.S. Environmental Protection Agency, 1992, *RCRA Ground-Water Monitoring: Draft Technical Guidance*; Washington, DC (EPA/530-R-93-001).

U.S. Environmental Protection Agency, 1987, *A Compendium of Superfund Field Operations Methods*; Washington, DC (EPA/540/P-87/001).

U.S Environmental Protection Agency, Region 1, *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* January 19, 2010 or latest version.

U.S Environmental Protection Agency, EPA SW-846.

U.S Environmental Protection Agency, 40 CFR 136.

U.S Environmental Protection Agency, 40 CFR 141.

Vroblesky, Don A., Clifton C. Casey, and Mark A. Lowery, Summer 2007, Influence of Dissolved Oxygen Convection on Well Sampling, *Ground Water Monitoring & Remediation* 27, no. 3: 49-58.

APPENDIX A
PERISTALTIC PUMPS

Before selecting a peristaltic pump to collect groundwater samples for VOCs and/or dissolved gases (e.g., methane, carbon dioxide, etc.) consideration should be given to the following:

- The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data.
- If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable.
- If minor differences in the groundwater concentrations could effect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device should NOT be used for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

EPA and USGS have documented their concerns with the use of the peristaltic pumps to collect water sample in the below documents.

- "Suction Pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987.
- "The agency does not recommend the use of peristaltic pumps to sample ground water particularly for volatile organic analytes" *RCRA Ground-Water Monitoring Draft Technical Guidance*, EPA Office of Solid Waste, November 1992.
- "The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and volatiles loss", *Low-flow (Minimal drawdown) Ground-Water Sampling Procedures*, by Robert Puls & Michael Barcelona, April 1996, EPA/540/S-95/504.
- "Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in the loss of volatile analytes", USGS Book 9 Techniques of Water-Resources Investigation, Chapter A4. (Version 2.0, 9/2006).

APPENDIX B

SUMMARY OF SAMPLING INSTRUCTIONS

These instructions are for using an adjustable rate, submersible pump or a peristaltic pump with the pump's intake placed at the midpoint of a 10 foot or less well screen or an open interval. The water level in the monitoring well is above the top of the well screen or open interval, the ambient temperature is above 32°F, and the equipment is not dedicated. Field instruments are already calibrated. The equipment is setup according to the diagram at the end of these instructions.

1. Review well installation information. Record well depth, length of screen or open interval, and depth to top of the well screen. Determine the pump's intake depth (e.g., mid-point of screen/open interval).

2. On the day of sampling, check security of the well casing, perform any safety checks needed for the site, lay out a sheet of polyethylene around the well (if necessary), and setup the equipment. If necessary a canopy or an equivalent item can be setup to shade the pump's tubing and flow-through-cell from the sun light to prevent the sun light from heating the groundwater.

3. Check well casing for a reference mark. If missing, make a reference mark. Measure the water level (initial) to 0.01 ft. and record this information.

4. Install the pump's intake to the appropriate depth (e.g., midpoint) of the well screen or open interval. Do not turn-on the pump at this time.

5. Measure water level and record this information.

6. Turn-on the pump and discharge the groundwater into a graduated waste bucket. Slowly increase the flow rate until the water level starts to drop. Reduce the flow rate slightly so the water level stabilizes. Record the pump's settings. Calculate the flow rate using a graduated container and a stop watch. Record the flow rate. Do not let the water level drop below the top of the well screen.

If the groundwater is highly turbid or colored, continue to discharge the water into the bucket until the water clears (visual observation); this usually takes a few minutes. The turbid or colored water is usually from the well being disturbed during the pump installation. If the water does not clear, then you need to make a choice whether to continue purging the well (hoping that it will clear after a reasonable time) or continue to the next step. Note, it is sometimes helpful to install the pump the day before the sampling event so that the disturbed materials in the well can settle out.

If the water level drops to the top of the well screen during the purging of the well, stop purging the well, and do the following:

> Wait for the well to recharge to a sufficient volume so samples can be collected. This may take awhile (pump maybe removed from well, if turbidity is not a problem). The project manager will need to make the decision when samples should be collected and the reasons recorded in the site's log book. A water level measurement needs to be performed and recorded before samples are collected. When samples are being collected, the water level must not drop below the top of the screen or open interval. Collect the samples from the pump's tubing. Always collect the VOCs and dissolved gases samples first. Normally, the samples requiring a small volume are collected before the large volume samples are collected just in case there is not sufficient water in the well to fill all the sample containers. All samples must be collected, preserved, and stored according to the analytical method. Remove the pump from the well and decontaminate the sampling equipment.

If the water level has dropped 0.3 feet or less from the initial water level (water level measure before the pump was installed); proceed to Step 7. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are be collected.

7. Attach the pump's tubing to the "T" connector with a valve (or a three-way stop cock). The pump's tubing from the well casing to the "T" connector must be as short as possible to prevent the groundwater in the tubing from heating up from the sun light or from the ambient air. Attach a short piece of tubing to the other end of the end of the "T" connector to serve as a sampling port for the turbidity samples. Attach the remaining end of the "T" connector to a short piece of tubing and connect the tubing to the flow-through-cell bottom port. To the top port, attach a small piece of tubing to direct the water into a calibrated waste bucket. Fill the cell with the groundwater and remove all gas bubbles from the cell. Position the flow-through-cell in such a way that if gas bubbles enter the cell they can easily exit the cell. If the ports are on the same side of the cell and the cell is cylindrical shape, the cell can be placed at a 45-degree angle with the ports facing upwards; this position should keep any gas bubbles entering the cell away from the monitoring probes and allow the gas bubbles to exit the cell easily (see Low-Flow Setup Diagram). Note,

make sure there are no gas bubbles caught in the probes' protective guard; you may need to shake the cell to remove these bubbles.

8. Turn-on the monitoring probes and turbidity meter.

9. Record the temperature, pH, dissolved oxygen, specific conductance, and oxidation/reduction potential measurements. Open the valve on the "T" connector to collect a sample for the turbidity measurement, close the valve, do the measurement, and record this measurement. Calculate the pump's flow rate from the water exiting the flow-through-cell using a graduated container and a stop watch, and record the measurement. Measure and record the water level. Check flow-through-cell for gas bubbles and sediment; if present, remove them.

10. Repeat Step 9 every 5 minutes or as appropriate until monitoring parameters stabilized. Note at least one flow-through-cell volume must be exchanged between readings. If not, the time interval between readings will need to be increased. Stabilization is achieved when three consecutive measurements are within the following limits:

> **Turbidity** (10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized),
> **Dissolved Oxygen** (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
> **Specific Conductance** (3%),
> **Temperature** (3%),
> **pH** (± 0.1 unit),
> **Oxidation/Reduction Potential** (±10 millivolts).

If these stabilization requirements do not stabilize in a reasonable time, the probes may have been coated from the materials in the groundwater, from a buildup of sediment in the flow-through-cell, or a gas bubble is lodged in the probe. The cell and the probes will need to be cleaned. Turn-off the probes (not the pump), disconnect the cell from the "T" connector and continue to purge the well. Disassemble the cell, remove the sediment, and clean the probes according to the manufacturer's instructions. Reassemble the cell and connect the cell to the "T" connector. Remove all gas bubbles from the cell, turn-on the probes, and continue the measurements. Record that the time the cell was cleaned.

11. When it is time to collect the groundwater samples, turn-off the monitoring probes, and disconnect the pump's tubing from the "T" connector. If you are using a centrifugal or peristaltic pump check the pump's tubing to determine if the tubing is completely filled with water (no air space).

All samples must be collected and preserved according to the analytical method. VOCs and dissolved gases samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

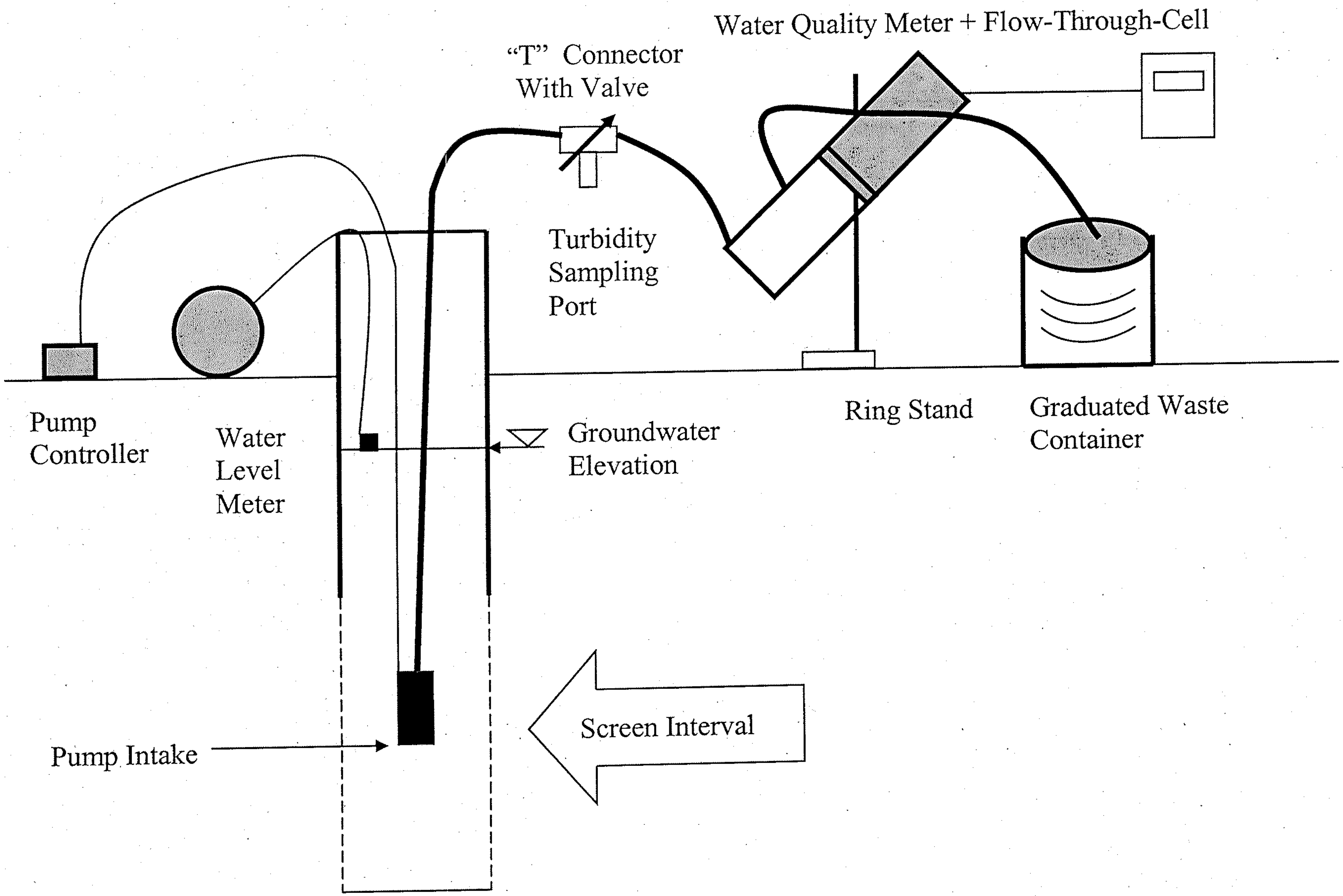
If the pump's tubing is not completely filled with water and the samples are being collected for VOCs and/or dissolved gases analyses using a centrifugal or peristaltic pump, do the following:

> All samples must be collected and preserved according to the analytical method. The VOCs and the dissolved gases (e.g., methane, ethane, ethene, and carbon dioxide) samples are collected last. When it becomes time to collect these samples increase the pump's flow rate until the tubing is completely filled. Collect the samples and record the new flow rate.

12. Store the samples according to the analytical method.

13. Record the total purged volume (graduated waste bucket). Remove the pump from the well and decontaminate the sampling equipment.

Low-Flow Setup Diagram



APPENDIX C
EXAMPLE (Minimum Requirements)
WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)______________________
Well Number______________ Date______________
Field Personnel______________________
Sampling Organization______________________
Identify MP______________________

Depth to ________/________ of screen
(below MP) top bottom
Pump Intake at (ft. below MP)__________
Purging Device; (pump type)__________
Total Volume Purged __________

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Turb-idity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	± 10 mv	10%	10%	

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25°C.
3. Oxidation reduction potential (ORP)

ARCADIS

Appendix B-1-10-B

Groundwater Purging and Sampling Procedures for Monitoring Wells and Piezometers with Saturated Screen Lengths Greater than 10 Feet

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Groundwater Purging and Sampling Procedures for Monitoring Wells and Piezometers with Saturated Screen Lengths Greater than 10 Feet

Rev. #: 1

Rev Date: May 4, 2010

ARCADIS

Approval Signatures

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Reviewed by: Michael J. Gefell Date: 5/4/2010
(Technical Expert)

I. Scope and Application

Groundwater samples will be collected from monitoring wells to evaluate groundwater quality. The protocol presented in this standard operating procedure (SOP) describes the procedures to be used to purge monitoring wells and piezometers with saturated screen lengths greater than 10 feet, and collect groundwater samples. This protocol has been developed in general accordance with the United States Environmental Protection Agency (USEPA) Region I Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells (USEPA SOP No. EQASOP-GW 001; Revision #3; January 19, 2010). Both filtered and unfiltered groundwater samples may be collected using this low-flow sampling method. Filtered samples will be obtained using a 0.45-micron disposable filter. No wells will be sampled until well development has been performed in accordance with the procedures presented in the SOP titled Monitoring Well Development, unless that well has been sampled or developed within the prior 1-year time period. Groundwater samples will not be collected within 2 week following well development.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading groundwater sample collection activities should have a minimum of 2 years of previous groundwater sampling experience. ARCADIS personnel providing assistance to groundwater sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences, engineering, hydrogeology, or geology.

The supervisor of the groundwater sampling team will have at least 1 year of previous supervised groundwater sampling experience.

Prior to mobilizing to the field, the groundwater sampling team should review and be thoroughly familiar with relevant site-specific documents including but not limited to the site work plan, field sampling plan, Quality Assurance Project Plan (QAPP), Health and Safety Plan (HASP), and historical information. Additionally, the groundwater sampling team should review and be thoroughly familiar with documentation provided by equipment manufacturers for all equipment that will be used in the field prior to mobilization.

III. Equipment List

Specific to this activity, the following materials (or equivalent) will be available:

- Health and safety equipment (as required in the site HASP).
- Site Plan, well construction records, prior groundwater sampling records (if available).
- Well keys
- Photoionization detector (PID) (i.e., RAE Systems MiniRAE 2000 or 3000)
- Sampling pump, which may consist of one or more of the following:
  - submersible pump (e.g., Grundfos Redi-Flo 2); or
  - bladder pump (e.g., Geotech portable bladder pump 0.85" outside diameter [O.D.]).
- Appropriate controller and power source for pump:
  - Submersible pumps require electric power from either a generator or a deep cell battery.
  - Submersible pumps such as Grundfos require a pump controller to run the pump
  - Bladder pumps require a pump controller and a gas source (e.g., air compressor or compressed N_2 or CO_2 gas cylinders).
- Polyethylene tubing of an appropriate size for the pump being used. The use of 1/4" or 3/8" (inside diameter) tubing is recommended to help ensure the tubing remains liquid filled when operating at very low pumping rates.
- Water-level probe and/or oil/water interface probe (e.g., Solinst or Heron).
- YSI 600 XL water-quality (dissolved oxygen [DO]/specific conductance/ temperature/pH/oxidation-reduction potential [ORP]) meter and flow-through measurement cell. Transparent, small volume flow-through-cells (e.g., 250 mL

or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

- Flow measurement supplies, including a graduated cylinder and stopwatch to measure flow rate; and a large graduated bucket to record total water purged from the well.
- Turbidity meter (e.g., Hach 2100P or LaMotte 2020). Turbidity measurements collected with multi-parameter meters have been shown to sometimes be unreliable due to fouling of the optic lens of the turbidity meter within the flow-through cell. Therefore, a separate turbidity meter will be used to measure turbidity during purging. Turbidity measurements will be taken from water collected prior to the sample stream entering the flow-through cell.
- Appropriate water sample containers (supplied by the laboratory).
- Appropriate blanks (trip blank supplied by the laboratory).
- Disposable polyethylene bailer(s).
- 0.45-micron disposable filters (if field filtering is required).
- Plastic syringe and/or peristaltic pump (if sampling with a bailer).
- Large glass mixing container (if sampling with a bailer).
- Teflon® stirring rod (if sampling with a bailer).
- Cleaning equipment.
- Groundwater sampling log (attached) or bound field logbook.

Note that in the future, the client may acquire different makes/models of some of this equipment if the listed makes/models are no longer available, or as a result of general upgrades or additional equipment acquisitions. In the event that the client uses a different make/model of the equipment listed, the client will use an equivalent type of equipment (e.g., pumps, flow-through analytical cells) and note the specific make/model of the equipment used during a sampling event on the groundwater sampling log. In addition, should the client desire to change to a markedly different sampling methodology (e.g., discrete interval samplers, passive diffusion bags, or a yet to be developed technique), the client will submit a proposed SOP for the new methodology for USEPA approval prior to implementing such a change.

The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment will be serviced by a qualified technician.

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area and monitoring well can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate groundwater samples.

Do not use permanent marker or felt-tip pens for labels on sample container or sample coolers – use indelible ink. The permanent markers could introduce volatile constituents into the samples.

It may be necessary to field filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to impacted based on previous analytical data. If no analytical data are available, samples are collected in order of upgradient, then furthest downgradient to source area locations.

Be careful not to over-tighten lids with Teflon® liners or septa (e.g., 40 mL vials). Over-tightening can cause the glass to shatter or impair the integrity of the Teflon seal.

V. Health and Safety Considerations

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.

Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.

Use caution when opening protective casing on stickup wells as wasps frequently nest inside the tops of the covers.

VI. Procedure

Groundwater will be purged from the wells using an appropriate pump. A submersible pump (i.e., Grundfos Redi-Flo 2) or bladder pump will be used to purge and sample all wells. Bladder pumps are preferred over submersible pumps if sampling of volatile organic compounds (VOCs) is required to prevent volatilization.

1. Calibrate field instruments in accordance with USEPA's *Calibration of Field Instruments* SOP (revised January 19, 2010; provided as Appendix B-1-20) and document in the field logbook.

2. Check well for security damage or evidence of tampering, and record pertinent observations in the field logbook.

3. Remove the pressure-fit well cap and immediately measure VOCs at the rim of the well with a PID; record the reading in the field logbook.

4. Measure initial depth to groundwater prior to placement of pumps. Ideally, a synoptic water level measurement round should be performed (in the shortest time possible) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft) and total well depth (to 0.1 ft) be measured the day before, to allow any particulates in the water column to settle. If measurement of total well depth in not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established reference point. If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), then make one. Describe its location and record the date of the mark in the field logbook.

5. Check newly constructed wells for the presence of light, non-aqueous phase liquid (LNAPL) or dense, non-aqueous phase liquid (DNAPL) before the initial sampling round. Record measurements in the field logbook.

6. Prepare and install pump in well: For submersible and non-dedicated bladder pumps, decontaminate pump according to site decontamination procedures. Non-dedicated bladder pumps will require a new Teflon® bladder and attachment of an air line, sample discharge line, and safety cable prior to placement in the well. Attach the air line tubing to the air port on the top of the bladder pump. Attach the sample discharge tubing to the water port on the top of the bladder pump. Care should be taken not to reverse the air and discharge tubing lines during bladder pump set-up as this could result in bladder failure or rupture. Attach and secure a safety cable to the eyebolt on the top of bladder pump (if present, depending on pump model used). Slowly lower pump, safety cable, tubing, and electrical lines into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Take care to avoid twisting and tangling of safety cable, tubing, and electrical lines while lowering pump into well; twisted and tangled lines could result in the pump becoming stuck in the well casing. Also, make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well as this could lead to well contamination.

7. Connect the pump to other equipment. If using a bladder pump, the discharge water line should be connected to the bottom inlet port on the flow-through cell connected to the water quality meter. Connect the air line to the pump controller output port. The pump controller should then be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose. Take care to tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon® tape may be used on the threads of the cylinder to provide a tighter seal. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin the gas flow. Measure the water level again with the pump in the well before starting the pump. A schematic low-flow sampling set-up is included in Attachment 1.

8. Turn on the pump controller if an on/off switch is present and verify that all batteries are charged and fully operating before beginning to pump. Start pumping the well at 100 to 500 milliliters (mL) per minute (or at lower site-specific rate if specified). The pump rate should be adjusted to cause little or no water level drawdown in the well (less than 0.3 feet below the initial static depth, if possible) and the water level should stabilize. If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize. The water level should be monitored at least every 5 minutes (or as appropriate, lower flow rates may require longer time between

readings) during pumping if the well diameter is of sufficient size to allow such monitoring. From the time the pump starts purging until the time the samples are collected, the purged water should be discharged into a graduated bucket to determine the total volume of groundwater purged. Care should be taken not to break pump suction or cause entrainment of air in the discharge line. Record pumping rate adjustments and depths to water. If necessary, pumping rates should be reduced to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters. A steady flow rate should be maintained to the extent practicable. Groundwater sampling records from previous sampling events (if available) should be reviewed prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for the well in order to more efficiently reach a stabilized pumping condition.

9. If the recharge rate of the well is very low, alternative purging techniques should be used, which will vary based on the well construction and screen position. For wells screened across the water table, the well should be pumped dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should be pumped until a stabilized level (which may be below the maximum displacement goal of 0.3 feet) can be maintained and monitoring for stabilization of field indicator parameters can commence. If a lower stabilization level cannot be maintained, the well should be pumped until the drawdown is at a level slightly higher than the bentonite seal above the well screen. Sampling should commence after one well volume has been removed and the well has recovered sufficiently to permit collection of samples.

10. During extreme weather conditions, stabilization of field indicator parameters may be difficult to obtain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) will be documented in the field notes. If other field conditions exist that preclude stabilization of certain parameters, an explanation of why the parameters did not stabilize will also be documented in the field logbook.

11. All wells with a well screen greater than 10 feet long require one saturated well screen volume to be purged prior to sampling.

    - Determine saturated screen length and calculate purge volume.

    - Establish pumping rate (see below) and monitor for water level stabilization. During groundwater sampling at the SRSNE Site, the water level will be considered “stabilized” when, during purging at a consistent rate, any of the following conditions is met:

- o The total drawdown is less than or equal to 0.3 feet after at least 10 minutes of pumping
- o The drawdown is greater than 0.3 feet and the increase in drawdown in any 10 minute period is less than 10% of the total drawdown since the beginning of pumping. Water level data may be collected more frequently than every 10 minutes to identify when this criterion is reached.[1] For example, say the increase in drawdown between 17 and 27 minutes of pumping is 0.30 feet, and the total drawdown at 27 minutes is 3.4 feet. The 10-minute drawdown increase over the total drawdown at 27 minutes is 0.30/3.4, or 8.8%. This is less than 10%, so the stabilization criterion has been satisfied.
- o If the water table is observed to rise in any 10-minute monitoring interval

- All of the water purged up to the point that the water level stabilizes (including the variable flow rate portion associated with identifying the appropriate flow rate as described below) will count toward the minimum one screen volume of purging required prior to sampling.
- Record field parameters throughout purging activities (under current protocols, field parameters aren't pertinent until after one screen volume has been purged, but collecting data from the start may provide information for a future change in procedure if approved by USEPA. In addition, supplemental low-flow groundwater samples will be collected from selected wells as discussed below; at those wells, the supplemental

[1] Water-level data may be collected more frequently than every 10 minutes, but the drawdown value for the numerator of the calculation must be based on a 10-minute interval. For example, measurements every one or two minutes may show that stabilization is achieved between 17 and 27 minutes whereas measurements every 10 minutes would not demonstrate stabilization until at least the 30-minute mark.

samples will be obtained upon initial stabilization of field parameters regardless of the volume purged at that point)

- After the water level has stabilized and at least one screen volume has been purged, monitor water quality parameters at intervals of either 5 minutes apart or the amount of time it takes for one flow-through cell volume to be purged, whichever is longer. Once parameters have stabilized per the criteria described below, collect sample. Note that the parameter stabilization is also dependent on the amount of time elapsed since purging started, so be sure to monitor and consider the time.

Inventory of Wells with Screens >10 Ft Long					
Well Screen Length	**Ovb**	**Rock**	**Total**	**Min. Required Purge Volume[1] (gal.)**	
				1.5" diam.	**2" diam.**
30	1	5	6	2.75	4.89
25	0	1	1	2.29	4.08
21	0	1	1	1.93	3.43
20	3	27	30	1.83	3.26
15	13	0	13	1.38	2.45
Totals:	**17**	**34**	**51**		

Notes:
1. Assumes entire well screen length is saturated.

12. **[Note: this step can be skipped once the target pumping rate has been established for a given well during prior sampling effort(s) and that rate is available for reference.]** To establish a baseline of pumping rates for future low flow sampling events, the following procedures should be used to determine the appropriate pump rate for each well:

- Establish the appropriate purge rate (<500 mL/min)
  - Start at pump rate of approximately 100 mL/min.
  - Begin collecting water quality data. Data, obtained before water-level stabilization cannot be used to demonstrate water-quality parameter stabilization, but should be recorded for future use in determining well-purging requirements prior to sampling.

- If drawdown is less than 0.3 feet, increase flow rate incrementally (100 mL/min every 10 min) until drawdown reaches approximately 0.3 feet.

- If drawdown exceeds 0.3 feet, decrease pumping rate – however, do not reduce pumping rate below 50 mL/min.

- Preferably, drawdown should not significantly exceed 0.3 ft unless pumping at the minimum rate of 50 mL/min.

- After water level stabilizes, continue water quality parameter monitoring and begin assessing parameter stabilization – again, none of the data collected prior to water level stabilization can be used in the assessment of water quality parameter stabilization.

- The pump rate can be reduced (to not less than 50 mL/min) to help promote stabilization of water quality parameters if water quality parameters are erratic.

- The volume of water removed while establishing purge rates will count towards the well screen volume removed for wells with screen length greater than 10 feet.

- Wells that go Dry

  - If head continues to drop even at minimum pumping rate of 50 mL/min, do not let the water level to drop below the top of the pump. Cease pumping prior to water-level reaching pump.

  - Monitor recovery.

  - Once recovered with sufficient volume of water to allow sampling for all required parameters, sample with new, disposable polyethylene bailer with no further well purging prior to sample collection.

13. Water Quality Parameters - Procedures for determining when a well is ready to sample:

- If the well screen is greater than 10 feet in length, the water quality measurements obtained prior to water-level stabilization or prior to purging of one full well screen volume should not be considered when determining when the well is suitable for sampling. However, water quality measurements should be obtained throughout the entire purging process.

- Per USEPA guidance, stabilization of water quality parameters is considered to be achieved when three consecutive readings are within the following limits:
  - **Turbidity** (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized)
  - **Dissolved Oxygen** (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized)
  - **Specific Conductance** (3%)
  - **Temperature** (3%)
  - **pH** (± 0.1 unit)
  - **Oxidation/Reduction Potential** (± 10 millivolts).
- Wells with saturated screens >10 feet long can be sampled once at least one well screen volume has been purged, the water level is stabilized, the above stabilization parameters are met, and/or at least two hours has elapsed since the purging began.

14. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection. Under no circumstances should analytical samples be collected from the discharge of the flow-through cell. If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. When the container is full, tightly screw on the cap. Samples should be collected in the following order: VOCs, TOC, SVOCs, metals and cyanide, and others (or other order as defined in the Site-specific Work Plan).

15 If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Install an in-line, disposable 0.45-micron particle filter on the discharge tubing after the appropriate unfiltered groundwater sample has been collected. Continue to run the pump until an initial volume of “flush” water has been run through the filter in accordance with the manufacturer’s directions (generally 100 to 300 mL). Collect filtered groundwater sample by diverting flow out of the filter into the appropriately labeled sample container. When the container is full, screw on the cap so that it is snug, but not overtightened.

16. Complete the sample label and cover the label with clear packing tape to secure the label onto the container. Secure with packing material and store at 4°C in an insulated transport container provided by the laboratory.

17. Record on the groundwater sampling log or bound field logbook the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the stabilized field indicator parameters as measured during the final reading during purging (Attachment 3 – Example Sampling Log).

18. Turn off the pump and air compressor or close the gas cylinder valve if using a bladder pump set-up. Slowly remove the pump, tubing, lines, and safety cable from the well. Do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them. .

19. If tubing is to be dedicated to a well, it should be folded to a length that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events. A length of rope or string should be used to tie the tubing to the well cap. Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date they may be coiled neatly and placed in a clean plastic bag that is clearly labeled with the well ID. Make sure the bag is tightly sealed before placing it in storage.

20. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment.

21. Purge water for all new wells where prior sampling data are not available, and from pre-existing wells where the most recent sampling indicated concentrations above Maximum Contaminant Level (MCL) will be containerized and transferred to the Hydraulic Containment and Treatment System (HCTS) for treatment. After allowing sediment to settle, the water will be treated by the treatment system.

Groundwater from the remaining pre-existing wells (i.e., those with no MCL exceedances in the most recent sampling round) will be decanted at ground surface adjacent to the well. The disposition for purge water for new wells during subsequent sampling events will be determined based on laboratory analytical data from the previous sampling event.

22. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody.

23. Complete decontamination procedures for flow-through analytical cell and submersible or bladder pump, as appropriate.

24. At the end of the day, perform calibration check of field instruments.

If it is not technically feasible to use the low-flow sampling method, purging and sampling of monitoring wells may be conducted using the bailer method as outlined below:

1. Don appropriate PPE (as required by the HASP).

2. Place plastic sheeting around the well.

3. Clean sampling equipment.

4. Open the well cover while standing upwind of the well. Remove well cap and place on the plastic sheeting. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field log. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the breathing zone reading is less than 5 PID units, proceed. If the PID reading in the breathing zone is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings. For wells that are part of the regular weekly monitoring program and prior PID measurements have not resulted in a breathing zone reading above 5 PID units, PID measurements will be taken monthly.

5. Measure the depth to water and determine depth of well by examining drilling log data or by direct measurement. Calculate the volume of water in the well (in

gallons) by using the length of the water column (in feet), multiplying by 0.163 for a 2-inch well or by 0.653 for a 4-inch well. For other well diameters, use the formula:

6. Volume (in gallons) = π TIMES well radius (in feet) squared TIMES length of water column (in feet) TIMES 7.481 (gallons per cubic foot)

7. Measure a length of rope or twine at least 10 feet greater than the total depth of the well. Secure one end of the rope to the well casing and secure the other end to the bailer. Test the knots and make sure the rope will not loosen. Check bailers so that all parts are intact and will not be lost in the well.

8. Lower bailer into well and remove one well volume of water. Contain all water in appropriate containers.

9. Monitor the field indicator parameters (e.g., turbidity, temperature, specific conductance, and pH). Measure field indicator parameters using a clean container such as a glass beaker or sampling cups provided with the instrument. Record field indicator parameters on the groundwater sampling log.

10. Repeat Steps 7 and 8 until three or four well volumes have been removed. Examine the field indicator parameter data to determine if the parameters have stabilized. The well is considered stabilized and ready for sample collection when turbidity values remain within 10% (or within 1 NTU if the turbidity reading is less than 10 NTU), the specific conductance and temperature values remain within 3%, and pH remains within 0.1 units for three consecutive readings collected once per well volume removed.

11. If the field indicator parameters have not stabilized, remove a maximum of five well volumes prior to sample collection. Alternatively, five well volumes may be removed without measuring the field indicator parameters.

12. If the recharge rate of the well is very low, wells screened across the water table may be bailed dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should only be bailed down to a level slightly higher than the bentonite seal above the well screen. The well should not be bailed completely dry, to maintain the integrity of the seal. Sampling should commence as soon as the well volume has recovered sufficiently to permit sample collection.

13. Following purging, allow water level in well to recharge to a sufficient level to permit sample collection.

14. Complete the sample label and cover the label with clear packing tape to secure the label onto the container.

15. Slowly lower the bailer into the screened portion of the well and carefully retrieve a filled bailer from the well causing minimal disturbance to the water and any sediment in the well.

16. The sample collection order (as appropriate) will be as follows:

    a. VOCs;

    b TOC;

    c. SVOCs;

    d. metals and cyanide; and

    e. others.

17. When sampling for volatiles, collect water samples directly from the bailer into 40-mL vials with Teflon®-lined septa.

18. For other analytical samples, remove the cap from the large glass mixing container and slowly empty the bailer into the large glass mixing container.

19. Continue collecting samples until the mixing container contains a sufficient volume for all laboratory samples.

20. Mix the entire sample volume with the Teflon® stirring rod and transfer the appropriate volume into the laboratory jar(s). Secure the sample jar cap(s) tightly.

21. If sampling for filtered metals and/or PCBs, groundwater samples will be filtered in the field using either: a new disposable or decontaminated plastic syringe, with a new 0.45 micron disc-style filter on the end of the syringe; or a peristaltic pump by pumping water through a 0.45-micron filter.

- If using the syringe option, the filter will be connected to the end of the syringe, the plunger will be temporarily removed and placed on clean plastic sheeting, water will be decanted from the large glass mixing container, the plunger will be pushed into the syringe, 10-15 milliliters (mL) of groundwater will be pushed through the filter, and then the sample water will be collected from the filter discharge directly into an appropriate bottle provided by the analytical laboratory.

- If using the peristaltic pump option, the intake line of the pump will be inserted into the large glass mixing container, the discharge tube from the pump will be equipped with a new disposable 0.45-micron filter, and the pump will be used to push water through the filter into an appropriate bottle provided by the laboratory.

- Following filtration, dissolved metals samples will be preserved by acidification to pH<2.

22. Secure with packing material and store at 4°C in an insulated transport container provided by the laboratory.

23. After sample containers have been filled, remove one additional volume of groundwater. Measure the pH, temperature, turbidity, and conductivity. Record on the groundwater sampling log or bound field logbook the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the field indicator parameters.

24. Remove bailer from well, secure well, and properly dispose of PPE and disposable equipment.

25. If a bailer is to be dedicated to a well, it should be secured inside the well above the water table, if possible. Dedicated bailers should be tied to the well cap so that inadvertent loss of the bailer will not occur when the well is opened.

26. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody.

VII. Waste Management

Materials generated during groundwater sampling activities, including disposable equipment, will be placed in appropriate containers. Containerized waste will be disposed of by the client consistent with the procedures identified in the HASP.

VIII. Data Recording and Management

Initial field logs and chain-of-custody records will be transmitted to the ARCADIS PM at the end of each day unless otherwise directed by the PM. The groundwater team leader retains copies of the groundwater sampling logs.

IX. Quality Assurance

In addition to the quality control samples to be collected in accordance with this SOP, the following quality control procedures should be observed in the field:

- Collect samples from monitoring wells in order of increasing concentration, to the extent known based on review of historical site information if available.

- Equipment blanks should include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well).

- Collect equipment blanks after wells with higher concentrations (if known) have been sampled.

- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook.

- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well using procedures for equipment decontamination.

X. References

United States Environmental Protection Agency (USEPA). 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).

USEPA. 1991. Handbook Groundwater, Volume II Methodology, Office of Research and Development, Washington, DC. USEPN62S, /6-90/016b (July, 1991).

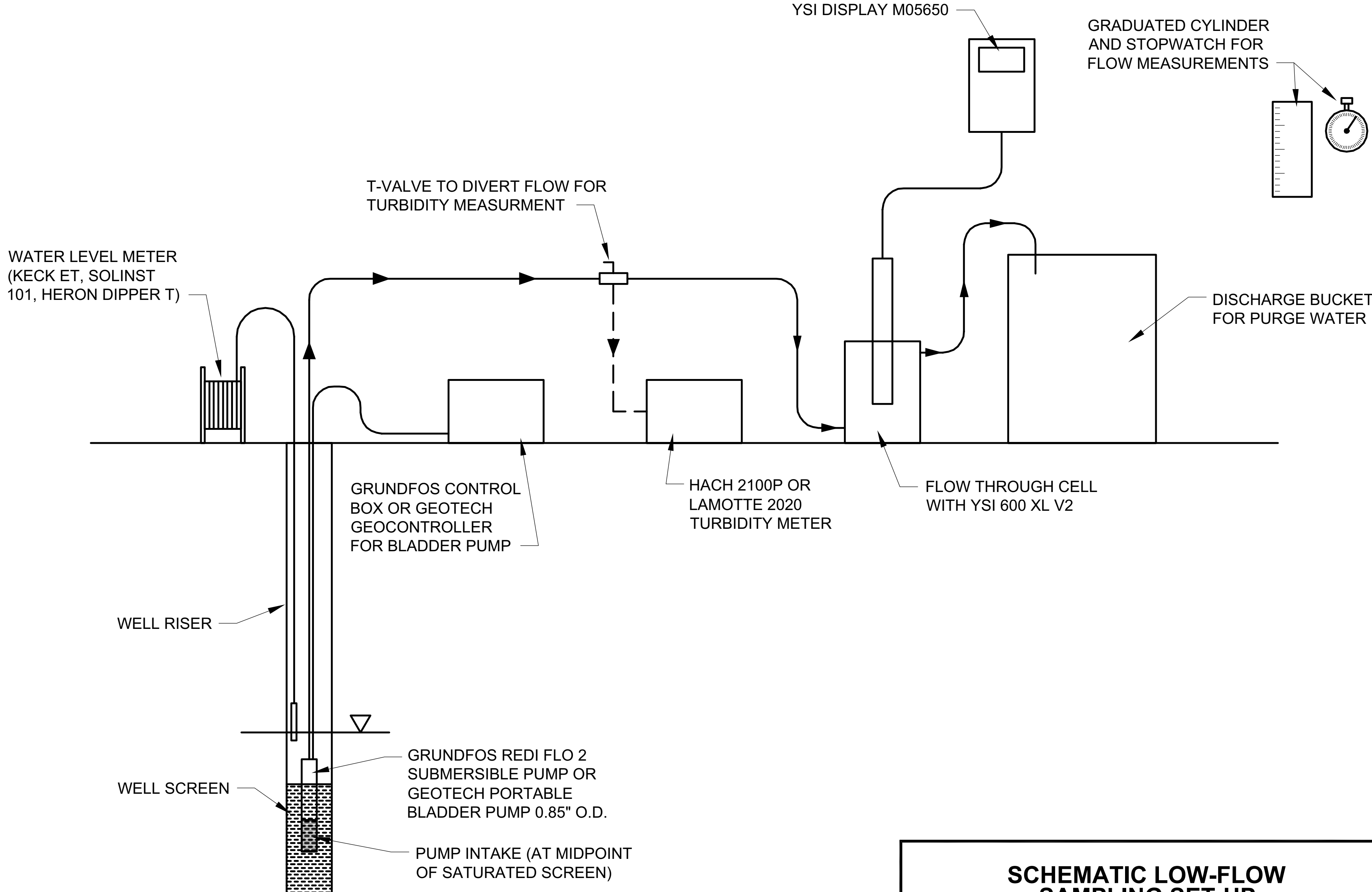
USEPA Region I. 2010. *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*.

USEPA Region I. 2010. *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction potential [ORP], and turbidity)*.

U.S. Geological Survey (USGS). 1977. National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination. Reston, Virginia.

Attachment 1

Schematic Low-Flow Sampling Set-Up



SCHEMATIC LOW-FLOW SAMPLING SET-UP

ARCADIS

FIGURE
1

Attachment 2

Oxygen Solubility in Fresh Water

Temperature (degrees C)	**Dissolved Oxygen** (mg/L)
0	14.6
1	14.19
2	13.81
3	13.44
4	13.09
5	12.75
6	12.43
7	12.12
8	11.83
9	11.55
10	11.27
11	11.01
12	10.76
13	10.52
14	10.29
15	10.07
16	9.85
17	9.65
18	9.45
19	9.26
20	9.07
21	8.9
22	8.72
23	8.56
24	8.4
25	8.24
26	8.09
27	7.95
28	7.81
29	7.67
30	7.54
31	7.41
32	7.28
33	7.16
34	7.05
35	6.93

Reference: Vesilind, P.A., *Introduction to Environmental Engineering*, PWS Publishing Company, Boston, 468 pages (1996).

Attachment 3

Groundwater Sampling Log

WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)______________________________
Well Number_______________Date_______________
Field Personnel______________________________
Sampling Organization______________________________
Identify MP______________________________

Depth to _______/________ of screen
(below MP) top bottom
Pump Intake at (ft. below MP)__________
Purging Device; (pump type)__________
Total Volume Purged __________

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Turb-idity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	± 10 mv	10%	10%	

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25°C.
3. Oxidation reduction potential (ORP)

ARCADIS

Appendix B-1-11

Groundwater Sampling with HydraSleeves^{TM}

ARCADIS
Infrastructure, environment, buildings

Imagine the result

Groundwater Sampling with HydraSleeves™ – Standard Operating Procedure

Rev. #: 1

Rev Date: May 3, 2010

Approval Signatures

Prepared by: ____________________ Date: 5/3/10

Erika L.W. Carter, Ph.D.

Reviewed by: ____________________ Date: 5/3/10

Craig Divine, Ph.D., P.G. (Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) establishes guidelines and procedures for use by field personnel in the deployment of HydraSleeves™ and subsequent collection and documentation of groundwater samples for chemical analysis. Proper collection procedures are necessary to assure the quality and integrity of all groundwater samples. The details within this SOP should be used in conjunction with site-specific work plans.

The HydraSleeve™ groundwater sampler can be used to collect a representative sample for most physical and chemical parameters without purging the well. It collects a groundwater sample from a user-defined interval (typically within the well screen), without mixing fluid from other intervals. The HydraSleeve™ is placed within the screened interval of the monitoring well, and a period of time is allocated for the well to re-equilibrate following HydraSleeve™ down-hole deployment. The sealed HydraSleeve™ can be activated and removed for sample collection within several hours to several months. When activated, the HydraSleeve™ collects a sample with no drawdown and minimal agitation or displacement of the water column. Once the sampler is full, the one-way reed valve collapses, preventing mixing of extraneous, non-representative fluid during HydraSleeve™ recovery from the well.

Use of this SOP will provide samples for Level III and Level IV analytical data for use in risk assessments, site characterizations, evaluation of remediation alternatives, engineering design of remediation activities, and in support during remediation activities.

II. Personnel Qualifications

All personnel shall meet the requirements of the site-specific Health and Safety Plan (HASP).

The Project Manager is responsible for ensuring that all sample collection activities are conducted in accordance with this SOP and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

The Field Manager is responsible for periodic observation of field activities and review of field generated documentation associated with this SOP. The Field Manager is also responsible for implementation of corrective action (e.g., retraining personnel, additional review of work plans and SOPs, variances to QC sampling requirements, issuing non-conformances, etc.) if problems occur.

Field personnel assigned to collect groundwater samples are responsible for completing their tasks according to specifications outlined in this SOP and other appropriate procedures. Field staff shall have prior experience in groundwater sampling. The determination of placement of the HydraSleeve™ in the monitoring well shall be made by a qualified geoscientist. All staff are responsible for reporting deviations from procedures in the Field Activity Daily Log, and to the Field Manager or Project Manager.

III. Equipment List

There are three main steps for collecting groundwater samples with HydraSleeves™: 1) assembly and deployment of the HydraSleeve™, 2) collecting the groundwater samples after the equilibration period, 3) and pouring the groundwater samples into containers. The equipment needed for each step is listed below.

Equipment needed for assembly and deployment of the HydraSleeves™:

- Appropriate personal protective equipment (PPE)
- Well location maps and table identifying HydraSleeve™ deployment locations/depths
- Well keys
- Flame ionization detector (FID) (as appropriate)
- Photoionization detector (PID) (as appropriate)
- Electronic water-level indicator, 0.01 ft accuracy
- Oil/water interface probe (as appropriate)
- Plastic sheeting to protect all down-hole sampling equipment from contact with potential sources of contamination.
- Decontamination equipment
- Appropriate size HydraSleeves™ for the wells being sampled:
    - 2” HydraSleeve™ (1.75” OD, 36” long; volume of 1 liter) for 2” wells
    - 1.6” HydraSleeve™ (1.6” OD, 30” long; volume of 650 mL) for 1.5” wells (i.e., MW-03, SRS-1 and SRS-3)

  - o 1” HydraSleeve™ (1” OD, 48” long; volume of 325 mL) for wells less than 1.5” (i.e., MW-05)

- 1/8-inch diameter braided polypropylene rope (for tethers)
- Weights (stainless steel or other inert material) to anchor HydraSleeves™ in wells
- Cable ties to anchor HydraSleeves™ to tether
- Measuring tape
- Plastic syringe (if sample filtration is required)
- 0.45 micron disc-style filter (if sample filtration is required)
- Cutting implement, such as scissor or knife
- Approved site-specific workplan, Field Sampling Plan (FSP), and HASP

Equipment needed for collection/dispensing of groundwater samples:

- Appropriate PPE
- Planned Sample Table (PST), sample labels, and Chain of Custody forms (COC)
- Sample bottles, coolers, ice
- Blank collection field forms
- Well keys, site maps, and sample list
- Electronic water-level indicator, 0.01 ft accuracy
- Oil/Water interface probe (as appropriate)
- Decontamination equipment
- Plastic sheeting to protect all down-hole sampling equipment from contact with potentialsources of contamination.

- Bucket or other container to hold extra groundwater

- Additional HydraSleeves™ and zip ties to deploy for the next sampling event, as appropriate

- Approved site-specific workplan, FSP, and HASP

Unless otherwise specified in the site-specific workplan, it is advisable to establish a sampling order starting with the least contaminated well and progressing to the most contaminated last.

IV. Cautions

The largest HydraSleeve™ (36-inch) holds 1 liter of sample; the smallest holds 325 mL of sample. The sample volume requirements must be verified with the laboratory before deploying the HydraSleeve™ samplers.

According to the manufacturer, HydraSleeve™ has been used successfully with no equilibration period at some sites for some analytical parameters. HydraSleeve™ does not require dissolved compounds to diffuse across a membrane as in the case of polyethylene diffusion bag (PDB) samplers (ITRC, 2004). Because the HydraSleeve™ mechanically obtains a "core" of the water column, rather than relying on diffusion through a membrane, the HydraSleeve™ sampler can be retrieved shortly after deployment in many cases. One way to conservatively estimate the maximum required equilibration period is to estimate the flush-out period for the well based on the Darcy velocity within the formation (hydraulic conductivity times gradient) (Attachment B). It should be noted, however, that representative groundwater sampling may occur with a shorter flushing period, or no flushing period, if the well contains minimal accumulated silt and care is taken to minimize well disturbance during HydraSleeve™ deployment. Site-specific testing versus another accepted groundwater sampling method can be performed at a subset of wells – preferably spanning a range of hydraulic conductivity, geologic materials, and chemical concentrations – to verify that the HydraSleeve™ device produces samples similar to those obtained from the other accepted method.

V. Health and Safety Considerations

The HASP will be followed at all times. Appropriate personal protective equipment (PPE) will be worn at all times. Other safety considerations include exposure to contaminated groundwater or non aqueous phase liquid (NAPL) and using sharp cutting tools (scissors, knife).

VI. Procedure

Field personnel will perform deployment of the HydraSleeves™ in accordance with the following procedures.

Preliminary Site Activities

1. Visually inspect the well to ensure that it is undamaged, properly labeled and secured. Damage or other conditions that may affect the integrity of the well will be recorded on the Field Activity Daily Log and brought to the attention of the Field Manager or Project Manager.

2. Equipment will either be new or decontaminated in accordance with SOPs prior to use.

3. Lay out plastic sheeting and set up monitoring and sampling equipment.

4. Don appropriate PPE.

5. If specified in the site-specific workplan, measure volatile organic compounds (VOCs) at the rim of the unopened well with a PID and FID and record the reading in the field logbook.

6. Observe if any air is flowing into or out of the casing. In the event such conditions are observed, they should be noted on the HydraSleeve™ Field Form (Attachment A).

7. Remove well cap.

8. If specified in the site-specific workplan, measure VOCs at the rim of the well with a PID and FID instrument record the reading in the field logbook.

9. If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Record all measurements from this mark.

10. If specified in the site-specific workplan, determine if non-aqueous phase liquid (NAPL) is present in the well using an oil/water interface probe in accordance with SOPs. If NAPL is present, record the depth to NAPL and static water level on the HydraSleeve™ Field Form. A HydraSleeve™ will not be deployed nor will samples be collected from wells where NAPL is present. If NAPL is not present, measure the static water level followed by the total depth of the well with an electronic

interface probe, and record the measurements on the HydraSleeve™ Field Form.

11. Measure and record the depth to water and the total depth of the groundwater monitoring well (to 0.01 ft) in all wells to be sampled. Care should be taken to minimize disturbance to the water column and to any particulates attached to the sides or at the bottom of the well.

12. Determine the total depth of the well. Compare the measurement of the total depth of the well with the previous measurement and check against the well construction logs to determine the percent of screen occluded by sediment (if any). If more than 20 percent of a well screen is occluded by sediment, the well will not be sampled until it is re-developed.

Assembly and Deployment of Hydrasleeves

1. Begin assembling the HydraSleeve™ by removing the HydraSleeve™ from the package and grasp top to "pop" open (Figure 1). Squeeze side fins together at top to bend reinforcing strips outward (Figure 2). Attach rope to hole at top of HydraSleeve™ (using cable ties) (Figure 3). Fold the two holes at bottom of HydraSleeve™ together and attach weight (using zip tie) (Figure 4). Sampler is ready to insert into the well at the predetermined depth specified in the site-specific workplan (Figure 5).

Figure 1

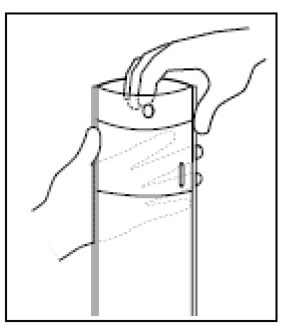


Figure 2

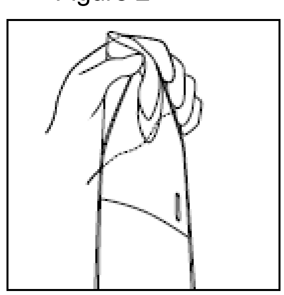


Figure 3

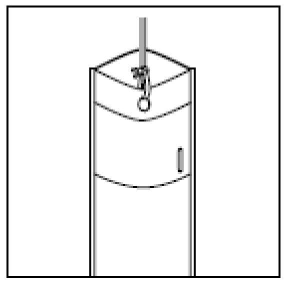


Figure 4

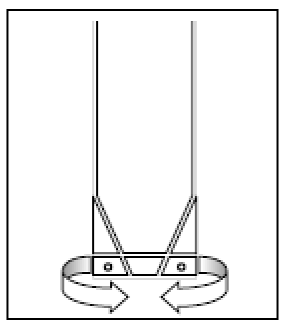
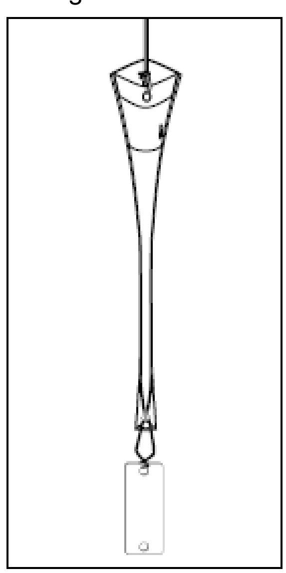


Figure 5



2. To deploy, position the top of the HydraSleeve™ so that it is below the midpoint of the saturated screened interval by a distance approximately equal to 0.75 times the full length of the HydraSleeve™. For example, a 36” HydraSleeve™ will be lowered so that the top of the HydraSleeve™ is approximately 27” below the midpoint of the saturated screened interval. This position is appropriate to collect the groundwater sample from approximately the middle of the saturated screened interval when the HydraSleeve™ is pulled upward.

   Using the determined well depth, calculate the distance from the bottom of the well to the desired sampling depth (specified on the HydraSleeve™ Field Form). Attach an appropriate length anchor line between the weight and the bottom of the sampler and *slowly* lower the assembly, allowing the top of the sampler to float at the correct sampling depth. The weight should *not* contact the bottom of the well during deployment. Attach the suspension line to the well cap to suspend the HydraSleeve™ at the correct depth until activated for sampling. Allow sufficient extra tether length such that if the tether becomes untied from the well cap and the sampler sinks to the bottom it may still be easily retrieved.

3. For wells in which another passive sampling device (e.g., passive diffusion bag [PDB]) is to be used concurrently, the HydraSleeve™ should be suspended from the same line directly beneath the other passive sampler. If the top-down deployment method is used, care should be taken to ensure the weight is not resting on the bottom of the well. If necessary, the weight may be placed at the top of the HydraSleeve™, as described below.

4. For wells with screen lengths less than 10 feet (specified on the HydraSleeve™ Field Form) or where the saturated screen length is less than 10 feet (determined during water level gauging), top-down deployment will be used as described above with the exception of the placement of the weight. The weight for these wells will be placed on the top of the HydraSleeve™ as shown in the figure below. The hanging clip is inserted locking the top of the HydraSleeve™ and the weight together. The tether will be attached to the apex of the clip, as shown below.

Photo 1

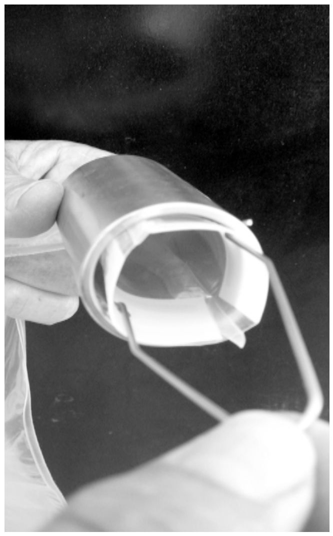
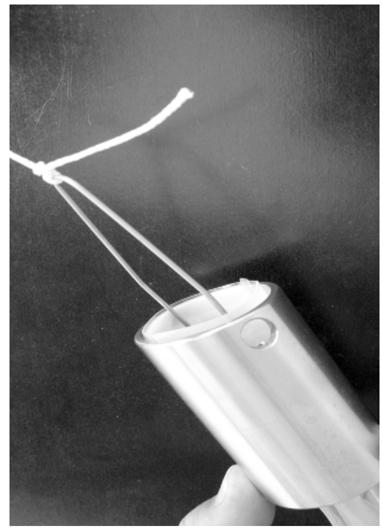


Photo 2



5. At this point deployment is complete. The well must be allowed time for the stabilization of well water and formation water following any disturbance caused by the sampler deployment before groundwater samples can be collected. The manufacturer's recommended deployment time is hours to months. The time shall be specified in the site-specific workplan. The maximum deployment time at the site will be one year.

6. After the equilibration period is complete; the groundwater samples are ready to be collected for analysis.

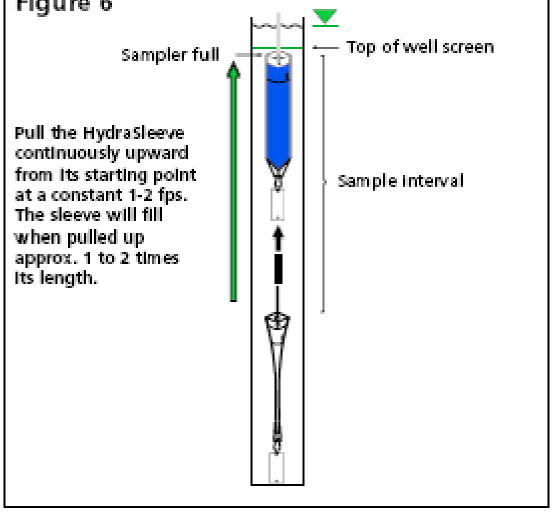
Collecting Groundwater Samples from HydraSleeves™

1. Conduct the Preliminary Site Activities detailed above with the following exception: The depth to groundwater/total well depth should be collected only after the HydraSleeve™ has been retrieved from the well.

2. The Continuous Pull method will be used for the majority of the wells. If the well to be sampled has a screen length less than 10 feet in length, use the Short Strokes method. The HydraSleeve™ Field Form will state the screen length and sample collection method for each well.

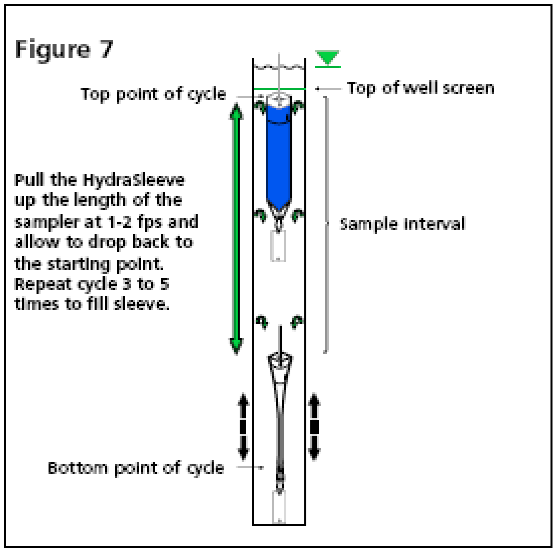
   a. Continuous Pull method – The HydraSleeve™ must move upward at an approximate rate of one foot per second or faster (about the speed a bailer is usually pulled upward) for water to pass through the check valve into the sample sleeve. The total upward distance the check valve must travel to fill the sample sleeve is about 1 to 2 times the length of the sampler. For example, a 36-inch HydraSleeve™ needs a total upward movement of 36 to no more than 72 inches to fill. Pull the HydraSleeve™ continuously upward from its starting point at a constant 1 to 2 feet per second until full. This method usually provides the least turbid samples and is analogous to coring the water column from the bottom up (Figure 6).

Figure 6



b. Short Strokes method – Pull the sampler upward at about 1 to 2 feet per second for the length of the sampler (36 inches) and let it drop back to the starting point. Repeat the cycle 3 to 5 times (Figure 7).

3. If the HydraSleeve™ is retrieved from the well and is not completely full, the sample will not be collected and a new HydraSleeve™ will be deployed. The replacement HydraSleeve™ will be allowed to equilibrate, as appropriate, prior to retrieval. After the equilibration time, the HydraSleeve™ may be collected again.



4. Collect sample parameters in the following order: VOCs (care should be taken to avoid agitation and volatilization of sample during the decanting process), explosives, metals, and other parameters. Samples will be collected and labeled in accordance with SOPs. Types of sample bottles and volume requirements for each analysis are provided in the Quality Assurance Project Plan (QAPP) and site-specific workplan. Metals samples will not be field filtered unless otherwise specified. Field filtration of no-purge (HydraSleeve™) groundwater samples, if required, will be performed using a new disposable or decontaminated plastic syringe, with a new 0.45 micron disc-style filter on the end of the syringe. The HydraSleeve™ discharge tube will be connected to the tip of the syringe, and the syringe will be filled by drawing back the plunger. After the syringe is filled and is disconnected from the discharge tube, the filter will be attached to the tip of the syringe. Finally, the plunger will be pushed into the syringe, 10-15 milliliters (mL) of groundwater will be pushed through the filter, and then the sample water will be collected from the filter discharge directly into an appropriate pre-preserved bottle provided by the analytical laboratory. Following filtration, dissolved metals samples will be preserved by acidification to pH<2. The 36-inch long HydraSleeve™ has a capacity of 1 liter. All groundwater samples, including QA/QC samples for a given well will be collected with one HydraSleeve™. If the volume requirement for sample analysis is more than 1 liter at a given well, the groundwater samples will be collected using the low-flow method. Complete sample documentation on the Groundwater Sample Log.

5. Inspect the sampling bottles (obtained from the analytical laboratory prior to the sampling event) to be used to ensure that they are appropriate for the samples being collected, are undamaged, and have had the appropriate types and volumes of preservatives added. The types of sample containers to be used and sample preservation requirements will be provided in the site-specific workplan.

6. To remove a sample from the HydraSleeve™ with the least amount of aeration and agitation use the short plastic discharge tube (included). First, squeeze the full sampler just below the top to expel water resting above the flexible check valve (Photo 3).

Photo 3

7. Then, push the pointed discharge tube through the outer polyethylene sleeve about 3-4 inches below the white reinforcing strips (Photo 4).

Photo 4

8. Discharge the sample into the desired container in the order described in step 4 (Photo 5). Raising and lowering the bottom of the sampler or pinching the sample sleeve just below the discharge tube will control the flow of the sample. The sample sleeve can also be squeezed, forcing fluid up through the discharge tube, similar to squeezing a tube of toothpaste.

   Photo 5

9. To obtain a duplicate/blind duplicate sample, collect a duplicate from the same bag as an original sample and send for analysis with the appropriate labeling.

10. To obtain an equipment blank, pour deionized water into a HydraSleeve and collect the blank using the same method as the samples and send for analysis with the appropriate labeling.

11. Place collected samples immediately in a sample cooler that is already full of ice or ice packs such that the samples are immediately chilled and stored at a temperature of 4 degrees Celsius, in accordance with SOPs.

12. Record depth to groundwater and total well depth.

13. Field parameters will be collected mid-screen from wells specified in the site-specific workplan. Calibrate all field analytical test equipment (e.g., pH, temperature, conductivity, ORP, turbidity, and DO) according to the instrument manufacturer's specifications and SOPs. Daily calibration results will be recorded on the appropriate form(s) as specified by the FSP and site-specific workplans. Instruments that cannot be calibrated according to the manufacturer's specifications will be removed from service and tagged.

14. Field parameter measurements (temperature, specific conductance, pH, DO, ORP and turbidity) will be taken after the HydraSleeve™ is removed from the well and the groundwater samples collected. This would occur through the use of a down-hole multi-meter (e.g., a YSI 600XL). Gently lower the probe of the meter down the well until it reaches the middle of the screen (screen intervals are found on the HydraSleeve™ Field Form). Follow the manufacturer's guidelines on how to determine stability of parameter readings. Once the meter readings have stabilized, record them on the HydraSleeve™ Field Form. Turbidity will be measured from groundwater taken directly from the HydraSleeve™.

15. After the groundwater samples and field measurements have been collected, it may be necessary to deploy another HydraSleeve™ in the well for future sampling events (e.g., quarterly, semi-annually, etc.). The site-specific workplan will state if another HydraSleeve™ is to be deployed. The same suspension line will be reused for additional deployment to ensure consistency in the deployment depth. Follow the steps outlined previously in this SOP for deployment instructions.

16. Secure the well.

17. Properly dispose of PPE and disposable equipment.

18. Decontaminate any cutting devices, reusable weights, suspension lines, or sampler attachment mechanisms after each usage in accordance with SOPs.

VII. Waste Management

Any unused water from the PDB sampler and water used to decontaminate cutting devices should be disposed following SOPs and in accordance with local, State, and Federal regulations.

VIII. Data Recording and Management

All data will be recorded on HydraSleeve™ field forms and groundwater sampling field forms. Daily field logs will be maintained. Records generated as a result of this SOP will be controlled and maintained in the project record files in accordance with project requirements.

IX. Quality Assurance

Quality assurance procedures shall be conducted in accordance with the site-specific QAPP.

X. References

Cordry, K.E., 2006. HydraSleeve™ Field Manual. Las Cruces, N.M.: GeoInsight, Inc. http://www.nopurgesampling.com/hydrasleeve/

Interstate Technology and Regulatory Council. 2004. Technical and Regulatory Guidance for Using Polyethylene Diffusion Bag Samplers to Monitor Volatile Organic Compounds in Groundwater. February.

XI. Attachments

A. HydraSleeve™ Field Form

B. Calculation of Maximum Required Equilibration Period (Flush-Out Time) Based On Well Geometry And Darcy Velocity

ARCADIS

Attachment A
HydraSleeve™ Field Form

Site: ______________________________
Location: ______________________________
Well ID: ______________________________

Well Type: • Monitoring • Other: ______________________________
Well Finish: • Stick Up • Flush Mount
Measuring Pt: • Top of Casing • Other (specify):____________________

Total Depth As Constructed (ftbgs): ____________ **Screened Interval (ftbgs):**____________
Well Casing: Diameter: ____________ Material: ____________
Well Screen: Diameter: ____________

Deployment

Date and Time of Deployment: Date: ____________ Time: ____________
Weather Conditions: ______________________________
Depth to groundwater at time of deployment: ______________________________
Total well depth at time of deployment: ______________________________
Dimensions of HydraSleeve™: Length (in.) ____________ Diameter (in.) ____________
Deployment Method/Position of Weight:
- Bottom Anchor: Weight attached to bottom of HydraSleeve™. Weight rests on well bottom.
- Top-Down: Weight attached to bottom of HydraSleeve™. Weight suspended in well.
- Top-Down: Weight attached to top of HydraSleeve™. Weight suspended in well.

Deployment Depth (Top of HydraSleeve™) (ftbgs): ______________________________

Retrieval

Date and Time of Retrieval: Date: ____________ Time: ____________
Total # of days deployed: ______________________________
Weather Conditions: ______________________________
Depth to groundwater at time of retrieval: ______________________________
Total well depth at time of retrieval: ______________________________
Downhole Field Parameters Upon Retrieval:
Temp:__________ **(°C)** **ORP:**____________ **(mV)** **Water quality meter:**__________________
pH:_____________ **DO:**____________ **(mg/L)** **Serial #:**____________________________

Notes/Observations:

Field Sampling Technician: Name(s) and Company

Name Company

____

____

ATTACHMENT B
CALCULATION OF MAXIMUM REQUIRED EQUILIBRATION PERIOD (FLUSH-OUT TIME) BASED ON WELL GEOMETRY AND DARCY VELOCITY

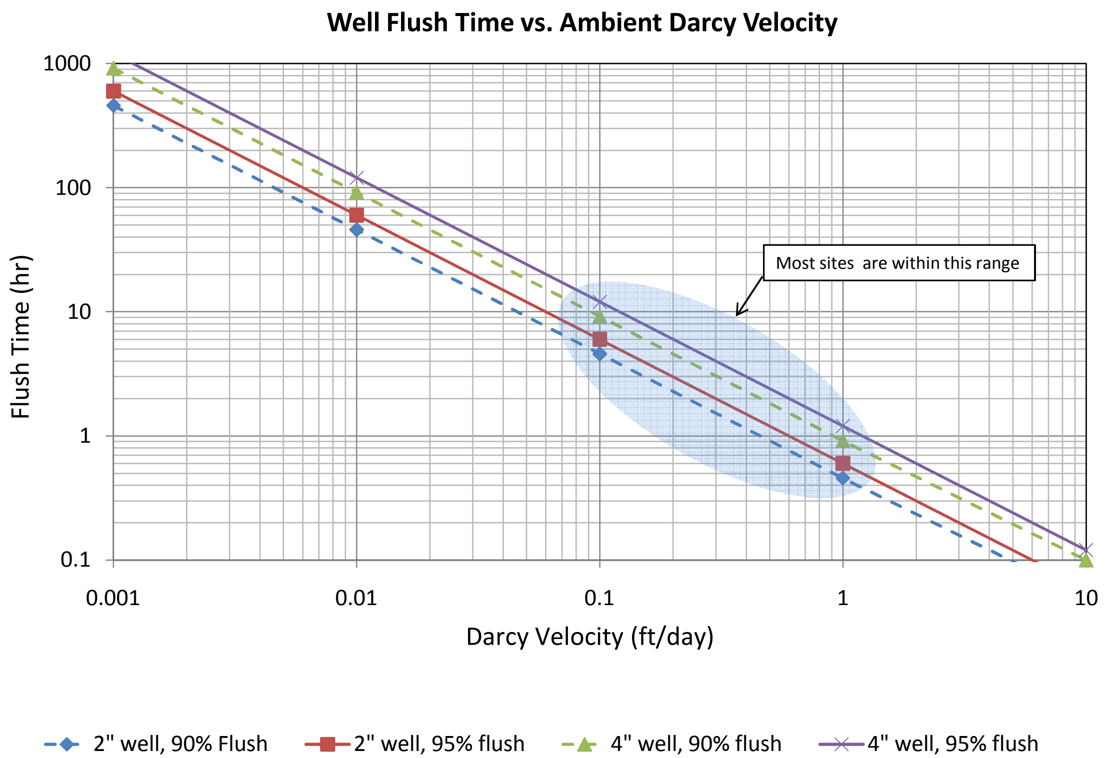
Example Calculations

Well Diam (inches)	Darcy v (ft/day)	Flush %	Flush Time (hours)
2	0.001	90	458
2	0.01	90	46
2	0.1	90	4.6
2	1	90	0.46
2	10	90	0.05
2	0.001	95	600
2	0.01	95	60
2	0.1	95	6.0
2	1	95	0.60
2	10	95	0.06
4	0.001	90	917
4	0.01	90	92
4	0.1	90	9.2
4	1	90	0.92
4	10	90	0.10
4	0.001	95	1200
4	0.01	95	120
4	0.1	95	12.0
4	1	95	1.20
4	10	95	0.12

General Equation for Flushing Time

t = [0.25 wd / (vd cf)] [-ln (1-f)]

where:
t = maximum required flushing time (hours)
wd = well diameter (inches)
vd = Darcy velocity, Ki (feet per day)
K = hydraulic conductivity (feet per day)
i = hydraulic gradient (dimensionless)
cf = flow convergence factor (typically between 2 and 3)
example calcs. assume cf = 2.5
f = % flush expressed as fraction
(e.g., 95% = 0.95, 90% = 0.90, etc.)



(Based on: Gaspar, E., and M. Onescu. 1972. Radioactive tracers in hydrology. Elsevier Publishing Co., Amsterdam)

ARCADIS

Appendix B-1-12

Down-Hole Groundwater Field Parameter Measurement

Imagine the result

Down-Hole Groundwater Field Parameter Measurement

Rev. #: 0

Rev Date: March 10, 2009

Approval Signatures

Prepared by: ______________________ Date: 3/10/09

Reviewed by: ______________________ Date: 3/10/09
(Technical Expert)

I. Scope and Application

This SOP provides procedures for collecting down-hole measurements of standard groundwater quality parameters such as pH, temperature, electrical conductivity, and dissolved oxygen and other parameters in wells or piezometers. The measurements are obtained with a portable field meter that can be lowered into the well on a cable. The data are shown visually on a hand-held display, and may be periodically saved into memory (i.e., data-logging) for later retrieval.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading groundwater sample collection activities should have a minimum of 1 years of previous groundwater sampling experience. ARCADIS personnel providing assistance to groundwater sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences, engineering, hydrogeology, or geology.

Prior to mobilizing to the field, the groundwater sampling team should review and be thoroughly familiar with relevant site-specific documents, including but not limited to the project work plan, Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), Health and Safety Plan (HASP), and pertinent historical information. Additionally, the groundwater sampling team should review and be thoroughly familiar with documentation provided by equipment manufacturers for all equipment that will be used in the field prior to mobilization.

III. Equipment List

The following materials (or equivalent) shall be available for collecting down-hole measurements of standard groundwater quality parameters at monitoring and remediation wells:

- Health and safety equipment (as required in the site-specific HASP).
- Site plan, well construction records, prior groundwater sampling records (if available).
- Portable groundwater quality meter suitable for lowering into a well. See Table 1 for list of suitable meters and capabilities.
- Water-level probe (e.g., Solinist Model 101 or equivalent).

- Cleaning equipment for decontamination, including containers and solutions, as specified in the FSP.

- Field logbook, groundwater sampling logs, and/or personal digital assistant (PDA) (as specified in the FSP).

The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment will be serviced by a qualified technician.

IV. Cautions

Groundwater quality meters should not be allowed to contact non-aqueous phase liquids (NAPLs). Do not perform measurements with a down-hole meter at wells where light non-aqueous phase liquids (LNAPLs) is present, or lower the instrument into DNAPL (if present) at the bottom of the well.

V. Health and Safety Considerations

Use caution when removing well caps, as the well may be under pressure. The well cap may dislodge forcefully and cause injury.

Use caution when opening the protective casing on stickup wells, as wasps frequently nest inside the casing. Also watch for fire ant mounds near well pads when sampling in the south or western U.S.

There is a potential pinch-point at the top of a well riser and casing when instruments are being lowered into wells. Fingers could become caught between the instrument, cable, and well casing.

If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.

VI. Procedure

1. Don appropriate PPE as required by the HASP.

2. Calibrate the field meter prior to the commencement of the day’s activities or according to manufacturer’s specifications. Record calibration activities in the field logbook and include at a minimum (where applicable):

- name of field meter calibrated
- field meter serial/ID number
- frequency of calibration
- date of calibration
- results of calibration
- name of person performing calibration
- identification and serial number of calibration fluid(s)

3. Record the site name, well identification, date and time of measurement, weather, absence/presence of odors, and other conditions in the field logbook, groundwater sampling logs, and/or PDA.

4. Prepare the work area and open the well.

5. Record the well diameter, total depth, screened interval, and stickup height from the well construction details. Confirm the well diameter and stickup height.

6. Measure and record the depth to water and total well/piezometer depth. Compare current total depth measurement to previous total depth and/or the total depth from the well construction details. If total depth has decreased, note and record the thickness of apparent silt/sediment accumulation.

7. The target depth of measurements is at the midpoint of the well screen or open interval, taking siltation into account as necessary. If additional information is sought regarding vertical stratification of water quality, then measurements can be obtained at other depths.

8. Steadily and carefully lower the field meter to the target depth. Try to avoid creating turbulence in the water column while the field meter is being lowered.

9. If the cable is marked in length units (e.g., feet, meters), monitor the depth of the instrument as it is lowered using the cable markings. If the cable is not marked, pre-measure the length of cable needed to reach the target depth with a measuring tape or water-level indicator cable. When referencing the depth based on the top of the riser, make sure to add the stickup height of the well riser (above ground surface) to the depth of the target depth below grade. (I.e., if

the target depth is 50 feet and the stickup is 1.5 feet above grade, the cable will read 51.5 feet when the probe is at the target depth).

10. When the field meter reaches the target depth, secure the cable so that the field meter does not move from the target depth.

11. Display the water quality data according to the manufacturer's instructions.

12. Monitor and record the water quality parameters every two minutes for a maximum of ten minutes. The monitoring period can be shorter if the field parameters meet the following stabilization criteria over three consecutive readings:

    - turbidity values (if monitored) remains within 10% (or within 1 NTU if the turbidity reading is less than 10 NTU)
    - specific conductance and temperature values remain within 3%
    - pH remains within •0.1 unit

13. If dissolved oxygen values are above the acceptable range for the temperature of groundwater (Table 2), then slowly raise and lower the meter in an effort to remove air bubbles that may be entrained on the probe. If the dissolved oxygen value is 0.00 or less, then the meter should be serviced and re-calibrated.

14. Slowly remove the cable and field meter from the well.

15. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment as specified in the FSP.

16. Complete decontamination procedures for the cable and field meter, as appropriate.

17. At the completion of the day's activities, perform a final calibration check of field instruments and record results.

VII. Waste Management

Materials generated during groundwater sampling activities, including disposable equipment, will be placed in appropriate containers. Containerized waste will be disposed of by the client consistent with the procedures identified in the FSP.

VIII. Data Recording and Management

Field notes from the field logbook or the groundwater sampling logs will be transmitted to the ARCADIS PM at the end of each day, unless otherwise directed by the PM. The groundwater team leader retains copies of the groundwater sampling notes and/or logs.

IX. Quality Assurance

The following quality control procedures should be observed in the field:

- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook as detailed above.

- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well using procedure for equipment decontamination as specified in the FSP.

X. References

Vesilind, P.A., Introduction to Environmental Engineering, PWS Publishing Company, Boston, 468 pages (1996).

Table 1

Down-Hole Water Quality Meters

Meter	Water Quality Parameter Measurement Capability								Minimum Well Diameter (in)	Maximum Depth (feet)	Data Logging
	pH	Temp	EC	DO	ORP	Turb	TDS	Salinity			
Horiba U-22	X	X	X	X	X	X	X	X	2	320	YES
YSI 556 MPS	X	X	X	X	X				2	65	YES
YSI 600XL Sonde	X	X	X	X	X				2	200	YES
YSI 6920 V2 Sonde	X	X	X	X	X	X		X	3	200	YES
HydroLab Quanta G	X	X	X	X	X			X	2	320	NO
Hanna Instruments 9828	X	X	X	X	X				2	320	YES
In-Situ Troll 9500	X	X	X	X	X	X	X	X	2	300	YES

Note: T = temperature, EC = electrical conductivity (aka “specific conductance”), DO = dissolved oxygen, ORP = oxygen-reduction potential, Turb = turbidity, TDS = total dissolved solids

Table 2

Oxygen Solubility in Fresh Water

Temperature (degrees C)	**Dissolved Oxygen** (mg/L)
0	14.6
1	14.19
2	13.81
3	13.44
4	13.09
5	12.75
6	12.43
7	12.12
8	11.83
9	11.55
10	11.27
11	11.01
12	10.76
13	10.52
14	10.29
15	10.07
16	9.85
17	9.65
18	9.45
19	9.26
20	9.07
21	8.9
22	8.72
23	8.56
24	8.4
25	8.24
26	8.09
27	7.95
28	7.81
29	7.67
30	7.54
31	7.41
32	7.28
33	7.16
34	7.05
35	6.93

Reference: Vesilind, P.A., *Introduction to Environmental Engineering*, PWS Publishing Company, Boston, 468 pages (1996).

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Appendix B-1-13

Water-Level and NAPL Thickness Measurement Procedures

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Water-Level and NAPL Thickness Measurement Procedures

Rev. #: 0

Rev Date: February 27, 2009

Approval Signatures

Prepared by: ______________________ Date: 2/27/09
Andrew Korik

Reviewed by: ______________________ Date: 2/27/09
Michael Gefell (Technical Expert)

I. Scope and Application

Monitoring well water levels and thickness of non-aqueous phase liquids (NAPLs) will be determined, as appropriate, to develop groundwater elevation contour maps and to assess the presence or absence of NAPL in wells. This SOP applies to light and/or dense NAPLs (LNAPLs and DNAPLs, respectively). In addition, because this SOP describes water-level measurement from surveyed measurement points, this SOP can be followed, to obtain surface water level measurements from surveyed measurement points.

Fluid levels will be measured using an electric water-level probe and/or NAPL-water interface probe from established reference points. Reference points are surveyed, and are established at the highest point at the top of well riser, and will be based on mean sea level, or local/onsite datum. The Operating and Maintenance (O&M) Instruction Manual for the electric water level probe and/or and interface probe should be reviewed prior to commencing work for safe and accurate operation.

II. Personnel Qualifications

Individuals conducting fluid level measurements will have been trained in the proper use of the instruments, including their use for measuring fluid levels and the bottom depth of wells. In addition, ARCADIS field sampling personnel will have current health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and CPR, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work. ARCADIS field personnel will also be compliant with client-specific training requirements, such as (but not limited to) LPS or other behavior-based training, and short-service employee restrictions.

III. Equipment List

The following materials, as required, shall be available during fluid level measurements.

- photoionization detector (PID)
- appropriate health and safety equipment, as specified in the site Health and Safety Plan (HASP)

- laboratory-type soap (Alconox or equivalent), methanol/hexane rinse, potable water, distilled water, and/or other equipment that may be needed for decontamination purposes
- electronic NAPL-water interface probe
- electronic water-level meter
- 6-foot engineer's rule
- portable containers
- plastic sheeting
- field logbook and/or personal digital assistant (PDA)
- indelible ink pen
- digital camera (optional, if allowed by site policy)

IV. Cautions

Electronic water-level probes and NAPL-water interface probes can sometimes produce false-positive readings. For example, if the inside surface of the well has condensation above the water level, then an electronic water-level probe may produce a signal by contacting the side of the well rather than the true water level in the well. In addition, NAPL-water interface probes can sometimes indicate false positive signals when contacting a sediment layer on the bottom of a well. In contrast, a NAPL-water interface probe may produce a false-negative (no signal) if a floating layer of non-aqueous phase liquid (NAPL) is too thin, such as a film or sheen. To produce reliable data, the electronic water level probe and/or interface probe should be raised and lowered several times at the approximate depth where the instrument produces a tone indicating a fluid interface to verify consistent, repeatable results. In addition, a bottom-loading bailer should periodically be used to check for the presence of NAPLs rather than relying solely on the NAPL-water interface probe.

The graduated tape or cable with depth markings is designed to indicate the depth of the electronic sensor that detects the fluid interface, but not the depth of the bottom of the instrument. When using these devices to measure the total well depth, the additional length of the instrument below the electronic sensor must be added to the apparent well depth reading, as observed on the tape or cable of the instrument, to obtain the true total depth of the well. If the depth markings on the tape or cable are worn or otherwise difficult to read, extra care must be taken in obtaining the depth readings.

V. Health and Safety Considerations

The HASP will be followed, as appropriate, to ensure the safety of field personnel. Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or NAPL. Other potential hazards include stinging insects that may inhabit well heads, other biologic hazards, and potentially the use of sharp cutting tools (scissors, knife). Appropriate personal protective equipment (PPE) will be worn during these activities. Field personnel will thoroughly review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives.

VI. Procedure

Calibration Procedures

If there is any uncertainty regarding the accuracy of the tape or cable associated with the electronic water-level probe or NAPL-water interface probe, it should be checked versus a standard length prior to use to assess if the tape or cable above the meter has been correctly calibrated by the manufacturer, and to identify evidence of tape or cable stretching, etc.

1. Measure the lengths between markers on the cable with a 6-foot engineer's rule or a fiberglass engineer's tape. The tape or cable associated with the electronic water-level probe or NAPL-water interface probe should be checked for the length corresponding to the deepest total well depth to be monitored during the data collection event.

2. If the length designations on the tape or cable associated with the electronic water-level probe or NAPL-water interface probe are found to be incorrect, the probe will not be used until it is repaired by the manufacturer.

3. Record verification of this calibration process in field logbook or PDA.

Measurement Procedures

The detailed procedure for obtaining fluid level depth measurements is as follows. Field notes on logs will be treated as secured documentation and indelible ink will be used. As a general rule, the order of measuring should proceed from the least to most contaminated monitoring wells, based on available data.

1. Identify site and well number in field logbook using indelible ink, along with date, time, personnel, and weather conditions.

2. Field personnel will avoid activities that may introduce contamination into monitoring wells. Activities such as dispensing gasoline into vehicles or generators should be accomplished well in advance of obtaining field measurements.

3. Don PPE as required by the HASP..

4. Clean the NAPL/water interface probe and cable in accordance with the appropriate cleaning procedures. Down-hole instrumentation should be cleaned prior to obtaining readings at the first monitoring well and upon completion of readings at each well.

5. Clean the NAPL/water level interface probe and cable with a soapy (Alconox) water rinse followed by a solvent rinse (if appropriate based on site-specific constituents of concern) an analyte-free water rinse Contain rinse water in a portable container that will be transferred to an on-site container.

6. Put clean plastic sheeting on the ground next to the well.

7. Unlock and open the well cover while standing upwind from the well. Place the well cap on the plastic sheeting.

8. Locate a measuring reference point on the well casing. If one is not found, initiate a reference point at the highest discernable point on the inner casing (or outer if an inner casing is not present) by notching with a hacksaw, or using an indelible marker. All down-hole measurements will be taken from the reference point established at each well on the inner casing (on the outer only if an inner casing is not present).

9. Measure to the nearest hundredth of a foot and record the height of the inner and outer casings (from reference point, as appropriate) to ground level.

10. Record the inside diameter of the well casing in the field log.

11. If an electronic water level probe is used to measure the water level, lower the probe until it emits a signal (tone and or light) indicating the top of the water surface. Gently raise and lower the instrument through this interface to confirm its depth. Measure and record the depth of the water surface, and the total well depth, to the nearest hundredth of a foot from the reference point at the top of

the well. Lower the probe to the bottom of the well to obtain a total depth measurement.

12. If a NAPL/water interface probe is being used to measure the depth and thickness of NAPL, lower the instrument until it emits a signal (tone and or light) indicating whether LNAPL is present. Continue to lower the NAPL/water level interface probe until it indicates the top of water. Lower the probe to the bottom of the well to obtain a total depth measurement. Note also of the depth indicating the bottom of water and top of DNAPL layer, if any, based on the signal emitted by the interface probe. At each fluid interface, gently raise and lower the instrument through each the interface to confirm its depth. Measure to the nearest hundredth of a foot and record the depth of each fluid interface, and the total well depth, from the reference point.

13. Clean the NAPL/water interface probe and cable in accordance with the appropriate cleaning procedures.

14. If using a bailer to confirm the presence/absence of NAPL, the bailer should either have been previously dedicated to the well, or be a new previously unused bailer.

15. Compare the depth of the well to previous records, and note any discrepancy.

16. Lock the well when all activities are completed.

VII. Waste Management

Decontamination fluids, PPE, and other disposable equipment will be properly stored on site in labeled containers and disposed of properly. Be certain that waste containers are properly labeled and documented in the field log book. Review appropriate waste management SOPs, which may be state- or client-specific.

VIII. Data Recording and Management

Fluid level measurement data will be recorded legibly on “write-in-the-rain” field notebook in indelible pen and/or a PDA. Field situations such as apparent well damage or suspected tampering, or other observations of conditions that may result in compromised data collection will be photographically documented where practicable.

IX. Quality Assurance

As described in the detailed procedure, the electronic water-level meter and/or NAPL-water interface probe will be calibrated prior to use versus an engineer's rule to ensure accurate length demarcations on the tape or cable. Fluid interface measurements will be verified by gently raising and lowering the instrument through each interface to confirm repeatable results.

X. References

No literature references are required for this SOP.

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Appendix B-1-14

Surface and Subsurface Soil Sampling Using Manual Methods

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Surface and Subsurface Soil Sampling Using Manual Methods

Rev. #: 1

Rev Date: March 6, 2009

Approval Signatures

Prepared by: ______________________ Date: 3/6/09

Reviewed by: ______________________ Date: 3/6/09
(Technical Expert)

I. Scope and Application

This document describes procedures for surface and subsurface soil sampling using hand tools.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading soil sampling activities should have a minimum of 2 years of previous environmental soil sampling experience. ARCADIS personnel providing assistance to soil sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences.

III. Equipment List

The following materials will be available, as required, during soil sampling activities:

- personal protective equipment (PPE), as specified by the site Health and Safety Plan (HASP);
- stainless steel bowls;
- stainless steel spoons;
- stainless steel spades;
- stainless steel hand augers;
- indelible ink pens;
- engineer's ruler or survey rod;
- sealable plastic bags (e.g., Ziploc®);
- equipment decontamination materials
- sample bottles and preservatives appropriate for the parameters to be sampled for laboratory analysis, if any;
- transport container with ice (if sampling for laboratory analysis);
- appropriate sample containers and forms; and

- field notebook and/or personal digital assistant (PDA).

Documentation forms and notebooks to have on hand include: soil sample log forms, chain-of-custody forms, sample labels and seals, field logbook/PDA.

IV. Cautions / Hazards

Task specific Job Safety Analysis (JSAs) must be developed to identify site hazards associated with the investigation and reviewed by all field crew members prior to the start of work. Safe Performance Self-Assessment (SPSA) to be performed by employees before performing a new task. Underground utilities will be cleared per the ARCADIS Utility Location Policy and Procedure.

V. Health and Safety Considerations

Soil sample collection will be performed in accordance with a site-specific Health and Safety Plan (HASP) and task specific JSA forms, copies of which will be present on site during such activities.

VI. Procedure

Soil samples may be collected at intervals from the ground surface to various depths. Sample locations will be identified using stakes, flagging, or other appropriate means, and will be noted in a field logbook, PDA, and/or soil sampling logs. Sample points will be located by surveying, use of a global positioning system (GPS), and/or measurements from other surveyed site features.

1. Equipment that will come in contact with the soil sample should be cleaned in accordance with the appropriate equipment decontamination SOP(s), or else new, disposable equipment should be used. Collect equipment blanks in accordance with the project Quality Assurance Project Plan (QAPP).

2. Clear the ground surface of brush, root mat, grass, leaves, or other debris.

3. Use a spade, spoon, scoop, or hand auger to collect a sample of the required depth interval.

4. Use an engineer's ruler to verify that the sample is collected to the correct depth and record the top and bottom depths from the ground surface.

5. To collect samples below the surface interval, remove the surface interval first; then collect the deeper interval. To prevent the hole from collapsing, it may be

necessary to remove a wider section from the surface or use cut polyvinyl chloride (PVC) tubing or pipe to maintain the opening.

6. Collect samples for volatile organic compounds (VOCs) as discrete samples using Encore® samplers or cut syringes (see Extraction/Preservation of Soil/Sediment Samples for VOCs SOP).

7. Homogenize samples for other analyses across the required interval or mix them with other discrete grab samples to form a composite sample (see Compositing or Homogenizing Samples SOP).

8. Place sample in clean sample container; label with sample identification number, date, and time of collection; and place on ice (if obtained for laboratory analysis). Prepare samples for packaging and shipping to the laboratory in accordance with the Chain-of-Custody Handling, Packing, and Shipping SOP.

9. Backfill sample holes to grade with native material or with clean builder's sand or other suitable material.

VII. Waste Management

Waste soils will be managed as specified in the FSP or Work Plan, and according to state and /or federal requirements. Personal Protective Equipment (PPE) and decontamination fluids will be contained separately and staged at the project site for appropriate disposal. Waste containers must be a sealed and labeled at the time of generation. Labels will indicate date, sample locations, site name, city, state, and description of the matrix (e.g., soil, PPE).

VIII. Data Recording and Management

Field documentation such as log book entries and chain-of –custody records will be transmitted to the ARCADIS PM or Task Manager each day unless otherwise directed. The field team leader will retain all site documentation while in the field and add to project files when the field mobilization is complete.

IX. Quality Assurance

Quality assurance samples (rinse blanks, duplicates, and MS/MSDs) will be collected at the frequency specified in the FSP and/or QAPP and depending on the project quality objectives. Reusable soil sampling equipment will be cleaned prior to use following equipment cleaning SOP. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site conditions. Any deviations from the SOP will be discussed with the project manager prior to changing any field procedures.

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Appendix B-1-15

Sub-Slab Soil Gas Sampling –
Temporary Ports

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Infrastructure, environment, buildings

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Sub-Slab Soil-Gas Sampling Using Temporary Sampling Ports

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Approval Signatures

Prepared by: ______________________ Date: May 20, 2008
Mitch Wacksman

Reviewed by: ______________________ Date: May 20, 2008
Robert Uppencamp

Approved by: ______________________ Date: November 14, 2008
Christopher Lutes

I. Scope and Application

This document describes the procedures to install a sub-slab sampling port and collect sub-slab soil gas samples for the analysis of volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15. In particular, this standard operating procedure (SOP) describes the installation and collection of a sub-slab soil gas sample using only hand tools and does not involve installation using a geoprobe or post run tubing (PRT) system. Method TO-15 uses a 6-liter or 1-liter SUMMA® passivated stainless steel canister. An evacuated SUMMA canister (less than 28 inches of mercury [Hg]) will provide a recoverable whole-gas sample that is then analyzed for VOCs using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and detailed instructions for installing sub-slab soil gas ports and collecting soil-gas samples.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training. Site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR) may be appropriate at some sites. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading sub-slab soil-gas sample collection activities must have previous sub-slab soil-gas sampling experience.

III. Equipment List

The equipment required to install and collect a temporary sub-slab vapor port is listed below. Any modifications to account for project- or regulatory-specific requirements should be noted in the accompanying work plan.

- Equipment for installing a sub-slab soil gas point
    - Appropriate PPE (as required by the Health and Safety Plan);
    - Hammer drill (Hilti, Bosch Hammer, or equilivant);
    - 1/2 inch-diameter concrete drill bit;

- Hand tools including open-end wrench (typically 9/16-inch);
- 1/4-inch OD tubing (Teflon, nylon, or Teflon-lined); Note that Nylaflow tubing has a somewhat higher background level of BTEX and much poorer recovery of tirchlorobenzene and naphthalene then Teflon, so should not be used on sites where these compounds are a concern (Hayes, 2006).
- Teflon® tape;
- Hydrated bentonite, VOC-free modeling clay or wax to seal drill hole;
- Extension cords; and
- Shop vac.

- Equipment for collecting a sub-slab soil gas point
  - Stainless steel SUMMA® canisters (6-liter, 1-liter or smaller; order at least one extra, if feasible);
  - Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g., 30 minutes, 8 hours, 24 hours) or flow rate (e.g., 200 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible); Flow rate should be selected based on expected subslab material/soil type (see below).
  - Swage-Lok fittings;
  - Stainless steel Swage-Lok “T” fitting (if collecting duplicate [i.e., split] samples);
  - Portable vacuum pump capable of producing very low flow rates (e.g., 100 to 200 milliliters per minute [mL/min]) (recommend SKC-PCXR8); vacuum pump should also be equipped with a vacuum guage
  - Rotameter or an electric flow sensor if vacuum pump does not have and accurate flow gauge;

- o Tracer gas testing supplies if applicable (refer to SOP for "Administering Tracer Gas");
- o Photo Ionization Detector (PID) with a lamp of 11.7 eV; detectable to ppb range (optional);
- o Tedlar bag to collect purge air;
- o Portable weather meter, if appropriate (temperature, barometric pressure, humidity, etc);
- o Quick setting grout or sika flex to seal abandoned holes;
- o Chain-of-custody (COC) form;
- o Sample collection log (attached); and
- o Field notebook.

IV. Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a sub-slab soil gas sample.

- When drilling sample collection holes be mindful of any utilities that may be in the area. If the driller is concerned about a particular location, consult the project manager about moving it to another location. Don't be hesitant to use your Stop Work Authority, if something doesn't seem right stop and remedy the situation.
- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens, wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.
- Ensure that the flow controller is pre-calibrated to the proper sample collection time by checking the regulators (check tags, markings, shipping forms) sent by the laboratory (if there is any doubt, confirm with laboratory).
- Care must be taken to properly seal around the vapor port at slab surface to prevent leakage of atmosphere into the soil vapor port during purging and sampling. Temporary points should be fit snug into the pre-drilled hole using

Teflon® tape or modeling clay and a seal hydrated bentonite, clay or wax at the surface.

- It is important to record the canister pressure, start and stop times and ID on a proper field sampling form. Often Summa canisters are collected with a 24 hour averaging period. You should observe and record the time/pressure at the start, and then again one or two hours after starting the sample collection. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29" to 27"). Consult your project manager (PM), risk assessor or air sampling expert by phone if the Summa canister does not appear to be working properly.

- Ensure that there is still measureable vacuum in the Summa after sampling. Sample integrity is maintained if the sampling event is shorter than the target duration, but sample integrity can be compromised if the event is extended to the point that the canister reaches atmospheric pressure. Excessive vacuum remaining in the canister can also result in elevated reporting limits.

- Many times the gauges sent from labs have large offset errors, or they stick. For the most precise pressure readings consider using a separate, more sensitive, device to do checks at the beginning and end of the sampling period. If this is used it must be tested beforehand to confirm that it does not introduce contaminants to the can during pressure checks

- When sampling carefully consider elevation. If your site is over 2,000' above sea level or the difference in elevation between your site and your lab is more than 2,000' then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum left in them http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped a day or two before the sampling date so that all materials can be checked.

- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

V. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. Review appropriate health and safety plan (HASP) and job safety analysis (JSA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. A full utility mark-out should be done prior to any drilling activities. If sample points are in questionable locations consult the project manager about moving sample point. For sub-slab vapor port installation, drilling with a hammer drill should be done only by personnel with prior experience using such a piece of equipment. New staff should be trained and supervised by experienced drill users.

VI. Procedure

Temporary sub-slab soil vapor ports are installed using equipment and procedures that allows the point to be installed quickly and abandoned after an initial sample is collected. These procedures are not recommended if the point is to be sampled more than once. Under those conditions refer to ARCADIS' SOP for permanent sub-slab soil gas installations.

Sub-slab Soil Gas Point Installation

1. A utility mark-out of the pertinent areas should be accomplished prior to any drilling activities.

2. Remove, only to the extent necessary, any covering on top of the slab (e.g., carpet).

3. Drill a 1/2 inch diameter hole through the concrete slab using the electric drill.

4. Advance the drill bit approximately 3 inches into the sub-slab material to create an open cavity. Note if possible from the drill cuttings any evidence for the types of materials in the immediate subslab – i.e. moisture barriers, sand, gravel, shrinkage gap?

5. Using a shop-vac, clean any material that may have fallen into and around the hole.

6. Re-drill the hole to ensure it remains clear. This can also be accomplished using a piece of steel rod, sample tubing, or even a piece of heavy wire (coat hanger).

7. Wrap the tubing with Teflon® tape or modeling clay, to the extent necessary, for a snug fit of tubing and hole.

8. Insert the tubing approximately 3 inches into the sub-slab material.

9. Prepare a hydrated bentonite mixture and apply bentonite at slab surface around the tubing. Instead of hydrated bentonite, either VOC free modeling clay or wax may be used to seal the tubing into the slab.

10. Purge the soil vapor port and tubing with a portable sampling pump. Purge approximately three volumes of air from the vapor port and sampling line using a portable pump [purge volume = 1.5 Pi r2h] at a rate of approximately 100 to 200 mL/min. All purge air should be collected into a tedlar bag to ensure VOCs are not released into any interior spaces. This flow rate should be suitable for a variety of gravel, silt and sand conditions but will not be achievable in some clays without excessive vacuum. Excessive vacuums should be avoided. The cutoff value for vacuum however differs in the sources however from 10" of water column (ITRC 2007) to 136" of water column or 10" of mercury (http://www.dtsc.ca.gov/lawsregspolicies/policies/SiteCleanup/upload/SMBR_ADV_activesoilgasinvst.pdf). A detailed discussion of the achievable flow rates in various permeability materials can be found in Nicholson 2007. Related issues of contaminant partitioning are summarized in ASTM D5314-92. Passive sampling approaches can be considered as an alternative for clay soils. Measure organic vapor levels with the PID, as appropriate.

11. Proceed to soil gas sample collection.

Sub-Slab Soil Gas Sample Collection

Once the temporary sample port is installed, the following procedure should be used to collect the sample in the Summa canister.

1. Remove the brass plug from the SUMMA® canister and connect the flow controller with in-line particulate filter and vacuum gauge to the SUMMA® canister. Do not open the valve on the SUMMA® canister.

2. Connect the sample collection tubing from the sample port to the flow controller and the SUMMA® canister valve.

3. Attach duplicate or other QA/QC samples as required by applicable regulations and guidance. Use a Swahe-Lok t-fitting supplied by the laboratory to connect two canisters to the sample port tubing.

4. If necessary, check the seal around the soil vapor port by using a tracer gas (e.g., helium) or other method established in the appropriate guidance document (see helium tracer gas SOP).

5. Open the SUMMA® canister valve to initiate sample collection.

6. Record the following information on the sample log, field notebook, and or COC:

   - Starting sample time;
   - Initial canister pressure;
   - Weather conditions including wind speed and direction; ambient outside and inside temperatures; barometric pressure; and relative humidity; and
   - Sample canister serial number and flow controller numbers.

7. If appropriate, take a photograph of the SUMMA® canister and surrounding area.

8. Depending on the sample collection duration it is generally advisable to wait for the canister to fill or to check on the canister at least once during the sample collection period. If the vacuum gauge does not appear to be working properly (see Section IV), then it may be appropriate to terminate the sample collection early and use another Summa canister for sample collection.

Termination of Sample Collection

Arrive at the SUMMA® canister location at least 10 to 15 minutes prior to the end of the required sampling interval in order to have sufficient time to terminate the sample collection.

1. Record the final vacuum pressure. Stop collecting the sample by closing the SUMMA® canister valves. The canister should have a minimum amount of vacuum (approximately 2 inches of Hg or slightly greater).

2. Record the date and time of valve closing in the sample collection log (attached) and COC form.

3. Remove the particulate filter and flow controller from the SUMMA® canister, re-install the brass plug on the canister fitting, and tighten with the appropriate wrench.

4. When the sub-slab soil gas sampling is complete, remove the tubing and grout the hole in the slab with quick-setting hydraulic cement powder, Sika-Flex, or other material similar to the slab. This step must be done carefully to ensure that the abandoned sampling point does not become a preferential flow pathway.

5. Replace the surface covering (e.g., carpet) to the extent practicable. Sample collection location should be returned to pre-sampling conditions.

6. Package the canister and flow controller in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canister does not require preservation with ice or refrigeration during shipment.

7. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with a string).

8. Complete the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via overnight carrier (e.g., Federal Express) for analysis.

9. Before shipping ensure that the valve is off and that Swagelok plug is on firmly.

VII. Waste Management

The volume of waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal.

VIII. Data Recording and Management

Information collected in the field should be recorded in the field notebook as well as written on the field sampling log and COC, as appropriate. The field notebook and sampling log must include the project name, sample date, sample start and finish time, sample location (e.g., global positioning system [GPS] coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, initial vacuum reading, and final pressure reading. Field sampling logs and COC records will be transmitted to the PM.

IX. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Generally, duplicates are taken of 10% of samples, but project specific requirements should take precedence.

Soil-gas sample analysis will generally be performed using USEPA TO-15 methodology or a project specific constituent list. Method TO-15 uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits (typically 0.5-ppbv for most VOCs).

X. References

ASTM – “Standard Guide for Soil Gas Monitoring in the Vadose Zone”, D5314-92.

Hayes, H. C., D.J. Benton and N. Khan “Impact of Sampling media on Soil Gas Measurements” Presented with short paper at AWMA Vapor Intrucion Conference January 2006, Philadelphia PA.

ITRC “Vapor Intrusion Pathway: A Practical Guide”, January 2007, Appendix F: “regulators Checklist for Reviewing Soil Gas Data”

Nicholson, P, D. Bertrand and T. McAlary. “Soil Gas Sampling in Low-Permeability Materials” Presented at AWMA Specialty Conference on Vapor Intrusion, Providence RI, Sept 2007.

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Appendix B-1-16

Administering Helium Tracer Gas for Leak Checks of Soil Gas or Sub-Slab Sampling Points

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Administering Helium Tracer Gas for Leak Checks of Soil Gas or Sub-slab Sampling Points

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Approval Signatures

Prepared by: ______________________ Date: May 20, 2008
Mitch Wacksman

Reviewed by: ______________________ Date: May 20, 2008
Robert Uppencamp

Approved by: ______________________ Date: November 14, 2008
Christopher Lutes

I. Scope and Application

When collecting subsurface vapor samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance/quality control device to verify the integrity of the vapor port seal. Without the use of a tracer, verification that a soil vapor sample has not been diluted by ambient or indoor air is difficult.

This standard operating procedure (SOP) focuses on using helium as a tracer gas. However, depending on the nature of the contaminants of concern, other compounds can be used as a tracer including sulfur hexafluoride (SF6), butane and propane (or other gases). In all cases, the protocol for using a tracer gas is consistent and includes the following basic steps: (1) enrich the atmosphere in the immediate vicinity where the port or sample tubing intersects the surface with the tracer gas; and (2) measure a vapor sample from the sample tubing for the presence of high concentrations (> 10%) of the tracer. A plastic pail, bucket, garbage can or even a plastic bag can serve to keep the tracer gas in contact with the port during the testing.

There are two basic approaches to testing for the tracer gas:

1. Include the tracer gas in the list of target analytes reported by the laboratory; or

2. Use a portable monitoring device to analyze a sample of soil vapor for the tracer prior to sampling for the compounds of concern. (Note that tracer gas samples can be collected via syringe, Tedlar bag, etc. They need not be collected in SUMMA® canisters or minicans.)

This SOP focuses on monitoring helium using a portable sampling device, although helium can also be analyzed by the laboratory along with other volatile organic compounds (VOCs). Real-time tracer sampling is generally preferred as the results can be used to confirm the integrity of the port seals prior to formal sample collection.

During the initial stages of a subsurface vapor sampling program, tracer gas samples should be collected at each of the sampling ports. If the results of the initial samples indicate that the port seals are adequate, the Project Manager can consider reducing the number of locations at which tracer gas samples are used. At a minimum, at least 10% of the subsequent samples should be supported with tracer gas analyses. When using permanent soil vapor ports as part of a long-term monitoring program, the port should be tested prior to the first sampling event. Tracer gas testing of subsequent sampling events is not necessary unless conditions have changed at the site.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the tracer gas testing must have previous experience conducting similar tests.

III. Equipment List

The equipment required to conduct a helium tracer gas test is presented below:

- Appropriate PPE for site (as required by the Health and Safety Plan)
- Helium (laboratory grade)
- Regulator for helium tank
- Shroud (plastic bucket, garbage can, etc)
    - The size of the shroud should be sufficient to fit over the sample port. It is worth noting that using a smaller shroud obviously uses less helium as well; this may be important when projects require a number of helium tracer tests.
    - The shroud will need to have three small holes in it. These holes will include one on the top (to accommodate the sample tubing), and two on the side (one for the helium detector probe, and one for the helium line).
    - The should ideally enclose the entire sampling train.
- Helium detector capable of measuring from 1 - 100% (Dielectric MGD-2002, Mark Model 9522, or equivalent)
- Tedlar bags
- Seal material for shroud (rubber gasket, modeling clay, bentonite, etc). Although the sealing material is not in direct contact with the sample if no leak occurs, sealing materials with high levels of VOC emissions should be

avoided, since they could easily contaminate a sample from a point in which a trace leak occurs.

- Field notebook

IV. Procedure

The procedure used to conduct the helium tracer test should be specific to the shroud being used and the methods of vapor port installation. The helium tracer test can be conducted when using temporary or permanent sample point installs and from inside or outside a facility. However when using the tracer gas within a indoor areas you must provide adequate ventilation because helium is an asphyxiant.

1. Attach Teflon or nylon sample tubing to the sample point. This can be accomplished utilizing a number of different methods depending on the sample install (i.e., barbed fitting, Swage-Lok fitting, ball valve, etc.).

2. Place the shroud over the sample point and tubing.

3. Pull the tubing through hole in top of shroud. Seal opening with modeling clay.

4. Place weight on top of shroud to help maintain a good seal with the ground.

5. Insert helium tubing into hole in side of shroud, seal with modeling clay to prevent leaks.

6. Fill shroud with helium. While filling shroud allow atmospheric air to escape either by leaving a crack with the surface or by providing a release value on the side of the shroud.

7. Use the helium detector to test level of helium gas from the bottom of the shroud (where the sample tubing intersects the ground). Helium should be added until the environment inside the shroud has > 60% helium.

8. Purge the sample point through the sample tubing into a Tedlar bag using a hand held sampling pump. The sample pump should be operating at a rate of approximately 100 ml/minute (the purge rate should typically not exceed the sample collection rate). Test the air in the Tedlar bag for helium using portable helium detector. If the port has been installed properly there should be zero helium in purge air.

9. If > 10% helium is noted in purge air, add more clay or other material to the seal

the sample port and repeat the testing procedure. If the seal cannot be fixed, re-install sample point.

10. Monitor and record helium level in shroud before, during and after tracer test.

11. Monitor and record helium level in purge exhaust.

12. At successful completion of tracer test and sample point purging, the soil vapor sample can be collected (if the helium shroud must be removed prior to sample collection be mindful not disturb the sample tubing and any established seals).

V. Cautions

Helium is an asphyxiant! Be cautious with its use indoors!

Care should be taken not to pressurize shroud while introducing helium. If the shroud is completely air tight and the helium is introduced quickly, the shroud can be over-pressurized and helium can be pushed into the ground.

Because minor leakage around the port seal should not materially affect the usability of the soil vapor sampling results, the mere presence of the tracer gas in the sample should not be a cause for alarm. Consequently, portable field monitoring devices with detection limits in the low ppm range are more than adequate for screening samples for the tracer. If high concentrations (> 10%) of tracer gas are observed in a sample, the port seal should be enhanced to reduce the infiltration of ambient air and the tracer test readministered. If the problem cannot rectified, a new sample point should be installed.

VI. Data Recording and Management

Measurements will be recorded in the field notebook at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location, and the helium concentrations in both the shroud and the purge air before, during, and after tracer testing. Any problems encountered should also be recorded in the field notes.

APPENDIX: Compressed Gases—Use and Storage

In general, a compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders should be handled as high-energy sources and therefore as potential explosives and projectiles. Prudent safety practices should be followed when handling compressed gases since they expose workers to both chemical and physical hazards.

Handling

- Safety glasses with side shields (or safety goggles) and other appropriate personal protective equipment should be worn when working with compressed gases.
- Cylinders should be marked with a label that clearly identifies the contents.
- All cylinders should be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., should be taken out of use immediately and returned to the manufacturer/distributor for repair.
- All gas cylinders (full or empty) should be rigidly secured to a substantial structure at 2/3 height. Only two cylinders per restraint are allowed in the laboratory and only soldered link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Handcarts shall be used when moving gas cylinders. Cylinders must be chained to the carts.
- All cylinders must be fitted with safety valve covers before they are moved.
- Only three-wheeled or four-wheeled carts should be used to move cylinders.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off. The correct position for the main valve is all the way on or all the way off.
- Cylinder valves should never be lubricated, modified, forced, or tampered with.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Regulators and valves should be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.
- Cylinders should not be placed near heat or where they can become part of an electrical circuit.
- Cylinders should not be exposed to temperatures above 50 °C (122 °F). Some rupture devices on cylinders will release at about 65 °C (149 °F). Some small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode if exposed to high temperatures.

- Rapid release of a compressed gas should be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.
- Appropriate regulators should be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Adaptors and homemade modifications are prohibited.
- Cylinders should never be bled completely empty. Leave a slight pressure to keep contaminants out.

Storage

- When not in use, cylinders should be stored with their main valve closed and the valve safety cap in place.
- Cylinders must be stored upright and not on their side. All cylinders should be secured.
- Cylinders awaiting use should be stored according to their hazard classes.
- Cylinders should not be located where objects may strike or fall on them.
- Cylinders should not be stored in damp areas or near salt, corrosive chemicals, chemical vapors, heat, or direct sunlight. Cylinders stored outside should be protected from the weather.

Special Precautions

Flammable Gases

- No more than two cylinders should be manifolded together; however several instruments or outlets are permitted for a single cylinder.
- Valves on flammable gas cylinders should be shut off when the laboratory is unattended and no experimental process is in progress.
- Flames involving a highly flammable gas should not be extinguished until the source of the gas has been safely shut off; otherwise it can reignite causing an explosion.

Acetylene Gas Cylinders

- Acetylene cylinders must always be stored upright. They contain acetone, which can discharge instead of or along with acetylene. Do not use an acetylene cylinder that has been stored or handled in a nonupright position until it has remained in an upright position for at least 30 minutes.
- A flame arrestor must protect the outlet line of an acetylene cylinder.
- Compatible tubing should be used to transport gaseous acetylene. Some tubing like copper forms explosive acetylides.

Lecture Bottles

- All lecture bottles should be marked with a label that clearly identifies the contents.
- Lecture bottles should be stored according to their hazard classes.
- Lecture bottles that contain toxic gases should be stored in a ventilated cabinet.
- Lecture bottles should be stored in a secure place to eliminate them from rolling or falling.
- Lecture bottles should not be stored near corrosives, heat, direct sunlight, or in damp areas.
- To avoid costly disposal fees, lecture bottles should only be purchased from suppliers that will accept returned bottles (full or empty). Contact the supplier before purchasing lecture bottles to ensure that they have a return policy.
- Lecture bottles should be dated upon initial use. It is advised that bottles be sent back to the supplier after one year to avoid accumulation of old bottles.

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Appendix B-1-17

Sub-Slab Soil Gas Sampling and Analysis Method TO-15 – Permanent Probe

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Imagine the result

Sub-Slab Soil Gas Sampling and Analysis Using USEPA Method TO-15 – Permanent Probe Approach

SOP # 425199

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Approval Signatures

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Approved by: ______________________________ Date: 07/07/2010
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I. Scope and Application

This document describes the procedures for installing permanent sub-slab sampling probe and collecting sub-slab soil-gas samples for the analysis of volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 (TO-15). Method TO-15 uses a 1-liter 3-liter or 6-liter SUMMA® passivated stainless steel canister. An evacuated SUMMA canister (less than 28 inches of mercury [Hg]) will provide a recoverable whole-gas sample of approximately 5 liters when allowed to fill to a vacuum of 6 inches of Hg. The whole-air sample is then analyzed for VOCs using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GS/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv).

The following sections list the necessary equipment and detailed instructions for installing permanent sub-slab soil-gas probes and collecting soil-gas samples for VOC analysis.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant standard operating procedures (SOPs) and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading sub-slab soil-gas sample collection activities must have previous sub-slab soil-gas sampling experience.

III. Health and Safety Considerations

All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task. Field sampling must be carefully performed to minimize the potential for injury and the spread of hazardous substances. For sub-slab vapor probe installation, drilling with an electric concrete impact drill should be done only by personnel with prior experience using such a piece of equipment or directly supervised by an experienced person and with the appropriate health and safety measures in place as presented in the JLA It is possible to encounter high concentrations of VOCs in subslab soil gas, so the amount of time the borehole remains open should be minimized. For the same reason, when installing subslab probes in spaces with minimal dilution potential, such as closets, it is advisable to provide local ventilation. Finally, subslab probe installation should be completed 24 hours in advance or after any indoor air sampling to avoid cross contamination of the indoor air samples.

IV. Equipment List

The equipment required to install a permanent sub-slab vapor probe is presented below:

- Appropriate personal protective equipment (PPE; as required by the site specific HASP and the JLA)
- Electric hammer drill (big – Bosch, Hilti, etc.);
- 1/2-inch and 1 ½-inch diameter concrete drill bits for impact drill (drill bit length contingent on slab thickness;
- Decontaminated stainless steel vapor probe (typically 1/4-inch outside diameter [OD] stainless steel tubing, 1/4-inch Swagelok by 1/4-inch Swagelok female coupling, (or equilivant), 1/4-inch Swagelok cap);
- Extra ¼-inch Swagelok front and back compression sleeves;
- Stainless steel washers;
- Tubing cutter with heavy-duty cutting wheel;
- Hand tools, including open-end wrench (typically $^{9}/_{16}$-inch), pliers, channel lock pliers, etc.;
- Teflon tape;
- Quick-setting non-shrink grout powder;
- Potable water for mixing grout;
- Disposable cups and spoons for mixing grout;
- Spray bottle with potable water;
- Whisk broom and dust pan;
- Paper towels;

- Nitrile gloves;
- Work gloves;
- Knee pads;
- Bottle brush;
- Ground fault circuit interrupter (GFCI);
- Extension cords capable of amperage required for hammer drill;
- Plastic sheeting; and
- Shop vacuum with clean fine-particle filter.

The equipment required for subslab soil-gas sample collection is presented below:

- 1,3, or 6 – liter stainless steel SUMMA® canisters (order at least one extra, if feasible) (batch certified canisters or individual certified canisters as required by the project) ;
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g.,30 minutes) or flow rate (e.g., 200 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible);
- 1/4-inch ID tubing (Teflon®, or similar);
- 1/4-inch Swagelok by 1/8-inch NPT male stainless steel coupling;
- Extra1/4-inch Swagelok front and back compression sleeves
- Decontaminated stainless steel Swagelok or comparable “T” fitting and needle valve for isolation of purge pump;
- Two 3-inch lengths of 1/4-inch OD Teflon tubing
- Stainless steel duplicate “T” fitting provided by the laboratory (if collecting duplicate [i.e., split] samples);

- Portable vacuum pump capable of producing very low flow rates (e.g., 100 to 200 mL/min) with vacuum gauge;

- Rotameter or an electric flow sensor if vacuum pump does not have an accurate flow gauge (Bios DryCal or equivalent);

- Tracer gas testing supplies (refer to “Administering Tracer Gas” SOP #416199);

- Appropriate-sized open-end wrench (typically 9/16-inch and ½”);

- Tedlar® bag to collect purge air or length of tubing sufficient to vent it outside the structure;

- Portable weather meter, if appropriate;

- Chain-of-custody (COC) form;

- Sample collection log (attached);

- Nitrile gloves;

- Work gloves;

- Field notebook

V. Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a sub-slab soil-gas sample.

- When drilling sample collection holes, be mindful of utilities that may be in the area. Always complete utility location, identification and marking before installing subslab ports as required by the ARCADIS Utility Location Policy and Procedure. Be aware that public utility locator organizations frequently do not provide location information within buildings so alternative lines of evidence must be used. If the driller is concerned about a particular location, consult the project manager about moving it to another location. Do not hesitate to use Stop Work Authority; if something doesn’t seem right stop and remedy the situation.

- Supplies such as stainless steel tubing and drill bit length will be based on the thickness of the slab encountered. Every effort will be made to establish the thickness of the slab during the preliminary investigation activities, such as interviews with site personnel, review of construction drawings, building walk through and utility clearance process.

- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (sharpies), wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.

- Ensure that the flow controller is pre-calibrated to the proper sample collection duration (confirm with laboratory). Sample integrity can be compromised if sample collection is extended to the point that the canister reaches atmospheric pressure. Sample integrity is maintained if sample collection is terminated prior to the target duration and a measurable vacuum (e.g., 3 -7 – inches Hg) remains in the canister when sample collection is terminated.

- Field personnel will properly seal the vapor port at the slab surface to prevent leaks of atmosphere into the soil vapor port during purging and sampling. Permanent ports will be fit snug into the predrilled hole using Teflon tape or modeling clay and cemented into the ground. If this is not done properly, the integrity of the sample port may be compromised.

- It is important to record the canister pressure, start and stop times, and sample identification on a proper field sampling form. Often SUMMA canisters are collected with a 24-hour averaging period. You should observe and record the time/pressure at the start, and then again one or two hours after starting the sample collection. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it is not stuck. If the canister is running correctly for a 24-hour period, the vacuum will have decreased slightly after one or two hours (for example from 29 inches to 27 inches). Consult your project manager, risk assessor or air sampling expert by phone if the SUMMA canister does not appear to be working properly.

- Ensure that there is still measureable vacuum in the SUMMA® after sampling. Sometimes the gauges sent from labs have offset errors, or they stick.

- Many times the gauges sent from labs have large offset errors, or the gauge needle does not move freely in response to changes in vacuum. For the most precise pressure readings, consider using a separate, more sensitive, device to check pressure at the beginning of the sampling period in a clean atmosphere. This should be done without moving a significant flow into the canister – for example using a pressure gauge on a dead-end leg. If used, this device must be tested beforehand to confirm that it does not introduce contaminants to the SUMMA canister during pressure checks

- When sampling carefully consider elevation. If your site is over 2,000’ above sea level or the difference in elevation between your site and your lab is more than 2,000’ then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum left in them. http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped a two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters and flow controllers from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- Check the seal around the soil-gas sampling port by using a tracer gas (e.g., helium) or other method established in the appropriate guidance document. See SOP “Administering Tracer Gas” #416199.

VI. Procedure

Permanent Vapor Probe Installation

Permanent sub-slab soil vapor probes are installed using an electric drill and manual placement of the probe. After a dry fit, the vapor probe is inserted into the hole and grouted with a quick-setting non-shrink grout powder. The vapor probe is equipped with a plug. The cap is removed and a compression fitting nut and ferrules are used to allow collection of a soil gas sample through Teflon tubing. The vapor probe and tubing will be purged with a portable sampling pump prior to collecting the soil gas sample. Detailed installation methods are as follows:

1. Complete the ARCADIS Utility Locate procedure prior to drilling activities.

2. Assemble the sample port assembly (stainless steel tubing, stainless steel Swagelok coupling, Swagelok nut). Teflon tape should never be used with Swagelok connections.

3. Remove, only to the extent necessary, any covering on top of the slab (e.g., carpet) if present.

4. Lay down plastic sheeting to keep the work area clean. Check to make sure shop vacuum is working properly and fine concrete particles will not pass through filter.

5. Advance the 1½-inch drill bit approximately 1½ inches into the slab. This hole is drilled deep enough to permit the top of the coupling to be set flush with the slab when the ¼-inch tubing is inserted into the ½-inch hole drilled under Step 7, below. Clean up cuttings with shop vacuum, bottle brush, and dust pan.

6. Drill a 1/2-inch-diameter hole into the concrete slab using the electric drill. Do not fully penetrate the slab at this time. Stop drilling approximately 1 inch short of penetrating the slab.

7. Use the shop vacuum, bottle brush and dust broom to clean up the work area and material that may have fallen into and around the drill hole.

8. Advance the 1/2-inch drill bit the remaining thickness of the slab and approximately 3 inched into the sub-slab material to create an open cavity. Record any observations from the drill cuttings if possible regarding approximate soil types and presence or absence of a plastic subslab sheet.

9. Use the bottle brush, dust broom and dust pan to clean material around and within the hole. Do not use the shop vacuum to clean up the drill hole after the full thickness of the slab has been penetrated.

10. Using an assembled sample probe assembly, test fit the components so that the proper length of ¼-inch tubing and depth of the 1½-inch hole provides enough space for the stainless steel coupling. Adjust so that the coupling will lie flush with the slab surface and does not create a tripping hazard.

11. Redrill the ½ inch hole to ensure it remains clear. This can also be accomplished using a piece of steel rod, sample tubing or a piece of heavy wire (e.g., coat hanger).

12. Wrap the sample probe assembly with Teflon tape, to the extent necessary, for a snug fit of the assembly and hole. Teflon tape or stainless steel washers can also be used to achieve the proper depth of the sample port assembly. Ensure that Teflon tape or stainless steel washers do not interfere with the cement that will be used to permanently fix and seal the sample probe.

13. Prepare a mixture of nonshrink cement and water according to the manufactures directions in a disposable cup using a plastic spoon for mixing.

ARCADIS

Appendix B-1-18

Indoor Air Sampling Analysis
Method TO-15

Infrastructure, environment, facilities

Imagine the result

Indoor Air Sampling and Analysis Using USEPA Method TO-15

Rev. #: 0

Rev Date: March 30, 2006

Approval Signatures

Prepared by: Susan Welt Date: 3/30/06

Reviewed by: Susan Welt Date: 3/30/06
(Technical Expert)

Reviewed by: ______________________ Date: ____________________
(Project Manager)

I. Scope and Application

This standard operating procedure (SOP) describes the procedures to collect indoor air samples for the analysis of volatile organic compounds (VOCs) using United States Environmental Protection Agency (USEPA) Method TO-15 (TO-15). The TO-15 method uses a 6-liter SUMMA® passivated stainless steel canister. An evacuated SUMMA® canister (<28 inches of mercury [Hg]) will provide a recoverable whole-gas sample of approximately 5.5 liters when allowed to fill to a vacuum of 2 inches of Hg. The whole-air sample is then analyzed for VOCs using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GS/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv).

The following sections list the necessary equipment and provide detailed instructions for placing the sampling device and collecting indoor air samples for VOC analysis.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading indoor air sample collection activities must have previous indoor air sampling experience.

III. Equipment List

The equipment required for indoor air sample collection is presented below:

- Photoionization detector (PID) with VOC detection limit capabilities in the ppb range;
- 6-liter, stainless steel SUMMA® canisters (order at least one extra, if feasible);
- Flow controllers with in-line particulate filters and vacuum gauges (flow controllers are pre-calibrated by the laboratory to a specified sample duration [e.g., 8-hour, 24-hour]). Confirm with lab that flow controller comes with in-line particulate filter and pressure gauge (order an extra set for each extra SUMMA® canister, if feasible);

- Stainless steel "T" fitting (for connection to SUMMA® canisters and Teflon® tubing to collect split [i.e., duplicate] samples);
- Appropriate-sized open-end wrench (typically 9/16-inch);
- Chain-of-custody (COC) form;
- Building survey and product inventory form (Attachment A);
- Sample collection log (Attachment B);
- Field notebook;
- Camera;
- Lock and chain; and
- Ladder or similar to hold canister above the ground surface (optional).

IV. Cautions

Care must be taken to minimize the potential for introducing interferences during the sampling event. As such, care must be taken to keep the canister away from heavy pedestrian traffic areas (e.g., main entranceways, walkways). If the canister is not to be overseen for the entire sample duration, precautions should be taken to maintain the security of the sample (e.g., do not place in areas regularly accessed by the public, fasten the sampling device to a secure object using lock and chain, label the canister to indicate it is part of a scientific project, place the canister in secure housing that does not disrupt the integrity/validity of the sampling event). Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens, wear/apply fragrances, or smoke cigarettes before and/or during the sampling event.

Care should also be taken to ensure that the flow controller is pre-calibrated to the proper sample collection time (confirm with laboratory). Sample integrity is maintained if the sampling event is shorter than the target duration, but sample integrity can be compromised if the event is extended to the point that the canister reaches atmospheric pressure.

V. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances.

VI. Procedure

Initial Building Survey

1. Complete the appropriate building survey form and product inventory form (e.g., state-specific form or ARCADIS form, Attachment A) at least 48 hours in advance of sample collection.

2. Survey the area for the apparent presence of items or materials that may potentially produce or emit constituents of concern and interfere with analytical laboratory analysis of the collected sample. Record relevant information on survey form and document with photographs.

3. Using the PID, screen indoor air in the location intended for sampling and the vicinity of potential VOC sources to preliminarily assess for the potential gross presence of VOCs.

4. Record date, time, location, and PID readings in the field notebook.

5. Items or materials that contain constituents of concern and/or exhibit elevated PID readings shall be considered probable sources of VOCs. Request approval of the owner or occupant to have these items removed at least 48 hours prior to sampling.

6. Set a time with the owner or occupant to return for placement of SUMMA® canisters.

Preparation of SUMMA®-Type Canister and Collection of Sample

1. Record the following information in the field notebook (contact the local airport or other suitable information source [e.g., weatherunderground.com] to obtain the following information):

   - ambient temperature;

   - barometric pressure; and

- relative humidity.

2. Choose the sample location in accordance with the sampling plan. If a breathing zone sample is required, place the canister on a ladder, tripod, or other similar stand to locate the canister orifice 3 to 5 feet above ground or floor surface. If the canister will not be overseen for the entire sampling period, secure the canister as appropriate (e.g., lock and chain). Canister may be affixed to wall/ceiling support with nylon rope or placed on a stable surface. In general, areas near windows, doors, air supply vents, and/or other potential sources of “drafts” shall be avoided.

3. Record SUMMA® canister serial number and flow controller number in the field notebook and COC form. Assign sample identification on canister ID tag, and record in the field notebook, sample collection log (Attachment B), and COC form.

4. Remove the brass dust cap from the SUMMA® canister. Attach the flow controller with in-line particulate filter and vacuum gauge (leave swage-lock cap on the vacuum gauge during this procedure) to the SUMMA® canister with the appropriate-sized wrench. Tighten with fingers first, then gently with the wrench.

5. Open the SUMMA® canister valve to initiate sample collection. Record the date and local time (24-hour basis) of valve opening in the field notebook, sample collection log, and COC form. Collection of duplicate/split samples will include attaching a stainless steel “T” to split the indoor air stream to two SUMMA® canisters, one for the original investigative sample and one for the duplicate/split sample.

6. Record the initial vacuum pressure in the SUMMA® canister in the field notebook and COC form. If the initial vacuum pressure does not register less than -28 inches of Hg, then the SUMMA® canister is not appropriate for use and another canister should be used.

7. Take a photograph of the SUMMA® canister and surrounding area.

Termination of Sample Collection

1. Arrive at the SUMMA® canister location at least 10 to 15 minutes prior to the end of the sampling interval (e.g., 8-hour).

2. Stop collecting the sample when the canister vacuum reaches approximately 2 inches of Hg (leaving some vacuum in the canister provides a way to verify if the

canister leaks before it reaches the laboratory) or when the desired sample time has elapsed.

3. Record the final vacuum pressure. Stop collecting the sample by closing the SUMMA® canister valve. Record the date, local time (24-hour basis) of valve closing in the field notebook, sample collection log, and COC form.

4. Remove the particulate filter and flow controller from the SUMMA® canister, re-install brass plug on canister fitting, and tighten with wrench.

5. Package the canister and flow controller in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canister does not require preservation with ice or refrigeration during shipment.

6. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with string).

7. Complete COC form and place requisite copies in shipping container. Close shipping container and affix custody seal to container closure. Ship to laboratory via overnight carrier (e.g., Federal Express) for analysis.

VII. Waste Management

No specific waste management procedures are required.

VIII. Data Recording and Management

PID measurements taken during the initial building survey will be recorded in the field notebook, with notations of project name, sample date, sample time, and sample location (e.g., description and GPS coordinates if available). A building survey form and product inventory form (Attachment A) will also be completed for each building within the facility being sampled during each sampling event.

Measurements will be recorded in the field notebook at the time of measurement, with notations of project name, sample date, sample start and finish times, sample location (e.g., description and GPS coordinates if available), canister serial number, flow controller number, initial vacuum reading, and final vacuum reading. Field notebooks and COC records will be transmitted to the Project Manager.

IX. Quality Assurance

Indoor air sample analysis will be performed using USEPA Method TO-15. This method uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits. The GC/MS system requires a 1-liter gas sample (which can easily be recovered from a 6-liter canister) to provide a 0.5 ppbv detection limit. The 6-liter canister also provides several additional 1-liter samples in case subsequent re-analyses or dilutions are required. This system also offers the advantage of the GC/MS detector, which confirms the identity of detected compounds by evaluating their mass spectra in either the SCAN or SIM mode.

X. References

[Click here and enter Text]

Attachment A – Building Survey and Product Inventory Form

Directions: This form must be completed for each residence or area involved in indoor air testing.

Preparer's Name: ___________________________________

Date/Time Prepared: ________________________________

Preparer's Affiliation: _______________________________

Phone No.: ____

Purpose of Investigation: ____

1. OCCUPANT:

Interviewed: Y / N

Last Name: _________________________ First Name: _________________________

Address: ____

County: ___________________________________

Home Phone: _______________________ Office Phone: ________________________

Number of Occupants/Persons at this Location: _________________

Age of Occupants: ______________________

2. OWNER OR LANDLORD: (Check if Same as Occupant ___)

Interviewed: Y / N

Last Name: _________________________ First Name: _________________________

Address: ____

County: _________________________________

Home Phone: ____________________ Office Phone: ____________________

3. BUILDING CHARACTERISTICS:

Type of Building: (circle appropriate response)

Residential	School	Commercial/Multi-use
Industrial	Church	Other: _________________

If the Property is Residential, Type? (circle appropriate response)

Ranch		2-Family 3-Family
Raised Ranch	Split Level	Colonial
Cape Cod	Contemporary	Mobile Home
Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other:_______________

If Multiple Units, How Many? ___________

If the Property is Commercial, Type?

Business Type(s) _____________________________________

Does it include residences (i.e., multi-use)? Y / N If yes, how many? _________

Other Characteristics:

Number of Floors______ Building Age______

Is the Building Insulated? Y / N How Air-Tight? Tight / Average / Not Tight

4. AIRFLOW:

Use air current tubes or tracer smoke to evaluate airflow patterns and qualitatively describe:

Airflow Between Floors

____

____

____

Airflow Near Source

____

____

____

Outdoor Air Infiltration

____

____

____

Infiltration Into Air Ducts

____

____

____

5. BASEMENT AND CONSTRUCTION CHARACTERISTICS: (circle all that apply)

a.	**Above grade construction:**	wood frame	concrete	stone brick
b.	**Basement type:**	full	crawlspace	slab other ________
c.	**Basement floor:**	concrete	dirt	stone other ________
d.	**Basement floor:**	uncovered	covered	covered with ______________
e.	**Concrete floor:**	unsealed	sealed	sealed with ______________
f.	**Foundation walls:**	poured	block stone	other ____________________
g.	**Foundation walls:**	unsealed	sealed	sealed with ______________
h.	**The basement is:**	wet	damp	dry moldy
i.	**The basement is:**	finished	unfinished	partially finished

j. Sump present? Y / N

k. Water in sump? Y / N / NA

Basement/lowest level depth below grade: ________(feet)

Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains)

____

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? Y / N

6. HEATING, VENTILATING, AND AIR CONDITIONING: (circle all that apply)

Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation	Heat pump	Hot water baseboard
Space heaters	Stream radiation	Radiant floor
Electric baseboard	Wood stove	Outdoor wood boiler
Other _________		

The primary type of fuel used is:

Natural base	Fuel oil	Kerosene
Electric	Propane	Solar
Wood coal		

Domestic hot water tank fueled by: ____________________________

Boiler/furnace located in: Basement Outdoors Main Floor Other___________

Air conditioning: Central Air Window Units Open Windows None

Are there air distribution ducts present? Y / N

Describe the supply and cold air return ductwork, and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.

____

____

____

7. OCCUPANCY:

Is basement/lowest level occupied? Full-time Occasionally Seldom Almost Never

General Use of Each Floor (e.g., family room, bedroom, laundry, workshop, storage):

Basement ____

1st Floor ____

2nd Floor ____

3rd Floor ____

4th Floor ____

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY:

a. Is there an attached garage? Y / N

b. Does the garage have a separate heating unit? Y / N / NA

c. Are petroleum-powered machines or vehicles stored in the garage (e.g., lawnmower, ATV, car)?

Y / N / NA Please specify: ____

d. Has the building ever had a fire? Y / N When? ________________________

e. Is a kerosene or unvented gas space heater present? Y / N Where? ______________

f. Is there a workshop or hobby/craft area? Y / N Where & Type? _____________

g. Is there smoking in the building? Y / N How frequently? ______________________

h. Have cleaning products been used recently? Y / N When & Type? ______________

i. Have cosmetic products been used recently? Y / N When & Type? ______________

j. Has painting/staining been done in the last 6 months? Y / N Where & When? __________

k**. Is there new carpet, drapes or other textiles? Y / N Where & When?** _____________

l. Have air fresheners been used recently? Y / N When & Type? __________________

m. Is there a kitchen exhaust fan? Y / N If yes, where ____________________

n. Is there a bathroom exhaust fan? Y / N If yes, where vented?__________________

o. Is there a clothes dryer? Y / N If yes, is it vented outside? Y / N

p. Has there been a pesticide application? Y / N When & Type?_________________

q. Are there odors in the building? Y / N

If yes, please describe: ____

Do any of the building occupants use solvents (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist) at work? Y / N

If yes, what types of solvents are used? ____

If yes, are their clothes washed at work? Y / N

Do any of the building occupants regularly use or work at a dry-cleaning service? (circle appropriate response)

Yes, use dry-cleaning regularly (weekly) No

Yes, use dry-cleaning infrequently (monthly or less) Unknown

Yes, work at a dry-cleaning service

Is there a radon mitigation system for the building/structure? Y / N

Date of Installation: ____________________

Is the system active or passive? Active/Passive

Are there any Outside Contaminant Sources? (circle appropriate responses)

Contaminated site with 1000-foot radius? Y / N Specify _____________________________

Other stationary sources nearby (e.g., gas stations, emission stacks, etc.): _________________

____

Heavy vehicle traffic nearby (or other mobile sources): ______________________________

9. WATER AND SEWAGE:

Water Supply:	Public Water	Drilled Well	Driven Well	Dug Well	Other: _______
Sewage Disposal:	Public Sewer	Septic Tank	Leach Field	Dry Well	Other: _______

10. RELOCATION INFORMATION: (for oil spill residential emergency)

a. Provide reasons why relocation is recommended: ________________________________

____

b. Residents choose to: remain in home relocate to friends/family relocate to hotel/motel

c. Responsibility for costs associated with reimbursement explained? Y / N

d. Relocation package provided and explained to residents? Y / N

11. FLOOR PLANS:

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note.

Basement:

First Floor:

12. OUTDOOR PLOT:

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s), and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.

13. PRODUCT INVENTORY FORM:

Make and Model of field instrument used: ____

List specific products found in the residence or area that have the potential to affect indoor air quality (e.g., gasoline or kerosene storage cans, glues, paints, cleaning solvents/products, polishes/waxes, new furniture/ carpet, nail polish/hairspray/cologne).

Location	Product Description	Size (units)	Condition*	Chemical Ingredients	Field Instrument Reading (units)	Photo** Y/N

14. SAMPLING INFORMATION:

Sample Technician: ____________________________ Phone number: (   ) _______ - __________

Sample Source: Indoor Air / Sub-Slab / Near Slab Soil Gas / Exterior Soil Gas

Sampler Type: Tedlar Bag / Sorbent / Stainless Steel Canister / Other (specify): _________________

Analytical Method: TO-15 / TO-17 / Other: _________ Cert. Laboratory: _________________

Sample Locations (floor, room):

Field ID # _____ - ________________________ Field ID # _____ - __________________________

Field ID # _____ - ________________________ Field ID # _____ - __________________________

If distributed to occupants prior to sampling event, were the state-specific "Instructions for Occupants" followed? Yes / No

If not, describe modifications: ____

15. METEOROLOGICAL CONDITIONS:

Was there significant precipitation within 12 hours prior to (or during) the sampling event? Yes / No

Describe the general weather conditions: ____

____

16. GENERAL OBSERVATIONS:

Provide any information that may be pertinent to the sampling event and may assist in the data interpretation process.

____

____

____

____

ATTACHMENT B

ARCADIS Infrastructure, environment, facilities	**Indoor/Ambient Air Sample Collection Log**	
	Sample ID:	

Client:		**Outdoor/Indoor:**	
Project:		**Sample Intake Height:**	
Location:		**Miscellaneous Equipment:**	
Project #:		**Time On/Off:**	
Samplers:		**Subcontractor:**	

Instrument Readings:

Time	Canister Pressure (inches of HG)	Temperature (F or C)	Relative Humidity (%)	Air Speed (ft/min)	Pressure Differential (inches of H20)	PID (ppm or ppb)

SUMMA Canister Information:

Size (circle one): 1 L 6 L

Canister ID:

Flow Controller ID: ____________________

General Observations/Notes:

Please record current weather information including wind speed and direction, ambient temperature, barometric pressure, and relative humidity via suitable information source (e.g., weatherunderground.com).

ARCADIS

Appendix B-1-19

Chain of Custody, Handling, Packing, and Shipping

ARCADIS

Infrastructure, environment, buildings

Imagine the result

Chain-of-Custody, Handling, Packing and Shipping

Rev. #: 2

Rev Date: March 6, 2009

Approval Signatures

Prepared by: ______________________ Date: 3/6/09
Caron Koll

Reviewed by: ______________________ Date: 3/6/09
Jane Kennedy(Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) describes the chain-of-custody, handling, packing, and shipping procedures for the management of samples to decrease the potential for cross-contamination, tampering, mis-identification, and breakage, and to insure that samples are maintained in a controlled environment from the time of collection until receipt by the analytical laboratory.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, Department of Transportation (DOT) training, site supervisor training, and site-specific training, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and possess the skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following list provides materials that may be required for each project. Project documents and sample collection requirements should be reviewed prior to initiating field operations:

- indelible ink pens (black or blue);
- polyethylene bags (resealable-type);
- clear packing tape, strapping tape, duct tape;
- chain of custody
- DOT shipping forms, as applicable
- custody seals or tape;
- appropriate sample containers and labels,;
- insulated coolers of adequate size for samples and sufficient ice to maintain 4°C during collection and transfer of samples;
- wet ice;
- cushioning and absorbent material (i.e., bubble wrap or bags);

- temperature blank
- sample return shipping papers and addresses; and
- field notebook.

IV. Cautions

Review project requirements and select appropriate supplies prior to field mobilization.

Insure that appropriate sample containers with applicable preservatives, coolers, and packing material have been supplied by the laboratory.

Understand the offsite transfer requirements for the facility at which samples are collected.

If overnight courier service is required schedule pick-up or know where the drop-off service center is located and the hours of operation. Prior to using air transportation, confirm air shipment is acceptable under DOT and International Air Transport Association (IATA) regulation

Schedule pick-up time for laboratory courier or know location of laboratory/service center and hours of operation.

Understand DOT and IATA shipping requirements and evaluate dangerous goods shipping regulations relative to the samples being collected (i.e. complete an ARCADIS shipping determination). Review the ARCADIS SOPs for shipping, packaging and labeling of dangerous goods. Potential samples requiring compliance with this DOT regulation include:

- Methanol preservation for Volatile Organic Compounds in soil samples
- Non-aqueous phase liquids (NAPL)

V. Health and Safety Considerations

Follow health and safety procedures outlined in the project/site Health and Safety Plan (HASP).

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

Some sample containers contain preservatives.

- The preservatives must be retained in the sample container and should in no instance be rinsed out.

- Preservatives may be corrosive and standard care should be exercised to reduce potential contact to personnel skin or clothing. Follow project safety procedures if spillage is observed.

- If sample container caps are broken discard the bottle. Do not use for sample collection.

VI. Procedure

Chain-of-Custody Procedures

1. Prior to collecting samples, complete the chain-of-custody record header information by filling in the project number, project name, and the name(s) of the sampling technician(s) and other relevant project information. Attachment 1 provides an example chain-o- custody record

2. Chain-of-custody information MUST be printed legibly using indelible ink (black or blue).

3. After sample collection, enter the individual sample information on the chain-of-custody:

   a. Sample Identification indicates the well number or soil location that the sample was collected from. Appropriate values for this field include well locations, grid points, or soil boring identification numbers (e.g., MW-3, X-20, SB-30). When the depth interval is included, the complete sample ID would be “SB-30 (0.5-1.0) where the depth interval is in feet. Please note it is very important that the use of hyphens in sample names and depth units (i.e., feet or inches) remain consistent for all samples entered on the chain-of-custody form. DO NOT use the apostrophe or quotes in the sample ID. Sample names may also use the abbreviations “FB,” “TB,” and “DUP” as prefixes or suffixes to indicate that the sample is a field blank, trip blank, or field duplicate, respectively. NOTE: The sample nomenclature may be dictated by the project database and require unique identification for each sample collected for the project. Consult the project data management plan for additional information regarding sample identification.

b. List the date o sample collection. The date format to be followed should be mm/dd/yy (e.g., 03/07/09) or mm/dd/yyyy (e.g. 03/07/2009).

c. List the time that the sample was collected. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

d. The composite field should be checked if the sample is a composite over a period of time or from several different locations and mixed prior to placing in sample containers.

e. The “Grab”. field should be marked with an “X” if the sample was collected as an individual grab sample. (e.g. monitoring well sample or soil interval).

f. Any sample preservation should be noted.

g. The analytical parameters that the samples are being analyzed for should be written legibly on the diagonal lines. As much detail as possible should be presented to allow the analytical laboratory to properly analyze the samples. For example, polychlorinated biphenyl (PCB) analyses may be represented by entering “PCBs” or “Method 8082.” Multiple methods and/or analytical parameters may be combined for each column (e.g., PCBs/VOCs/SVOCs or 8082/8260/8270). These columns should also be used to present project-specific parameter lists (e.g., Appendix IX+3 target analyte list. Each sample that requires a particular parameter analysis will be identified by placing the number of containers in the appropriate analytical parameter column. For metals in particular, indicate which metals are required.

h. Number of containers for each method requested. This information may be included under the parameter or as a total for the sample based on the chain of custody form used.

i. Note which samples should be used for site specific matrix spikes.

j. Indicate any special project requirements.

k. Indicate turnaround time required.

l. Provide contact name and phone number in the event that problems are encountered when samples are received at the laboratory.

m. If available attach the Laboratory Task Order or Work Authorization forms

n. The remarks field should be used to communicate special analytical requirements to the laboratory. These requirements may be on a per sample basis such as "extract and hold sample until notified," or may be used to inform the laboratory of special reporting requirements for the entire sample delivery group (SDG). Reporting requirements that should be specified in the remarks column include: 1) turnaround time; 2) contact and address where data reports should be sent; 3) name of laboratory project manager; and 4) type of sample preservation used.

o. The "Relinquished By" field should contain the signature of the sampling technician who relinquished custody of the samples to the shipping courier or the analytical laboratory.

p. The "Date" field following the signature block indicates the date the samples were relinquished. The date format should be mm/dd/yyyy (e.g., 03/07/2005).

q. The "Time" field following the signature block indicates the time that the samples were relinquished. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

r. The "Received By" section is signed by sample courier or laboratory representative who received the samples from the sampling technician or it is signed upon laboratory receipt from the overnight courier service.

3. Complete as many chain-of-custody forms as necessary to properly document the collection and transfer of the samples to the analytical laboratory.

4. Upon completing the chain-of-custody forms, forward two copies to the analytical laboratory and retain one copy for the field records.

5. If electronic chain-of-custody forms are utilized, sign the form and make 1 copy for ARCADIS internal records and forward the original with the samples to the laboratory.

Handling Procedures

1. After completing the sample collection procedures, record the following information in the field notebook with indelible ink:

- project number and site name;
- sample identification code and other sample identification information, if appropriate;
- sampling method;
- date;
- name of sampler(s);
- time;
- location (project reference);
- location of field duplicates and both sample identifications;
- locations that field QC samples were collected including equipment blanks, field blanks and additional sample volume for matrix spikes; and
- any comments.

2. Complete the sample label with the following information in indelible ink:

- sample type (e.g., surface water);
- sample identification code and other sample identification information, if applicable;
- analysis required;
- date;
- time sampled; and
- initials of sampling personnel;

- sample matrix; and
- preservative added, if applicable.

3. Cover the label with clear packing tape to secure the label onto the container and to protect the label from liquid.

4. Confirm that all caps on the sample containers are secure and tightly closed.

5. In some instances it may be necessary to wrap the sample container cap with clear packing tape to prevent it from becoming loose.

6. For some projects individual custody seals may be required. Custody seal evidence tape may be placed on the shipping container or they may be placed on each sample container such that the cooler or cap cannot be opened without breaking the custody seal. The custody seal should be initialed and dated prior to relinquishing the samples.

Packing Procedures

Following collection, samples must be placed on wet ice to initiate cooling to 4°C immediately. Retain samples on ice until ready to pack for shipment to the laboratory.

1. Secure the outside and inside of the drain plug at the bottom of the cooler being used for sample transport with "Duct" tape.

2. Place a new large heavy duty plastic garbage bag inside each cooler

3. Place each sample bottle wrapped in bubble wrap inside the garbage bag. VOC vials may be grouped by sample in individual resealable plastic bags). If a cooler temperature blank is supplied by the laboratory, it should be packaged following the same procedures as the samples. If the laboratory did not include a temperature blank, do not add one. Place 1 to 2 inches of cushioning material (i.e., vermiculite) at the bottom of the cooler.

4. Place the sealed sample containers upright in the cooler.

5. Package ice in large resealable plastic bags and place inside the large garbage bag in the cooler. Samples placed on ice will be cooled to and maintained at a temperature of approximately 4°C.

6. Fill the remaining space in the cooler with cushioning material such as bubble wrap. The cooler must be securely packed and cushioned in an upright position and be surrounded (Note: to comply with 49 CFR 173.4, filled cooler must not exceed 64 pounds).

7. Place the completed chain-of-custody record(s) in a large resealable bag and tape the bag to the inside of the cooler lid.

8. Close the lid of the cooler and fasten with packing tape.

9. Wrap strapping tape around both ends of the cooler.

10. Mark the cooler on the outside with the following information: shipping address, return address, “Fragile, Handle with Care” labels on the top and on one side, and arrows indicating “This Side Up” on two adjacent sides.

11. Place custody seal evidence tape over front right and back left of the cooler lid, initial and date, then cover with clear plastic tape.

Note: Procedure numbers 2, 3, 5, and 6 may be modified in cases where laboratories provide customized shipping coolers. These cooler types are designed so the sample bottles and ice packs fit snugly within preformed styrofoam cushioning and insulating packing material.

Shipping Procedures

1. All samples will be delivered by an express carrier within 48 hours of sample collection. Alternatively, samples may be delivered directly to the laboratory or laboratory service center or a laboratory courier may be used for sample pickup.

2. If parameters with short holding times are required (e.g., VOCs [EnCore™ Sampler], nitrate, nitrite, ortho-phosphate and BOD), sampling personnel will take precautions to ship or deliver samples to the laboratory so that the holding times will not be exceeded.

3. Samples must be maintained at 4°C+2°C until shipment and through receipt at the laboratory

4. All shipments must be in accordance with DOT regulations and ARCADIS dangerous goods shipping SOPs.

5. When the samples are received by the laboratory, laboratory personnel will complete the chain-of-custody by recording the date and time of receipt of samples, measuring and recording the internal temperature of the shipping container, and checking the sample identification numbers on the containers to ensure they correspond with the chain-of-custody forms.

Any deviations between the chain-of-custody and the sample containers, broken containers, or temperature excursions will be communicated to ARCADIS immediately by the laboratory.

VII. Waste Management

Not applicable

VIII. Data Recording and Management

Chain-of-custody records will be transmitted to the ARCADIS PM or designee at the end of each day unless otherwise directed by the ARCADIS PM. The sampling team leader retains copies of the chain-of-custody forms for filing in . the project file. Record retention shall be in accordance with project requirements.

IX. Quality Assurance

Chain-of-custody forms will be legibly completed in accordance with the applicable project documents such as Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Work Plan, or other project guidance documents. A copy of the completed chain-of-custody form will be sent to the ARCADIS Project Manager or designee for review.

X. References

Not Applicable

Attachment 1

ARCADIS
Infrastructure, environment, facilities

ID#:

CHAIN OF COUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ___ of ___

Lab Work Order #

Send Results to:		
Contact & Company Name:		Telephone:
Address:		Fax:
City: State: Zip:		E-mail Address:
Project Name/Location (City, State):		Project #:
Sampler's Printed Name:		Sampler's Signature:

Preservative							
Filtered (✓)							
# of Containers							
Container Information							

PARAMETER ANALYSIS & METHOD

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: ________
G. Other: ________
H. Other: ________

Container Information Key:
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: ________
10. Other: ________

Matrix Key:
SO - Soil; SE - Sediment; NL - NAPL/Oil
W - Water; SL - Sludge; SW - Sample Wipe
T - Tissue; A - Air; Other: ________

Sample ID	Collection Date	Collection Time	Type (✓) Comp	Type (✓) Grab	Matrix									REMARKS

Special Instructions/Comments:

☐ **Special QA/QC Instructions(✓):**

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Lab Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name:
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt:	Firm:	Firm/Courier:	Firm/Courier:	Firm:
Shipping Tracking #:	Condition/Cooler Temp: ________	Date/Time:	Date/Time:	Date/Time:	Date/Time:

20730826 CofC AR Form 01.12.2007 **Distribution:** **WHITE – Laboratory returns with results** **YELLOW – Lab copy** **PINK – Retained by BBL**

ARCADIS

Appendix B-1-20

Draft Calibration of Field Instruments (USEPA 1998)

STANDARD OPERATING PROCEDURE
CALIBRATION OF FIELD INSTRUMENTS
(temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction potential [ORP], and turbidity)

Quality Assurance Unit
U.S. Environmental Protection Agency – Region 1
11 Technology Drive
North Chelmsford, MA 01863

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Prepared by: Charles Porfert 1/19/10
(Charles Porfert, Quality Assurance Unit) Date

Approved by: Gerard Sotolongo 1-19-10
(Gerard Sotolongo, Quality Assurance Unit) Date

Revision Page

Date	**Rev #**	**Summary of changes**	**Sections**
6/03/98	1	Draft	
01/19/10	2	Finalized	

TABLE OF CONTENTS

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide a framework for calibrating field instruments used to measure water quality parameters for groundwater and surface water. Water quality parameters include temperature, pH, dissolved oxygen, specific conductance, oxidation/reduction potential [ORP], and turbidity. This SOP supplements, but does not replace, EPA analytical methods listed in 40 CFR 136 and 40 CFR 141 for temperature, dissolved oxygen, conductivity/specific conductance, pH and turbidity.

This SOP is written for instruments that measure temperature, pH, dissolved oxygen, specific conductance, turbidity, and/or oxidation/reduction potential [ORP] and the probe readings for pH, dissolved oxygen, and specific conductance are automatically corrected for temperature.

For groundwater monitoring, the instrument must be equipped with a flow-through-cell and the display/logger or computer display screen needs to be large enough to simultaneously contain the readouts of each probe in the instrument. Turbidity is measured using a separate instrument. It must not be measured in a flow-through-cell because the flow-through-cell acts as a sediment trap. This procedure is applicable for use with the *EPA Region 1 Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells.*

2.0 HEALTH AND SAFETY WARNINGS

Read all labels on the standards and note any warnings on the labels. Wear appropriate personal protection equipment (e.g., gloves, eye shields, etc.) when handling the standards. If necessary, consult the Material Safety Data Sheets (MSDS) for additional safety information on the chemicals in the standards.

3.0 GENERAL

All monitoring instruments must be calibrated before they are used to measure environmental samples. For instrument probes that rely on the temperature sensor (pH, dissolved oxygen, specific conductance, and oxidation/reduction potential [ORP]), each temperature sensor needs to be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST). Before any instrument is calibrated or used to perform environmental measurements, the instrument must stabilize (warm-up) according to manufacturer's instructions and must have no air bubbles lodged between the probe and probe guard.

Most projects will require at least two standards to bracket the expected measurement range. This means that one standard is less than the expected value and one is higher. When an environmental sample measurement falls outside the calibration range, the instrument must be re-calibrated to bracket the new range before continuing measurements. Otherwise, the measurements that are outside the calibration range will need to be qualified.

This SOP requires that the manufacturer's instruction manual (including the instrument specifications) accompany the instrument into the field.

4.0 FREQUENCY OF CALIBRATION

At a minimum, the instrument is calibrated prior to use on the day the measurements are to be performed. A post calibration check at the end of the day is performed to determine if the instrument drifted out of calibration. Some projects may require more frequent calibration checks throughout the day in addition to the check at the end of the day. For these checks, the instrument can be recalibrated during the day if the instrument drifted out of calibration and only the data measured prior to the check would need to be qualified. The calibration/post calibration data information is recorded in Table 1.

Instruments (e.g., sonde) that monitor continuously over a period of time are calibrated before deployment. When these instruments are recovered, the calibration is checked to determine if any of them drifted out of calibration.

Some instruments lose their calibration criteria when they are turned off. Those instruments can either be left on all day (battery dependent) or calibrated at each sampling location. If they are calibrated at each sampling location, a post calibration check is not needed.

Ideally, the temperature of the standards should be close to the temperature of the ambient water that is being measured.

5.0 CALIBRATION PROCEDURES

Prior to calibration, all instrument probes and cable connections must be cleaned and the battery checked according to the manufacturer's instructions. Failure to perform these steps (proper maintenance) can lead to erratic measurements.

If a multi-probe instrument is to be used, program the instrument to display the parameters to be measured (e.g., temperature, pH, percent dissolved oxygen, mg/L dissolved oxygen, specific conductance, and ORP).

The volume of the calibration solutions must be sufficient to cover both the probe and temperature sensor (see manufacturer's instructions for the volume to be used).

Check the expiration date of the standards. Do not use expired standards.

All standards are stored according to manufacturer instructions.

5.1 TEMPERATURE

Most instrument manuals state there is no calibration of the temperature sensor, but the temperature sensor must be checked to determine its accuracy. This accuracy check is performed at least once per year and the accuracy check date/information is kept with the instrument. If the accuracy check date/information is not included with the instrument or the last check was over a year, the temperature sensor accuracy needs to be checked at the beginning of the sampling event. If the instrument contains multiple temperature sensors, each sensor must be checked. This procedure is not normally perform in the field. If the instrument is obtained from a rental company, the rental company should performed the calibration check and include with the instrument documentation that it was performed.

Verification Procedure

1. Fill a container with water and adjust the water temperature to below the water body's temperature to be measured. Use ice or warm water to adjust the temperature.

2. Place a thermometer that is traceable to the National Institute of Standards and Technology (NIST) and the instrument's temperature sensor into the water. Wait for both temperature readings to stabilize.

3. Compare the two measurements. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (e.g., $\pm 0.2\,^{\circ}C$). If the measurements do not agree, the instrument may not be working properly and the manufacturer needs to be consulted.

4. Adjust the water temperature to a temperature higher than the water body to be measured.

5. Compare the two measurements. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (e.g.,

$\pm 0.2^\circ C$). If the measurements do not agree, the instrument may not be working properly and the manufacturer needs to be consulted.

5.2 pH (electrometric)

The pH of a sample is determined electrometrically using a glass electrode.

Choose the appropriate buffered standards that will bracket the expected values at the sampling locations. If the water body's pH is unknown, then three standards are needed for the calibration: one close to seven, one at least two pH units below seven, and the other at least two pH units above seven. Instruments that will not accept three standards will need to be re-calibrated if the water sample's pH is outside the initial calibration range described by the two standards.

<u>Calibration Procedure</u>

1. Allow the buffered standards to equilibrate to the ambient temperature.

2. Fill calibration containers with the buffered standards so each standard will cover the pH probe and temperature sensor.

3. Remove probe from its storage container, rinse with deionized water, and remove excess water.

4. Select measurement mode. Immerse probe into the initial standard (e.g., pH 7).

5. Wait until the readings stabilize. If the reading does not change within 30 seconds, select calibration mode and then select "pH". Enter the buffered standard value into instrument.

6. Remove probe from the initial standard, rinse with deionized water, and remove excess water.

7. Immerse probe into the second standard (e.g., pH 4). Repeat step 5.

8. Remove probe from the second standard, rinse with deionized water, and remove excess water. If instrument only accepts two standards, the calibration is complete. Go to step 11. Otherwise continue.

9. Immerse probe in third buffered standard (e.g., pH 10) and repeat step 5.

10. Remove probe from the third standard, rinse with deionized water, and remove excess water.

11. Select measurement mode, if not already selected. To ensure that the initial calibration standard (e.g., pH 7) has not changed, immerse the probe into the initial standard. Wait for the readings to stabilize. The reading should read the initial standard value within the manufacturer's specifications. If not, re-calibrate the instrument. If re-calibration does not help, the calibration range may be too great. Reduce calibration range by using standards that are closer together.

12. The calibration is complete. Rinse the probe with deionized water and store the probe according to manufacturer's instructions.

13. Record the calibration information on Table 1.

5.3 DISSOLVED OXYGEN

Dissolved oxygen (DO) content in water is measured using a membrane electrode. To insure proper operation, the DO probe's membrane and electrolyte should be replaced prior to calibration for the sampling event. The new membrane may need to be conditioned before it is used; consult manufacturer's manual on how the conditioning is to be performed. Failure to perform this step may lead to erratic measurements. Before performing the calibration/measurements, inspect the membrane for air bubbles and nicks.

Note: some manufacturers require an altitude correction instead of a barometric correction. In that case, enter the altitude correction according to the manufacturer's directions in Step 5 and then proceed to Step 6.

Note: some instruments have a built-in barometer. Follow the manufacturer's instructions for entering the barometric value in step 5.

<u>Calibration Procedure</u>

1. Gently dry the temperature sensor and remove any water droplets from the DO probe's sensor membrane according to manufacturer's instructions. Note that the evaporation of moisture on the temperature sensor or DO probe may influence the readings during calibration.

2. Create a 100 percent water-saturated air environment by placing a wet sponge or a

wet paper towel on the bottom of the DO calibration container. Place the DO probe into the calibration container. The probe is loosely fitted into the calibration container to prevent the escape of moisture evaporating from the sponge or paper towel while maintaining ambient pressure (see manufacturer's instructions). Note that the probe and the temperature sensor must not come in contact with these wet items.

3. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 10 to 15 minutes). During this time, turn on the instrument to allow the DO probe to warm-up. Select the measurement mode. Check the temperature readings. Readings must stabilize before continuing to the next step.

4. Select calibration mode; then select "DO %".

5. Enter the local barometric pressure (usually in mm of mercury) for the sampling location into the instrument. This measurement must be determined from an on-site barometer. Do not use barometric pressure obtained from the local weather services unless the pressure is corrected for the elevation of the sampling location. [Note: inches of mercury times 25.4 mm/inch equals mm of mercury or consult Oxygen Solubility at Indicated Pressure chart attached to the SOP for conversion at selected pressures].

6. The instrument should indicate that the calibration is in progress. After calibration, the instrument should display percent saturated DO.

7. Select measurement mode and set the display to read DO mg/L and temperature. Compare the DO mg/L reading to the Oxygen Solubility at Indicated Pressure chart attached to the SOP. The numbers should agree. If they do not agree within the accuracy of the instrument (usually ± 0.2 mg/L), repeat calibration. If this does not work, change the membrane and electrolyte solution.

8. Remove the probe from the container and place it into a 0.0 mg/L DO solution (see footnote). Check temperature readings. They must stabilize before continuing.

9. Wait until the "mg/L DO" readings have stabilized. The instrument should read less than 0.5 mg/L (assuming an accuracy of ± 0.2 mg/L). If the instrument reads above 0.5 mg/L or reads negative, it will be necessary to clean the probe, and change the membrane and electrolyte solution. If this does not work, try a new 0.0 mg/L DO solution. If these changes do not work, contact the manufacturer. Note: some projects and instruments may have different accuracy requirements. The 0.5 mg/L

value may need to be adjusted based on the accuracy requirements of the project or instrument.

10. After the calibration has been completed, rinse the probe with tap or deionized water and store the probe according to manufacturer's instructions. It is important that all of the 0.0 mg/L DO solution be rinsed off the probe so as not to effect the measurement of environmental samples.

11. Record calibration information on Table 1.

Note: You can either purchase the 0.0 mg/L DO solution from a vendor or prepare the solution yourself. To prepare a 0.0 mg/L DO solution, follow the procedure stated in Standard Methods (Method 4500-O G). The method basically states to add excess sodium sulfite (until no more dissolves) and a trace amount of cobalt chloride (read warning on the label before use) to water. This solution is prepared prior to the sampling event. Note: this solution can be made without cobalt chloride, but the probe will take longer to respond to the low DO concentration.

5.4 SPECIFIC CONDUCTANCE

Conductivity is used to measure the ability of an aqueous solution to carry an electrical current. Specific conductance is the conductivity value corrected to 25°C.

Most instruments are calibrated against a single standard which is near the specific conductance of the environmental samples. The standard can be either below or above the specific conductance of the environmental samples. A second standard is used to check the linearity of the instrument in the range of measurements.

When performing specific conductance measurement on groundwater or surface water and the measurement is outside the initial calibration range defined by the two standards, the instrument will need to be re-calibrated using the appropriate standards.

<u>Specific Conductance Calibration Procedure</u>

1. Allow the calibration standards to equilibrate to the ambient temperature.

2. Fill calibration containers with the standards so each standard will cover the probe and temperature sensor. Remove probe from its storage container, rinse the probe with deionized water or a small amount of the standard (discard the rinsate), and place the

probe into the standard.

3. Select measurement mode. Wait until the probe temperature has stabilized.

4. Select calibration mode, then specific conductance. Enter the specific conductance standard value. Make sure that the units on the standard are the same as the units used by the instrument. If not, convert the units on the standard to the units used by the instrument.

5. Select measurement mode. The reading should remain within manufacturer's specifications. If it does not, re-calibrate. If readings continue to change after re-calibration, consult manufacturer or replace calibration solution.

6. Remove probe from the standard, rinse the probe with deionized water or a small amount of the second standard (discard the rinsate), and place the probe into the second standard. The second standard will serve to verify the linearity of the instrument. Read the specific conductance value from the instrument and compare the value to the specific conductance on the standard. The two values should agree within the specifications of the instrument. If they do not agree, re-calibrate. If readings do not compare, then the second standard may be outside the linear range of the instrument. Use a standard that is closer to the first standard and repeat the verification. If values still do not compare, try cleaning the probe or consult the manufacturer.

7. After the calibration has been completed, rinse the probe with deionized water and store the probe according to manufacturer's instructions.

8. Record the calibration information on Table 1.

Note: for projects where specific conductance is not a critical measurement it may be possible to calibrate with one standard in the range of the expected measurement.

5.5 OXIDATION/REDUCTION POTENTIAL (ORP)

The oxidation/reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent.

Calibration or Verification Procedure

1. Allow the calibration standard (a Zobell solution: read the warning on the label before use) to equilibrate to ambient temperature.

2. Remove the probe from its storage container and place it into the standard.

3. Select measurement mode.

4. Wait for the probe temperature to stabilize, and then read the temperature.

5. If the instrument is to be calibrated, do Steps 6 and 7. If the instrument calibration is to be verified, then go to Step 8.

6. Look up the millivolt (mv) value at this temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. You may need to interpolate millivolt value between temperatures. Select "calibration mode", then "ORP". Enter the temperature-corrected ORP value into the instrument.

7. Select measurement mode. The readings should remain unchanged within manufacturer's specifications. If they change, re-calibrate. If readings continue to change after re-calibration, try a new Zobell solution or consult manufacturer. Go to Step 9.

8. If the instrument instruction manual states that the instrument is factory calibrated, then verify the factory calibration against the Zobell solution. If they do not agree within the specifications of the instrument, try a new Zobell solution. If it does not agree, the instrument will need to be re-calibrated by the manufacturer.

9. After the calibration has been completed, rinse the probe with deionized water and store the probe according to manufacturer's instructions.

10. Record the calibration information on Table 1.

5.6 TURBIDITY

The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A turbidimeter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed ninety degrees to the path of the light source. Note: the below calibration procedure is for a turbidimeter which the sample is placed into a cuvette.

Some instruments will only accept one standard. For those instruments, the second, third, etc., standards will serve as check points.

Calibration Procedures

1. Allow the calibration standards to equilibrate at the ambient temperature. The use of commercially available polymer primary standards (AMCO-AEPA-1) is preferred; however, the standards can be prepared using Formazin (read the warning on the label before use) according to the EPA analytical Method 180.1. Other standards may be used if they can be shown that they are equivalent to the previously mentioned standards.

2. If the standard cuvette is not sealed, rinse a cuvette with deionized water. Shake the cuvette to remove as much water as possible. Do not wipe dry the inside of the cuvette because lint from the wipe may remain in the cuvette. Add the standard to the cuvette.

3. Before performing the calibration procedure, make sure the cuvettes are not scratched and the outside surfaces are dry and free from fingerprints and dust. If the cuvette is scratched or dirty, discard or clean the cuvette respectively. Note: some manufacturers require the cuvette to be orientated in the instrument in a particular direction for accurate reading.

4. Select a low value standard such as a zero or 0.02 NTU and calibrate according to manufacturer's instructions. Note: a zero standard (approximately 0 NTU) can be prepared by passing distilled water through a 0.45 micron pore size membrane filter.

5. Select a high standard and calibrate according to manufacturer's instructions or verify the calibration if instrument will not accept a second standard. In verifying, the instrument should read the standard value to within the specifications of the instrument. If the instrument has range of scales, check each range that will be used during the sampling event with a standard that falls within that range.

6. Record the calibration information on Table 1.

6.0 POST CALIBRATION CHECK

After the initial calibration is performed, the instrument's calibration may drift during the measurement period. As a result, you need to determine the amount of drift that occurred after collecting the measurements. This is performed by placing the instrument in measurement mode (not calibration mode) and placing the probe in one or more of the standards used during the initial calibration; for turbidity place the standard in a cuvette and then into the turbidimeter. Wait for the instrument to stabilize and record the measurement (Table 1). Compare the measurement value to the initial calibration value. This difference in value is then compared to the drift criteria or post calibration criteria described in the quality assurance project plan or the sampling and analysis plan for the project. If the check value is outside the criteria, then the measurement data will need to be qualified.

For the dissolved oxygen calibration check, follow the calibration instructions steps one through three while the instrument is in measurement mode. Record dissolved oxygen value (mg/L), temperature, and barometric pressure. Compare the measurement value to the Oxygen Solubility at Indicated Pressure chart attached to this SOP. The value should be within the criteria specified for the project. If measurement value drifted outside the criteria, the data will need to be qualified.

If the quality assurance project plan or the sampling and analysis plan do not list the drift criteria or the post-calibration criteria, use the criteria below.

Measurement	**Post Calibration Criteria**
Dissolved Oxygen	± 0.5 mg/L of sat. value* < 0.5 mg/L for the 0 mg/L solution, but not a negative value
Specific Conductance	±5% of standard or ± 10 µS/cm (whichever is greater)
pH	± 0.3 pH unit with pH 7 buffer*
Turbidity	± 5% of standard
ORP	± 10 mv*

Note: * Table 8.1, USEPA Region 1 *YSI 6-Series Sondes and Data Logger SOP*, January 30, 2007, revision 9.

7.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All calibration records must be documented in the project's log book or on a calibration log sheet. At a minimum, include the instrument manufacturer, model number, instrument identification number (when more than one instrument of the same model is used), the standards used to calibrate the instruments (including source), the calibration date, the instrument readings, the post calibration check, and the name of the person(s) who performed the calibration. An example of a calibration log sheet is shown in Table 1.

8.0 References

Standard Methods for the Examination of Water and Wastewater, 20th edition, 1998.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

Turbidity - Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, August 1993.

USEPA Region 1 YSI 6-Series Sondes and Data Logger SOP, January 30, 2007, revision 9.

USGS Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting, Techniques and Methods 1-D3.

TABLE 1
INSTRUMENT CALIBRATION LOG

Project Name__________________ Date___________________
Weather____________

Calibrated by__________________ Instrument_____________
Serial Number___________

Parameters	Morning Calibration	Morning Temperature	End of Day Calibration Check*	End of Day Temperature
Specific Conductance Standard #1				
Specific Conductance Standard #2				
pH (7)				
pH (4)				
pH (10)				
ORP Zobel solution				
Dissolved Oxygen 100% water saturated air mg/L				
Dissolved Oxygen Zero Dissolved Oxygen Solution mg/L				
Barometric Pressure mm Hg		NA		NA
Turbidity Standard #1				
Turbidity Standard #2				
Turbidity Standard #3				

* For each Parameter, chose one standard as your check standard. If possible, choose the one that is closest to the ambient measurement value.

Oxygen Solubility at Indicated Pressure

Temp.	Pressure (Hg)							
	760	755	750	745	740	735	730	mm
°C	29.92	29.72	29.53	29.33	29.13	28.94	28.74	in
0	14.57	14.47	14.38	14.28	14.18	14.09	13.99	mg/l
1	14.17	14.08	13.98	13.89	13.79	13.70	13.61	
2	13.79	13.70	13.61	13.52	13.42	13.33	13.24	
3	13.43	13.34	13.25	13.16	13.07	12-98	12.90	
4	13.08	12.99	12.91	12.82	12.73	12.65	12.56	
5	12.74	12.66	12.57	12.49	12.40	12.32	12.23	
6	12.42	12.34	12.26	12.17	12.09	12.01	11.93	
7	12.11	12.03	11.95	11.87	11.79	11.71	11.63	
8	11.81	11.73	11.65	11.57	11.50	11.42	11.34	
9	11.53	11.45	11.38	11.30	11.22	11.15	11.07	
10	11.28	11.19	11.11	11.04	10.96	10.89	10.81	
11	10.99	10.92	10.84	10.77	10.70	10.62	10.55	
12	10.74	10.67	10.60	10.53	10.45	10.38	10.31	
13	10.50	10.43	10.36	10.29	10.22	10.15	10.08	
14	10.27	10.20	10.13	10.06	10.00	9.93	9.86	
15	10.05	9.98	9.92	9.85	9.78	9.71	9.65	
16	9.83	9.76	9.70	9.63	9.57	9.50	9.43	
17	9.63	9.57	9.50	9.44	9.37	9.31	9.24	
18	9.43	9.37	9.30	9.24	9.18	9.11	9.05	
19	9.24	9.18	9.12	9.05	8.99	8.93	8.87	
20	9.06	9.00	8.94	8.88	8.82	8.75	8.69	
21	8.88	8.82	8.76	8.70	8.64	8.58	8.52	
22	8.71	8.65	8.59	8.53	8.47	8.42	8.36	
23	8.55	8.49	8.43	8.38	8.32	8.26	8.20	
24	8.39	8.33	8.28	8.22	8.16	8.11	8.05	
25	8.24	8.18	8.13	8.07	8.02	7.96	7.90	
26	8.09	8.03	7.98	7.92	7.87	7.81	7.76	
27	7.95	7.90	7.84	7.79	7.73	7.68	7.62	
28	7.81	7.76	7.70	7.65	7.60	7.54	7.49	
29	7.68	7.63	7.57	7.52	7.47	7.42	7.36	
30	7.55	7.50	7.45	7.39	7.34	7.29	7.24	
31	7.42	7.37	7.32	7.27	7.22	7.16	7.11	
32	7.30	7.25	7.20	7.15	7.10	7.05	7.00	
33	7.08	7.13	7.08	7.03	6.98	6.93	6.88	
34	7.07	7.02	6.97	6.92	6.87	6.82	6.78	
35	6.95	6.90	6.85	6.80	6.76	6.71	6.66	
36	6.84	6.79	6.76	6.70	6.65	6.60	6.55	
37	6.73	6.68	6.64	6.59	6.54	6.49	6.45	
38	6.63	6.58	6.54	6.49	6.44	6.40	6.35	
39	6.52	6.47	6.43	6.38	6.35	6.29	6.24	
40	6.42	6.37	6.33	6.28	6.24	6.19	6.15	
41	6.32	6.27	6.23	6.18	6.14	6.09	6.05	
42	6.22	6.18	6.13	6.09	6.04	6.00	5.95	
43	6.13	6.09	6.04	6.00	5.95	5.91	5.87	
44	6.03	5.99	5.94	5.90	5.86	5.81	5.77	
45	5.94	5.90	5.85	5.81	5.77	5.72	5.68	

(Continued)

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

Oxygen Solubility at Indicated Pressure (continued)

Temp.	Pressure (Hg)								
	725	720	715	710	705	700	695	690	mm
°C	28.54	28.35	28.15	27.95	27.76	27.56	27.36	27.17	in
0	13.89	13.80	13.70	13.61	13.51	13.41	13.32	13.22	mg/l
1	13.51	13.42	13.33	13.23	13.14	13.04	12.95	12.86	
2	13.15	13.06	12.07	12.88	12.79	12.69	12.60	12.51	
3	12.81	12.72	12.63	12.54	12.45	12.36	12.27	12.18	
4	12.47	12.39	12.30	12.21	12.13	12.04	11.95	11.87	
5	12.15	12.06	11.98	11.89	11.81	11.73	11.64	11.56	
6	11.84	11.73	11.68	11.60	11.51	11.43	11.35	11.27	
7	11.55	11.47	11.39	11.31	11.22	11.14	11.06	10.98	
8	11.26	11.18	11.10	11.02	10.95	10.87	10.79	10.71	
9	10.99	10.92	10.84	10.76	10.69	10.61	10.53	10.46	
10	10.74	10.66	10.59	10.51	10.44	10.36	10.29	10.21	
11	10.48	10.40	10.33	10.28	10.18	10.11	10.04	9.96	
12	10.24	10.17	10.10	10.02	9.95	9.88	9.81	9.46	
13	10.01	9.94	9.87	9.80	9.73	9.66	9.59	9.52	
14	9.79	9.72	9.65	9.68	9.51	9.45	9.38	9.31	
15	9.58	9.51	9.44	9.58	9.31	9.24	9.18	9.11	
16	9.37	9.30	9.24	9.17	9.11	9.04	8.97	8.91	
17	9.18	9.11	9.05	8.98	8.92	8.85	8.79	8.73	
18	8.99	8.92	8.86	8.80	8.73	8.67	8.61	8.54	
19	8.81	8.74	8.68	8.62	8.56	8.49	8.43	8.37	
20	8.63	8.57	8.51	8.45	8.39	8.33	8.27	8.21	
21	8.46	8.40	8.34	8.28	8.22	8.16	8.10	8.04	
22	8.30	8.24	8.18	8.12	8.06	8.00	7.95	7.89	
23	8.15	8.09	8.03	7.97	7.91	7.86	7.80	7.74	
24	7.99	7.94	7.88	7.82	7.76	7.71	7.65	7.59	
25	7.85	7.79	7.74	7.68	7.60	7.57	7.51	7.46	
26	7.70	7.65	7.59	7.54	7.48	7.43	7.37	7.32	
27	7.57	7.52	7.46	7.41	7.35	7.30	7.25	7.19	
28	7.44	7.38	7.33	7.28	7.22	7.17	7.12	7.06	
29	7.31	7.26	7.21	7.15	7.10	7.05	7.00	6.94	
30	7.19	7.14	7.08	7.03	6.98	6.93	6.88	6.82	
31	7.06	7.01	6.96	6.91	6.86	6.81	6.76	6.70	
32	6.95	6.90	6.85	6.80	6.70	6.70	6.64	6.59	
33	6.83	6.78	6.73	6.68	6.83	6.58	6.53	6.48	
34	6.73	6.68	6.63	6.58	6.53	6.48	6.43	6.38	
35	6.61	6.56	6.51	6.47	6.42	6.37	6.36	6.27	
36	6.51	6.46	6.41	6.36	6.31	6.27	6.22	6.17	
37	6.40	6.35	6.31	6.26	6.21	6.16	6.12	6.07	
38	6.30	6.26	6.21	6.16	6.12	6.07	6.02	5.98	
39	6.26	6.15	6.11	6.06	6.01	5.97	5.92	5.87	
40	6.10	6.06	6.01	5.96	5.92	5.86	5.83	5.78	
41	6.00	5.96	5.91	5.87	5.82	5.78	5.73	5.69	
42	5.91	5.86	5.82	5.77	5.73	5.69	5.64	5.60	
43	5.82	5.78	5.73	5.69	5.65	5.60	5.56	5.51	
44	5.72	5.68	5.64	5.59	5.55	5.51	5.46	5.42	
45	5.64	5.59	5.55	5.51	5.47	5.42	5.38	5.34	

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

ARCADIS

Appendix B-1-21

Investigation-Derived Waste Handling and Storage

ARCADIS
Infrastructure, environment, buildings

Imagine the result

Investigation-Derived Waste Handling and Storage

Rev. #: 3

Rev Date: November 6, 2009

Approval Signatures

Prepared by: Andrew Kanik Date: 11/6/09

Reviewed by: Liz Marsh Date: 11/6/09
(Technical Expert)

I. Scope and Application

The objective of this Standard Operating Procedure (SOP) is to describe the procedures to manage investigation-derived wastes (IDW), both hazardous and non-hazardous, generated during site activities, which may include, but are not limited to - drilling, trenching/excavation, construction, demolition, monitoring well sampling, soil sampling, decontamination and remediation. Please note that this SOP is intended for materials that have been deemed a solid waste as defined by 40 CFR § 261.2 (which may includes liquids, solids, and sludges). In some cases, field determinations will be made based on field screening or previous data that materials are not considered a solid waste. IDW may include soil, groundwater, drilling fluids, decontamination liquids, personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials that may have come in contact with potentially impacted materials. IDW will be collected and staged at the point of generation. Quantities small enough to be containerized in 55-gallon drums will be taken to a designated temporary storage area (discussed in further detail under Drum Storage) onsite pending characterization and disposal. Waste materials will be analyzed for constituents of concern to evaluate proper disposal methods. PPE and disposable sampling equipment will be placed in DOT-approved drums prior to disposal and typically does not require laboratory analysis. This SOP describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures necessary for proper handling and storage of IDW up to the time it is properly disposed. The procedures for handling IDW are based on the United States Environmental Protection Agency's Guide to Management of Investigation Derived Wastes (USEPA 1992). IDW is assumed to be contaminated with the site constituents of concern (COCs) until analytical evidence indicates otherwise. IDW will be managed to ensure the protection of human health and the environment and will comply with all applicable or relevant and appropriate requirements (ARAR). The following Laws and Regulations on Hazardous Waste Management are potential ARAR for this site.

State Laws and Regulations

- To Be Determined Based on Location of Site and Location of Treatment, Storage, and/or Disposal Facility (TSDF) to be utilized

Federal Laws and Regulations

- Resource Conservation and Recovery Act (RCRA) 42 USC § 6901-6987
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) 42 USC § 9601-9675

- Superfund Amendments and Reauthorization Act (SARA)
- Department of Transportation (DOT) Hazardous Materials Transportation

Pending characterization, IDW will be stored appropriately within each area of contamination (AOC). Under RCRA, “storage” is defined as the holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed of, or stored elsewhere” (40 CFR § 260.10). The onsite waste staging area will be in a secure and controlled area. Waste characterization can either be based on generator knowledge, such as using materials safety data sheets (MSDS’), or can be based upon analytical results. The laboratory used for waste characterization analysis must have the appropriate state and federal certifications and be approved by ARCADIS and Client. IDW will be classified as RCRA hazardous or non-regulated under RCRA based on the waste characterization.

If IDW is characterized as RCRA hazardous waste, RCRA and DOT requirements must be followed for packaging, labeling, transporting, storing, and record keeping as described in 40 CFR § 262 and 49 CFR § 171-178. Wastes judged to potentially meet the criteria for hazardous wastes shall be stored in DOT approved packaging. Waste material classified as RCRA non-hazardous may be handled and disposed of as an industrial waste.

Liquid wastes judged to potentially meet the criteria for hazardous wastes shall be stored in DOT approved 55 gallon drums or other approved containers that are compatible with the type of material stored therein. Solid materials deemed to potentially meet hazardous criteria will be drummed where practicable. Large quantities of potentially hazardous solid materials must be containerized (such as in a roll-off box) for up to a maximum of 90 or 180 days as described in the Excavated Solids Section. Waste material classified as non-hazardous may be handled and disposed of as an industrial waste and is not subject to the 90-day or 180-day on-site storage limitation.

This is a standard (i.e., typically applicable) operating procedure which may be varied or changed as required, dependent upon site conditions, equipment limitations, or limitations imposed by the procedure. The ultimate procedure employed will be documented in the project work plans or reports. If changes to the sampling procedures are required due to unanticipated field conditions, the changes will be discussed with the Project Manager and Client as soon as practicable and documented in the report.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and CPR, as needed. ARCADIS personnel may sign manifests on a case-to-case basis for clients, provided the appropriate agreement is in place between ARCADIS and the client documenting that ARCADIS is not the generator, but is acting as authorized representative for the generator. ARCADIS personnel who sign hazardous waste manifests will have the current DOT hazardous materials transportation training according to 49 CFR § 172.704. ARCADIS field personnel will also comply with client-specific training such as LPS. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following materials, as required, shall be available for IDW handling and storage:

Appropriate personal protective equipment as specified in the Site Health and Safety Plan

- 55-gallon steel drums, DOT 1A2 or equivalent
- ¾ -inch socket wrench
- Hammer
- Leather gloves
- Drum dolly
- Appropriate drum labels (outdoor waterproof self adhesive)
- Polyethylene storage tank
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as specified in the *Chain-of-Custody* SOP and *Field Sampling Handling, Packing, and Shipping* SOP.
- Indelible ink and/or permanent marking pens
- Plastic sheeting

- Appropriate sample containers, labels, and forms
- Stainless-steel bucket auger
- Stainless steel spatula or knife
- Stainless steel hand spade
- Stainless steel scoop
- Digital camera
- Field logbook.

IV. Cautions

- Filled drums can be very heavy, always use appropriate moving techniques and equipment.
- Similar media will be stored in the same drums to aid in sample analysis and disposal.
- Drum lids must be secured to prevent rainwater from entering the drums.
- Drums containing solid material may not contain any free liquids.
- Waste containers stored for extended periods of time may be subject to deterioration. Drum over packs may be used as secondary containment.
- All drums must be in good condition to prevent potential leakage and facilitate subsequent disposal. Inspect the drums for dents and rust, and verify the drum has a secure lid prior to use.

V. Health and Safety Considerations

- Appropriate personal protective equipment must be worn by all field personnel within the designated work area.
- Air monitoring may be required during certain field activities as required in the Site Health and Safety Plan.

- If excavating in potentially hazardous areas is possible, contingency plans should be developed to address the potential for encountering gross contamination or non-aqueous phase liquids.

- ARCADIS field personnel will be familiar and compliant with Client-specific health and safety requirements such as Chevron's hand safety policy including the prohibition of fixed and/or folding blade knives.

VI. Procedure

Waste storage and handling procedures to be used depend upon the type of generated waste. For this reason, IDW should be stored in a secure location onsite in separate 55-gallon storage drums, solids can be stockpiled onsite (if non-hazardous), and purge water may be stored in polyethylene tanks. Waste materials such as broken sample bottles or equipment containers and wrappings will be stored in 55-gallon drums unless they were not in contact with sample media.

Management of IDW

Minimization of IDW should be considered by the Project Manager during all phases of the project. Site managers may want to consider techniques such as replacing solvent-based cleaners with aqueous-based cleaners for decontamination of equipment, reuse of equipment (where it can be decontaminated), limitation of traffic between exclusion and support zones, and drilling methods and sampling techniques that generate little waste. Alternative drilling and subsurface sampling methods may include the use of small diameter boreholes, as well as borehole testing methods such as a core penetrometer or direct push technique instead of coring (USEPA 1993).

Drum Storage

Drums containing hazardous waste shall be stored in accordance with the requirements of 40 CFR 265 Subpart I (for containers) and 265 Subpart DD (for containment buildings). All 55-gallon drums will be stored at a secure, centralized on-site location that is readily accessible for vehicular pick-up. Drums confirmed as, or believed to contain hazardous waste will be stored over an impervious surface provided with secondary containment. The storage location will, for drums containing liquid, have a containment system that can contain at least the larger of 10% of the aggregate volume of staged materials or 100% of the volume of the largest container. Drums will be closed during storage and be in good condition in accordance with the Guide to Management of Investigation-Derived Wastes (USEPA 1992).

Hazardous Waste Determination

Waste material must be characterized to determine if it meets any of the federal definitions of hazardous waste as required by 40 CFR § 262.11. If the waste does not meet any of the federal definitions, it must then be established if any state-specific hazardous waste criteria exist/apply.

Generator Status

Once hazardous waste determination has been made, the generator status will be determined. Large quantity generators (LQG) are generators who generate more than 1,000 kilograms of hazardous waste in a calendar month. Small quantity generators (SQG) of hazardous waste are generators who generate greater than 100 kilograms but less than 1,000 kilograms of hazardous waste in a calendar month. Conditionally exempt small quantity generators (CESQG) are generators who generate less than 100 kilograms of hazardous waste per month. Please note that a generator status may change from month to month and that a notice of this change is usually required by the generator's state agency.

Accumulation Time for Hazardous Waste

A LQG may accumulate hazardous waste on site for 90 days or less without a permit and without having interim status provided that such accumulation is in compliance with specifications in 40 CFR § 262.34. A SQG may accumulate hazardous waste on site for 180 days or less without a permit or without having interim status subject to the requirements of 40 CFR § 262.34(d). CESQG requirements are found in 40 CFR § 261.5. **NOTE**: The CESQG and SQG provisions of 40 CFR § 261.5, 262.20(e), 262.42(b) and 262.44 may not be recognized by some states (e.g. Rhode Island). **State-specific regulations must be reviewed and understood prior to the generation of hazardous waste.**

<u>Satellite Accumulation of Hazardous Waste</u>

Satellite accumulation (SAA) shall mean the accumulation of as much as fifty-five (55) gallons of hazardous waste, or the accumulation of as much as one quart of acutely hazardous waste, in containers at or near any point of generation where the waste initially accumulates, which is under the control of the operator of the process generating the waste, without a permit or interim status and without complying with the requirements of 40 CFR § 262.34(a) and without any storage time limit, provided that the generator complies with 40 CFR § 262.34(c)(1)(i).

Once more than 55 gallons of hazardous waste accumulates in SAA, the generator has three days to move this waste into storage.

Storage recommendations for hazardous waste include:

- Ignitable Hazardous wastes must be >50 feet from the property line per 40 CFR § 265.176 (LQG generators only).
- Hazardous waste must be stored on a concrete slab (asphalt is acceptable if there are no free liquids in the waste) per 40 CFR § 265.176.
- Drainage must be directed away from the accumulation area.
- Area must be properly vented.
- Area must be secure.

Drum/Container Labeling

Drums will be labeled on both the side and lid of the drum using a permanent marking pen. Old drum labels must be removed to the extent possible, descriptions crossed out should any information remain, and new labels affixed on top of the old labels. Other containers used to store various types of waste (polyethylene tanks, roll-off boxes, end-dump trailers, etc.) will be labeled with an appropriate "Waste Container" or “Testing in Progress” label pending characterization. Drums and containers will be labeled as follows:

- Appropriate waste characterization label (Testing in Progress, Hazardous, or Non-Hazardous)
- Waste generator's name (e.g., client name)
- Project name
- Name and telephone number of ARCADIS project manager
- Composition of contents (e.g., used oil, acetone 40%, toluene 60%)
- Media (e.g., solid, liquid)
- Accumulation start date

- Drum number of total drums as reconciled with the Drum Inventory maintained in the field log book.

IDW containers will remain closed except when adding or removing waste. Immediately upon beginning to place waste into the drum/container, a “Waste Container” or “Testing in Progress” label will be filled out to include the information specified above, and affixed to the container. Once the contents of the container are identified as either non-hazardous or hazardous, the following additional labels will be applied. Containers with waste determined to be non-hazardous will be labeled with a green and white "Non-Hazardous Waste" label over the "Waste Container" label. Containers with waste determined to be hazardous will be stored in an onsite storage area and will be labeled with the "Hazardous Waste" label and affixed over the "Waste Container" label. The ACCUMULATION DATE for the hazardous waste is the date the waste is first placed in the container and is the same date as the date on the "Waste Container" label. DOT hazardous class labels must be applied to all hazardous waste containers for shipment offsite to an approved disposal or recycling facility. In addition a DOT proper shipping name shall be included on the hazardous waste label. The transporter should be equipped with the appropriate DOT placards. However, placarding or offering placards to the initial transporter is the responsibility of the generator per 40 CFR § 262.33.

Inspections and Documentation

All IDW will be documented as generated on a Drum Inventory Log maintained in the field log book. The Drum Inventory will record the generation date, type, quantity, matrix and origin (e.g. Boring-1, Test Pit 3, etc) of materials in every drum, as well as a unique identification number for each drum. The drum inventory will be used during drum pickup to assist with labeling of drums. The drum storage area and any other areas of temporarily staged waste, such as soil/debris piles, will be inspected weekly. The weekly inspections will be recorded in the field notebook or on a Weekly Inspection Log. Digital photographs will be taken upon the initial generation and drumming/staging of waste, and final labeling after characterization to document compliance with labeling and storage protocols, and condition of the container. Evidence of damage, tampering or other discrepancy should be documented photographically.

Emergency Response and Notifications

Specific procedures for responding to site emergencies will be detailed in the HASP. If the generator is designated as a LQG, a Contingency Plan will need to be prepared to include emergency response and notification procedures per 40 CFR § 265 Subpart D. In the event of a fire, explosion, or other release which could threaten human health outside of the site or when Client or ARCADIS has knowledge of a spill that has reached surface water, Client or ARCADIS must immediately notify the National Response Center (800-424-8802) in accordance with 40 CFR § 262.34. Other notifications to state agencies may also be necessary.

Drilling Soil Cuttings and Muds

Soil cuttings are solid to semi-solid soils generated during trenching activities, subsurface soil sampling, or installation of monitoring wells. Depending on the drilling method, drilling fluids known as "muds" may be used to remove soil cuttings. Drilling fluids flushed from the borehole must be directed into a settling section of a mud pit. This allows reuse of the decanted fluids after removal of the settled sediments. Soil cuttings will be labeled and stored in 55-gallon drums with bolt-sealed lids.

Excavated Solids

Excavated solids may include, but are not limited to soil, fill and construction and demolition debris. Excavated solids may be temporarily stockpiled onsite as long as the material is a RCRA non-hazardous waste and the solids will be treated onsite pursuant to a certified, authorized, or permitted treatment method, or properly disposed off-site. Stockpiled materials characterized as hazardous must be immediately containerized and removed from the site within 90 days of generation (except for soils using satellite accumulation). Excavated solids should be stockpiled and maintained in a secure area onsite. At a minimum, the floor of the stockpile area will be covered with a 20-mil high density polyethylene liner that is supported by a foundation or at least a 60-mil high density polyethylene liner that is not supported by a foundation. The excavated material will not contain free liquids. The owner/operator will provide controls for windblown dispersion, run-on control, and precipitation runoff. The run-on control system will prevent flow onto the active portion of the pile during peak discharge from at least a 25-year storm and the run-off management system will collect and control at least the water volume resulting from a 24-hour, 25-year storm (EPA, 1992). Additionally, the stockpile area will be inspected on a weekly basis and after storm events. Individual states may require that the stockpile be inspected/certified by a licensed professional engineer. Stockpiled material will be covered with a 6-mil polyvinyl chloride (PVC) liner. The stockpile cover will be secured in place with appropriate material (concrete blocks, weights, etc.) to prevent the movement of the cover. Excavated solids may also be placed in roll off containers and covered with a 6-mil PVC liner pending results for waste characterization.

Decontamination Solutions

Decontamination solutions are generated during the decontamination of personal protective equipment and sampling equipment. Decontamination solutions may range from detergents, organic solvents and acids used to decontaminate small field sampling equipment to steam cleaning rinsate used to wash heavy field equipment. These solutions are to be labeled and stored in 55-gallon drums with bolt-sealed lids.

Disposable Equipment

Disposable equipment includes personal protective equipment (tyvek coveralls, gloves, booties and APR cartridges) and disposable sampling equipment such as trowels or disposable bailers. If the media sampled exhibits hazardous characteristics per results of waste characterization sampling, disposable equipment will also be disposed of as a hazardous waste. These materials will be stored onsite in labeled 55-gallon drums pending analytical results for waste characterization.

Purge Water

Purge water includes groundwater generated during well development, groundwater sampling, or aquifer testing. The volume of groundwater generated will dictate the appropriate storage procedure. Monitoring well development and groundwater sampling may generate three well volumes of groundwater or more. This volume will be stored in labeled 55-gallon drums. Aquifer tests may generate significantly greater volumes of groundwater depending on the well yield and the duration of the test. Therefore, large-volume portable polyethylene tanks will be considered for temporary storage pending groundwater-waste characterization.

Purged Water Storage Tank Decontamination and Removal

The following procedures will be used for inspection, cleaning, and offsite removal of storage tanks used for temporary storage of purge water. These procedures are intended to be used for rented portable tanks such as Baker Tanks or Rain for Rent containers. Storage tanks will be made of inert polyethylene materials.

The major steps for preparing a rented tank for return to a vendor include characterizing the purge water, disposing of the purge water, decontaminating the tank, final tank inspection, and mobilization. Decontamination and inspection procedures are describe in further detail below.

- Tank Cleaning: Most vendors require that tanks be free of any sediment and water before returning, a professional cleaning service may be required. Each specific vendor should be consulted concerning specific requirements for returning tanks.

- Tank Inspection: After emptying the tank, purged water storage tanks should be inspected for debris, chemical staining, and physical damage. The vendors require that tanks be returned in the original condition (i.e., free of sediment, staining and no physical damage).

VII. Waste Characterization Sampling and Shipping

Soil/Solids Characterization

Waste characterization will be conducted in accordance with waste hauler, waste handling facility, and state/federal requirements. In general, RCRA hazardous wastes are those solid wastes determined by a Toxicity Characteristic Leaching Procedure (TCLP) test or to contain levels of certain toxic metals, pesticides, or other organic chemicals above specific federally regulated thresholds. If the one or more of 40 toxic compounds listed in Table I of 40 CFR § 261.24 are detected in the sample at levels above the maximum unregulated concentrations, the waste must be characterized as a toxic hazardous waste. Wastes can also be considered “listed” hazardous waste depending on site-specific processes.

Composite soil samples will be collected at a frequency of one sample per 10 cubic yard basis for stockpiled soil or one per 55-gallon drum for containerized. A four point composite sample will be collected per 10 cubic yards of stockpiled material and for each drum. Sample and composite frequencies may be adjusted in accordance with the waste handling facility’s requirements. Waste characterization samples may be analyzed for the TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls, as well as corrosivity (pH), reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis.

Wastewater Characterization

Waste characterization will be conducted in accordance with the requirements of the waste hauler, waste handling facility, and state/federal governments. In general, purge water should be analyzed by methods appropriate for the known contaminants, if any, that have been historically detected in the monitoring wells. Samples will be collected and analyzed in accordance with the requirements of the waste disposal facility.

Wastewater characterization samples may be analyzed for TCLP VOCs, TCLP SVOCs, TCLP RCRA metals, and polychlorinated biphenyls, as well as corrosivity (pH), reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis.

Sample Handling and Shipping

All samples will be appropriately labeled, packed, and shipped, and the chain-of-custody will be filled out in accordance with the Chain-of-Custody SOP and Field Sampling Handling, Packing, and Shipping SOP and Hazardous Materials Packaging and Shipping SOP.

It should be noted that additional training is required for packaging and shipping of hazardous and/or dangerous materials. Please reference the following ARCADIS intranet team page for more information: http://team/sites/hazmat/default.aspx.

Preparing Waste Shipment Documentation (Hazardous and Non-Hazardous)

Waste profiles will be prepared by the ARCADIS PM and forwarded, along with laboratory analytical data to the Client PM for approval/signature. The Client PM will then return the profile to ARCADIS who will then forward to the waste removal contractor for preparation of a manifest. The manifest will be reviewed by ARCADIS prior to forwarding to the Client PM for approval. Upon approval of the manifest, the Client PM will return the original signed manifest directly to the waste contractor or to the ARCADIS PM for forwarding to the waste contractor.

Final drum labeling and pickup will be supervised by an ARCADIS representative who is experienced with waste labeling procedures. The ARCADIS representative will have a copy of the drum inventory maintained in the field book and will reconcile the drum inventory with the profile numbers on the labels and on the manifest. Different profile numbers will be generated for different matrices or materials in the drums. For example, the profile number for drill cuttings will be different than the profile number for purge water. **When there are multiple profiles it is critical that the proper label, with the profile number appropriate to a specific material be affixed to the proper drums.** A copy of the ARCADIS drum inventory will be provided to the waste transporter during drum pickup and to the facility receiving the waste.

At least two weeks in advance of the preferred shipment date, USEPA will be provided with the following information:

- Facility name(s)
- USEPA ID number

- City and state in which each potential receiving facility is located
- Type and quantity of waste(s) to be shipped
- When waste is to be shipped

No waste will be shipped off-site until contacted by USEPA.

VIII. Data Recording and Management

Waste characterization sample handling, packing, and shipping procedures will be documented in accordance with the *Quality Assurance Project Plan*, if one exists. Copies of the chains-of-custody forms will be maintained in the project file.

Following waste characterization, IDW containers will be re-labeled with the appropriate waste hazardous or non-hazardous waste labels and the client will initiate disposal at the appropriate waste disposal facility.

IX. Quality Assurance

The chain-of-custody and sample labels for waste characterization samples will be filled out in accordance with the *Quality Assurance Project Plan*.

X. References

United States Environmental Protection Agency. 1992. Guide to Management of Investigation-Derived Wastes. Office of Remedial and Emergency Response. Hazardous Site Control Division. January 1992.

United States Environmental Protection Agency. 1991. *Guide to Discharging CERCLA Aqueous Wastes to Publicly Owned Treatment Works (POTWs)*. Office of Remedial and Emergency Response. Hazardous Site Control Division 0S-220W. March 1991.

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Appendix B-1-22

Field Equipment Decontamination

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Field Equipment Decontamination

Rev. #: 3

Rev Date: April 26, 2010

Approval Signatures

Prepared by: ______________________ Date: 4/26/2010

Reviewed by: ______________________ Date: 4/26/2010

I. Scope and Application

Equipment decontamination is performed to ensure that sampling equipment that contacts a sample, or monitoring equipment that is brought into contact with environmental media to be sampled, is free from analytes of interest and/or constituents that would interfere with laboratory analysis for analytes of interest. Equipment must be cleaned prior to use for sampling or contact with environmental media to be sampled, and prior to shipment or storage. The effectiveness of the decontamination procedure should be verified by collecting and analyzing equipment blank samples.

The equipment cleaning procedures described herein includes pre-field, in the field, and post-field cleaning of sampling tools which will be conducted at an established equipment decontamination area (EDA) on site (as appropriate). Equipment that may require decontamination at a given site includes: soil sampling tools; groundwater, sediment, and surface-water sampling devices; water testing instruments; down-hole instruments; and other activity-specific sampling equipment. Non-disposable equipment will be cleaned before collecting each sample, between sampling events, and prior to leaving the site. Cleaning procedures for sampling equipment will be monitored by collecting equipment blank samples as specified in the applicable work plan or field sampling plan. Dedicated and/or disposable (not to be re-used) sampling equipment will not require decontamination.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, and site-specific training, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and possess the skills and experience necessary to successfully complete the desired fieldwork. The project HASP and other documents will identify any other training requirements such as site specific safety training or access control requirements.

III. Equipment List

- health and safety equipment, as required in the site Health and Safety Plan (HASP);
- distilled water;

- Non-phosphate detergent such as Alconox or, if sampling for phosphorus phosphorus-containing compounds, Luminox (or equivalent);
- tap water;
- rinsate collection plastic containers;
- DOT-approved waste shipping container(s), as specified in the work plan or field sampling plan (if decontamination waste is to be shipped for disposal);
- brushes;
- large heavy-duty garbage bags;
- spray bottles;
- (Optional) – Isopropyl alcohol (free of ketones) or methanol;
- Ziploc-type bags; and
- plastic sheeting.

IV. Cautions

Rinse equipment thoroughly and allow the equipment to dry before re-use or storage to prevent introducing solvent into sample medium. If manual drying of equipment is required, use clean lint-free material to wipe the equipment dry.

Store decontaminated equipment in a clean, dry environment. Do not store near combustion engine exhausts.

If equipment is damaged to the extent that decontamination is uncertain due to cracks or dents, the equipment should not be used and should be discarded or submitted for repair prior to use for sample collection.

A proper shipping determination will be performed by a DOT-trained individual for cleaning materials shipped by ARCADIS.

V. Health and Safety Considerations

Review the material safety data sheets (MSDS) for the cleaning materials used in decontamination. If solvent is used during decontamination, work in a well-ventilated area and stand upwind while applying solvent to equipment. Apply solvent in a manner that minimizes potential for exposure to workers. Follow health and safety procedures outlined in the HASP.

VI. Procedure

A designated area will be established to clean sampling equipment in the field prior to sample collection. Equipment cleaning areas will be set up within or adjacent to the specific work area, but not at a location exposed to combustion engine exhaust. Detergent solutions will be prepared in clean containers for use in equipment decontamination.

Cleaning Sampling Equipment

1. Wash the equipment/pump with potable water.

2. Wash with detergent solution (Alconox, Liquinox or equivalent) to remove all visible particulate matter and any residual oils or grease.

3. If equipment is very dirty, precleaning with a brush and tap water may be necessary.

4. (Optional) – Flush with isopropyl alcohol (free of ketones) or with methanol. This step is optional but should be considered when sampling in highly impacted media such as non-aqueous phase liquids or if equipment blanks from previous sampling events showed the potential for cross contamination of organics.

5. Rinse with distilled/deionized water.

Decontaminating Submersible Pumps

Submersible pumps may be used during well development, groundwater sampling, or other investigative activities. The pumps will be cleaned and flushed before and between uses. This cleaning process will consist of an external detergent solution wash and tap water rinse, a flush of detergent solution through the pump, followed by a flush of potable water through the pump. Flushing will be accomplished by using an appropriate container filled with detergent solution and another contained filled with potable water. The pump will run long enough to effectively flush the pump housing and hose (unless new, disposable hose is used). Caution should be exercised to avoid contact with the pump casing and water in the container while the pump is running (do not use metal drums or garbage cans) to avoid electric shock. Disconnect the pump from the power source before handling. The pump and hose should be placed on or in clean polyethylene sheeting to avoid contact with the ground surface.

VII. Waste Management

Equipment decontamination rinsate will be managed in conjunction with all other waste produced during the field sampling effort. Waste management procedures are outlined in the work plan or Waste Management Plan (WMP).

VIII. Data Recording and Management

Equipment cleaning and decontamination will be noted in the field notebook. Information will include the type of equipment cleaned, the decontamination location and any deviations from this SOP. Specific factors that should be noted include solvent used (if any), and source of water.

Any unusual field conditions should be noted if there is potential to impact the efficiency of the decontamination or subsequent sample collection.

An inventory of the solvents brought on site and used and removed from the site will be maintained in the files. Records will be maintained for any solvents used in decontamination, including lot number and expiration date.

Containers with decontamination fluids will be labeled.

IX. Quality Assurance

Equipment blanks should be collected to verify that the decontamination procedures are effective in minimizing potential for cross contamination. The equipment blank is prepared by pouring deionized water over the clean and dry tools and collecting the deionized water into appropriate sample containers. Equipment blanks should be analyzed for the same set of parameters that are performed on the field samples collected with the equipment that was cleaned. Equipment blanks are collected per equipment set, which represents all of the tools needed to collect a specific sample.

X. References

USEPA Region 9, Field Sampling Guidance #1230, Sampling Equipment Decontamination.

USEPA Region 1, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

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Appendix B-1-23

Heavy Equipment Decontamination

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Heavy Equipment Decontamination

Rev. #: 1

Rev Date: April 10, 2009

Approval Signatures

Prepared by: _________________ ________ Date: April 10, 2009

Reviewed by: _______________________________ Date: April 10, 2009

I. Scope and Application

This procedure applies to heavy equipment, such as drill rigs, well casings, and auger flights. These could contain potential sources of interference to environmental samples. The sampling equipment may have come in contact with the materials adjacent to the matrix being sampled or media may be attached to the actual sampling equipment. Heavy equipment may also retain contaminants from other sources such as roadways and storage areas, or material from previous job sites that were not adequately removed. For these reasons, it is important that the sampling equipment be cleaned prior to use.

Two methods are used for cleaning heavy equipment: steam-cleaning or pressure washing and manual scrubbing. Steam-cleaning or pressure washing can remove visible debris. Since steam-cleaners or pressure washers provide a high pressure medium, they are very effective for solids removal. They are also easy to handle and generate low volumes of wash solutions.

A second method involves manual scrubbing of equipment using brushes. This procedure can be as effective as steam-cleaning or pressure washing and is preferred in situations where steam-cleaning or pressure washing fails to remove visible materials. Disadvantages to manual scrubbing are that it is labor-intensive and generates large volumes of wash and rinse solutions.

Heavy equipment will be thoroughly steam-cleaned or pressure washed or manually scrubbed upon arrival on site and when moved between sampling locations as well as prior to removal from the site. Drill rig items (such as auger flights, drill rods, and drill bits) will be cleaned before changing sample locations.

II. Personnel Qualifications

Training shall be provided to all project personnel to ensure compliance with the site specific Health and Safety Plan (HASP) and technical competence to successfully complete the equipment cleaning procedures. Based on site requirements, personnel performing decontamination will complete the 40-hour health and safety training program where the project requires training and certification under Occupational Safety and Health Administration (OSHA), under Code of Federal Regulations (CFR) 1910.120. Each employee must successfully complete a minimum of 8 hours of refresher training annually to maintain the certification. Employee training records are maintained in the ARCADIS office where the employee resides. Any special requirements for personal possession of certification cards will be adhered to as project necessary.

The project HASP and other documents will identify any other training requirements such as site specific safety training or access control requirements.

III. Equipment List

The following equipment will be required for use during cleaning procedures:

- shop vacuum
- lint-free absorbent towels
- 6-mil polyethylene sheeting
- assorted scrub brushes
- waste disposal drums
- cleaning fluids, such as Knights Super Kleen, Simple Green, Aquanex MC, Zep Formula 50, Zep Big Orange, or equal
- aluminum duct tape
- oil/water absorbent Speedi-Dry compounds

IV. Cautions

Before a piece of equipment can be cleaned, it must be disconnected and disabled in accordance with standard Energy Control and Power Lock-Out Procedures. All energy sources, including stored energy, must be removed prior to cleaning.

Do not attempt to clean equipment that is in service or still connected to power.

Protective clothing is required during cleaning. The Cleaning Contractor shall have a written health and safety plan (HASP) appropriate for the expected operations, including measurements for determining the need for more stringent levels of protection. The minimum allowable protective clothing shall include:

- plastic face shields
- disposable Tyvek™ coveralls (Dupont/Saranex 23-P, or equal)
- impervious rubber boots (neoprene, viton, or equal)
- impervious gloves (neoprene, Viton, or equal)

Additional protective equipment may be required for some tasks. These contingencies are to be included in the HASP.

Do not use degreasers. Use non-phosphate soaps and steam or pressure washers to remove oil, grease, or hydraulic fluid.

V. Health and Safety Considerations

Do not attempt to clean equipment that is in service or still connected to power.

Review the material safety data sheets (MSDS) for the detergents and solvents to be used in the decontamination. If possible, avoid use of spray bottles to apply solvent on equipment to minimize potential for introducing vapors into breathing zone. Work in a well ventilated area and stand upwind while applying solvent to equipment during the decontamination process. Application of solvent to the equipment will be completed in a manner that minimizes potential for exposure to all workers.

Follow health and safety procedures outlined in the HASP.

VI. Procedure

Setup

1. Don appropriate personal protective equipment (PPE) as specified in the site HASP.

2. Provide proper signs and barricades for the cleaning area to control access.

3. Place the item to be cleaned on a cart inside one of the equipment decontamination area (EDA) washing areas or move large equipment into the decontamination zone.

Cleaning Procedures

1. Pre-clean the entire piece of equipment to remove all loose dust, dirt, and scale using a shop vacuum designed for solid material, supplemented by scraping, chipping, and detergent to remove encrusted materials (solvents or degreasers should not be used).

2. Apply the cleaning solution to each surface of the item via a mist, aerosol spray, or cloth soaked in the cleaning solution. Control the application so that little or none of the cleaning solution puddles in the EDA. Make sure that all surfaces are wetted. Use scrubbing brushes, if necessary, to loosen any visible dirt, stains, or grease and then wipe down all surfaces with clean

absorbent towels to clean and dry. For larger items, it may be appropriate to clean the equipment in sections.

3. Rinse the equipment with water in the EDA high-pressure (1,500 psi) washing area.

4. Repeat Steps 2 and 3. The item should be clean and dry. The equipment is ready to be re-used on site.

5. Completely cover the equipment with polyethylene sheeting and secure the sheeting.

6. Use the shop vacuum to remove all loose material from the plastic sheeting on the floor.

7. Update the equipment tag and log.

8. Before leaving the area where a piece of equipment has been cleaned, conduct a final check to make sure all discarded materials, including paper towels, plastic sheeting, and disposable gloves, have been picked up and placed in a properly labeled drum.

9. As employees leave the cleaning area, boots and gloves must be left behind. At the end of the day, all personal protective equipment must be cleaned and stored on site. No contaminated clothing or equipment will be permitted to leave the site.

VII. Waste Management

Equipment decontamination rinsate and associated materials will be managed in conjunction with all other waste produced during the field sampling effort. Waste management procedures are outlined in the Sampling and Analysis Plan (SAP).

VIII. Data Recording and Management

Equipment cleaning and decontamination will be noted in the field notebook. Information will include the type of equipment cleaned, the location and any deviations from this SOP. Deviations that should be noted include solvent used, source of water.

Any unusual field conditions should be noted if there is potential to impact the efficiency of the decontamination.

An inventory of the solvents brought on site and used and removed from the site will be maintained in the files.

Records should be maintained for solvents including lot number and expiration date.

Containers with decontamination fluids will be labeled.

IX. Quality Assurance

All liquid and solid materials, including spent detergents, rinse waters, disposable clothing, residues from scraping and vacuuming, paper towels, plastic, and any other wastes generated during cleaning procedures, are to be collected and stored in DOT-approved drums. All drums shall be properly marked, labeled, stored, and disposed in accordance with the procedures identified in the HASP.

X. References

USEPA Region 9, Field Sampling Guidance #1230, Sampling Equipment Decontamination

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Appendix B-2

Field Activity Forms

Appendix B-2 – Building Survey and Product Inventory Form

Directions: This form must be completed for each residence or area involved in indoor air testing.

Preparer's Name: ____________________________________

Date/Time Prepared: _________________________________

Preparer's Affiliation: ________________________________

Phone No.: ____

Purpose of Investigation: ____

1. OCCUPANT:

Interviewed: Y / N

Last Name: _________________________ First Name: _________________________

Address: ____

County: ___________________________________

Home Phone: _______________________ Office Phone: ________________________

Number of Occupants/Persons at this Location: _________________

Age of Occupants: ______________________

2. OWNER OR LANDLORD: (Check if Same as Occupant ___)

Interviewed: Y / N

Last Name: _________________________ First Name: _________________________

Address: ____

County: _________________________________

Home Phone: ____________________ Office Phone: ____________________

3. BUILDING CHARACTERISTICS:

Type of Building: (circle appropriate response)

Residential	School	Commercial/Multi-use
Industrial	Church	Other: _________________

If the Property is Residential, Type? (circle appropriate response)

Ranch		2-Family 3-Family
Raised Ranch	Split Level	Colonial
Cape Cod	Contemporary	Mobile Home
Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other:_______________

If Multiple Units, How Many? ___________

If the Property is Commercial, Type?

Business Type(s) _____________________________________

Does it include residences (i.e., multi-use)? Y / N If yes, how many? _________

Other Characteristics:

Number of Floors______ Building Age______

Is the Building Insulated? Y / N How Air-Tight? Tight / Average / Not Tight

4. AIRFLOW:

Use air current tubes or tracer smoke to evaluate airflow patterns and qualitatively describe:

Airflow Between Floors

____

____

____

Airflow Near Source

____

____

____

Outdoor Air Infiltration

____

____

____

Infiltration Into Air Ducts

____

____

____

5. BASEMENT AND CONSTRUCTION CHARACTERISTICS: (circle all that apply)

a.	**Above grade construction:**	wood frame	concrete	stone brick
b.	**Basement type:**	full	crawlspace	slab other ________
c.	**Basement floor:**	concrete	dirt	stone other ________
d.	**Basement floor:**	uncovered	covered	covered with ______________
e.	**Concrete floor:**	unsealed	sealed	sealed with ________________
f.	**Foundation walls:**	poured	block stone	other ____________________
g.	**Foundation walls:**	unsealed	sealed	sealed with ________________
h.	**The basement is:**	wet	damp	dry moldy
i.	**The basement is:**	finished	unfinished	partially finished

j. Sump present? Y / N

k. Water in sump? Y / N / NA

Basement/lowest level depth below grade: ________(feet)

Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains)

____

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? Y / N

6. HEATING, VENTILATING, AND AIR CONDITIONING: (circle all that apply)

Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation	Heat pump	Hot water baseboard
Space heaters	Stream radiation	Radiant floor
Electric baseboard	Wood stove	Outdoor wood boiler
Other __________		

The primary type of fuel used is:

Natural base	Fuel oil	Kerosene
Electric	Propane	Solar
Wood coal		

Domestic hot water tank fueled by: ______________________________

Boiler/furnace located in:	Basement	Outdoors	Main Floor	Other____________
Air conditioning:	Central Air	Window Units	Open Windows	None

Are there air distribution ducts present? Y / N

Describe the supply and cold air return ductwork, and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.

____

____

____

7. OCCUPANCY:

Is basement/lowest level occupied? Full-time Occasionally Seldom Almost Never

General Use of Each Floor (e.g., family room, bedroom, laundry, workshop, storage):

Basement ____

1st Floor ____

2nd Floor ____

3rd Floor ____

4th Floor ____

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY:

a. Is there an attached garage? Y / N

b. Does the garage have a separate heating unit? Y / N / NA

c. Are petroleum-powered machines or vehicles stored in the garage (e.g., lawnmower, ATV, car)?

Y / N / NA Please specify: ____

d. Has the building ever had a fire? Y / N When? ______________________________

e. Is a kerosene or unvented gas space heater present? Y / N Where? ___________________

f. Is there a workshop or hobby/craft area? Y / N Where & Type? _________________

g. Is there smoking in the building? Y / N How frequently? ____________________________

h. Have cleaning products been used recently? Y / N When & Type? __________________

i. Have cosmetic products been used recently? Y / N When & Type? __________________

j. Has painting/staining been done in the last 6 months? Y / N Where & When? ____________

k. **Is there new carpet, drapes or other textiles? Y / N Where & When?** ________________

l. Have air fresheners been used recently? Y / N When & Type? _______________________

m. Is there a kitchen exhaust fan? Y / N If yes, where __________________________

n. Is there a bathroom exhaust fan? Y / N If yes, where vented?________________________

o. Is there a clothes dryer? Y / N If yes, is it vented outside? Y / N

p. Has there been a pesticide application? Y / N When & Type?______________________

q. Are there odors in the building? Y / N

If yes, please describe: ____

Do any of the building occupants use solvents (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist) at work? Y / N

If yes, what types of solvents are used? ____

If yes, are their clothes washed at work? Y / N

Do any of the building occupants regularly use or work at a dry-cleaning service? (circle appropriate response)

Yes, use dry-cleaning regularly (weekly) No

Yes, use dry-cleaning infrequently (monthly or less) Unknown

Yes, work at a dry-cleaning service

Is there a radon mitigation system for the building/structure? Y / N

Date of Installation: ______________________

Is the system active or passive? Active/Passive

Are there any Outside Contaminant Sources? (circle appropriate responses)

Contaminated site with 1000-foot radius? Y / N Specify ________________________________

Other stationary sources nearby (e.g., gas stations, emission stacks, etc.): ___________________

____

Heavy vehicle traffic nearby (or other mobile sources): __________________________________

9. WATER AND SEWAGE:

Water Supply:	Public Water	Drilled Well	Driven Well	Dug Well	Other: _______
Sewage Disposal:	Public Sewer	Septic Tank	Leach Field	Dry Well	Other: _______

10. RELOCATION INFORMATION: (for oil spill residential emergency)

a. Provide reasons why relocation is recommended: ________________________________

____

b. Residents choose to: remain in home relocate to friends/family relocate to hotel/motel

c. Responsibility for costs associated with reimbursement explained? Y / N

d. Relocation package provided and explained to residents? Y / N

11. FLOOR PLANS:

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note.

Basement:

First Floor:

12. OUTDOOR PLOT:

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s), and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.

13. PRODUCT INVENTORY FORM:

Make and Model of field instrument used: ____
List specific products found in the residence or area that have the potential to affect indoor air quality (e.g., gasoline or kerosene storage cans, glues, paints, cleaning solvents/products, polishes/waxes, new furniture/ carpet, nail polish/hairspray/cologne).

Location	Product Description	Size (units)	Condition*	Chemical Ingredients	Field Instrument Reading (units)	Photo** Y/N

14. SAMPLING INFORMATION:

Sample Technician: ____________________________ Phone number: ( ) _______ - __________

Sample Source: Indoor Air / Sub-Slab / Near Slab Soil Gas / Exterior Soil Gas

Sampler Type: Tedlar Bag / Sorbent / Stainless Steel Canister / Other (specify): _________________

Analytical Method: TO-15 / TO-17 / Other: _________ Cert. Laboratory: _________________

Sample Locations (floor, room):

Field ID # _____ - ________________________ Field ID # _____ - __________________________

Field ID # _____ - ________________________ Field ID # _____ - __________________________

If distributed to occupants prior to sampling event, were the state-specific “Instructions for Occupants” followed? Yes / No

If not, describe modifications: ____

15. METEOROLOGICAL CONDITIONS:

Was there significant precipitation within 12 hours prior to (or during) the sampling event? Yes / No

Describe the general weather conditions: ____

____

16. GENERAL OBSERVATIONS:

Provide any information that may be pertinent to the sampling event and may assist in the data interpretation process.

____

____

____

____

Appendix B-2

ARCADIS Infrastructure, environment, facilities	**Indoor/Ambient Air Sample Collection Log**	
	Sample ID:	

Client:		**Outdoor/Indoor:**	
Project:		**Sample Intake Height:**	
Location:		**Miscellaneous Equipment:**	
Project #:		**Time On/Off:**	
Samplers:		**Subcontractor:**	

Instrument Readings:

Time	Canister Pressure (inches of HG)	Temperature (F or C)	Relative Humidity (%)	Air Speed (ft/min)	Pressure Differential (inches of H20)	PID (ppm or ppb)

SUMMA Canister Information:

Size (circle one): 1 L 6 L

Canister ID:

Flow Controller ID: ____________________

General Observations/Notes:

Please record current weather information including wind speed and direction, ambient temperature, barometric pressure, and relative humidity via suitable information source (e.g., weatherunderground.com).

WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)________________________________
Well Number__________________Date_________________________
Field Personnel____
Sampling Organization____
Identify MP____

Depth to _______/________ of screen
(below MP) top bottom
Pump Intake at (ft. below MP)__________
Purging Device; (pump type)__________
Total Volume Purged ______________

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Turb-idity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	± 10 mv	10%	10%	

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25°C.
3. Oxidation reduction potential (ORP)

WELL INTEGRITY ASSESSMENT FORM

Site Name:________________________________
Well I.D.:________________________________
Date: ____________________________________

(For each item, circle the appropriate response or fill in the blank)

Well I.D. Clearly Marked: YES NO
Well Completion: FLUSH MOUNT ABOVE-GRADE STANDPIPE
Lockable Cover: YES NO DAMAGED *(Describe below)*
Lock Present: YES NO ADDED Key Brand/Number:______________________________
Measuring Point Marked: YES NO ADDED
Well Riser Diameter (inches): ____________________
Well Riser Type: PVC Stainless Steel Other *(Describe)* _____________________

Surface Condition

Cement Intact: YES NO *(Describe below)*
Curb Box/Well Cover Present: YES NO DAMAGED *(Describe below)*
All Bolts Present: YES NO *(Describe below)* NOT APPLICABLE
Ground Surface Slopes
Away from Well YES NO *(Describe below)*

Well Condition

Well Cap: PVC Slip Cap Pressure-fit Cap None
Well Vent: Slot Cut in Riser Vent Hole in Cap None Not Applicable *(Flush Mount Well)*
Reported Well Riser Stickup (feet): _____________*(use negative number if below grade)*
Measured Well Riser Stickup (feet): _____________ *(use negative number if below grade)*

Depth to Water (feet from Top of Well Riser): _________________ -*or*- DRY

Reported Total Depth of Well (feet below grade): _________________
Measured Total Depth of Well (feet below grade): _________________
Well Obstructed: YES NO If yes, list depth in feet from Top of Well Riser: _____________________
Well Bottom: SOFT *(contains sediment)* FIRM *(no sediment)*

Recommendations

Repair Concrete/Surface Completion: YES NO If yes, list date performed:______________________
Re-Survey Well: YES NO If yes, list date performed:______________________
Remove Sediment, Redevelop & Re-Measure Depth: YES NO If yes, list date performed:______________________
Replace Well Cap: YES NO If yes, list date performed:______________________
Replace Bolts: YES NO If yes, list date performed:_______________
Replace Lock: YES NO If yes, list date performed:______________________
Other/Miscellaneous Observations:

____
____

Inspector(s):____

WELL INTEGRITY ASSESSMENT FORM

Photograph of Well:

Date of Photograph: ______________________________

Additional Comments:

ARCADIS
Infrastructure, environment, facilities

ID#:

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ___ of ___

Lab Work Order #

Send Results to:

Contact & Company Name:	Telephone:
Address:	Fax:
City / State / Zip	E-mail Address:
Project Name/Location (City, State):	Project #:
Sampler's Printed Name:	Sampler's Signature:

Preservative							
Filtered (✓)							
# of Containers							
Container Information							

PARAMETER ANALYSIS & METHOD

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: ________
G. Other: ________
H. Other: ________

Container Information Key:
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: ________
10. Other: ________

Matrix Key:
SO - Soil, W - Water, T - Tissue, SE - Sediment, SL - Sludge, A - Air, NL - NAPL/Oil, SW - Sample Wipe, Other: _______

Sample ID	Collection Date	Collection Time	Type (✓) Comp	Type (✓) Grab	Matrix								REMARKS

Special Instructions/Comments:

☐ **Special QA/QC Instructions(✓):**

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Lab Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name:
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt:	Firm:	Firm/Courier:	Firm/Courier:	Firm:
Shipping Tracking #:	Condition/Cooler Temp: _________	Date/Time:	Date/Time:	Date/Time:	Date/Time:

Distribution: WHITE – Laboratory returns with results YELLOW – Lab copy PINK – Retained by ARCADIS

ARCADIS

Appendix B-2
HydraSleeve™ Field Form

Site: ______________________________

Location: ______________________________

Well ID: ______________________________

Well Type: • Monitoring • Other: ______________________________

Well Finish: • Stick Up • Flush Mount

Measuring Pt: • Top of Casing • Other (specify):____________________

Total Depth As Constructed (ftbgs): ____________ **Screened Interval (ftbgs):**____________________

Well Casing: Diameter: ____________ Material: ____________________

Well Screen: Diameter: ____________

Deployment

Date and Time of Deployment: Date: ____________ Time: ____________

Weather Conditions: ______________________________

Depth to groundwater at time of deployment: ______________________________

Total well depth at time of deployment: ______________________________

Dimensions of HydraSleeve™: Length (in.) ____________ Diameter (in.) ____________

Deployment Method/Position of Weight:

• Top-Down: Weight attached to bottom of HydraSleeve™. Weight suspended in well.

• Top-Down: Weight attached to top of HydraSleeve™. Weight suspended in well.

Deployment Depth (Top of HydraSleeve™) (ftbgs): ______________________________

Retrieval

Date and Time of Retrieval: Date: ____________ Time: ____________

Total # of days deployed: ______________________________

Weather Conditions: ______________________________

Depth to groundwater at time of retrieval: ______________________________

Total well depth at time of retrieval: ______________________________

Downhole Field Parameters Upon Retrieval:

Temp:__________ **(^{o}C)** **ORP:**____________ **(mV)** **Water quality meter:**__________________

pH:_____________ **DO:**____________ **(mg/L)** **Serial #:**____________________________

Notes/Observations:

Field Sampling Technician: Name(s) and Company

Name Company

____

____

ARCADIS
Infrastructure, environment, facilities

Sub-Slab Sample Collection Log

		Sample ID:	
Client:		**Boring Equipment:**	
Project:		**Sealant:**	
Location:		**Tubing information:**	
Project #:		**Miscellaneous Equipment:**	
Samplers:		**Subcontractor:**	
Sample Point Location:		**Moisture Content of Sampling Zone (circle one):**	Dry / Moist
Sampling Depth:		**Approximate Purge Volume and Method:**	
Time of Collection:			

Instrument Readings:

Time	Canister Pressure (inches of HG)	Temperature (F or C)	Relative Humidity (%)	Air Speed (ft/min)	Pressure Differential (inches of H20)	PID (ppm or ppb)

SUMMA Canister Information:

Size (circle one): **1 L** **6 L**

Canister ID:

Flow Controller ID: ______________

General Observations/Notes:

Approximating One-Well Volume (for purging): When using 1¼-inch "Dummy Point" and a 6-inch sampling interval, sampling space will have a volume of approximately 150 mL. Each foot of ¼-inch tubing will have a volume of approximately 10 mL.

Please record current weather information including wind speed and direction, ambient temperature, barometric pressure and relative humidity via a suitable information source (e.g., weatherunderground.com).