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SAMPLING AND ANALYSIS PLAN AMENDMENT FOR AREA OF CONCERN A (AOC A) FLUVIAL DEPOSITS GROUNDWATER DRAFT FINAL MILLINGTON SUPPACT TN
9/1/2014
RESOLUTION CONSULTANTS

DRAFT FINAL
SAMPLING AND ANALYSIS PLAN AMENDMENT

AREA OF CONCERN A — FLUVIAL DEPOSITS GROUNDWATER (SWMU 15)
NAVAL SUPPORT ACTIVITY MID-SOUTH
MILLINGTON, TENNESSEE

Version Number: 0

Prepared For:

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Contract Number: N62470-11-D-8013
CTO JM17

September 2014

SAP WORKSHEET #1: TITLE AND APPROVAL PAGE

(UFP-QAPP Manual Section 2.1)

SAMPLING AND ANALYSIS PLAN AMENDMENT

AREA OF CONCERN A — FLUVIAL DEPOSITS GROUNDWATER (SWMU 15)
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Ben Brantley, Resolution Consultants
Task Order Manager/Date

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EXECUTIVE SUMMARY

A soil removal conducted in 2003 by Solutions to Environmental Problems (STEP) resulted in the removal of 57,000 tons of petroleum contaminated soil from the former N-94 Underground Tank Farm, where nine fuel tanks and one oil tank, all 25,000 gallon in size, had been removed. Despite the soil removal, consistently elevated benzene concentrations have been detected in the upper fluvial deposits groundwater during the Area of Concern (AOC) A groundwater monitoring. The AOC A Sampling and Analysis Plan (Resolution Consultants, 2012) contained an investigative component using direct push technology (DPT) to assess possible upgradient sources to the groundwater. Additional subsequent groundwater investigations conducted in 2014 indicate the benzene is originating from the east, where several remaining structures associated with or related to the former fuel farm, still reside (i.e., oil water separator, truck loading station, old fuel lines, etc.). This Sampling and Analysis Plan (SAP) amendment outlines an investigative approach to evaluate soil from the possible source areas through use of a DPT technology and field screening methods — the objective being to identify grossly contaminated soil that may be acting as a petroleum soil source to groundwater. A subset of soil samples will be retained for analytical purposes to corroborate field data and determine whether supplemental investigative or remedial measures may be later warranted.

This amendment to the AOC A *Sampling and Analysis Plan* (SAP; Resolution Consultants, 2012) outlines the soil screening and sampling approach that will be implemented. Table E-1 lists the original worksheets and those that have been modified per this SAP Amendment, which includes the following:

Worksheet #10	Conceptual Site Model
Worksheet #11	Data Quality Objectives/Systematic Planning Process
Worksheet #12	Field Quality Control Samples
Worksheet #15	Reference Limits and Evaluation Table
Worksheet #17	Sampling Design and Rational
Worksheet #34	Verification (Step I) Process Table
Worksheet #35	Validation (Steps IIa and IIb) Process
Worksheet #36	Validation (Steps IIa and IIb) Summary Table
Worksheet #37	Usability Assessment

Table E-1 UFP SAP Amendment Crosswalk			
UFP SAP Worksheet #	**Required Information**	**Changes Provided (Yes/No)**	**Crosswalk to Related Information**
A. Project Management and Objectives			
Documentation			
1	Title and Approval Page	No	Included in Appendix A
ES	Executive Summary	**Yes**	**Added worksheet provides an overview of supplemental sampling.**
TOC	Table of Contents	Yes	Table of Contents for SAP Amendment
2	SAP Identifying Information	No	Included in Appendix A
3	Distribution List	No	Included in Appendix A
4	Project Personnel Sign-Off Sheet	No	Included in Appendix A
Project Organization			
5	Project Organizational Chart	No	Included in Appendix A
6	Communication Pathways	No	Included in Appendix A
7	Personnel Responsibilities Table	No	Included in Appendix A
8	Special Personnel Training Requirements Table	No	Included in Appendix A
Project Planning/Problem Definition			
9	Project Scoping Session Participants Sheet	No	Included in Appendix A
10	Conceptual Site Model	**Yes**	**Added worksheet specific to SWMU 15 with benzene conceptual model and proposed soil-sampling locations.**
11	Project Quality Objectives/Systematic Planning Process Statements	**Yes**	**Criteria to be used in the field for step-outs and added borings.**
12	Field Quality Control Samples	**Yes**	**The only QC samples that will be collected are trip blanks — one per cooler.**
13	Secondary Data Criteria and Limitations Table	No	Included in Appendix A
14	Field Project Tasks	No	Included in Appendix A
15	Reference Limits and Evaluation Tables	**Yes**	**Added soil screening levels**
16	Project Schedule/Timeline Table	No	Included in Appendix A
B. Measurement/Data Acquisition			
Sampling Tasks			
17	Sampling Design and Rationale	**Yes**	**Proposed soil/boring locations and rationale for placement**
18	Location-Specific Sampling Methods/SOP Requirements Table	No	Included in Appendix A
19	Field Sampling Requirements Table	No	Included in Appendix A
20	Field quality control (QC) Sample Summary Table	No	Included in Appendix A
21	Project Sampling SOP References Table	**Yes**	**Includes added SOPs not in the original SAP**
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	No	Included in Appendix A

Table E-1 UFP SAP Amendment Crosswalk			
UFP SAP Worksheet #	**Required Information**	**Changes Provided (Yes/No)**	**Crosswalk to Related Information**
Analytical Tasks			
23	Analytical SOP References Table	No	Included in Appendix A
24	Analytical Instrument Calibration Table	No	Included in Appendix A
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	No	Included in Appendix A
Sample Collection			
26	Sample Handling System	No	Included in Appendix A
27	Sample Custody Requirements	No	Included in Appendix A
Quality Control Samples			
28	Laboratory QC Samples Table	No	Included in Appendix A Worksheet indicates the matrix is groundwater but the laboratory QC sample requirements are the same for soil.
Data Management Tasks			
29	Project Documents and Records Table	No	Included in Appendix A
30	Analytical Services Table	No	Included in Appendix A
C. Assessment Oversight			
31	Planned Project Assessments Table	No	Included in Appendix A
32	Assessment Findings and Corrective Action Responses Table	No	Included in Appendix A
33	Quality assurance (QA) Management Reports Table	No	Included in Appendix A
D. Data Review			
34	Verification (Step I) Process Table	**Yes**	**Data validation will not be performed since data is for screening purposes only.**
35	Validation (Steps IIa and IIb) Process Table	**Yes**	
36	Validation (Steps IIa and IIb) Summary Table	**Yes**	
37	Usability Assessment	**Yes**	

Notes:

UFP = Uniform Federal Policy for Quality Assurance Project Plans
SAP = Sampling and Analysis Plan
SOP = Standard operating procedure
QC = Quality Control

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SAP WORKSHEET #11: DATA QUALITY OBJECTIVES/SYSTEMATIC PLANNING PROCESS ... WS 11-1

SAP WORKSHEET #15: REFERENCE LIMITS AND EVALUATION TABLE ..... WS 15-1

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Figure 17-1 Proposed Soil Sampling Locations 17-3

Tables

Table E-1 UFP SAP Amendment Crosswalk ii

Appendices

Appendix A Sampling and Analysis Plan, Area of Concern A — Fluvial Deposits Groundwater (Resolution Consultants 2012)
Appendix B Standard Operating Procedures

Acronyms and Abbreviations

AOC	Area of Concern
DL	Detection limit
DPT	Direct push technology
EPH	Extractable petroleum hydrocarbons
FID	Flame Ionization Detector
GRO	Gasoline range organics
LOD	Limit of detection
LOQ	Limit of quantitation
LUC	Land use control
µg/L	Micrograms per liter
MCL	Maximum contaminant level
mg/kg	Milligrams per kilogram
PAH	Polynuclear aromatic hydrocarbon
ppm	Parts per million
QC	Quality Control
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
STEP	Solutions to Environmental Problems
SWMU	Solid Waste Management Unit
TDEC	Tennessee Department of Environment and Conservation
TNEPH	Tennessee extractable petroleum hydrocarbon
TPH	Total petroleum hydrocarbon
UFP	Uniform Federal Policy
UST	Underground storage tank

SAP WORKSHEET #10: CONCEPTUAL SITE MODEL

(UFP-QAPP Manual Section 2.5.2)

Figure 10-1 illustrates the current benzene conceptual model which is based on a combination of DPT data and monitoring well data. The contamination is present within the upper section of the fluvial deposits aquifer, a confined aquifer, the top of which ranges in depths between 28 and 43 feet (all upper fluvial monitoring wells screen the uppermost 10 feet of the aquifer). The footprint of the former removal action (STEP, 2004) is outlined in yellow, as a result, soil within the area 40,000 square-foot-area can be considered clean, as it contains compacted soil fill (discussed further below). The groundwater generally flows in a west-southwest based on the July 2014 measurements. Historically, it has also flowed in a northwest direction. Given the orientation of the benzene plume and the groundwater flow direction, the structures identified to the east and northeast of the benzene plume have been identified as possible source areas for the benzene noted on the figure.

Background/Site History

Solid Waste Management Unit (SWMU 15) consisted of ten 25,000-gallon underground storage tanks (USTs) previously located in a single tank-hold near Building N-94. The USTs were used to store aviation fuel and lubricating oil supplying the nearby flight line and a truck loading station east of the site. The USTs were removed in early 1992, but the excavation was backfilled and no soil removal activities were conducted. A subsequent Resource Conservation and Recovery Act Facility Investigation (EnSafe, 1999) indicated petroleum levels in soil and groundwater above the Tennessee Department of Environment and Conservation UST Division's site-specific standard (1,000 milligrams per kilogram (mg/kg) total petroleum hydrocarbon (TPH) and 100 mg/kg soil cleanup standard), resulting in the 2003 removal of approximately 57,000 tons of petroleum-contaminated soil from the former tank hold. Clean closure was obtained in all samples minus the southwest corner of the excavation where 1,500 mg/kg extractable petroleum hydrocarbons (EPH) and 1,200 mg/kg gasoline range organics (GRO) were identified, respectively (benzene was not detected in the soil samples). Subsequent long-term monitoring of well 015G01UF indicated elevated benzene levels, triggering a DPT investigation, two phases of well drilling (adding 13 wells) and a soil gas investigation. While the results of the soil gas study were inconclusive, the distribution of benzene overlain with the groundwater flow direction map points to an eastward, upgradient source area where several structures remain that may be harboring a petroleum source to the groundwater.

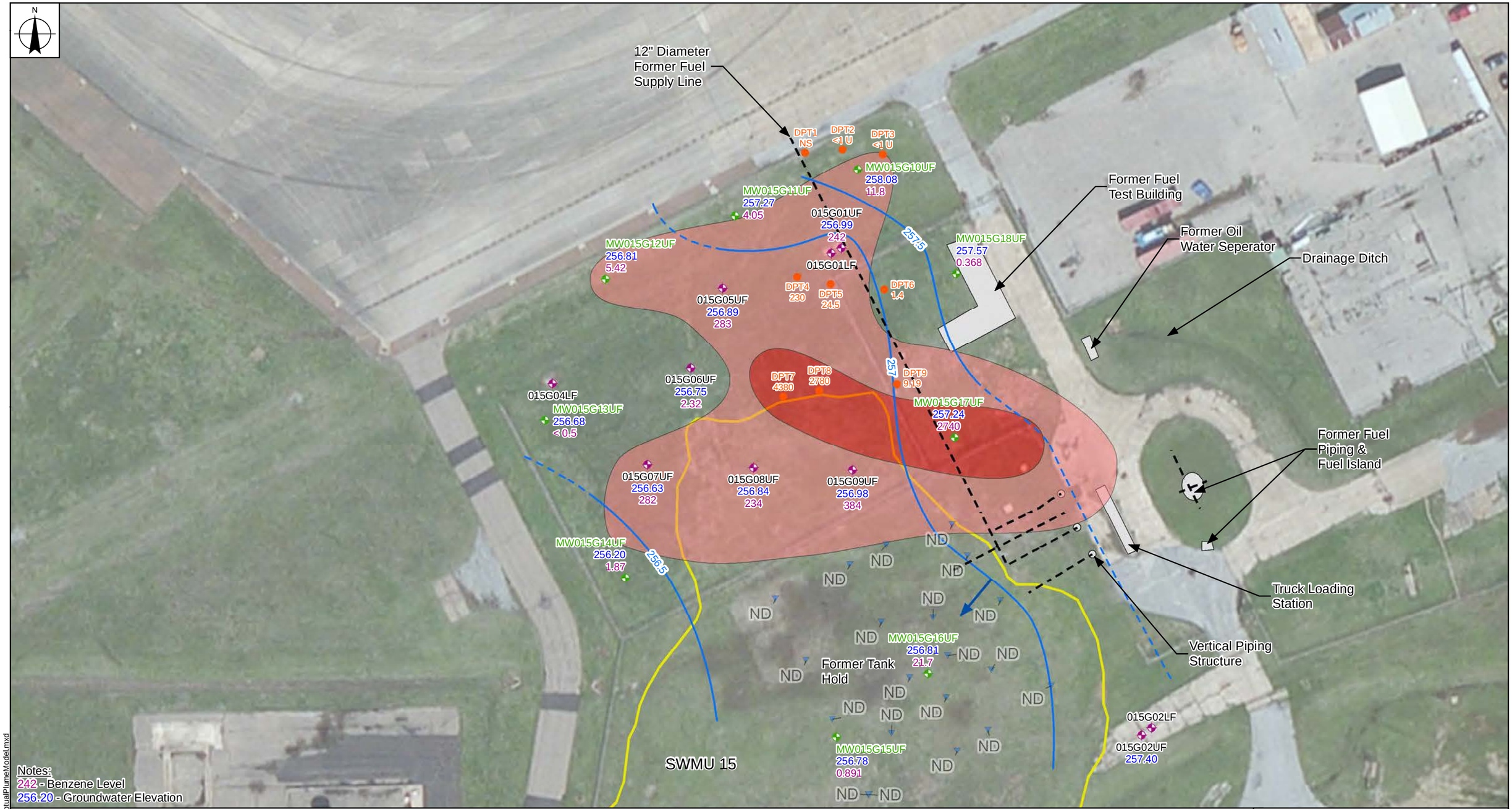
Hydrogeology

The impacted aquifer is overlain by a layer of loess — windblown deposits of clay and silt which ranges between 25 and 45 feet thick. Because of its relatively low permeability, the loess serves as an upper confining unit to the fluvial deposits aquifer. The contaminants reside in the uppermost section of the fluvial aquifer with 45 feet being the average well depth of the existing SWMU 15 wells. The impacted aquifer is not used as a potable water source since municipal supplies are available in the area. A land use control (LUC) prohibiting residential development and groundwater use of the fluvial deposits aquifer are maintained for AOC A and County ordinances prohibit its usage for potable water since municipal water supplies are available. Hence, a human health exposure pathway does not exist for the contaminants; however, it requires the maintenance and enforcement of LUCs until the groundwater maximum contaminant levels (MCLs) are met for the contaminants in the groundwater.

Proposed Investigation

The potential source areas shown on Figure 10-1 will be evaluated for petroleum impacted soils (discussed in detail in Worksheet #17). Use of DPT methods and field screening will be used to assess the areas with a subset of samples retained for laboratory analyses. The areas that will be assessed include the following:

- The former truck loading station east of the former removal area/tank hold.
- The vertical piping structures west of the fuel island.
- The former vehicle fuel island (inside the grass oval)
- The former fuel test building
- The former oil water separator (1620) and adjacent drainage ditch.
- The former northwest trending 12-inch fuel supply line.



Notes:
242 - Benzene Level
256.20 - Groundwater Elevation

- Monitoring Wells
- Newly Constructed Wells (06/12/2014)
- DPT Groundwater Sample (Oct./Nov. 2012)
- RFI DPT Fluvial Groundwater Sampling Point
- Approximate Location of Former Pipe Line
- Potentiometric Surface Contour - June 2014 (ft)
- Groundwater Flow Direction
- Approximate Structure Location
- Benzene Concentration Plume (µg/L) >5 ppb
- Benzene Concentration Plume (µg/L) >1,000 ppb
- Former SWMU 15 Removal Area

1 inch = 60 feet

0 60 120 Feet

FIGURE 10-1
BENZENE CONCECPTUAL
PLUME MODEL
NSA MID-SOUTH
MILLINGTON, TENNESSEE

NAVFAC Naval Facilities Engineering Command
RESOLUTION CONSULTANTS

REQUESTED BY: B. BRANTLEY	DATE: 7/16/2014
DRAWN BY: B. LIPSCOMB	TASK ORDER NUMBER: JM50

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SAP WORKSHEET #11: DATA QUALITY OBJECTIVES/SYSTEMATIC PLANNING PROCESS

(UFP-QAPP Manual Section 2.6.1)

11.1 Problem Statement

As noted on Figure 10-1, benzene in groundwater is above the 5 micrograms per liter (µg/L) MCL and extends over a broad area of the site, roughly measuring 200 feet by 200 feet. The core of the benzene plume ranges from 2,740 µg/L to 4,380 µg/L and it is partly located outside the former removal area footprint, suggesting an alternate source area outside the former tank hold may be responsible for the contamination.

11.2 Identify the Goals of the Study

The goal of this study is to find the petroleum soil source(s) that may be contributing to the benzene detected in groundwater. Several former structures and/or piping have been identified hydraulically upgradient of the groundwater benzene plume. Soil from beneath these areas will be assessed with the goal being not to identify the nature and extent of petroleum contamination but rather identify whether grossly contaminated soils that may exist beneath the areas (with "grossly" meaning a combination of indicators, including obvious staining, petroleum odors, and Flame Ionization Detector [FID] detections > 10 parts per million [ppm]). A subset of samples will be retained and submitted to the laboratory to corroborate field interpretations and quantify the petroleum contaminants of concern — using petroleum benchmarks from the Tennessee Department of Environment and Conservation (TDEC) Division of USTs (outlined in Worksheet #15), for later evaluation of possible remedial actions or further investigation.

11.3 Inputs to Problem Resolution

To resolve the problem statements above, the following information is needed:

1. Visually inspect and screen soil samples beneath the possible source areas identified in Figure 10-1 for petroleum hydrocarbons from the ground surface to a depth of 20 feet. Screening consists of noting any petroleum odors and evaluating the total organic vapor concentrations using a FID. Appendix B outlines how to use the FID to screen for organic vapors.

2. One soil sample will be retained from soil borings exhibiting signs of petroleum contamination. The soil sample exhibiting the most elevated FID detection will be submitted to the laboratory for the following analyses: benzene, ethyl benzene, toluene, total xylenes, methyl tertiary butyl ether, naphthalene and EPH.

11.4 Define the Study Boundaries

Spatial Boundaries: The SWMU 15 boundary (Figure 10-1) is defined by the N-94 former fuel farm and the ancillary structures and piping surrounding east and northeast of it. Shallow soil in the uppermost 20 feet beneath the remaining structures and piping is the media of interest. Soil impacts associated with the former USTs holds were addressed in the 2003 removal action.

11.5 Analytical Approach

A combination of a field screening and laboratory analyses will be used to evaluate whether petroleum impacted soils reside beneath the remaining fuel farm structures and piping. The following decision rules will be used for the proposed sampling:

Decision Rule #1: Assessing Potential Source Areas

Soil beneath the suspected source areas shown on Figure 10-1 will be field screened to determine if grossly contaminated soil exists beneath the areas. Field screening will consist of a combination of inspection of soils for staining, odors, and/or FID detections. If FID readings are greater than 10 ppm and noted staining/petroleum odors are present, then the soil will be considered impacted. Soil samples will be retained from intervals exhibiting the most impacts for laboratory analysis and comparison to the site screening levels listed in Worksheet 15 and for possible further action (i.e., interim measures and/or site assessment).

Decision Rule #2: Soil Investigation — Vertical Delineation

If visual/olfactory evidence or FID detections indicate petroleum impacted soils extend beyond 20 feet in depth, the soil boring will be advanced and continuous sampling will continue until indications of petroleum impactions are absent or until groundwater is encountered, whichever occurs first.

Decision Rule #3: Soil Investigation — Horizontal Delineation

If there is evidence of petroleum impacts, step out borings will be placed by field personnel in the direction and distance deemed appropriate. Step out distances of 10 to 20 feet are anticipated if an initial boring contains significant contamination.

11.6 Performance Criteria

Please refer to Section 11.6 of the AOC A *Sampling and Analysis Plan* on Appendix A.

11.7 Optimize the Design for Obtaining Data

Please refer to Section 11.6 of the AOC A *Sampling and Analysis Plan* on Appendix A.

SAP WORKSHEET #15: REFERENCE LIMITS AND EVALUATION TABLE

(UFP-QAPP Manual Section 2.8.1)

Reference Limits and Evaluation Table							
Matrix:	Soil						
Analytical Group:	Volatile Organic Compounds, Extractable petroleum hydrocarbons						
Analyte	**CAS**	**Analytical Method**	**TNDEC UST Screening Levels for Commercial Use [a] (mg/kg)**	**Project Quantitation Limit Goal (mg/kg)**	**Laboratory Specific Limits**		
					LOQ (mg/kg)	**LOD (mg/kg)**	**DL (mg/kg)**
Benzene	71-43-2	8260B	3.8	1.3	0.005	0.0025	0.00125
Ethylbenzene	100-41-4	8260B	1,310	437	0.005	0.0025	0.00125
Methyl-tert-butyl-ether	1634-04-4	8260B	364	121	0.005	0.0025	0.00125
Toluene	108-88-3	8260B	62	21	0.005	0.0025	0.00125
Xylene (Total)	1330-20-7	8260B	88	29	0.015	0.0075	0.00375
Naphthalene	91-20-3	8260B	403	135	0.005	0.0025	0.00125
Extractable Petroleum Hydrocarbons		TNEPH	500	167	13.3	6.67	6.67

Notes:

[a] = From Table 5 — Initial Screening Levels; TDEC Division of UST — UST System Closure Assessment Guidelines (September, 2006).
TDEC = Tennessee Department of Environment and Conservation
UST = Underground Storage Tank
LOQ = Limit of quantitation
LOD = Limit of detection
DL = Detection limit
mg/kg = Milligrams per kilogram
TNEPH = Tennessee Extractable petroleum hydrocarbons method

SAP WORKSHEET #17: SAMPLING DESIGN AND RATIONALE

(UFP-QAPP Manual Section 3.1.1)

17.1 General Sampling Design and Rationale

The conceptual model suggests a benzene source area in the hydraulic upgradient direction of the plume. A total of 20 exploratory soil borings are proposed to assess the various structures in the SWMU 15. Proposed sampling locations are shown on Figure 17-1 and the selection of the areas is based on a either historical fuel handling practices (fuel test building) and possible disposal practices (oil water separator), spills (truck loading and fuel dispenser island), and possible piping leaks. The decision to expand beyond the initial 22 borings will be based per the decision criteria in Section 11. Specifically, the soil borings and screening will be placed in the following areas:

- Truck Loading Station — eight borings will be placed encircling the former truck area. Given the high volume of fuel handling, leaking piping structures, spills and overfilling deems this area as suspect.

- Fuel Dispenser Island — three boring will be placed in the grass oval where a piping structure and vehicle fuel dispenser were formerly located. The same reasons mentioned above make this area a suspected possible source for petroleum contaminated soils.

- Fuel Lines — three soil borings will be placed west of the truck loading station where abandoned, 3- or 4-inch diameter fuel lines enter/exit the ground. Four additional soil borings will be placed northwest of the truck loading station, near where a 12-inch fuel main supplied fuel pits along the tarmac.

- Former Oil Water Separator — one soil boring is proposed will be placed at the former oil water separator and one soil boring is proposed in the drainage ditch adjacent to it.

- Fuel Test Building — Two soil borings will be placed beneath the former fuel test building to evaluate whether past disposal practices of tested fuel impacted the soil there.

Field personnel will have supplies to collect 30 soil samples for laboratory analyses; however, only soil borings containing evident petroleum contamination will be sampled, as such, the soil interval containing the highest FID reading will be retained for analyses. The sample collection and processing protocols outlined in Appendix B (SOPs) of this amendment will be adhered to during

all field activities. Protocols for calibrating and screening soil with an FID are also included in Appendix B. Empirical Laboratories, LLC, which holds current Department of Defense Environmental Laboratory Accreditation Program certification, will provide the analyses of the collected samples. Upon receipt and validation of the proposed data, it will be compared to the site screening levels to determine whether additional actions (i.e., site assessment, interim measures) are warranted.

Proposed Soil Boring to 20' in Depth
Monitoring Wells
Newly Constructed Wells (06/12/2014)
DPT Groundwater Sample (Oct./Nov. 2012)
RFI DPT Fluvial Groundwater Sampling Point
Approximate Location of Former Pipe Line
Potentiometric Surface Contour - June 2014 (ft)

Groundwater Flow Direction
Approximate Structure Location
Benzene Concentration Plume (µg/L) >5 ppb
Benzene Concentration Plume (µg/L) >1,000 ppb
Former SWMU 15 Removal Area

1 inch = 60 feet

0 60 120 Feet

FIGURE 17-1
PROPOSED SOIL
BORING LOCATIONS
NSA MID-SOUTH
MILLINGTON, TENNESSEE

NAVFAC Naval Facilities Engineering Command
RESOLUTION CONSULTANTS

REQUESTED BY: B. BRANTLEY	DATE: 7/16/2014
DRAWN BY: B. LIPSCOMB	TASK ORDER NUMBER: JM50

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SAP WORKSHEET #21: PROJECT SAMPLING SOP REFERENCES TABLE

(UFP-QAPP Manual Section 3.1.2)

Added Field SOPs Reference Table					
SOP Reference Number	**Title/Author**	**Revision Date or Version Number**	**Location of SOP**	**Any planned deviation for Project Work**	**Comments**
SOP-3-19	Headspace Screening for Total VOCs	Revision 0; May 2012	Appendix B	No	Charcoal filter will be used to obtain non-methane VOC reading with a Flame Ionization Detector
SOP-3-21	Surface and Subsurface Soil Sampling Procedures	Revision 0; May 2012	Appendix B	No	

Notes:
Additional standard operating procedures may be found in Area of Concern A Sampling and Analysis Plan located in Appendix A.
SOP = Standard operating procedure
VOC = Volatile organic compound

Appendix A

AOC A LTM Sampling and Analysis — NSA Mid-South **(Resolution Consultants 2012)**

DRAFT-FINAL
SAMPLING AND ANALYSIS PLAN
Tier II

AREA OF CONCERN A — FLUVIAL DEPOSITS GROUNDWATER
NAVAL SUPPORT ACTIVITY MID-SOUTH
MILLINGTON, TENNESSEE

Version Number: 0

Prepared For:

Department of the Navy
Naval Facilities Engineering Command, Southeast
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Contract Number: N62470-11-D-8013
CTO JM02

September 2012

SAP WORKSHEET #1: TITLE AND APPROVAL PAGE

(UFP-QAPP Manual Section 2.1)

SAMPLING AND ANALYSIS PLAN
TIER II

AREA OF CONCERN A — FLUVIAL DEPOSITS GROUNDWATER
NAVAL SUPPORT ACTIVITY MID-SOUTH
MILLINGTON, TENNESSEE

Version Number: 0

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Tina Cantwell, Resolution Consultant
Project Chemist/QA Officer September 11, 2012

Ben Brantley, Resolution Consultant
Task Order Manager September 11, 2012

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Kenneth Bowers, NAVFAC Atlantic
Quality Assurance Officer/Chemist September 11, 2012

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Stacin Martin, NACFAC Atlantic
Remedial Project Manager September 11, 2012

EXECUTIVE SUMMARY

This Sampling and Analysis Plan (SAP) constitutes the planning document for the continued groundwater monitoring and supplemental interim measures at Area of Concern (AOC) A at Naval Support Activity Mid-South in Millington, Tennessee (Appendix A — Figure 1). Specifically, this SAP outlines the data quality objectives associated with the long term groundwater monitoring and the remedy optimization components as specified in the *Supplemental Interim Measures Work Plan* (EnSafe, 2012).

This SAP has been prepared by Resolution Consultants on behalf of the United States Navy, Naval Facilities Engineering Command (NAVFAC) Southeast Division, Comprehensive Long-term Environmental Action Navy Contract N62470-11-D-8013, Contract Task Order JM02 in accordance with the Navy's Uniform Federal Policy SAP policy guidance. An abbreviated Tier II SAP has been prepared since the majority of remaining work is associated with corrective measures and only a minor investigative component.

AOC A was designated after the 1990 Resource Conservation and Recovery Act Facility Investigation of Solid Waste Management Unit (SWMU) 7 (Building N-126 dry well), which found a broad area of trichloroethylene (TCE) contamination extending into the airfield apron and operations area, independent of the original SWMU. Since TCE could not be tied to a specific SWMU and it overlapped with multiple neighboring SWMUs, all the fluvial deposits groundwater on the Northside, both SWMU and non-SWMU areas, was consolidated under AOC A to expedite corrective measures.

TCE in groundwater is the primary contaminant of concern with lesser concentrations of tetrachloroethylene, cis-1,2-dichloroethylene, vinyl chloride, carbon tetrachloride, and benzene. The impacts reside in the fluvial deposits aquifer — a sand and gravel unit that was once a potable water-source before municipal supplies were introduced to the area. The aquifer is confined, and lies below a surficial clay/silt layer of loess that varies between 25 and 40 feet in thickness. The base of the fluvial deposits aquifer, where most of the contamination resides, ranges in depths from 75 and 95 feet below land surface. The site risk is ingestion of groundwater; however, water use is restricted by a land use control prohibiting potable water use. Local county ordinances also prohibit construction of potable water-wells in the aquifer since the area is served by municipal water supplies.

Interim corrective measures consisting of enhanced bioremediation were implemented in 2004 for Sub-Plumes A, B, C, and D, while monitored natural attenuation monitoring was selected for other SWMU and non-SWMU areas where lesser volatile organic compound concentrations were present.

The enhanced bioremediation at Sub-Plumes A-D consisted of injecting a mixture of sodium acetate and ammonium phosphate in areas hydraulically upgradient of the TCE hot spots, and the conversion of the aquifer from aerobic to anaerobic, facilitating the reductive dechlorination of TCE. The carbon substrate injections were suspended in October 2009 and the remedy transitioned to monitored natural attenuation as a result of significant mass reduction in the source areas. Subsequent semi-annual and annual groundwater monitoring through November 2010 indicated no contaminant rebound in the year after suspending injections. Before fully transitioning to monitored natural attenuation monitoring only, supplemental corrective measures were requested by the Tennessee Department of Environment and Conservation (TDEC) Division of Solid Waste Management (TDEC-DSWM) and agreed to by the Base Cleanup Team, which consists of the TDEC-DSWM and representatives from NAVFAC Atlantic, NAVFAC Southeast, Naval Support Activity Mid-South, U.S. Geological Survey, and Resolution Consultants. Supplemental interim corrective measures were agreed to for the following areas:

(1) residual TCE hot spots remaining in Sub-Plumes A and D

(2) along the base perimeter where TCE has migrated off the property

(3) SWMU 15 (the former tank farm) where benzene concentrations persist despite the soil removal actions

A *Supplemental Interim Measures Work Plan* (EnSafe, 2012*)* submitted to the TDEC-DSWM proposing a remedial and investigative approach to address the above concerns was approved on May 11, 2012. This SAP outlines the data collection needs, field-sampling protocols, and analytical methods for implementing the work plan and ensuring that the long-term data quality objectives are met for the project.

All figures referenced in the SAP are included in Appendix A. Standard operating procedures for all field procedures and data collecting are provided in Appendix B. Field forms to be used for this project are provided in Appendix C.

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Appendix B Standard Operating Procedures

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Acronyms and Abbreviations

AOC	Area of Concern
BOD	Biochemical Oxygen Demand
BCT	Base Cleanup Team
bgs	Below Ground Surface
BRAC	Base Realignment and Closure Program
C	Celsius
CCV	Continuing Calibration Verification
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Contaminant of Concern
COD	Chemical Oxygen Demand
CSM	Conceptual Site Model
CT	Cycle Threshold
CTO	Contract Task Order
DL	Detection Limit
DoD	Department of Defense
DO	Dissolved Oxygen
DBCM	Deputy Base Closure Manager
DNA	Deoxyribonucleic acid
DNAPL	Dense Non-Aqueous Phase Liquids
DO	Dissolved Oxygen
DPT	Direct Push Technology
DQO	Data Quality Objective
DSWM	Division of Solid Waste Management
ELAP	Environmental Laboratory Accreditation Program
ft	Feet
FTL	Field Team Leader
GC	Gas Chromatograph
GC/FID	Gas Chromatography/Flame Ionization Detector
GC/MS	Gas Chromatograph/Mass Spectrometer
GFAA	Graphite Furnace Atomic Absorption
H&S	Health and Safety
HCL	Hydrochloric Acid
IC	Ion Chromatography
ICAL	Initial Calibration
ICP-AES	Inductively Coupled Plasma-Atomic Emission Spectrometry
ID	Identification
IDW	Investigative Derived Waste
IM	Interim Measures

Lab PM	Laboratory Project Manager
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOD	Limit of Detection
LOQ	Limit of Quantification
LUC	Land Use Controls
LTM	Long Term Monitoring
MCL	Maximum Contaminant Level
MNA	Monitored Natural Attenuation
MSA	Method of Standard Addition
MS/MSD	Matrix Spike/Matrix Spike Duplicate
µg/L	Micrograms per Liter
mg/L	Milligrams per Liter
mL	Milliliter
mV	Millivolt
ORP	Oxidation-Reduction Potential
N	Nitrogen
NA	Not Applicable
NAVFAC	Naval Facilities Engineering Command
NAVFAC LANT	Naval Facilities Engineering Command Atlantic Division
NIRIS	Naval Installation Restoration Information Solution
NSA	Naval Support Activity
%	Percent
%D	Percent Difference
%R	Percent Recovery
PAL	Project Action Level
PE	Professional Engineer
PM	Project Manager
POC	Point of Contact
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
qPCR	Quantitative real time polymerase chain reaction
QSM	Quality Systems Manual
RC	Resolution Consultants Inc.
RCRA	Resource Conservation and Recovery Act
RPD	Relative Percent Difference
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SCHD	Shelby County Health Department
SOP	Standard Operating Procedure
SWAP	Safe Work Assessment Permit
SWMU	Solid Waste Management Unit

TDB	To Be Determined
TCA	1,1,1-Trichlorethane
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TDEC	Tennessee Department of Environment and Conservation
TN GRO	Tennessee Gasoline Range Organics
TN EPH	Tennessee Extractable Petroleum Hydrocarbons
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
UFP	Uniform Federal Policy
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
VC	Vinyl Chloride
VOC	Volatile Organic Compounds

SAP WORKSHEET #2: SAMPLING AND ANALYSIS PLAN IDENTIFYING INFORMATION

(UFP-QAPP Manual Section 2.2.4)

Site Name/Number: Area of Concern (AOC) A — Fluvial Deposits Groundwater; Long Term Monitoring and Remedy Optimization

Operable Unit: Not Applicable (N/A)

Contractor Name: Resolution Consultants

Contract Number: N62470-11-D-8013

Contract Title: Comprehensive Long-term Environmental Action (CLEAN)

Work Assignment Number: Contract Task Order (CTO) JM02

1. **This sampling and analysis plan (SAP) was prepared in accordance with the requirements of:**
   - *Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP)* (EPA 2005)
   - United States (U.S.) Environmental Protection Agency (EPA) *Guidance for Quality Assurance Project Plans, EPA QA/G-5* (EPA 2002).
   - *Guidance on Systematic Planning Using the Data Quality Objective Process* (USEPA, 2006).

2. **Identify regulatory program:**
   Resource Conservation and Recovery Act (RCRA)

3. **This Sampling and Analysis Plan (SAP) is a <u>project specific</u> SAP.**

4. **List dates of scoping sessions that were held:**

Scoping Session	Date
Base Cleanup Team Meeting; Millington, Tennessee	March 23-24, 2011
Navy and TDEC-DSWM Meeting; Millington, Tennessee	May 3, 2012

5. List organizational partners (stakeholders) and connection with lead organizations:

Regulatory Stakeholder (Lead) — Tennessee Department of Environment and Conservation Division of Solid Waste Management (TDEC DSWM)

Regulatory Stakeholder (Local) — Shelby County Health Department (SCHD)

Lead Organization — Naval Facilities Engineering Command Atlantic Division (NAVFAC LANT)

Support to Lead Organization — Base Realignment and Closure Program Management Office Southeast (BRAC PMO-SE)

Site Owner — Naval Support Activity (NSA) Mid-South

6. Lead Agency: Department of Navy

7. If any required SAP elements and required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below:

Since this is an abbreviated Tier II SAP, the following worksheets have been omitted: #s 7, 8, 13, 24, 25, 26, 27, 29, 31, 32, 33, and 37. Though these specific worksheets have been omitted, the Tier I worksheet elements have been addressed either within other worksheets or the USP-SAP crosswalk format, found in Table 1.

Table 1
UFP Tier II SAP Crosswalk

UFP SAP Worksheet #	Required Information	Crosswalk to Related Information
A. Project Management and Objectives		
Documentation		
1	Title and Approval Page	Title and Approval Page
2	SAP Identifying Information	SAP Worksheet 2
3	Distribution List	SAP Worksheet 3
4	Project Personnel Sign-Off Sheet	Worksheet not provided; field personnel will be required to review SAP prior to activities. Empirical Laboratory will provide an email acknowledgement of receipt.

Table 1 UFP Tier II SAP Crosswalk		
UFP SAP Worksheet #	**Required Information**	**Crosswalk to Related Information**
Project Organization		
5	Project Organizational Chart	SAP Worksheet 5
6	Communication Pathways	SAP Worksheet 6
7	Personnel Responsibilities Table	SAP Worksheet 7
8	Special Personnel Training Requirements Table	Worksheet not provided; no specialized or non-route training is anticipated. Field personnel will adhere to the project standard operating procedures (SOPs).
Project Planning/Problem Definition		
9	Project Scoping Session Participants Sheet	SAP Worksheet 9
10	Conceptual Site Model	SAP Worksheet 10
11	Project Quality Objectives/Systematic Planning Process Statements	SAP Worksheet 11
12	Field Quality Control Samples	SAP Worksheet 12
13	Secondary Data Criteria and Limitations Table	Worksheet not provided; the only secondary criteria anticipated are historical results which will be compared to new LTM data to assess post-closure conditions.
14	Summary of Project Tasks	SAP Worksheet 14
15	Reference Limits and Evaluation Tables	SAP Worksheet 15
16	Project Schedule/Timeline Table	SAP Worksheet 16
B. Measurement/Data Acquisition		
Sampling Tasks		
17	Sampling Design and Rationale	SAP Worksheet 17
18	Location-Specific Sampling Methods/SOP Requirements Table	Combined SAP Worksheets 18, 19, 20, and 30
19	Field Sampling Requirements Table	Combined SAP Worksheets 18, 19, 20, and 30
20	Field quality control (QC) Sample Summary Table	Combined SAP Worksheets 18, 19, 20, and 30
21	Project Sampling SOP References Table	SAP Worksheet 21
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	Worksheet not provided; field SOPs will be followed.
Analytical Tasks		
23	Analytical SOP References Table	SAP Worksheet 23
24	Analytical Instrument Calibration Table	Worksheet not provided; laboratory will follow the procedures specified in the *Department of Defense Quality Systems Manual*, Version 4.2 (and subsequent versions) and their SOPs.
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	Worksheet not provided; laboratory will follow the procedures specified in the *Department of Defense Quality Systems Manual*, Version 4.2 (and subsequent versions) and their SOPs.

Table 1
UFP Tier II SAP Crosswalk

UFP SAP Worksheet #	Required Information	Crosswalk to Related Information
Sample Collection		
26	Sample Handling System	Worksheet not provided; Resolution Consultants personnel will be responsible for sample collection and shipment and Empirical Laboratory will be responsible for sample receipt and analysis, sample archiving, and disposal.
27	Sample Custody Requirements	Worksheet not provided; sample identification will follow the existing long-term monitoring scheme. Custody procedures may be found in field Resolution Consultants SOP 3-03 *Sample Labeling and Chain of Custody Procedures*, provided in Appendix B.
Quality Control Samples		
28	Laboratory QC Samples Table	SAP Worksheet 28
Data Management Tasks		
29	Project Documents and Records Table	Worksheet not provided; all final documents and records will be uploaded to the Naval Installation Restoration Information Solution database.
30	Analytical Services Table	Combined SAP Worksheets 18, 19, 20, and 30
C. Assessment Oversight		
31	Planned Project Assessments Table	Worksheet not provided; external laboratory systems audits will be conducted every two years by the Department of Defense Environmental Laboratory Accreditation Program.
32	Assessment Findings and Corrective Action Responses Table	Worksheet not provided; Empirical Laboratory will be responsible for addressing external laboratory systems audits.
33	QA Management Reports Table	Worksheet not provided; project QA manager and field personnel will notify the project manager when significant plan deviations result from unanticipated circumstances.
D. Data Review		
34-36	Data Verification and Validation (Steps I and IIa/IIb) Process Table	Combined SAP Worksheets 34, 35, and 36

Notes:
UFP = Uniform Federal Policy
SAP = sample and analysis plan
QA = quality assurance
QC = quality control
LTM = long term monitoring
SOP = standard operating procedure

SAP WORKSHEET #3: DISTRIBUTION LIST

(UFP-QAPP Manual Section 2.3.2)

Distribution List				
SAP Recipients	**Title**	**Organization**	**Telephone Number**	**E-mail Address or Mailing Address**
Stacin Martin	Naval Remedial Project Manager (RPM)	NAVFAC Atlantic	(757) 322-4780	stacin.martin@navy.mil
David Criswell	BRAC Environmental Coordinator/RPM	BRAC PMO-SE	(843) 743-2130	david.criswell@navy.mil
Jim Heide	Head of Public Works/Env.	NSA Mid-South	(901) 874-5367	jim.heide@navy.mil
Roger Donovan	RPM	TDEC DSWM	(615) 532-0864	roger.donovan@tn.gov
Charlie Burroughs	Program Head	TDEC DSWM	(615) 532-0863	charles.burroughs@tn.gov
Jack Carmichael	Technical Specialist	U.S. Geological Survey (USGS)	(615) 837-4704	jkcarmic@usgs.gov
Mark Thomas	Shelby County Health Department	Manager	(901) 544-7391	mark.thomas@shelbycountytn.gov
Lori Goetz	Project Engineer (PE)	Resolution Consultants	(901) 372-7962	lgoetz@ensafe.com
Tina Cantwell	Project Chemist/Data Manager/Quality Assurance Officer (QAO)	Resolution Consultants	(901) 372-7962	tcantwell@ensafe.com
Corey Coleman	Field Team Leader (FTL)	Resolution Consultants	(901) 372-7962	ccoleman@ensafe.com
Ryan Rylands	Lab Project Manager	Microseeps/Lab PM	(412) 826-5245	rrylands@microseeps.com
Sonya Gordon	Lab Project Manager	Empirical Laboratory/Lab PM	(615) 345-1115	sgordon@empirlabs.com
Ben Brantley	Task Order Manager (TOM)	Resolution Consultants	(901) 372-7962	bbrantley@ensafe.com

SAP WORKSHEET #4: PROJECT PERSONNEL SIGN-OFF SHEET

(UFP-QAPP Manual Section 2.3.2)

Project Personnel Sign-Off Sheet

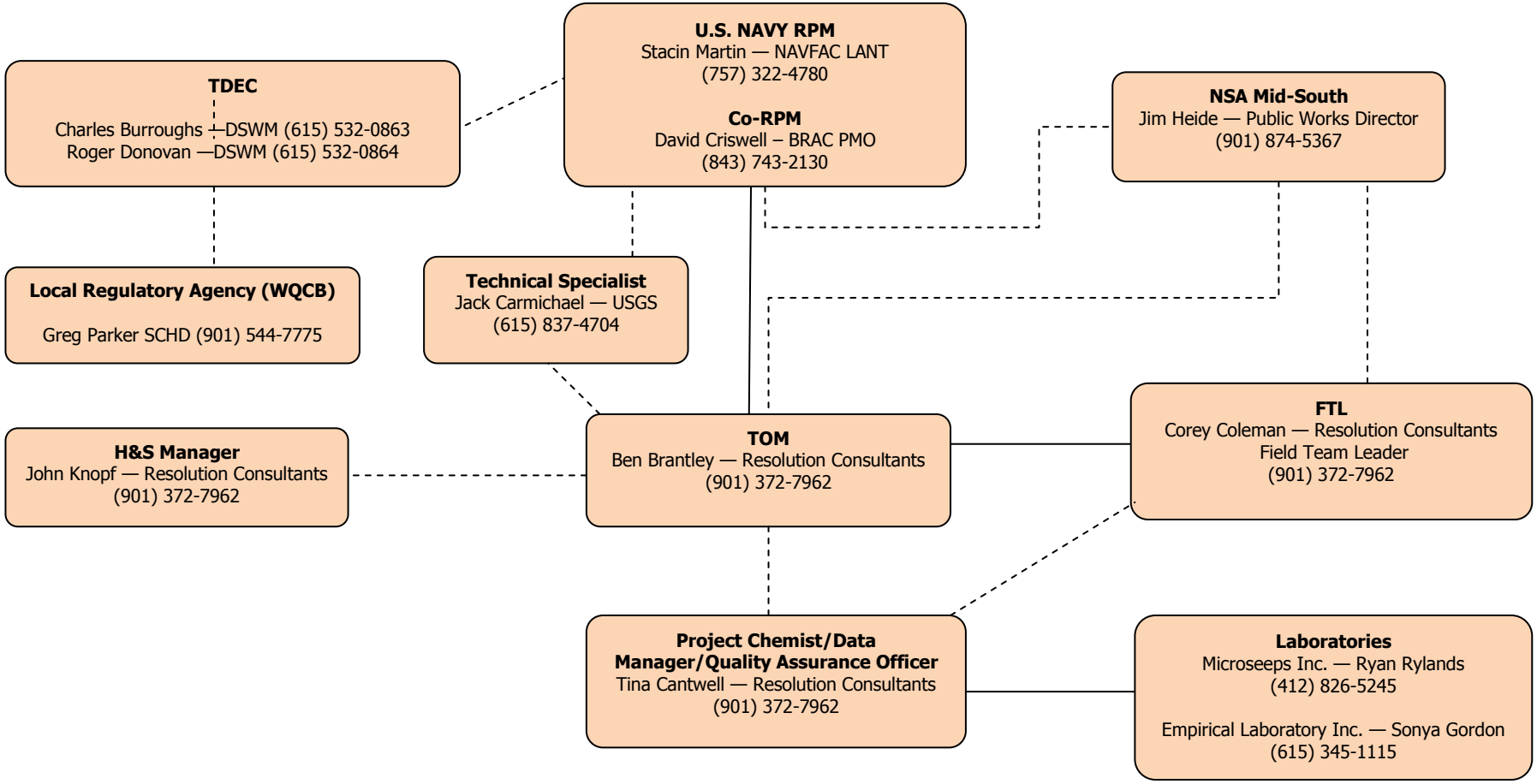
Name	Organization/Title/Role	Telephone Number	Signature/email receipt	SAP Section Reviewed	Date SAP Read
Navy and Regulator Project Team Personnel					
Stacin Martin	NAVFAC Atlantic/RPM	(757) 322-4780	See Signature Page of SAP	All	
David Criswell	BRAC PMO-SE/RPM	(843) 743-2130		All	10/9/12
Roger Donovan	TDEC DSWM/RPM	(615) 532-0864		All	10/9/12
Charlie Burroughs	TDEC DSWM/Division Head	(615) 532-0863			10/9/12
Resolution Consultants Project Team Personnel					
Lori Goetz	Resolution Consultants/PE	(901) 372-7962			10/24/12
Tina Cantwell	Resolution Consultants/ Chemist/Data Manager/Validator	(901) 372-7962	Tina Cantwell	All	10/24/12
Corey Coleman	RC/FTL	(901) 372-7962	Corey Coleman	All	10/26/12
Ben Brantley	RC/TOM	(901) 372-7962	Ben Brantley	All	10/1/12
Subcontractor Personnel					
Ryan Rylands	Microseeps/Lab PM	(412) 826-5245	Ryan Rylands	yes	10/31/12
Sonya Gordon	Empirical Laboratory/Lab PM	(615) 345-1115		WS#5,6,12,14,15,17-20,23,28,30	10/08/2012
Kate Freeman	EnSafe, Inc	(901)372-7962	K Freeman	All	10/24/2012

Note:
Persons listed on this worksheet will be responsible for distributing the SAP to the appropriate people within their organization.

SAP WORKSHEET #5: PROJECT ORGANIZATIONAL CHART

(UFP-QAPP Manual Section 2.4.1)

Lines of Authority ———— Lines of Communication - - - - - - - -



SAP WORKSHEET #6: COMMUNICATION PATHWAYS

(UFP-QAPP Manual Section 2.4.2)

The communication pathways for the SAP are shown below.

Communication Pathways				
Communication Drivers	**Responsible Entity**	**Name**	**Phone Number and/or email**	**Procedure (Timing, Pathway To/From, etc.)**
Communication with Navy	Navy RPM	Stacin Martin	stacin.martin@navy.mil (757) 322-4780	Primary point of contact (POC) for Navy; can delegate communication to other internal or external points of contact. RPM, or designee, will notify TDEC via email or telephone call within 24 hours of field changes that have a significant effect upon the scope. Navy is assumed to require 30 days for review of all draft reports before submitting to regulatory agencies.
Communication with TDEC	TDEC DSWM RPM	Roger Donovan	roger.donovan@tn.gov (615) 532-0864	Primary POC for TDEC; can delegate communication to other internal or external points of contact. Upon notification of field changes, TDEC will have 24 hours to approve or comment on the proposed changes. Correspondence sent directly by Resolution Consultants with Navy authorization. TDEC is assumed to require 30 days for review of all correspondence.
Communication with Navy	Co-RPM	David Criswell	david.criswell@navy.mil (843) 743-2130	Provides support to the Navy RPM and the primary POC for Navy for offsite access issues, land use controls (LUCs), and technical support to Navy RPM.
Communication with USGS	Technical Specialist	Jack Carmichael	jkcarmic@usgs.gov (615) 837-4704	Primary POC for USGS; provides technical Navy support and reviews Resolution Consultants correspondence before submitting to regulatory agencies. Works directly with Resolution Consultants PM and Navy RPM, as needed. Active participant in base cleanup team (BCT) meetings.
Communication with NSA Mid-South	Head of Public Works	Jim Heide	jim.heide@navy.mil (901) 874-5367	Primary POC for NSA Mid-South; provides support for all field efforts including utility location, water access, equipment storage, assistance with investigative derived waste (IDW) handling and disposal; interfaces directly with local SCHD water quality control board; hosts annual BCT meetings; is copied on all correspondence to the Navy and TDEC DSWM. One week notification to be provided by Resolution Consultants before initiating any field activities.

Communication Pathways				
Communication Drivers	**Responsible Entity**	**Name**	**Phone Number and/or email**	**Procedure (Timing, Pathway To/From, etc.)**
Communication with RC	Resolution Consultants TOM	Ben Brantley	bbrantley@ensafe.com (901) 372-7962	Primary POC for Resolution Consultants; responsible for interfacing directly with Navy and regulatory agencies, procuring subcontractors, meeting field work and deliverable schedules, personnel management, billing, and contract discussions.
SAP/Work Plan Changes	Resolution Consultants TOM	Ben Brantley	bbrantley@ensafe.com (901) 372-7962	Any changes of the approved SAP will be made only upon authorization of the Navy RPM and TDEC RPM. The Resolution Consultants TOM is responsible for initiating any SAP change requests via the communication channels described for the Navy and TDEC.
Field Progress Reports, SAP/Work Plan Changes in the Field	Resolution Consultants FTL	Corey Coleman	ccoleman@ensafe.com (901) 372-7962	All field activities documented daily by the FTL in the field log book and applicable field forms (groundwater sampling forms, soil boring/well construction logs, etc.). The FTL will update the PM on a daily basis of the field progress, which will include any deviations from the SAP, health and safety issues (near misses), schedule slippage, personnel issues, and others as relevant.
Stop Work due to Safety Issues	Resolution Consultants FTL	Corey Coleman	ccoleman@ensafe.com (901) 372-7962	Responsible for all team members and subcontractors adhering to the safety requirements described in the Health & Safety (H&S) Plan. The FTL will report any incidents and near misses within 24-hours to the PM and the H&S Manager. The FTL has the discretion (and responsibility) to stop work practices at any time that may be deemed unsafe or have questionable safety issues.
Field Corrective Actions	Resolution Consultants FTL Resolution Consultants TOM	Corey Coleman Ben Brantley	ccoleman@ensafe.com (901) 372-7962 bbrantley@ensafe.com (901) 372-7962	Any field corrective actions will be determined by the Resolution Consultants FTL and/or PM on an as needed basis and reported to the Navy RPM (verbally or via email) within one day of discovery.
Sample Receipt/Lab Quality Variances	Empirical Laboratory Microseeps Inc.	Sonya Gordon Ryan Rylands	sgordon@empirlabs.com (615) 345-1115 rrylands@microseeps.com (412) 826-5245	All Quality Assurance (QA)/Quality Control (QC) issues with project field samples will be reported within two days to the project chemist by the laboratory.

Communication Pathways				
Communication Drivers	**Responsible Entity**	**Name**	**Phone Number and/or email**	**Procedure (Timing, Pathway To/From, etc.)**
Notification of Non-Usable Data	Empirical Laboratory PM Microseeps Inc. PM RC Project Chemist	Sonya Gordon Ryan Rylands Tina Cantwell	sgordon@empirlabs.com (615) 345-1115 rrylands@microseeps.com (412) 826-5245 tcantwell@ensafe.com (901) 372-7962	The laboratory shall contact the Resolution Consultants project chemist within one working day of identifying any quality variances that renders the results non-usable. The project chemist will notify RC's PM within one business day for corrective action, including potential resampling.
Laboratory Corrective Actions	Empirical Laboratory PM Microseeps Inc. PM RC Project Chemist	Sonya Gordon Ryan Rylands Tina Cantwell	sgordon@empirlabs.com (615) 345-1115 rrylands@microseeps.com (412) 826-5245 tcantwell@ensafe.com (901) 372-7962	The laboratory shall notify the Resolution Consultants project chemist of any analytical data anomaly within one business day of discovery for guidance. After the laboratory receives guidance from RC's project chemist the laboratory shall initiate any corrective action to prevent further anomalies. For serious laboratory issues, the Navy RPM will be notified who at their discretion, may contact the Navy Chemist.
Reporting Data Validation Issues Data Validation Corrective Actions	RC Project Chemist	Tina Cantwell	tcantwell@ensafe.com (901) 372-7962	The project chemist or data validation specialist will perform validation as specified in Worksheets #34, #35, and #36, and will contact the laboratory as soon as possible if issues are found with the data for corrective action. Validation finding will be documented in the *Data Quality Assessment Report.* No analytical data will be released until data validation is completed.

Notes:

DBCM	=	Deputy Base Closure Manager
FTL	=	Field Team Leader
NSA	=	Naval Support Activity
PM	=	Project Manager
RPM	=	Remedial Project Manager
SAP	=	Sampling and Analysis Plan
USGS	=	United States Geological Survey
TDEC — DSWM	=	Tennessee Department of Environment and Conservation — Division of Solid Waste Management

SAP WORKSHEET #9: PROJECT PLANNING SESSION PARTICIPANTS SHEET

(UFP-QAPP Manual Section 2.5.1)

Project Name: NSA Mid-South **Project Dates of Sampling:** Field Activities for 2012 **Project Manager:** Ben Brantley	**Site Name:** AOC A — Fluvial Deposits Groundwater **Site Location:** NSA Mid-South; Millington, Tennessee
Date of Session: March 3, 2011 Base Cleanup Team Meeting **Scoping Session Purpose:** Path forward for AOC A Interim Measures	

Name	Title	Affiliation	Phone #	E-mail Address
Roger Donovan	RPM	TDEC DSWM	(615) 532-0864	roger.donovan@tn.gov
Charles Burroughs	Head of DSWM	TDEC DSWM	(615) 532-0863	charles.burroughs@state.tn.us
Jim Heide	Head of Public Works/Envir.	NSA Mid-South	(901) 874-5467	jim.heide@navy.mil
Jack Carmichael	Technical Specialist	USGS	(615) 837-4704	jkcarmic@usgs.gov
Stacin Martin	RPM	NAVFAC-LANT	(757) 322-4780	stacin.martin@navy.mil
David Criswell	co-RPM	BRAC PMO-SE	(843) 743-2130	david.criswell@navy.mil
Mark Thomas	SCHD Case Manager	SCHD	(901) 544-7391	mark.thomas@shelbycountytn.gov
Corey Coleman	Resolution Consultants FTL	RC	(901) 372-7962	ccoleman@ensafe.com
Ben Brantley	Resolution Consultants TOM	RC	(901) 372-7962	bbrantley@ensafe.com

Comments: The semi-annual BCT meeting concluded that additional actions were needed at AOC A to address increasing trichloroethylene (TCE) concentrations in offsite well 007G52LF, persistently elevated benzene levels in well 015G01UF, and residual TCE hot-spots remaining in Sub-Plumes A and D.

Consensus Decisions:

The Project Team reached consensus that the following tasks should be accomplished:

- Install additional injection wells and inject carbon substrate at the property boundary to create an anaerobic reductive zone that will mitigate further offsite migration of TCE
- Inject a long-lasting carbon substrate at select Sub-Plume A and D injection wells to treat residual TCE hot-spots
- Install additional monitoring wells to assess efficacy of remediation and evaluate downgradient extent of TCE off the former base property

- Assess the area of AOC A well 015G01UF for benzene and evaluate upgradient areas for a possible source

The tasks were outlined in the approved *Supplemental Interim Measures Work Plan* (EnSafe, 2012).

Action Items: Implement *Supplemental Interim Measures Work Plan* (EnSafe, 2012) and continue the long term groundwater monitoring as outlined in the SAP

SAP WORKSHEET #10: CONCEPTUAL SITE MODEL

(UFP-QAPP Manual Section 2.5.2)

This SAP is for the long term monitoring (LTM) program of the remedy effectiveness at AOC A. An investigative component associated with possible source areas at SWMU 15 and offsite TCE delineation are also included in the SAP.

Information related to site history, contaminant sources, exposure pathways, and the basis for the conceptual site model (CSM) development are described below. This SAP worksheet incorporates discussions with Project Team members and information from the following documents:

- *AOC A RCRA Facility Investigation* (EnSafe, 2000)
- *AOC A Interim Measures Work Plan* (EnSafe, 2003)
- *AOC A Progress Report* (EnSafe, 2011)
- *Supplemental Interim Measures Work Plan (EnSafe, 2012)*

Background/Site History

The Base was acquired by the Navy in 1942. From the 1940s to 1997, its primary mission was to serve as the host command for the Naval Air Technical Training Center. Operational closure was completed in October 1997 as a result of the BRAC of 1990. In 1999, the 551-acre airfield parcel was transferred to the Millington Municipal Airport Authority, while the 1,311 non-airfield parcel was transferred to the city of Millington (the transferred parcel is shown on Figure 1 in Appendix A). The non-transferred portion of the Northside was realigned with the Southside as NSA Mid-South.

AOC A was designated after the 1990 RCRA Facility Investigation (RFI) (EnSafe, 2000) of Solid Waste Management Unit (SWMU) 7 (Building N-126 dry well) identified a broad area of TCE contamination extending into the airfield apron and operations area, independent of the SWMUs. AOC A was designated for Northside fluvial deposits groundwater, both SWMU and non-SWMU areas, since TCE could not be tied to a specific source and it overlapped with multiple SWMUs.

Most of the AOC A investigative and remedial activities focused on the 551 acre airfield transfer parcel where a TCE has been identified, with a maximum concentration of 4,400 µg/L. Four sub-plume areas, A through D, were designated within AOC A (red-polygon shown on Figure 2) which have been the focus of the interim corrective measures. AOC A also contains SWMUs 5, 7, 15, 18, 21, 60, and Background Location 5, which are also shown on Figure 2, where

lesser amounts of contaminants have been identified and individual wells from these sites are retained in the LTM program.

Hydrogeology

The impacted fluvial deposits aquifer is from a Pleistocene fluvial paleo-environment, consisting of inter-braided clays, silts, sands, and gravels. Many shallow domestic wells were completed in the aquifer but have since been abandoned as a result of municipal water supplies being introduced in these areas in the mid to late 1970s. The aquifer is overlain by a layer of loess — windblown deposits of clay and silt which ranges between 25 and 45 feet thick. Because of its relatively low permeability, the loess serves as an upper confining unit to the fluvial deposits aquifer.

The base of the fluvial deposits aquifer, ranging in depths between 75 and 90 feet, generally contains an increase in gravel content and is the more conductive zone within the aquifer. The aquifer is underlain by an interbedded sand, clay, silt, and lignite, which forms the uppermost part of the Jackson-upper Claiborne confining unit, which separates the fluvial deposits aquifer from the Memphis aquifer, a municipal water source that is actively used today. Thickness of this confining unit varies between 35 and 245 feet in thickness. The potential for interconnection between the shallower fluvial deposits aquifer and the Memphis sand aquifer, the municipal water supply for the city of Millington and NSA Mid-South, was evaluated in the RFI and through multiple lines of evidence; it was concluded that no evidence of interconnection exists between the two aquifers. Vertical hydraulic conductivities of soil samples collected from the upper section of the Cockfield formation were measured to range from 5.5×10^{-5} centimeter per second (cm/s) and 1.6 and 10^{-6} cm/s. This coupled with the high total organic carbon content (0.2% and 12%) of the unit was concluded to be one of several factors contributing to the absence of volatile organic compounds (VOCs) in the monitoring wells set within the Cockfield and water samples analyzed from the Memphis sand aquifer.

Conceptual Site Model

The disposal practices and the source of the chlorinated solvents found in the fluvial deposits aquifer are poorly known. The few sites where solvents were reportedly released directly to the ground, contained relatively low solvent concentrations in groundwater, if any, while numerous locations were identified that cannot be tied to an individual source or exact location. TCE, 1,1,1-trichlorethane (TCA), and carbon tetrachloride were reportedly used to clean and degrease aircraft parts and operations in the apron area; however, TCE is the predominant solvent

with little evidence of TCA and carbon tetrachloride. The oldest documented release dates back to the 1960s indicating that the plumes are at least 40 years old and multiple modes of release reportedly occurred. Possible sources included solvent waste (1) allowed to drip from mobile bowsers parked near the N-126 hangar, (2) dumped from buckets on the pavement areas, grassy areas, or into storm sewers near the hangars, (3) from airplane rinsing at former wash racks, (4) leaking waste tanks, (5) generated from former paint/spray booths, and (6) possible usage in former aircraft "octagon" parking areas north of the runway.

An exhaustive RFI study of soil and perched groundwater in the possible source areas failed to identify a release area. Vertical contaminant structure has never been identified that would point to a ground surface source or a solvent point of entry. Instead the contaminant mass is discontinuous and complexly dispersed; data do not suggest the presence of dense non-aqueous phase liquids (DNAPLs). The conceptual transport model put forth in the RFI was that that earlier DNAPL releases left isolated, micro-scale, saturated-phase globules, that became distributed in a spatially complex way within a network of multiple, small dissolved phase plumes with complex geometries and varying degrees of mechanical, chemical, and biological degradation.

The conceptual TCE groundwater plume model is provided in Figure 3 (Appendix A). Aquifer heterogeneities are significant, as indicated in not only the vertical contaminant distribution, but also the varying plume lengths. TCE concentrations are highest in the upper and middle sections of the fluvial deposits aquifer (approximately 50 feet below ground surface [bgs]) at Sub-Plume D, which measures approximately 750 feet in length. While the TCE plume is concentrated in the basal, lower section of the aquifer (approximately 75 feet bgs) in Sub-Plumes A and B which converge and extend approximately 3,300 feet downgradient, and extend a minimum of 200 feet beyond the former Base property boundary.

Potential Receptors

The impacted aquifer is not used as a potable water source since municipal supplies are available in the area. A LUC prohibiting residential development and groundwater use of the fluvial deposits aquifer are maintained for AOC A and County ordinances prohibit its usage for potable water since municipal water supplies are available. Hence, a human health exposure pathway does not exist for the contaminants; however, it requires the maintenance and enforcement of LUCs until the project action levels (PALs) or maximum contaminant levels (MCLs) are met for the contaminants in the groundwater.

Interim Corrective Measures

Groundwater interim measures consisting of enhanced bioremediation in the source areas near the former hangars and airfield taxiways were implemented at Sub-Plume A through D in 2004. Injection wells placed in the source areas were formerly used for monthly delivery of carbon substrate into the aquifer to manipulate its geochemistry from aerobic to anaerobic and trigger the reductive dechlorination of TCE. Carbon substrate injections were suspended in October 2009 and the remedy transitioned to MNA. The former injection wells and TCE plumes constructed from the November 2010 data set are shown on Figure 4.

Proposed Supplemental Corrective Measures

The BCT decided that supplemental AOC A corrective measures were necessary to address three issues before the AOC A remedy could fully transition from enhanced bioremediation to monitored natural attenuation (MNA) only. These were the following:

- **Sub-Plume A:** Providing additional carbon substrate in a subset of Sub-Plume A injection wells (Figure 5A) to address residual TCE hotspots and maintain a lasting carbon source for continued anaerobic degradation of TCE.

- **Sub-Plume D:** Treating residual TCE hotspots and an area west, outside of the former treatment Sub-Plume D area, where elevated TCE levels (> 600 µg/L) were identified. Wells that will be used to deliver carbon substrate are shown on Figure 5B. Additionally, three downgradient monitoring wells (Figure 5B) are proposed to monitor remedy effectiveness with the injections.

- **Offsite TCE Migration:** Construction of ten injections wells (Figure 5C) and carbon substrate injection for preventing further offsite TCE impacts. Evaluating the downgradient extent of TCE by expanding the monitoring well network with two additional offsite monitoring wells (Figure 5C).

- **SWMU 15:** Collect additional groundwater data from the six proposed sampling locations (Figure 6) at the former fuel farm to evaluate whether residual source exists and collect necessary remedial design data.

SAP WORKSHEET #11: DATA QUALITY OBJECTIVES/SYSTEMATIC PLANNING PROCESS

(UFP-QAPP Manual Section 2.6.1)

The data quality objectives (DQOs) for these investigations were developed based on the *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4) (EPA 2006) and are presented below.

11.1 Problem Statements

- **AOC A: Sub-Plumes A — D**

  LTM consisting of semi- and annual monitoring, as agreed to by the Project Team, must be conducted to verify that the enhanced bioremediation/MNA remedy is effective.

- **AOC A: Offsite TCE**

  TCE has increased in offsite wells, triggering regulatory requirements of supplemental investigative and remedial measures. Carbon substrate injections are required at the former property boundary to mitigate further offsite impacts and two additional offsite monitoring wells are required for delineating the downgradient extent of TCE impacts.

- **AOC A: SWMUs 5, 18, 21; North Fuel Farm, Background Location #5**

  Enhanced bioremediation has not been conducted at these sites since COPCs were isolated in nature or slightly above their PALs. However, LTM data are necessary to demonstrate whether MNA conditions remain ongoing or supplemental interim measures are warranted.

- **AOC A: SWMU 15**

  Elevated benzene concentrations persist in the fluvial deposits aquifer at SWMU 15 despite prior soil removal actions. In response to regulatory requirements, additional data collection will be conducted to determine if a residual benzene source remains in the former fuel farm area so that appropriate corrective measures can be evaluated.

11.2 Identify the Goals of the Study

Groundwater samples will be collected to generate data for purposes of evaluating the performance of the groundwater remedy and determining whether supplemental corrective measures are warranted. Groundwater samples will also be collected for investigating possible source areas (SWMU 15) and the offsite extent of TCE impacts. LTM data will be assessed against the PALs

detailed for each contaminant of concern (COC) in Worksheet #15 to determine whether the remedy is effective toward achieving cleanup goals and preventing further offsite migration of TCE.

11.3 Inputs to Problem Resolution

To resolve the problem statements above, the following information is needed:

1. Measured semi-annual and annual data from AOC A wells (Figures 5D and 5E) for the groundwater analytes listed in Worksheets #18, 19, 20, 30. The sampling and analytical methods that are necessary for collecting the samples are provided in Worksheet #15.

2. Groundwater data from multiple discrete intervals at six locations (Figure 6) hydraulically upgradient of well 015G01UF, near the former fuel farm.

3. Groundwater Well Stabilization Parameters — pH, specific conductance, dissolved oxygen (DO), oxidation-reduction potential (ORP), temperature, and turbidity.

4. Groundwater level measurement from each well during each semi-annual and annual sampling event to a precision of 0.01 foot. Water levels will be collected from all AOC A wells (shown on Figures 5D and 5E) during the annual monitoring event within a 24-hour period.

5. Land survey data from all proposed monitoring/injection wells and DPT groundwater sample locations using a Tennessee registered land surveyor. Monitoring well top-of-casing and ground surface elevations shall be read to the nearest 0.01 feet and tied to the nearest North American Vertical Datum of 1983 (NAVD 83) datum bench mark.

11.4 Define the Study Boundaries

Spatial Boundaries: The AOC A boundary (Figure 2) is defined by the footprint of the former NSA Mid-South Northside and an offsite area extending 2,500 feet northwest of the former base property boundary. Vertically, AOC A is defined by its upper contact with the surficial loess/silt layer (25 to 40 feet bgs) and its lower contact with the Cockfield formation, a confining unit comprised of fine sand, clay, and lignite that ranges in depths between 75 and 120 feet bgs.

The primary population of interest is groundwater at the base of the fluvial deposits aquifer with exception to SWMU 15 and Sub-Plume D, where groundwater in the upper and upper-middle sections of the aquifer is the focus. Sub-Plumes A-D (Figure 2) comprise the largest impacted area of AOC A with the remainder of the monitoring well network scattered over multiple Northside SWMUs, a subset of which undergo LTM are SWMUs 5, 15, 18, 21, and Background location #5 for individual wells were PALs are exceeded. Ninety six monitoring wells are sampled annually and 38 are sampled semi-annually. Well locations and their designated purpose in the monitoring program are shown on Figures 5D and 5E. LTM is expected to continue 30 years or until COPCs have been reduced to below PALs.

11.5 Analytical Approach

Changes in COPC concentrations must be monitored to determine whether a response action is necessary, or continued monitoring is appropriate. Over time, the monitoring strategy will be optimized by the Project Team to make the most cost-effective use of the resources while achieving the remedial goals protective of human health and the environment. The proposed data will be used in the following project decisions:

Decision Rule #1: AOC A — Sub-Plumes A — D

If the MNA data evaluation (in aggregate) suggest that conditions are favorable for ongoing TCE degradation and/or daughter product cis-1,2DCE and VC, then the remedy will be considered effective and monitoring will continue under the current schedule until optimized by the Project Team. If the MNA data suggest that conditions are not favorable for TCE degradation and/or daughter products cis-1,2DCE and VC, then the Project Team will consider remedy optimization. Three lines of evidence will be used for a holistic evaluation of MNA and deciding whether it is effective: (1) trend analyses of COPCs using Mann-Kendall (M-K)[1], (2) parent-daughter product ratios, and (3) geochemical data analyses.

Decision Rule #2: AOC A — Offsite TCE

If COPCs are identified above the PALs in the proposed offsite monitoring wells, then supplemental monitoring wells will be proposed to the Project Team for evaluating the extent of offsite impacts.

[1] If the M-K analysis indicates an upward or downward trend with at the 95% confidence level (alpha aka false positive = 5%), then the upward or downward trend will be considered statically significant.
If M-K analysis indicates an upward or downward trend with at less than 95% confidence level (alpha aka false positive = 5%), then the upward or downward trend will be considered statically insignificant, or to have "no trend."
A "No Trend" situation is further evaluated to identify whether concentrations are stable over time through a measure of data dispersion, or its coefficient of variation (CV). If the CV of the time-series data is less than 1, then the trend analysis result is identified as "stable" otherwise the data is considered as having "no trend".

Decision Rule #3: AOC A — SWMUs 5, 18, 21; North Fuel Farm, Background Location #5

If the M-K analysis indicates a downward trend, then natural attenuation conditions will be considered effective and monitoring will continue under the current schedule until optimized by the Project Team. If M-K analysis indicates an upward trend or no trend, and COPCs are above the PALs, then the Project Team will consider remedy alternatives.

Decision Rule #4: AOC A — SWMU 15

If benzene in groundwater at the proposed SWMU 15 sample locations exceeds the MCLs and M-K trend analyses indicates PALs will not be achieved within five years at 015G01UF, then an interim measures work plan will be prepared for remediating groundwater. If the supplemental groundwater data does not indicate a benzene groundwater source (detected benzene concentrations are below that detected in downgradient well 015G01UF) and M-K trend analyses indicate benzene concentrations in 015G01UF will achieve the PAL within 5 years, then monitoring will continue until PALs are achieved.

11.6 Performance Criteria

The objective of this section is to complete the following:

- Identify potential sources of study error (i.e., field error, analytical error)
- Establish and identify the methods used to reduce potential sources of error
- Determine how decision errors will be managed during the project

The monitoring program is based on a pre-selected number of wells set by the Project Team and have been selected to ensure sufficient coverage of groundwater is achieved for the LTM program. After each sampling event, the data validation criteria described in Worksheets #34-#36 will determine whether data of sufficient type, quantity, and quality have been collected to support project objectives. All data will be presented to the BCT in the annual progress reports for review and if any data gaps are identified, the BCT will determine, based on the number and severity of data gaps, whether to collect more data or to accept the limitations as incurred as a result of the data gaps. If data gaps are determined by the Project Team to affect the ability to achieve project objectives, additional data collection will be recommended to address the data gaps. Data will be used to evaluate the remedy effectiveness and supportive of conclusions and recommendations provided in the annual progress reports.

11.6.1 Sampling Strategy

The groundwater sampling design was developed to monitor the remedy effectiveness implemented at the NSA Mid-South Millington, TN site.

11.6.2 Sources of Error

Sources of error in the LTM may be divided into two main categories: sampling errors and measurement errors. A sampling error occurs when the sampling design, planning, and implementation do not provide for a representative range of heterogeneity at the site. A measurement error occurs because of performance variance from laboratory instrumentation, analytical methods, and operator error. The EPA identifies the combination of all these errors as a "total study error" (EPA 2006). One objective of the investigation is to reduce the total study error so that decision-makers can be confident that the data collected accurately represent the chemical characteristics of the site.

11.6.3 Managing Decision Error

The investigation will utilize decision-error minimization techniques in sampling design, sampling methodologies, and laboratory measurement of COCs. Possible decision errors will be minimized during the field investigation by using the following methods:

- Use standard field sampling methodologies (as discussed in Worksheets #18 and #21).
- Use applicable analytical methods (discussed in Worksheets #23, #24, and #25) for sample analysis by a competent analytical laboratory certified by the DoD ELAP to reduce measurement errors.
- Confirm analytical data to identify and control potential laboratory error and sampling error by using spikes, blanks, and replicated samples.

Decision errors associated with judgmental sampling are based on sample design and measurement errors. Assuming that the best possible professional judgment was used to develop the judgmental sampling plan (i.e., position sampling locations), the most important decision errors will be associated with field and laboratory techniques involved in the collection and analysis of the data.

Sampling Methodologies and Procedures

Possible decision errors generated by sampling errors will be minimized during the field investigation by applying standardized field sampling methodologies (to be discussed in Worksheets #18, #20, #21, and #22). Sampling activities will be performed in accordance with the SOPs specified in this SAP.

Laboratory Measurement of COCs

Possible decision errors generated by laboratory measurement errors will be minimized by using applicable analytical methods (discussed Worksheet #23) for sample analysis by a competent analytical laboratory evaluated and certified by the DoD NELAP.

Managing Laboratory Sampling Error

Control of potential laboratory error and sampling error will be minimized using spikes, blanks, and duplicates. Sampling error may be introduced when the laboratory chemist selects a single portion of the field sample for laboratory analysis. However, this issue is less relevant to the discrete sampling approach as sub-sampling is generally not implemented at the laboratory.

11.7 Optimize the Design for Obtaining Data

The sampling design for the site was developed to optimize resources and generate data to satisfy the data quality objectives is presented in Worksheet #17 and sample locations and analyses conducted on each well may be found on Worksheet #18.

11.7.1 Field Data Logs

All sample information will be transcribed into a field logbook and/or onto field data sheets. Field data sheets will be e-mailed to the project management team to track progress.

11.7.2 Analytical Laboratory Sample Management

The sample matrix, number of samples, and number and type of laboratory quality assurance (QA)/quality control (QC) samples are summarized in the "Sample Details" table in the Section titled "Field Project Implementation (Field Project Instructions)" of this SAP. Details on the analytical group, sample volumes, sample container specifications, preservation requirements, and maximum holding times are also identified in the "Sample Details" table in the Section titled "Field Project Implementation (Field Project Instructions)" of this SAP.

The laboratory will provide full electronic data deliverable files, portable document format (PDF) files of the data deliverables for all project data, and a hard copy of data deliverables for all results including results from secondary subcontract laboratories. Designated samples will be used to obtain necessary subsamples for laboratory QC measurements (i.e., analytical sample duplicate and sample matrix spike/matrix spike duplicate [MS/MSD]). Tasks will be completed using the laboratory standard operating procedures (SOPs).

Resolution Consultants will provide data validation services and verify and evaluate the usability of the data as identified in the Section titled "Verification and Validation (Steps I and IIA/IIB) Process Table" of this SAP.

PDF copies of all analytical data packages will be stored on CD-ROM, archived in the NAVFAC LANT Administrative Record, and uploaded onto the Naval Installation Restoration Information Solution (NIRIS) system at the close of the project. All other data generated in the field and reports generated for the project will be stored as computer readable data files by Resolution Consultants.

SAP WORKSHEET #12: FIELD QUALITY CONTROL SAMPLES

(UFP-QAPP Manual Section 2.6.2)

Measurement Performance Criteria Table — Field QC Samples

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
Trip Blanks	VOCs	One per cooler to the laboratory containing volatiles	Accuracy/Bias/ Contamination	No analytes > ½ LOQ, except common lab contaminants, which must be < LOQ
Equipment Rinsate Blanks	All	One per 20 field samples per matrix per sampling equipment [1]	Accuracy/Bias/ Contamination	No analytes > ½ LOQ, except common lab contaminants, which must be < LOQ
Field Duplicates	All	One per 20 field samples	Precision	Values > 5X LOQ: Relative RPD ≤30%
Matrix Spike/Matrix Spike Duplicate	VOCs/SVOCs	One pair per 20 field samples	Accuracy/Bias/ Precision	Percent recoveries — DoD QSM Limits RPD must be ≤ 30%
Matrix Spike/Matrix Spike Duplicate	Metals/TOC/BOD/COD/ Dissolved Gases	One pair per 20 field samples	Accuracy/Bias/ Precision	Percent recoveries — DoD QSM Limits RPD must be ≤ 20%
Matrix Spike/Matrix Spike Duplicate	Chloride, Nitrate, Nitrite, Sulfate	One pair per 20 field samples	Accuracy/Bias/ Precision	Percent recoveries — DoD QSM Limits RPD must be ≤ 10%
Cooler Temperature Indicator	All	One per cooler	Representativeness	Temperature less than 6 degrees Celsius

Notes:

VOCs = Volatile organic compounds
LOQ = Limit of quantitation
DoD QSM = Department of Defense Quality Systems Manual
RPD = Relative percent difference
[1] = Equipment rinsate blanks will be collected if decontamination is required and will not apply if dedicated equipment is used

SAP WORKSHEET #14: FIELD PROJECT TASKS

(UFP-QAPP Manual Section 2.8.1)

FIELD PROJECT IMPLEMENTATION (FIELD PROJECT INSTRUCTIONS)

Pre-Sampling Tasks

- Subcontract procurement
- Equipment and supply requisition
- Schedule field and support staff
- Prepare site-specific H&S Plan
- Locate underground utilities
- Apply for well construction and injection permits

Groundwater Sampling Tasks

- Reference Worksheet #21 for the appropriate groundwater sampling SOPs.

- Complete all applicable forms (monitoring well sampling logs, SWAP) on a daily basis.

- Review health and safety plan with field sampling crews.

- Groundwater Level Measurements:

  — One comprehensive round of water levels will be collected from all AOC A monitoring wells during the annual monitoring event. Water level measurements will be completed within the shortest time possible and no sooner than 24 hours after a significant rainfall event. Water level measurements will be recorded to the nearest 0.01 foot and referenced to a top of casing mark designated on each well. The water level indicator will be decontaminated before conducting measurements and immediately after each well.

  — Measure water levels in all wells before the start of purging activities. The depth from the top of casing to water level will be recorded to the nearest 0.010 foot. The indicator will be decontaminated after use in each well.

- Collect Groundwater Samples:

  — See Worksheets #18, 19, 20, and 30 for wells to be sampled semi-annually and annually, designated sample IDs, and analyses. Monitoring well locations are shown on Figures 5D and 5E in Appendix A.

  — The most downgradient, least contaminated wells will be sampled first concluding with upgradient source area wells.

  — Groundwater samples will be collected from monitoring wells using dedicated sample tubing and low-flow methods with a bladder pump.

  — Groundwater samples will be collected from monitoring wells by placing the pump/tubing 5-feet from the bottom of the well screen interval. Water quality parameters (specific conductance, pH, turbidity, temperature, DO, and ORP) will be measured and recorded (approximately every 5 minutes) prior to sampling using a flow-through cell multi-meter. Groundwater sampling will begin when water quality parameters have stabilized for three consecutive readings and water level drawdown is stable. Depth to groundwater before and during pumping, water quality parameter readings, purge and sample flow rates, total well depths, sample dates and times will be recorded on the groundwater sampling form.

- Worksheets #18, 19, 20, and 30 specify the required bottle types, preservation, target analytes, analytical methods, and holding times for this investigation.

DPT Groundwater Investigation

- Reference Worksheet #21 for the appropriate DPT sampling SOP

- Verify utility clearance at proposed DPT locations

- Complete all applicable forms (soil boring logs, SWAP) daily

- Review health and safety plan with DPT contractor

- Vertically profile groundwater at SWMU 15

  — A Geoprobe rig will be used to vertically profile groundwater at nine locations shown on Figure 6 in Appendix A.

  — Groundwater samples will be collected from three depth intervals (35, 45, and 55 feet) at each location using a Geoprobe sampler.

  — Dedicated Teflon tubing attached to a peristaltic pump will be used to purge and collect discrete water samples from inside the drill rods. Water quality parameters (specific conductance, pH, turbidity, temperature, DO, and ORP) will be measured and recorded (approximately every 5 minutes) prior to sampling using a flow-through multi-meter. Groundwater sampling will begin when water quality parameters have stabilized for three consecutive readings.

  — The Geoprobe rods and sampler will be retrieved after each sample collection, decontaminated, and advanced to the next depth interval.

  — All purge water will be staged in portable 275 gallon poly tanks and transported to a Northside staging area designated by RC.

- Worksheets #18, 19, 20, and 30 specify the target analytes and analytical methods for this investigation.

- Samples for TPH and MNA analyses will be collected directly from the discharge side of the peristaltic pump. The sample aliquot for VOC analysis will be collected last by slowly removing the Teflon tube from the sampler and allowing the contents to gravity drain from the tubing end into the VOC vial.

Field Decontamination

- Reference Worksheet #21 for the appropriate decontamination SOPs.

Field Documentation Procedures

- A summary of all field activities will be properly recorded in a bound, field logbook assigned to the project as outlined in the Logbook SOP. All entries will be made in ink and

incorrect entries will be stricken with a single line, initialed, and dated by the person making the correction.

- At a minimum, the following information will be included in the field logbook:
  - Project name
  - Date of field activities
  - Arrival and departures times of field sampling crews
  - Name of all field personnel, subcontract personnel, and contact info
  - Description of subcontractor activities
  - Description of well construction, sampling, injection activities, any relevant site activities
  - Sample pick-up/delivery information, air-bill numbers, carrier, lab purchase order, chain of custody number
  - Health and safety issues

Analytical Tasks

Analyses will be performed in accordance with the analytical methods identified in Worksheet #18, 19, 20, and 30.

- Chemical analysis for AOC A (VOCs, sulfate/chloride, iron, total organic carbon) and SWMU 15 (VOCs, sulfate, nitrate, iron, manganese, biological oxygen demand, chemical oxygen demand, TPH) will be performed by Empirical Laboratories, which is a DoD Environmental Laboratory Accreditation Program (ELAP) approved laboratory.

- Methane, ethane, ethene, and hydrogen analyses will be provided by Microseeps Inc., which is a specialized laboratory.

Data Management

- *Data Handling and Management:* Upon completion of field activities, all secondary data from field sampling forms will be organized by date and entered into Excel for electronic archiving/data evaluation. The field forms, chain of custody, air bills, and logbooks will be placed in the project files after the completion of the field program. The electronic data results will be automatically downloaded into the RC database for use in data evaluation and subsequent report preparation. Final validated environmental data, special data, and Land Use Control information for Controlled Areas will be uploaded into the NIRIS database.

- *Data Tracking:* Data will be tracked from its generation to its archiving in the Resolution Consultants project-specific files for NSA Mid-South. The Resolution Consultants project chemist (or designee) is responsible for tracking the samples collected and shipped to the subcontracted laboratory. Upon receipt of the data packages from the analytical laboratory, the project chemist will oversee the data validation effort, which includes verifying that the data packages are complete and results for all samples have been delivered by the analytical laboratory.

- *Data Storage, Archiving, and Retrieval:* The data packages received from the subcontracted laboratory are tracked in the data validation logbook. After the data are validated, the data packages will be entered into the RC CLEAN file system and archived in secure project files. The field records including logbooks, sample logs, chain-of-custody records, and field calibration logs will be submitted into the CLEAN file system prior to archiving by the Project Manager (or designee). The project files are audited for accuracy and completeness by the Project Manager (or designee). At the completion of the Navy contract, all original e-records will be stored by RC and eventually transferred to the Navy.

Documentation and Reporting

- All field activities associated with the SWMU 15 investigation, construction of monitoring and/or injection wells will be incorporated into a Task Summary report, which will include a summary of the completed tasks, well construction logs, field records, water quality parameters, any baseline groundwater monitoring data, and deviations that may have occurred from the original work plan.

- All AOC A monitoring data will compiled and evaluated in the annual Progress Report and submitted to the Base Cleanup Team members for review, comment, and finalization.

- All administrative record files, post decision files, and site files will submitted to the NIRIS data management system in accordance with the *Environmental Restoration Recordkeeping Program Manual, Appendix G, NAVFAC Contractor Work Instruction* (NFESC, September 2009)

SAP WORKSHEET #15: REFERENCE LIMITS AND EVALUATION TABLE

(UFP-QAPP Manual Section 2.8.1)

Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: Volatile Organic Compounds and Monitored Natural Attenuation

Analyte	CAS	Analytical Method	Units	Project Action Limit: USEPA MCL	Project Quantitation Limit Goal	Laboratory Specific Limits		
						LOQ	LOD	DL
1,1,1-Trichloroethane	71-55-6	8260B	µg/L	200	1	1	0.5	0.25
1,1,2,2-Tetrachloroethane	79-34-5	8260B	µg/L	—	0.5	0.5	0.25	0.1
1,1,2-Trichloroethane	79-00-5	8260B	µg/L	5	0.5	0.5	0.25	0.1
1,1-Dichloroethane	75-34-3	8260B	µg/L	—	1	1	0.5	0.25
1,1-Dichloroethene	75-35-4	8260B	µg/L	7	1	1	0.5	0.25
1,2-Dichloroethane	107-06-2	8260B	µg/L	5	0.5	0.5	0.25	0.1
1,2-Dichloropropane	78-87-5	8260B	µg/L	5	0.5	0.5	0.25	0.1
2-Butanone (MEK)	78-93-3	8260B	µg/L	—	10	10	5	2.5
2-Hexanone	591-78-6	8260B	µg/L	—	5	5	2.5	1.25
4-Methyl-2-Pentanone (MIBK)	108-10-1	8260B	µg/L	—	5	5	2.5	1.25
Acetone	67-64-1	8260B	µg/L	—	10	10	5	2.5
Benzene	71-43-2	8260B	µg/L	5	0.5	0.5	0.25	0.1
Bromodichloromethane	75-27-4	8260B	µg/L	80	0.5	0.5	0.25	0.1
Bromoform	75-25-2	8260B	µg/L	80	1	1	0.5	0.25
Bromomethane	74-83-9	8260B	µg/L	—	2	2	1	0.5
Carbon disulfide	75-15-0	8260B	µg/L	—	1	1	0.5	0.25
Carbon tetrachloride	56-23-5	8260B	µg/L	5	0.5	0.5	0.25	0.1
Chlorobenzene	108-90-7	8260B	µg/L	100	1	1	0.5	0.25

Reference Limits and Evaluation Table

Matrix:	Groundwater
Analytical Group:	Volatile Organic Compounds and Monitored Natural Attenuation

Analyte	CAS	Analytical Method	Units	Project Action Limit: USEPA MCL	Project Quantitation Limit Goal	Laboratory Specific Limits		
						LOQ	LOD	DL
Chloroethane	75-00-3	8260B	µg/L	—	2	2	1	0.5
Chloroform	67-66-3	8260B	µg/L	80	0.5	0.5	0.25	0.1
Chloromethane	74-87-3	8260B	µg/L	—	1	1	0.5	0.25
cis-1,2-Dichloroethene	156-59-2	8260B	µg/L	70	1	1	0.5	0.25
cis-1,3-Dichloropropene	10061-01-5	8260B	µg/L	—	0.5	0.5	0.25	0.1
Dibromochloromethane	124-48-1	8260B	µg/L	80	0.5	0.5	0.25	0.1
Ethylbenzene	100-41-4	8260B	µg/L	700	1	1	0.5	0.25
m,p-Xylene	108-38-3/106-42-3	8260B	µg/L	10,000	2	2	1	0.5
Methylene chloride	75-09-2	8260B	µg/L	5	2	2	1	0.5
Methyl-tert-butyl-ether (MTBE)	1634-04-4	8260B	µg/L	—	1	1	0.5	0.25
o-Xylene	95-47-6	8260B	µg/L	10,000	1	1	0.5	0.25
Styrene	100-42-5	8260B	µg/L	100	1	1	0.5	0.25
Tetrachloroethene	127-18-4	8260B	µg/L	5	0.5	0.5	0.25	0.1
Toluene	108-88-3	8260B	µg/L	1,000	1	1	0.5	0.25
trans-1,2-Dichloroethene	156-60-5	8260B	µg/L	100	1	1	0.5	0.25
trans-1,3-Dichloropropene	10061-02-6	8260B	µg/L	—	0.5	0.5	0.25	0.1
Trichloroethene	79-01-6	8260B	µg/L	5	1	1	0.5	0.25
Vinyl chloride	75-01-4	8260B	µg/L	2	0.5	0.5	0.25	0.1
Xylene (Total)	1330-20-7	8260B	µg/L	10,000	3	3	1.5	0.75
Chloride	16887-00-6	USEPA 300.0	mg/L	—	0.5	0.5	0.330	0.17

Reference Limits and Evaluation Table

Matrix:	Groundwater
Analytical Group:	Volatile Organic Compounds and Monitored Natural Attenuation

Analyte	CAS	Analytical Method	Units	Project Action Limit: USEPA MCL	Project Quantitation Limit Goal	Laboratory Specific Limits		
						LOQ	LOD	DL
Nitrate (as N)	14797-55-8	USEPA 300.0	mg/L	10	0.200	0.200	0.100	0.033
Nitrite (as N)	14797-65-0	USEPA 300.0	mg/L	1	0.200	0.200	0.100	0.033
Sulfate	14808-79-8	USEPA 300.0	mg/L	—	2.0	2.0	1.0	0.33
Iron	7439-89-6	SW6010B	mg/L	—	100	100	60	30
Manganese	7439-96-5	SW6010B	mg/L	—	15	15	6	3
Total Organic Carbon	-28	SW9060A	mg/L	—	1.00	1.00	0.500	0.250
Biochemical Oxygen Demand	-19	SM 5210B	mg/L	—	2.00	2.00	2.00	2.00
Chemical Oxygen Demand	-13	USEPA 410.4	mg/L	—	20.0	20.0	40.0	60.0
Gasoline Range Organics (C6-C10)	-3534	TN GRO	mg/L	—	0.15	0.15	0.1	0.05
Extractable Petroleum Hydrocarbons (C12-C40)	-264	TN EPH	mg/L	—	0.100	0.100	0.100	0.100
Hydrogen	1333-74-0	AM20GAX	nM	—	0.6	0.6	0.6	0.25
Ethane	74-84-0	AM20GAX	µg/L	—	0.01	0.01	0.01	0.002
Ethene	74-85-1	AM20GAX	µg/L	—	0.01	0.01	0.01	0.001
Methane	74-82-8	AM20GAX	µg/L	—	0.015	0.015	0.015	0.003

Notes:

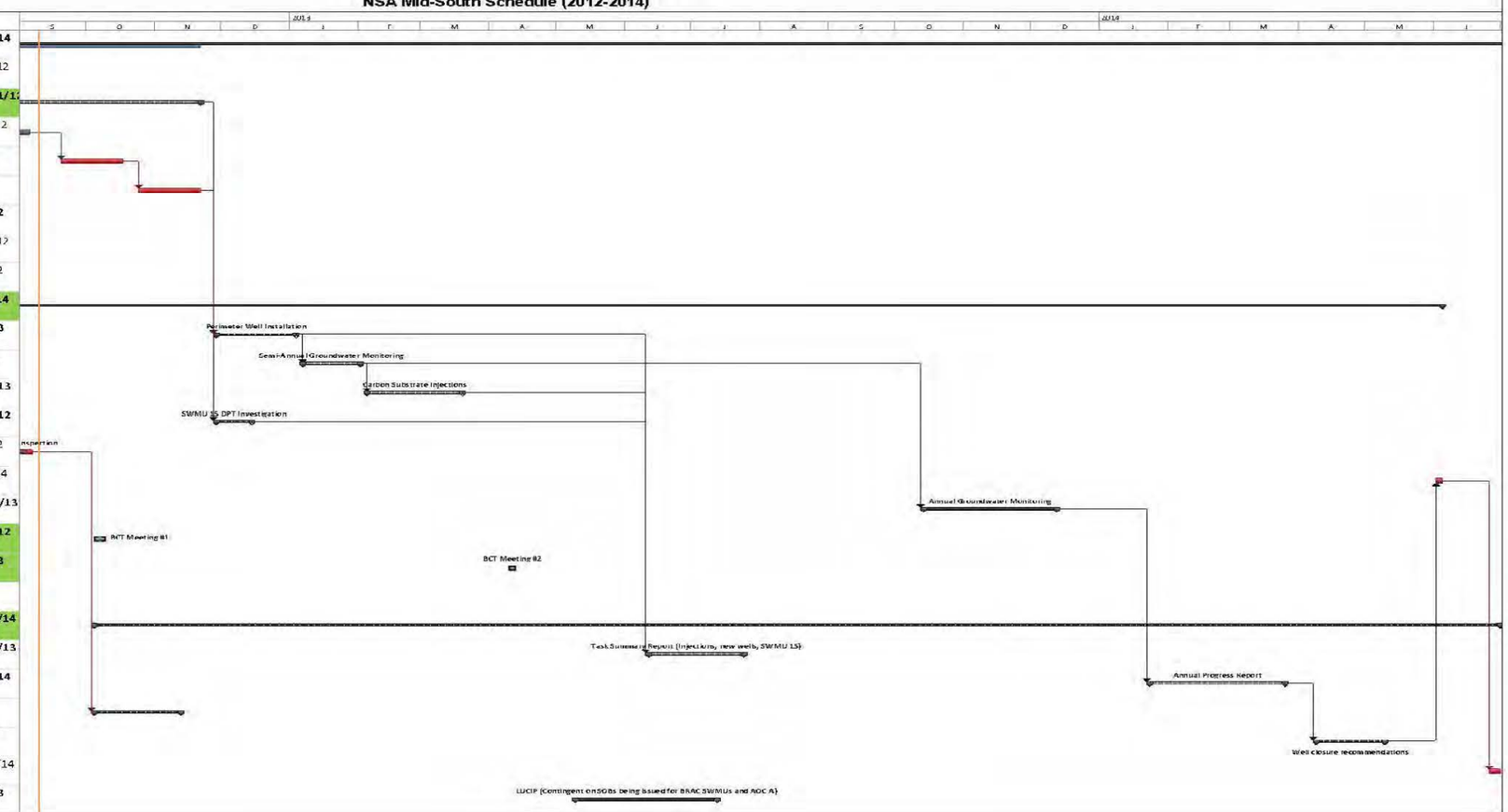
MCL = UESPA Maximum Contaminant Level
LOQ = Limit of quantitation
LOD = Limit of detection
DL = Detection limit
µg/L = Micrograms per liter
mg/L = Milligrams per liter
USEPA = U.S Environmental Protection Agency

SAP WORKSHEET #16: PROJECT SCHEDULE/TIMELINE TABLE

(UFP-QAPP Manual Section 2.8.2)

AOC A Interim Measures Optimization/LTM
NSA Mid-South Schedule (2012-2014)

ID	Task Name	Start	Finish
1	**AOC A IM Optimization and LTM**	**Thu 5/10/12**	**Thu 7/31/14**
2	**Obtain TDEC Approval of Sup. IM WP**	Thu 5/10/12	Thu 5/10/12
3	**SAP**	**Tue 8/28/12**	**Wed 11/21/12**
4	Draft SAP (Navy Approved)	Tue 8/28/12	Wed 9/5/12
5	Draft Final SAP (TDEC Review)	Thu 9/20/12	Wed 10/17/12
6	Final SAP	Thu 10/25/12	Wed 11/21/12
7	**Injection Permit Variance**	**Thu 5/10/12**	**Fri 5/11/12**
8	Apply to WCCB for Injection Permit	Thu 5/10/12	Thu 5/10/12
9	WQCB Public Meeting (Petition for variance)	Fri 5/11/12	Fri 5/11/12
10	**Field Activities**	**Mon 8/20/12**	**Wed 6/4/14**
11	**AOC A Well Installation**	**Thu 11/29/12**	**Thu 1/3/13**
17	**Semi-Annual Monitoring**	**Mon 1/7/13**	**Fri 2/1/13**
21	**Carbon Substrate Injections**	**Tue 2/5/13**	**Tue 3/19/13**
25	**SWMU 15 DPT Investigation**	**Thu 11/29/12**	**Fri 12/14/12**
28	**Basewide Well Inspection**	Mon 8/20/12	Thu 9/6/12
29	**Well Abandonment (20 wells)/Repair**	Mon 6/2/14	Wed 6/4/14
30	**Annual Groundwater Monitoring**	**Mon 10/14/13**	**Thu 12/12/13**
34	**BCT Meeting No. 1**	**Fri 10/5/12**	**Tue 10/9/12**
35	**BCT Meeting No. 2**	**Wed 4/10/13**	**Fri 4/12/13**
36			
37	**Reporting**	**Fri 10/5/12**	**Mon 6/30/14**
38	**Task Summary Report**	**Wed 6/12/13**	**Wed 7/24/13**
41	**Annual Progress Report**	**Fri 1/24/14**	**Tue 3/25/14**
44	**Well Inspection Summary Report**	**Fri 10/5/12**	**Mon 11/12/12**
47	**Well Abandonment Work Plan/Tech Memo**	**Wed 4/9/14**	**Fri 5/9/14**
50	**Well Abandonment Report**	Thu 6/26/14	Mon 6/30/14
51	**Land Use Control Implementation Plan**	**Fri 5/10/13**	**Fri 7/12/13**



Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Critical | Critical Split | Progress

SAP WORKSHEET #17: SAMPLING DESIGN AND RATIONALE

(UFP-QAPP Manual Section 3.1.1)

General Approach

The descriptions below provide an overview of the monitoring rationale for AOC A and the SWMU 15 investigation. Groundwater is the media of concern and the sampling approach was developed in accordance with the Navy, USEPA, and TDEC DSWM data requirements. Low to moderate concentrations are anticipated based on historical data.

The **AOC A** groundwater populations of interest include:

- Sub-Plumes A through D TCE source areas.
- Downgradient of the TCE source areas to evaluate natural attenuation/biodegradation of daughter products cis-1,2-DCE and vinyl chloride (VC).
- Offsite monitoring wells to evaluate plume stability and effects of remedy optimization.
- SWMUs where low level VOC concentrations are undergoing natural attenuation (SWMUs 5, 15, 18, 21, N-12, and background cluster BG05).
- Three new on-site monitoring wells — Three new middle fluvial monitoring wells will be placed at Sub-Plume D (Figure 5B) to monitor the downgradient groundwater following the proposed groundwater injections at Sub-Plume D. In light of the proposed conversion of monitoring wells PESMW-8D, PESMW-8S, 007G85MF, and 007G86MF into injection wells, the nearest downgradient monitoring wells (007G24MF, 007G25MF, 007G26MF) are 500 feet away. The BCT decided the three additional wells were necessary nearer the treatment areas to better monitor the remedy effectiveness.
- Two off-site monitoring wells — The BCT decided two additional off-site monitoring wells were necessary to monitor the increases in VOC concentrations in offsite well 007G52LF, located upgradient of the two proposed wells. Monitoring wells will be placed in the lower fluvial deposits at locations shown on Figure 5C which are hydraulically downgradient of the 007G52LF.

The **SWMU 15** groundwater populations of interest include:

- Natural attenuation of benzene in groundwater at 015G01UF

- Areas hydraulically upgradient of well 015G01UF to evaluate residual source areas and collect remedial design data

Sample Locations and Numbers

- **AOC A** groundwater sample locations are shown on Figure 5D and 5E in Appendix A. Monitoring wells will be sampled for VOCs with a subset being sampled for sulfate, chloride, iron, total organic carbon, hydrogen, methane, ethane, and ethene. The list of wells, analyses, sample frequency, and IDs are provided in Worksheets #18, 19, 20, and 30.

- **SWMU 15** groundwater sample locations are shown on Figure 6 in Appendix A. Nine locations will be sampled with three grab groundwater samples collected with DPT methods from each location to vertically profile COCs in groundwater upgradient of well 015G01UF. Groundwater samples will be analyzed for VOCs with a subset of samples being analyzed for sulfate, nitrate/nitrite, iron, manganese, biological oxygen demand, chemical oxygen demand, TN GRO, and EPH. The sample analyses and IDs are provided in Worksheets #18, 19, 20, and 30.

Sampling Frequency

- **AOC A** groundwater samples will be collected semi-annually and annually from select pre-existing monitoring wells.

- **SWMU 15** — A single DPT sampling event is assumed adequate for defining the extent of petroleum impacts upgradient of well 015G01UF.

Monitoring Optimization

AOC A LTM data will be evaluated annually for remedy effectiveness and any adjustments in the monitoring plan. Possible monitoring adjustments may include sampling frequency, discontinued monitoring of select wells, recommendations for well abandonment, and addition of new monitoring wells. The steps that will be taken for data evaluation and monitoring optimization include:

- Compare AOC A semi-annual and annual data with historical data to evaluate changes in VOC concentrations and plume size/shape.

- Evaluate VOC variability against water level and MNA data to evaluate causal effects for any trends.

- Provide rationale for any well closure recommendations including historical VOC data, trend analyses, plume/potentiometric maps and any supporting data to support TDEC DSWM approval and concurrence.

- Discuss VOC trends with Project Team and any proposed adjustments in sampling frequencies, addition/removal of monitoring wells, and whether supplemental IMs should be considered.

- Evaluate any revised sampling strategy with DQOs.

SAP WORKSHEETS #18, 19, 20, AND 30: LOCATION-SPECIFIC SAMPLING METHODS/SOP REQUIREMENTS TABLE

(UFP-QAPP Manual Sections 3.1.1 and 3.5.2.3)

Field Project Implementation (Field Project Instructions)

Sample Details													
NSA Mid-South CTO JM02, AOC A							**Analysis Group**	**VOCs**	**Sulfate/Chloride**	**Iron**	**TOC**	**Hydrogen**	**Methane, Ethane, Ethene**
Groundwater Monitoring							**Preparation and Analytical Method**	SW846 5030/8260B	USEPA 300.0	SW846 3005A/6010B	SW846 9060A	AM20GAX	AM20GAX
							Analytical Laboratory SOP Reference	SOP 202	SOP 145	SOP 105	SOP 221	AM20GAX	AM20GAX
Semi-Annual and Annual Monitoring							**Data Package Turnaround Time**	21 days	21 days	21 days	21 days	21 days	21 days
Laboratories							**Container Type/ Volume required**	3 — 40 mL glass vials	1 — 250 mL poly	1 — 250 mL poly	1 — 250 mL poly	1 — 20 mL glass, stopper septa	2 — 40 mL glass vials
Empirical Laboratories, LLC, 621 Mainstream Drive, Suite 270, Nashville, Tennessee 37228, (615) 345-1115, Sonya Gordon, sgordon@empirlabs.com							**Preservative**	HCL to pH <2; Cool to ≤ 6C; no headspace	Cool to ≤6C	HNO3 to pH <2	HCL or H2SO4 to pH<2; Cool to ≤ 6C	None	Cool to ≤6C
Microseeps, Inc. (Hydrogen, Methane, Ethane, Ethene), 220 William Pitt Way, Pittsburgh, Pennsylvania 15238, (412) 826-5245, Ryan Rylands, rrylands@microseeps.com							**Holding Time (Preparation/Analysis)[1]**	14 days to analysis	28 days	6 months	28 days	14 days to analysis	14 days to analysis
Site	**Matrix**	**Well ID**	**Sample ID {Well ID-Quarter}**	**Coordinates X**	**Coordinates Y**	**Semi-Annual[2]**	**Depth/Sampling Interval (ft bgs)**						
AOC A	Groundwater	005G04UF	005G04UF-3Q11	811602	389976		52	1					
AOC A	Groundwater	005G08LF	005G08LF-3Q11	811522	390004		75	1					
AOC A	Groundwater	007G01LF	007G01LF-3Q11	813658	391814		72	1					
AOC A	Groundwater	007G01UF	007G01UF-3Q11	813655	391820		42	1					
AOC A	Groundwater	007G03LF	007G03LF-3Q11	813897	391936	Y	81	2					
AOC A	Groundwater	007G04LF	007G04LF-3Q11	813773	392183	Y	70	2					
AOC A	Groundwater	007G04UF	007G04UF-3Q11	813777	392176		48	1					
AOC A	Groundwater	007G05LF	007G05LF-3Q11	813333	392052		79	1					
AOC A	Groundwater	007G06LF	007G06LF-3Q11	813821	391482		81	1					
AOC A	Groundwater	007G09UF	007G09UF-3Q11	813448	391866		46	1					
AOC A	Groundwater	007G09LF	007G09LF-3Q11	813445	391872		81	1					
AOC A	Groundwater	007G10LF	007G10LF-3Q11	813702	393099		78	1					
AOC A	Groundwater	007G11LF	007G11LF-3Q11	813820	392805	Y	70	2					
AOC A	Groundwater	007G12LF	007G12LF-3Q11	814738	393056		90	1					
AOC A	Groundwater	007G15LF	007G15LF-3Q11	814961	392221		100	1	1	1	1	1	1
AOC A	Groundwater	007G16LF	007G16LF-3Q11	814104	391872		80	1					
AOC A	Groundwater	007G18LF	007G18LF-3Q11	812726	392223		100	1					
AOC A	Groundwater	007G21LF	007G21LF-3Q11	813673	392560	Y	75	2	2	2	2	2	2
AOC A	Groundwater	007G22LF	007G22LF-3Q11	813906	392658	Y	76	2					
AOC A	Groundwater	007G23LF	007G23LF-3Q11	814087	392728		82	1					
AOC A	Groundwater	007G24MF	007G24MF-3Q11	814611	392816		70	1					
AOC A	Groundwater	007G25MF	007G25MF-3Q11	814790	392888		81	1					

Sample Details

NSA Mid-South CTO JM02, AOC A	Analysis Group	VOCs	Sulfate/Chloride	Iron	TOC	Hydrogen	Methane, Ethane, Ethene
Groundwater Monitoring	**Preparation and Analytical Method**	SW846 5030/8260B	USEPA 300.0	SW846 3005A/6010B	SW846 9060A	AM20GAX	AM20GAX
	Analytical Laboratory SOP Reference	SOP 202	SOP 145	SOP 105	SOP 221	AM20GAX	AM20GAX
Semi-Annual and Annual Monitoring	**Data Package Turnaround Time**	21 days	21 days	21 days	21 days	21 days	21 days
Laboratories	**Container Type/ Volume required**	3 — 40 mL glass vials	1 — 250 mL poly	1 — 250 mL poly	1 — 250 mL poly	1 — 20 mL glass, stopper septa	2 — 40 mL glass vials
Empirical Laboratories, LLC, 621 Mainstream Drive, Suite 270, Nashville, Tennessee 37228, (615) 345-1115, Sonya Gordon, sgordon@empirlabs.com	**Preservative**	HCL to pH <2; Cool to ≤ 6C; no headspace	Cool to ≤6C	HNO3 to pH <2	HCL or H2SO4 to pH<2; Cool to ≤ 6C	None	Cool to ≤6C
Microseeps, Inc. (Hydrogen, Methane, Ethane, Ethene), 220 William Pitt Way, Pittsburgh, Pennsylvania 15238, (412) 826-5245, Ryan Rylands, rrylands@microseeps.com	**Holding Time (Preparation/Analysis)[1]**	14 days to analysis	28 days	6 months	28 days	14 days to analysis	14 days to analysis

Site	Matrix	Well ID	Sample ID {Well ID-Quarter}	Coordinates X	Coordinates Y	Semi-Annual[2]	Depth/Sampling Interval (ft bgs)						
AOC A	Groundwater	007G26MF	007G26MF-3Q11	814923	392954		70	1					
AOC A	Groundwater	007G28LF	007G28LF-3Q11	813467	393310	Y	80	2					
AOC A	Groundwater	007G29LF	007G29LF-3Q11	813594	393384	Y	80	2					
AOC A	Groundwater	007G31LF	007G31LF-3Q11	813333	393234	Y	78	2					
AOC A	Groundwater	007G32LF	007G32LF-3Q11	813604	392699	Y	78	2					
AOC A	Groundwater	007G33LF	007G33LF-3Q11	813206	392912		85	1					
AOC A	Groundwater	007G35LF	007G35LF-3Q11	812924	393736		91	1					
AOC A	Groundwater	007G36LF	007G36LF-3Q11	812748	393592		92	1					
AOC A	Groundwater	007G37LF	007G37LF-3Q11	812575	393714		91	1					
AOC A	Groundwater	007G38LF	007G38LF-3Q11	812593	393399		88	1					
AOC A	Groundwater	007G41LF	007G41LF-3Q11	812368	393876		93	1					
AOC A	Groundwater	007G42LF	007G42LF-3Q11	811565	394573	Y	85	2					
AOC A	Groundwater	007G45LF	007G45LF-3Q11	811901	394932	Y	83	2					
AOC A	Groundwater	007G48LF	007G48LF-3Q11	812942	396175	Y	113	2					
AOC A	Groundwater	007G49LF	007G49LF-3Q11	814783	392931		98	1					
AOC A	Groundwater	007G52LF	007G52LF-3Q11	812022	395738	Y	85	2	2	2	2	2	2
AOC A	Groundwater	007G53LF	007G53LF-3Q11	812124	396195	Y	78	2					
AOC A	Groundwater	007G54LF	007G54LF-3Q11	812878	392837		85	1					
AOC A	Groundwater	007G55LF	007G55LF-3Q11	810649	398360		105	1					
AOC A	Groundwater	007G56LF	007G56LF-3Q11	811100	398282		115	1					
AOC A	Groundwater	007G57LF	007G57LF-3Q11	813751	392232	Y	75	2					
AOC A	Groundwater	007G58LF	007G58LF-3Q11	813775	392158	Y	80	2					
AOC A	Groundwater	007G59LF	007G59LF-3Q11	813790	392164	Y	75	2					
AOC A	Groundwater	007G60LF	007G60LF-3Q11	813797	392114		85	1	1	1	1	1	1
AOC A	Groundwater	007G61LF	007G61LF-3Q11	813813	392122		75	1					

Sample Details

NSA Mid-South CTO JM02, AOC A	Analysis Group	VOCs	Sulfate/Chloride	Iron	TOC	Hydrogen	Methane, Ethane, Ethene
Groundwater Monitoring	**Preparation and Analytical Method**	SW846 5030/8260B	USEPA 300.0	SW846 3005A/6010B	SW846 9060A	AM20GAX	AM20GAX
	Analytical Laboratory SOP Reference	SOP 202	SOP 145	SOP 105	SOP 221	AM20GAX	AM20GAX
Semi-Annual and Annual Monitoring	**Data Package Turnaround Time**	21 days	21 days	21 days	21 days	21 days	21 days
Laboratories	**Container Type/ Volume required**	3 — 40 mL glass vials	1 — 250 mL poly	1 — 250 mL poly	1 — 250 mL poly	1 — 20 mL glass, stopper septa	2 — 40 mL glass vials
Empirical Laboratories, LLC, 621 Mainstream Drive, Suite 270, Nashville, Tennessee 37228, (615) 345-1115, Sonya Gordon, sgordon@empirlabs.com	**Preservative**	HCL to pH <2; Cool to ≤ 6C; no headspace	Cool to ≤6C	HNO3 to pH <2	HCL or H2SO4 to pH<2; Cool to ≤ 6C	None	Cool to ≤6C
Microseeps, Inc. (Hydrogen, Methane, Ethane, Ethene), 220 William Pitt Way, Pittsburgh, Pennsylvania 15238, (412) 826-5245, Ryan Rylands, rrylands@microseeps.com	**Holding Time (Preparation/Analysis)[1]**	14 days to analysis	28 days	6 months	28 days	14 days to analysis	14 days to analysis

Site	Matrix	Well ID	Sample ID {Well ID-Quarter}	Coordinates X	Coordinates Y	Semi-Annual[2]	Depth/Sampling Interval (ft bgs)						
AOC A	Groundwater	007G62LF	007G62LF-3Q11	813795	392125	Y	75	2					
AOC A	Groundwater	007G63LF	007G63LF-3Q11	813807	392130	Y	75	2					
AOC A	Groundwater	007G64LF	007G64LF-3Q11	813740	392220	Y	77	2					
AOC A	Groundwater	007G65LF	007G65LF-3Q11	813692	392333	Y	77	2	2	2	2	2	2
AOC A	Groundwater	007G66LF	007G66LF-3Q11	813777	392137	Y	78	2					
AOC A	Groundwater	007G69LF	007G69LF-3Q11	813899	392691	Y	78	2					
AOC A	Groundwater	007G71LF	007G71LF-3Q11	813612	392535	Y	78	2	2	2	2	2	2
AOC A	Groundwater	007G87LF	007G87LF-3Q11	813565	392649	Y	83	2					
AOC A	Groundwater	007G88LF	007G88LF-3Q11	813647	392689		78	1					
AOC A	Groundwater	007G89LF	007G89LF-3Q11	813729	392733		73	1					
AOC A	Groundwater	007G90LF	007G90LF-3Q11	813808	392772		73	1					
AOC A	Groundwater	007G91LF	007G91LF-3Q11	813885	392812		74	1					
AOC A	Groundwater	007G92LF	007G92LF-3Q11	813497	393043	Y	79	2	2	2	2	2	2
AOC A	Groundwater	007GPZ03	007GPZ03-3Q11	812309	395402	Y	85	2					
AOC A	Groundwater	015G01LF	015G01LF-3Q11	812901	391853	Y	85	2					
AOC A	Groundwater	015G01UF	015G01UF-3Q11	812908	391856	Y	50	2					
AOC A	Groundwater	015G02LF	015G02LF-3Q11	813106	391549		85	1					
AOC A	Groundwater	015G02UF	015G02UF-3Q11	813100	391544		46	1					
AOC A	Groundwater	015G03LF	015G03LF-3Q11	812773	391350		88	1					
AOC A	Groundwater	015G04LF	015G04LF-3Q11	812723	391770		96	1					
AOC A	Groundwater	018G01LF	018G01LF-3Q11	814583	391519		93	1					
AOC A	Groundwater	PESGMW1D	PESGMW1D-3Q11	815062	392116		80	1					
AOC A	Groundwater	PESGMW1S	PESGMW1S-3Q11	815062	392116		55	1					
AOC A	Groundwater	PESGMW2S	PESGMW2S-3Q11	815038	392229	Y	65	2	2	2	2	2	2
AOC A	Groundwater	PESGMW2D	PESGMW2D-3Q11	815038	392229	Y	85	2	2	2	2	2	2

Sample Details

NSA Mid-South CTO JM02, AOC A							Analysis Group	VOCs	Sulfate/Chloride	Iron	TOC	Hydrogen	Methane, Ethane, Ethene
Groundwater Monitoring							**Preparation and Analytical Method**	SW846 5030/8260B	USEPA 300.0	SW846 3005A/6010B	SW846 9060A	AM20GAX	AM20GAX
							Analytical Laboratory SOP Reference	SOP 202	SOP 145	SOP 105	SOP 221	AM20GAX	AM20GAX
Semi-Annual and Annual Monitoring							**Data Package Turnaround Time**	21 days	21 days	21 days	21 days	21 days	21 days
Laboratories							**Container Type/ Volume required**	3 — 40 mL glass vials	1 — 250 mL poly	1 — 250 mL poly	1 — 250 mL poly	1 — 20 mL glass, stopper septa	2 — 40 mL glass vials
Empirical Laboratories, LLC, 621 Mainstream Drive, Suite 270, Nashville, Tennessee 37228, (615) 345-1115, Sonya Gordon, sgordon@empirlabs.com							**Preservative**	HCL to pH <2; Cool to ≤ 6C; no headspace	Cool to ≤6C	HNO3 to pH <2	HCL or H2SO4 to pH<2; Cool to ≤ 6C	None	Cool to ≤6C
Microseeps, Inc. (Hydrogen, Methane, Ethane, Ethene), 220 William Pitt Way, Pittsburgh, Pennsylvania 15238, (412) 826-5245, Ryan Rylands, rrylands@microseeps.com							**Holding Time (Preparation/Analysis)[1]**	14 days to analysis	28 days	6 months	28 days	14 days to analysis	14 days to analysis
Site	**Matrix**	**Well ID**	**Sample ID {Well ID-Quarter}**	**Coordinates X**	**Coordinates Y**	**Semi-Annual[2]**	**Depth/Sampling Interval (ft bgs)**						
AOC A	Groundwater	PESGMW3S	PESGMW3S-3Q11	815052	392235	Y	55	2	2	2	2	2	2
AOC A	Groundwater	PESGMW3D	PESGMW3D-3Q11	815052	392235	Y	75	2	2	2	2	2	2
AOC A	Groundwater	0BGG05LF	0BGG05LF-3Q11	810278	389929		78	1					
AOC A	Groundwater	0BGG05UF	0BGG05UF-3Q11	810291	389931		55	1					
AOC A	Groundwater	021G03LF	021G03LF-3Q11	814804	391671		88	1					
AOC A	Groundwater	021G04UF	021G04UF-3Q11	814863	391696		50	1					
AOC A	Groundwater	N12G02LF	N12G02LF-3Q11	813376	391678		85	1					
AOC A	Groundwater	N12G01LF	N12G01LF-3Q11	813738	391627		87	1					
Proposed Wells													
AOC A	Groundwater	007G93LF	007G93LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G94LF	007G94LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G95LF	007G95LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G96LF	007G96LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G97LF	007G97LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G98LF	007G98LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G99LF	007G99LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G100LF	007G100LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G101MF	007G101LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G102MF	007G102LF-3Q11	Perimeter	Perimeter	Y [4]	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G103MF	007G103MF-3Q11	Plume D	Plume D	Y	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G104MF	007G104MF-3Q11	Plume D	Plume D	Y	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G105MF	007G105MF-3Q11	Plume D	Plume D	Y	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G106MF	007G106MF-3Q11	Offsite	Offsite	Y	TBD	2	2	2	2	2	2
AOC A	Groundwater	007G107MF	007G107MF-3Q11	Offsite	Offsite	Y	TBD	2	2	2	2	2	2

Sample Details

NSA Mid-South CTO JM02, AOC A	Analysis Group	VOCs	Sulfate/Chloride	Iron	TOC	Hydrogen	Methane, Ethane, Ethene
	Preparation and Analytical Method	SW846 5030/8260B	USEPA 300.0	SW846 3005A/6010B	SW846 9060A	AM20GAX	AM20GAX
Groundwater Monitoring	**Analytical Laboratory SOP Reference**	SOP 202	SOP 145	SOP 105	SOP 221	AM20GAX	AM20GAX
Semi-Annual and Annual Monitoring	**Data Package Turnaround Time**	21 days	21 days	21 days	21 days	21 days	21 days
Laboratories	**Container Type/ Volume required**	3 — 40 mL glass vials	1 — 250 mL poly	1 — 250 mL poly	1 — 250 mL poly	1 — 20 mL glass, stopper septa	2 — 40 mL glass vials
Empirical Laboratories, LLC, 621 Mainstream Drive, Suite 270, Nashville, Tennessee 37228, (615) 345-1115, Sonya Gordon, sgordon@empirlabs.com	**Preservative**	HCL to pH <2; Cool to ≤ 6C; no headspace	Cool to ≤6C	HNO3 to pH <2	HCL or H2SO4 to pH<2; Cool to ≤ 6C	None	Cool to ≤6C
Microseeps, Inc. (Hydrogen, Methane, Ethane, Ethene), 220 William Pitt Way, Pittsburgh, Pennsylvania 15238, (412) 826-5245, Ryan Rylands, rrylands@microseeps.com	**Holding Time (Preparation/Analysis)[1]**	14 days to analysis	28 days	6 months	28 days	14 days to analysis	14 days to analysis

Site	Matrix	Well ID	Sample ID {Well ID-Quarter}	Coordinates X	Coordinates Y	Semi-Annual[2]	Depth/Sampling Interval (ft bgs)						
Field Quality Control Samples													
AOC A	Field Duplicate		TBD	NA	NA	Y	NA	12	2	2	2	2	2
AOC A	Matrix Spike		TBD[5]	NA	NA	Y	NA	8					
AOC A	Matrix Spike Duplicate		TBD[5]	NA	NA	Y	NA	8					
AOC A	Equipment Blank		EBMMDDYY	NA	NA	Y	NA	5					
AOC A	Trip Blank		TBMMDDYY	NA	NA	Y	NA	20					
							Total Number of Samples to the Laboratory	181	50	50	50	50	50

Notes:
For field quality control sample scoping, the semiannual event is anticipated to last two weeks; annual event is expected to last four weeks
Frequency of field QC sample collection (limited to primary volatile analysis):

- Field Duplicate — One per 10 field samples
- Matrix spike/matrix spike duplicate — One pair per 20 field samples (including field QC samples)
- Trip Blank — One per cooler to the laboratory containing volatiles
- Equipment Blank — One per week of sampling

AOC A = Area of Concern A
C = Celsius
CTO = contract task order
HCL = hydrochloric acid
NA = Not applicable
NSA = Naval Support Activity
SOP = Standard operating procedure
TBD = To be determined
TOC = Total organic carbon
USEPA = United States Environmental Protection Agency
VOCs = volatile organic compounds

[1] Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted
[2] Several wells will be collected both annually and semi-annually, as denoted by Y (Yes)
[3] Coordinates to be determined in the field
[4] Wells will be sampled for two events (baseline and semi-annual) followed with conversion to injection wells
[5] Samples used for matrix spike/matrix spike duplicates will be determined in the field and will use the same sample ID appended with an MS or MSD

Field Project Implementation (Field Project Instructions), continued

Sample Details

NSA Mid-South CTO JM02, AOC A						Analysis Group	VOCs	Sulfate	Nitrate / Nitrate (as N)	Iron and Manganese[1]	BOD	COD	TN GRO	TN EPH
SWMU 15 DPT Investigation						Preparation and Analytical Method	SW846 5030/ 8260B	USEPA 300.0	USEPA 300.0	SW846 3005A/6010B	SM 5210B	USEPA 410.4	TN GRO	TN EPH
						Analytical Laboratory SOP Reference	SOP 202	SOP 145	SOP 145	SOP 105	SOP 169	SOP 163	SOP 219	SOP 219
						Data Package Turnaround Time	21 Days	21 Days	21 Days	21 Days	21 Days	21 Days	21 Days	21 Days
Laboratories						Container Type/ Volume required	3 — 40mL glass vials	1 — 250mL poly		1 — 250mL poly	1 — 500mL	1 — 250mL poly	3 — 40mL VOC Vials	2 x 1L
Empirical Laboratories, LLC, 621 Mainstream Drive, Suite 270, Nashville, Tennessee 37228, (615) 345-1115, Sonya Gordon, sgordon@empirlabs.com						Preservative	HCL to pH <2; Cool to ≤ 6C; no headspace	Cool to ≤ 6C	Cool to ≤ 6C	HNO3 to pH <2	Cool to ≤ 6C	H2SO4 to pH <2; Cool to ≤ 6C	HCL to pH <2; Cool to ≤ 6C; no headspace	HCL or H2SO4 to pH <2; Cool to ≤ 6C
Microseeps, Inc. (Hydrogen, Methane, Ethane, Ethene), 220 William Pitt Way, Pittsburgh, Pennsylvania 15238, (412) 826-5245, Ryan Rylands rrylands@microseeps.com						Holding Time (Preparation/ Analysis)[2]	14 days to analysis	28 Days	48 hours	6 months	48 hours	28 Days	14 days to analysis	7 Days to Extraction/ 40 Days to Analysis
Site	Matrix	Station ID	Sample ID[3]	Coordinates X	Coordinates Y	Depth/Sampling Intervals (ft/bgs)								
SWMU15	Groundwater	015GDPT01	015GDPT01[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT01	015GDPT01[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT01	015GDPT01[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT02	015GDPT02[depth]	TBD[4]	TBD[4]	TBD[4]	1	1	1	1	1	1	1	1
SWMU15	Groundwater	015GDPT02	015GDPT02[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT02	015GDPT02[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT03	015GDPT03[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT03	015GDPT03[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT03	015GDPT03[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT04	015GDPT04[depth]	TBD[4]	TBD[4]	TBD[4]	1	1	1	1	1	1	1	1
SWMU15	Groundwater	015GDPT04	015GDPT04[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT04	015GDPT04[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT05	015GDPT05[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT05	015GDPT05[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT05	015GDPT05[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT06	015GDPT06[depth]	TBD[4]	TBD[4]	TBD[4]	1	1	1	1	1	1	1	1
SWMU15	Groundwater	015GDPT06	015GDPT06[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT06	015GDPT06[depth]	TBD[4]	TBD[4]	TBD[4]	1							

Field Project Implementation (Field Project Instructions), continued

Sample Details														
NSA Mid-South CTO JM02, AOC A						**Analysis Group**	**VOCs**	**Sulfate**	**Nitrate / Nitrate (as N)**	**Iron and Manganese[1]**	**BOD**	**COD**	**TN GRO**	**TN EPH**
SWMU 15 DPT Investigation						**Preparation and Analytical Method**	SW846 5030/ 8260B	USEPA 300.0	USEPA 300.0	SW846 3005A/6010B	SM 5210B	USEPA 410.4	TN GRO	TN EPH
						Analytical Laboratory SOP Reference	SOP 202	SOP 145	SOP 145	SOP 105	SOP 169	SOP 163	SOP 219	SOP 219
						Data Package Turnaround Time	21 Days	21 Days	21 Days	21 Days	21 Days	21 Days	21 Days	21 Days
Laboratories						**Container Type/ Volume required**	3 — 40mL glass vials	1 — 250mL poly		1 — 250mL poly	1 — 500mL	1 — 250mL poly	3 — 40mL VOC Vials	2 x 1L
Empirical Laboratories, LLC, 621 Mainstream Drive, Suite 270, Nashville, Tennessee 37228, (615) 345-1115, Sonya Gordon, sgordon@empirlabs.com						**Preservative**	HCL to pH <2; Cool to ≤ 6C; no headspace	Cool to ≤ 6C	Cool to ≤ 6C	HNO3 to pH <2	Cool to ≤ 6C	H2SO4 to pH <2; Cool to ≤ 6C	HCL to pH <2; Cool to ≤ 6C; no headspace	HCL or H2SO4 to pH <2; Cool to ≤ 6C
Microseeps, Inc. (Hydrogen, Methane, Ethane, Ethene), 220 William Pitt Way, Pittsburgh, Pennsylvania 15238, (412) 826-5245, Ryan Rylands rrylands@microseeps.com						**Holding Time (Preparation/ Analysis)[2]**	14 days to analysis	28 Days	48 hours	6 months	48 hours	28 Days	14 days to analysis	7 Days to Extraction/ 40 Days to Analysis
Site	**Matrix**	**Station ID**	**Sample ID[3]**	**Coordinates X**	**Coordinates Y**	**Depth/Sampling Intervals (ft/bgs)**								
SWMU15	Groundwater	015GDPT07	015GDPT07[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT07	015GDPT07[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT07	015GDPT07[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT08	015GDPT08[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT08	015GDPT08[depth]	TBD[4]	TBD[4]	TBD[4]	1	1	1	1	1	1	1	1
SWMU15	Groundwater	015GDPT08	015GDPT08[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT09	015GDPT09[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT09	015GDPT09[depth]	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Groundwater	015GDPT09	015GDPT09[depth]	TBD[4]	TBD[4]	TBD[4]	1							
Field Quality Control Samples														
SWMU15	Field Duplicate	TBD	TBD	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Field Duplicate	TBD	TBD	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Field Duplicate	TBD	TBD	TBD[4]	TBD[4]	TBD[4]	1							
SWMU15	Matrix Spike		TBD[5]			NA	2							
SWMU15	Matrix Spike Duplicate		TBD[5]			NA	2							
SWMU15	Equipment Blank		EBMMDDYY			NA	1							
SWMU15	Trip Blank		TBMMDDYY			NA	3							
Total Number of Samples to the Laboratory							39	4	4	4	4	4	4	4

Notes:
For field quality control sample scoping, the sampling event is anticipated to last three days
Sample identified for field duplicates, geochemical, and biological samples may change in the field
Frequency of QA/QC sample collection (limited to primary volatile analysis):

- Field Duplicate — One per 10 field samples
- Matrix spike/matrix spike duplicate — One pair per 20 field samples (including field QC samples)

- Trip Blank — One per cooler to the laboratory containing volatiles
- Equipment Blank — One per week of sampling

AOC A = Area of Concern A
BOD = Biochemical oxygen demand
COD = Chemical oxygen demand
C = Celsius
CTO = contract task order
ft bgs = Feet below ground surface
HCL = hydrochloric acid
HNO_3 = nitric acid
H_2SO_4 = sulfuric acid
NA = Not applicable
mL = milliliter
NSA = Naval Support Activity
Poly = polyethylene
SM = Standard Methods
SOP = Standard operating procedure
TBD = To be determined
TN EPH = Tennessee Extractable Petroleum Hydrocarbons
TN GRO = Tennessee Gasoline Range Organic
USEPA = United States Environmental Protection Agency
VOC = volatile organic compounds

[1] Manganese will be analyzed as both total and dissolved (laboratory-filtered) fractions. The laboratory-filtered aliquot will not be preserved in the field
[2] Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted
[3] Sample ID will be the station ID and the bottom depth, to be determined in the field. Example: 015GDPT0155 (015GDPT01 at 55 feet)
[4] Coordinates and sample depths will be determined in the field
[5] Samples used for matrix spike/matrix spike duplicates will be determined in the field and will use the same sample ID appended with an MS or MSD

SAP WORKSHEET #21: PROJECT SAMPLING SOP REFERENCES TABLE

(UFP-QAPP Manual Section 3.1.2)

Field SOPs Reference Table					
SOP Reference Number	**Title/Author**	**Revision Date or Version Number**	**Location of SOP**	**Any planned deviation for Project Work**	**Comments**
SOP-3-01	Utility Clearance/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-02	Field Log Books/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-03 (MS)	Sample Labeling and Chain of Custody/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-04 (MS)	Packaging and Shipping Procedures for Low Concentration Samples/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-05 (MS)	Investigative Derived Waste Management/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-6	Equipment Decontamination/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-08 (MS)	Soil Classification/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-12 (MS)	Rotosonic Well Installation/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-14 (MS)	Monitoring Well Sampling/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-17	Water Quality Parameter Testing for Groundwater Sampling/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-18 (MS)	Direct Push Sampling Techniques/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-3-19 (MS)	Substrate Injection/Resolution Consultants	Revision 0; May 2012	Appendix B	No	
SOP-SM 9	Collection of Dissolved Gases from Water Using the "Bubble Strip" Sampling Technique at the Well Site/Microseeps, Inc.	Version 6; March 2012	Appendix B	No	

SAP WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION TABLE

(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Activity[1]	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference	Comments
Electronic Water Level Indicator	Visual Inspection Field checks as per manufacturer	Daily Once upon receiving from vendor or company stock	0.01 foot accuracy	Operator correction or replacement	Resolution Consultants FTL	NA	None
YSI 556 Series (or similar) Multi-Parameter Water Quality Meter	Visual Inspection Calibration/Verification	Daily Beginning of each day	pH ± 0.2 standard units Specific Conductance ± 5% Dissolved oxygen ± 0.03 mg/L Temperature ±0.15 C Oxygen reduction potential ± 10 mV	Operator correction or replacement	Resolution Consultants FTL	3-17	None
LaMotte Model 2020e (or similar) Turbidity Meter	Visual Inspection Calibration/Verification	Daily Beginning of each day	Nephelometric Turbidity Unit <10	Operator correction or replacement	Resolution Consultants FTL	3-17	None
Spectrophotometer Hach DR/4000 (or similar)	Visual Inspection Calibration/Verification	Daily Beginning of each day and as required for each test	Measurement within the calibration range for each stored procedure	Operator correction, replacement, or sample dilution	Resolution Consultants FTL	3-17	None

Notes:

1 = Activities may include calibration, verification, testing, maintenance, and/or inspection.
FTL = Field Team Leader
% = percent
mg/L = milligrams per liter
C = degrees Celsius
mV = millivolts

SAP WORKSHEET #23: ANALYTICAL SOP REFERENCES TABLE

(UFP-QAPP Manual Section 3.2.1)

Analytical SOP References Table

Empirical Laboratories, LLC
621 Mainstream Drive, Suite 270
Nashville, Tennessee 37228
Sonya Gordon (615) 345-1115

Lab SOP Number	Title, Revision Date, and Number	Definitive or Screening Data	Analytical Group and Matrix	Instrument	Variance to QSM	Modified for Project Work? (Y/N)
Empirical SOP202	*GC/MS Volatiles by EPA Method 624 & SW846 Method 8260B Including Appendix IX Compounds*, Rev23 09/13/2011	Definitive	VOCs — Groundwater and QC blanks	Agilent GC/MS	None	N
Empirical SOP219	*Gas Chromatography/Flame Ionization Detector (GC/FID) Nonhalogenated Volatile Organics and Total Petroleum Hydrocarbons (TPH) by Method 8015B/8015C/TN EPH/GRO*, Rev15 08/22/2011	Definitive	TN GRO — Groundwater	GC/FID	None	N
Empirical SOP219	*Gas Chromatography/Flame Ionization Detector (GC/FID) Nonhalogenated Volatile Organics and Total Petroleum Hydrocarbons (TPH) by Method 8015B/8015C/TN EPH/GRO*, Rev15 08/22/2011	Definitive	TN EPH — Groundwater	GC/FID	None	N
Empirical SOP145	*Determination of Inorganic Anions in water by ION Chromatograph using the Dionex dx-500 Ion Chromatograph with Hydroxide Eluent And Dionex AS18 Column, USEPA Method 300.0/SW846 Method 9056*, Rev8 05/16/2011	Definitive [1]	Sulfate, Chloride, Nitrate (as N), Nitrite (as N) — Groundwater	IC	None	N
Empirical SOP100	*Metals Digestion/Preparation Methods 3005A/USEPA CLPILM0 4.1 Aqueous, 3010A, 3030C, 3050B, USEPA CLPILM0 4.1 (Soil/Sediment), 200.7, Standard Methods 3030C 21st See Addendum for USEPA CLPILM 05.2 (Aqueous & Soil/Sediment)*, Rev22 11/17/2010	Definitive [1]	Iron, Manganese — Groundwater	Preparative	None	N
Empirical SOP105	*Metals by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-ACS) Technique References: SW-846, Method 6010B, December 1996; SW-846, Method 6010C, Revision 3 February 2007; USEPA, Method 200.7, June 1991; Standard Methods 19th Edition 2340B; 1995 USEPA CLP, ILM 04.1. See Addendum for USEPA CLPILM 05.2*, Rev17 05/16/2011	Definitive [1]	Iron, Manganese — Groundwater	ICP-AES	None	N

Analytical SOP References Table

Empirical Laboratories, LLC
621 Mainstream Drive, Suite 270
Nashville, Tennessee 37228
Sonya Gordon (615) 345-1115

Lab SOP Number	Title, Revision Date, and Number	Definitive or Screening Data	Analytical Group and Matrix	Instrument	Variance to QSM	Modified for Project Work? (Y/N)
Empirical SOP221	*Total Organic Carbon (TOC) by SM5310C, SW846 Method 9060/9060A and Lloyd Kahn Method "Determination of TOC in Sediment"*, Rev10 08/22/2011	Definitive [1]	TOC — Groundwater	TOC Analyzer	None	N
Empirical SOP169	*Biochemical Oxygen Demand (BOD) & Carbonaceous Biological Oxygen Demand(CBOD), by EPA Method 405.1 (5 days, 20°C)*, Rev12 10/31/2011	Definitive [1]	BOD — Groundwater	BOD meter	None	N
Empirical SOP163	*Chemical Oxygen Demand (High Level) by EPA Method 410.4 (Colorimetric, Manual)*, Rev8 08/22/2011	Definitive [1]	COD — Groundwater	Spectrophotometer	None	N

Notes:

[1] Analytical procedure produces definitive results; however, the end use of the data will be screening level to assess remedial effectiveness

SOP = Standard operating procedure
QSM = *Department of Defense Quality Systems Manual for Environmental Laboratories*, Version 4.2, October 2010
Y/N = Yes/No
VOC = Volatile organic compounds
QC = Quality control
GC/MS = Gas chromatography/mass spectrometer
TN GRO = Tennessee gasoline range organics method
GC/FID = Gas chromatography/flame ionization detector
TN EPH = Tennessee extractable range organics method
N = Nitrogen
IC = Ion chromatography
ICP-AEC = Inductivity coupled plasma-atomic emission spectrometry
TOC = Total organic carbon
BOD = Biochemical oxygen demand
COD = Chemical oxygen demand

Microseeps, Inc. **220 William Pitt Way, Pittsburgh, Pennsylvania** **Ryan Rylands (412) 826-5245**						
Lab SOP Number	**Title, Revision Date, and Number**	**Definitive or Screening Data**	**Analytical Group and Matrix**	**Instrument**	**Variance to QSM**	**Modified for Project Work? (Y/N)**
Microseeps SOP-AM20GAX	*Analytical Method AM20GAX Standard Operating Procedure for the Analysis of Biodegradation Indicator Gases*	Screening	Hydrogen Bubble strip Vapor and Dissolved Gases — Groundwater	GC-flame ionization detector/ thermoconductivity detector/reduction gas detector	None	N
Microseeps SOP-SM9	*Standard Operating Procedure for the Collection of Dissolved Gases from Water Using the "Bubble strip" Sampling Technique at the Well Site* (Revision 6)	Screening	Hydrogen Bubble strip Vapor and Dissolved Gases — Groundwater	Sampling Procedure	None	N
Microseeps SOP-PM01	*Standard Operating Procedure for the Preparation of Samples for the Analysis of Biodegradation Indicator Gases* (Revision 5)	Screening	Hydrogen Bubble strip Vapor and Dissolved Gases — Groundwater	Preparation Procedure	None	N

Notes:

SOP = Standard operating procedure
QSM = *Department of Defense Quality Systems Manual for Environmental Laboratories*, Version 4.2, October 2010
Y/N = Yes/No
GC = Gas chromatograph

SAP WORKSHEET #28: LABORATORY QC SAMPLES TABLE

(UFP-QAPP Manual Section 3.4)

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Volatile Organic Compounds					
Analytical Method:	SW-846 8260B					
SOP Reference:	Empirical SOP202					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
Internal Standard	Every field sample, standard, and QC sample: Fluorobenzene, Chlorobenzene-d5, 1,4-dichlorobezene-d4	Retention times must be within ± 30 seconds and the response areas must be within -50% to +100% of the ICAL midpoint standard.	Inspect MS and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	Retention times ± 30 seconds from the retention time of the midpoint in the ICAL: the response areas must be within -50% to +100% of ICAL midpoint standard.
Method Blank	One per preparatory batch of 20 or fewer samples.	All analytes must be ≤ ½ LOQ and ≤ 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater), except common lab contaminants, which must be < LOQ.	Investigate source of contamination and rerun method blank prior to analysis of samples, if possible. Evaluate the samples and associated QC: if blank results are above LOQ, then report sample results which are <LOQ or >10X the blank concentration. Re-prepare and reanalyze blank and samples >LOQ and <10X the blank.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1 in QSM V4.2).
Laboratory Control Sample/Laboratory Control Sample Duplicate (not required)	One per preparatory batch of 20 or fewer samples.	%R — DoD QSM Limits RPD must be ≤ 30 (for LCS/LCSD).	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias Precision also, if LCSD is analyzed	DoD QSM Limits

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Volatile Organic Compounds					
Analytical Method:	SW-846 8260B					
SOP Reference:	Empirical SOP202					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix.	%R — DoD QSM Limits RPD must be ≤ 30	Corrective actions will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD %Rs are unacceptable, then re-prepare and reanalyze the samples and QC.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias/ Precision	DoD QSM Limits
Surrogate	All field and QC samples - four per sample	%R — DoD QSM Limits 1,2-Dichloroethane-d4 (70-120) 4-Bromofluorobenzene (75-120) Dibromofluoromethane (85-115) Toluene-d8 (85-120)	If sample volume is available, then re-prepare and reanalyze for confirmation of matrix interference when appropriate.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	DoD QSM Limits

Notes:

QC	=	Quality control
SOP	=	Standard operating procedure
ICAL	=	Initial calibration
MS/MSD	=	Matrix spike/matrix spike duplicate
CCV	=	Continuing calibration verification
LOQ	=	Limit of quantitation
LCS	=	Laboratory control sample
LCSD	=	Laboratory control sample duplicate
%R	=	Percent recovery
DOD QSM	=	*Department of Defense Quality Systems Manual for Environmental Laboratories*, Version 4.2, October 2010
RPD	=	Relative percent difference

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Iron and Manganese					
Analytical Method:	SW-846 6010B					
SOP Reference:	Empirical SOP105					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
Method Blank	One per preparatory batch of 20 or fewer samples.	All analytes must be ≤ ½ LOQ and ≤ 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	If the blank value > LOQ, then report sample results. If the blank value < LOQ or >10x the blank value, then redigest. If blank value is less than negative LOQ, then report sample results. If >10x the absolute value of the blank result, then redigest.	Analyst, Laboratory Department Manager, and Data Validator	Bias/Contamination	No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1 in QSM V4.2).
LCS LCSD (not required)	One per preparatory batch of 20 or fewer samples.	%R — DoD QSM Limits (80 - 120%) RPD must be ≤ 20 (for LCS/LCSD).	Correct problem, then redigest and reanalyze all associated samples for failed analyte(s).	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias Precision also, if LCSD is analyzed	DoD QSM Limits (80-120%) RPD must be ≤ 20% (for LCS/LCSD).
Duplicate Sample (or MSD)	One per preparatory batch of 20 or fewer samples per matrix.	The RPD should be ≤20%.	Narrate any results that are outside control limits.	Analyst, Laboratory Department Manager, and Data Validator	Precision	The RPD should be ≤20%.
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix.	%R — DoD QSM Limits (80 - 120%), if sample < 4x spike added. RPD must be ≤ 20	Flag results for affected analytes for all associated samples with "N."	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	%R — DoD QSM Limits (80-120%), if sample < 4x spike added. RPD must be ≤ 20

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Iron and Manganese					
Analytical Method:	SW-846 6010B					
SOP Reference:	Empirical SOP105					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
Serial Dilution	One per preparatory batch with sample concentration(s) >50x the LOD.	The 5-fold dilution result must agree within ± 10%D of the original sample result.	For ICP-AES, perform Post Digestion Spike. For GFAA, perform Recovery Test.	Analyst, Laboratory Department Manager, and Data Validator	Precision	The 5-fold dilution result must agree within ± 10%D of the original sample result.
Post Digestion Spike	One is performed when serial dilution fails or analyte concentration(s) in all samples are < 50x LOD.	The %R must be within 75 — 125% of expected value to verify the absence of interference. Spike addition should produce a concentration of 10-100x the LOQ.	Flag results of samples of same matrix as estimates in case narrative.	Analyst, Laboratory Department Manager, and Data Validator	Precision	The %R must be within 75-125% of expected value to verify the absence of interference.
Method of Standard Addition (ICP-AES and GFAA only)	Used when matrix interferences are present.	NA	Document use of MSA in case narrative.	Analyst, Laboratory Department Manager, and Data Validator	Precision	NA

Notes:

QC = Quality control
SOP = Standard operating procedure
LOQ = Limit of quantitation
LCS = Laboratory control sample
LCSD = Laboratory control sample duplicate
%R = Percent recovery
RPD = Relative percent difference
DOD QSM = *Department of Defense Quality Systems Manual for Environmental Laboratories*, Version 4.2, October 2010
LOD = Limit of detection
MS/MSD = Matrix spike/matrix spike duplicate
%D = Percent difference
ICP-AES = Inductively coupled plasma-atomic emission spectrometry
GFAA = Graphite furnace atomic absorption
MSA = Method of standard addition

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Chloride, Nitrate, Nitrite, Sulfate					
Analytical Method:	USEPA 300.0/SW-846 9056					
SOP Reference:	Empirical SOP145					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
Method Blank	One per batch of up to 20 samples.	Analyte concentration must be <½ LOQ.	Correct problem, re-prepare, and reanalyze along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1 in QSM V4.2).
Calibration Blank	At the beginning of analytical sequence, after every 10 samples, and at the end of the sequence.	Analyte concentration must be < 2x DL.	Correct problem, re-prepare, and reanalyze along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	Analyte concentration must be < 2x DL.
LCS	One per batch of up to 20 samples.	%R must be within 80-120% of true value.	Correct problem, re-prepare, and reanalyze the LCS along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	%R must be within 80-120% of true value.
Sample Duplicate (Replicate)	One per every 20 samples.	RPD must be ≤ 10%.	Correct problem, reanalyze sample, and duplicate.	Analyst, Laboratory Department Manager, and Data Validator	Precision	RPD must be ≤ 20%.

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Chloride, Nitrate, Nitrite, Sulfate					
Analytical Method:	USEPA 300.0/SW-846 9056					
SOP Reference:	Empirical SOP145					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
MS/MSD	One per batch of up to 20 samples.	%R should be within 80-120% of true value. RPD should be ≤10%.	Corrective action will not be taken for samples when recoveries are outside limits and LCS criteria are met. If both the LCS and MS/MSD %Rs are unacceptable, then re-prepare and reanalyze the samples and QC.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias Precision	%R should be within 80-120% of true value. RPD should be≤ 20%.

Notes:

USEPA = U.S. Environmental Protection Agency
QC = Quality control
SOP = Standard operating procedure
LOQ = Limit of quantitation
DL = Detection limit
LCS = Laboratory control sample
%R = Percent recovery
RPD = Relative percent difference
MS/MSD = Matrix spike/matrix spike duplicate

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Tennessee Gasoline and Extracted Petroleum Hydrocarbons					
Analytical Method:	TN GRO and TN EPH 8260B					
SOP Reference:	Empirical SOP219					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
Method Blank	One per preparatory batch of 20 or fewer samples.	All analytes must be ≤ ½ LOQ and ≤ 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater), except common lab contaminants, which must be < LOQ.	Investigate source of contamination and rerun method blank prior to analysis of samples, if possible. Evaluate the samples and associated QC: if blank results are above LOQ, then report sample results, which are <LOQ or >10X the blank concentration. Re-prepare and reanalyze blank and samples >LOQ and <10X the blank.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1 in QSM V4.2).
LCS/LCSD (not required)	One per preparatory batch of 20 or fewer samples.	%R — 50-150% RPD must be ≤ 30 (for LCS/LCSD).	Evaluate and reanalyze if possible. If an MS/MSD was performed in the same 12 hour clock and acceptable, then narrate. If the LCS %Rs are high, but the sample results are <LOQ, then narrate. Otherwise, re-prepare and reanalyze the LCS and associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias Precision also, if LCSD is analyzed	%R — 50-150% RPD must be ≤ 30% (for LCS/LCSD).
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix.	%R — 50-150% RPD must be ≤ 30	Corrective actions will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD %Rs are unacceptable, then re-prepare and reanalyze the samples and QC.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias/ Precision	%R — 50-150% RPD must be ≤ 30%

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Tennessee Gasoline and Extracted Petroleum Hydrocarbons					
Analytical Method:	TN GRO and TN EPH 8260B					
SOP Reference:	Empirical SOP219					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
Surrogate	All field and QC samples	Bromofluorobenzene (GRO) 50%-150% water/soil 2-Fluorobiphenyl (DRO) 50%-150% water/soil o-Terphenyl (DRO) 30%-140% water 35%-140% soil	If sample volume is available, then re-prepare and reanalyze for confirmation of matrix interference when appropriate.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	Bromofluorobenzene (GRO) 50%-150% water/soil 2-Fluorobiphenyl (DRO) 50%-150% water/soil o-Terphenyl (DRO) 30%-140% water 35%-140% soil

Notes:

QC = Quality control
SOP = Standard operating procedure
LOQ = Limit of quantitation
DL = Detection limit
LCS = Laboratory control sample
LCSD = Laboratory control sample duplicate
%R = Percent recovery
RPD = Relative percent difference
MS/MSD = Matrix spike/matrix spike duplicate
GRO = Gasoline range organics
DRO = Diesel range organics

Laboratory QC Samples	
Matrix:	Groundwater
Analytical Group:	Total Organic Carbon
Analytical Method:	SW-846 9060A
SOP Reference:	Empirical SOP221

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	One per preparatory batch of 20 or fewer samples.	Analyte concentration must be <½ LOQ.	Correct problem, re-prepare and reanalyze along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1 in QSM V4.2).
Calibration Blank	At the beginning of analytical sequence, after every 10 samples, and at the end of the sequence.	Analyte concentration must be < 2x DL.	Correct problem, re-prepare, and reanalyze along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	Analyte concentration must be < 2x DL.
LCS	One per preparatory batch of 20 or fewer samples.	%R must be within 80 — 120% of true value.	Correct problem, re-prepare, and reanalyze the LCS along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	%R must be within 80-120% of true value.
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix.	%R should be within 75 — 125% of true value. RPD should be ≤20%.	Corrective action will not be taken for samples when recoveries are outside limits and LCS criteria are met. If both the LCS and MS/MSD %Rs are unacceptable, then re-prepare and reanalyze the samples and QC.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias/ Precision	%R should be within 80-120% of true value. RPD should be ≤20%.

Notes:

QC	=	Quality control
SOP	=	Standard operating procedure
LOQ	=	Limit of quantitation
DL	=	Detection limit
LCS	=	Laboratory control sample
%R	=	Percent recovery
RPD	=	Relative percent difference
MS/MSD	=	Matrix spike/matrix spike duplicate

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Biochemical Oxygen Demand					
Analytical	Standard Methods 5210B					
SOP Reference:	Empirical SOP169					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
Method Blank	One per preparatory batch of 20 or fewer samples.	Analyte concentration must be <½ LOQ.	Determine the source of the error, notify the client, and narrate appropriately.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	≤ 0.2 mg/L oxygen depletion.
LCS	One per preparatory batch of 20 or fewer samples.	%R must be within 85 — 115% of true value.	Determine the source of the error, notify the client, and narrate appropriately.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	%R must be within 85-115% of true value.
Sample Duplicate (Replicate)	One per every 10 samples.	RPD must be ≤20%.	Determine the source of the error, notify the client and narrate appropriately.	Analyst, Laboratory Department Manager, and Data Validator	Precision	RPD must be ≤20%.

Notes:

QC = Quality control
SOP = Standard operating procedure
LOQ = Limit of quantitation
LCS = Laboratory control sample
%R = Percent recovery
RPD = Relative percent difference

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Chemical Oxygen Demand					
Analytical	USEPA 410.4					
SOP Reference:	Empirical SOP163					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
Method Blank	One per preparatory batch of 20 or fewer samples.	Analyte concentration must be <½ LOQ.	Correct problem, re-prepare and reanalyze along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1 in QSM V4.2).
LCS	One per preparatory batch of 20 or fewer samples.	%R must be within 80-120% of true value.	Correct problem, re-prepare, and reanalyze the LCS along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	%R must be within 80-120% of true value.
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix.	%R should be within 75-125% of true value. RPD should be ≤20%.	Corrective action will not be taken for samples when recoveries are outside limits and LCS criteria are met. If both the LCS and MS/MSD %Rs are unacceptable, then re-prepare and reanalyze the samples and QC.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/ Bias/Precision	%R should be within 80-120% of true value. RPD should be ≤20%.

Notes:

USEPA = U.S. Environmental Protection Agency
QC = Quality control
SOP = Standard operating procedure
LOQ = Limit of quantitation
LCS = Laboratory control sample
%R = Percent recovery
RPD = Relative percent difference
MS/MSD = Matrix spike/matrix spike duplicate

Laboratory QC Samples						
Matrix:	Groundwater					
Analytical Group:	Dissolved Gases					
Analytical Method:	Microseeps AM20GAX					
SOP Reference:	Microseeps AM20GAX					
QC Sample	**Frequency & Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator**	**Measurement Performance Criteria**
Method Blank	One per preparatory batch of 20 or fewer samples.	Analyte concentration must be <½ LOQ.	Correct problem, re-prepare and reanalyze along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	No analytes detected > ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL (see Box D-1 in QSM V4.2).
Calibration Blank	At the beginning of analytical sequence, after every 15 samples, and at the end of the sequence.	Analyte concentration must be <½ LOQ.	Correct problem, re-prepare, and reanalyze along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Bias/ Contamination	Analyte concentration must be <½ LOQ.
LCS	One per preparatory batch of 20 or fewer samples.	%R must be within 80-120% of true value.	Re-prepare, and reanalyze the LCS along with all associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	%R must be within 80-120% of true value.

Notes:

QC = Quality control
SOP = Standard operating procedure
LOQ = Limit of quantitation
DL = Detection limit
LCS = Laboratory control sample
%R = Percent recovery
RPD = Relative percent difference

SAP WORKSHEETS #34-36: DATA VERIFICATION AND VALIDATION (STEPS I AND IIA/IIB) PROCESS TABLE

(UFP-QAPP Manual Section 5.2.1), (UFP-QAPP Manual Section 5.2.2), (Figure 37 UFP-QAPP Manual), (Table 9 UFP-QAPP Manual)

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/External
Verification (Step I) Chain-of-custody forms Sample Login/ Receipt	The laboratory sample custodians will review the sample shipment for completeness, integrity, and sign accepting the shipment. All sample labels will be checked against the chain-of-custody form, and any discrepancies will be identified, investigated, and corrected. The samples will be logged in at every storage area and work station required by the designated analyses. Individual analysts will verify the completeness and accuracy of the data recorded on the forms.	Laboratory sample custodians and analysts, Empirical, Microseeps	Internal
Verification (Step I) Chain-of-custody forms	The Resolution Consultants data validators will check that the chain-of-custody form was signed/dated by the sampler relinquishing the samples and by the laboratory sample custodian receiving the samples for analyses.	Project chemist or data validators, Resolution Consultants	External
Verification (Step I) SAP sample tables	Verify that all proposed samples listed in the SAP tables have been collected	FTL or designee, Resolution Consultants	Internal
Verification (Step I) Sample log sheets and field notes	Verify that information recorded in the log sheets and field notes are accurate and complete.	FTL or designee, Resolution Consultants	Internal
Verification (Step I) Field QC samples	Check that field QC samples, described in Worksheet #12 and listed in Worksheet #20 were collected as required.	FTL or designee, Resolution Consultants	Internal
Verification (Step I) Analytical data package	All analytical data packages will be verified internally for completeness by the laboratory performing the work. The laboratory project manager (or designee) will sign the case narrative for each data package.	Laboratory project manager, Empirical, Microseeps,	Internal
Verification (Step I) Analytical data package	The data package will be verified for completeness by the data validators. Missing information will be requested from the laboratory and validation will be suspended until missing data are received.	Project chemist or data validators, Resolution Consultants	External
Verification (Step I) Electronic data deliverables	The electronic data will be verified against the chain-of-custody and hard copy data package for accuracy and completeness.	Data manager and/or validator, Resolution Consultants	External
Validation (Step IIa) Chain-of-custody	Examine the traceability of the data from time of sample collection until reporting of data. Ensure that the custody and integrity of the samples were maintained from collection to analysis and the custody records are complete and any deviations are recorded.	Project chemist or data validators, Resolution Consultants	External

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/External
Validation (Step IIa) Holding Times	Review that the samples were shipped and stored at the required temperature and sample pH for chemically-preserved samples meet the requirements listed in Worksheet #19. Ensure that the analyses were performed within the holding times. If holding times were not met, confirm that deviations were documented.	Project chemist or data validators, Resolution Consultants	External
Validation (Steps IIa/IIb) Laboratory data results for accuracy	Ensure that the laboratory QC samples were analyzed and that the measurement performance criteria, listed in Worksheet #28, were met for all field samples and QC analyses. Check that specified field QC samples were collected and analyzed, as listed in Worksheet #12, and that the analytical QC criteria were met.	Project chemist or data validators, Resolution Consultants	External
Validation (Steps IIa/IIb) Field and laboratory duplicate analyses for precision	Check the field sampling precision by calculating the RPD for field duplicate samples. Check the laboratory precision by reviewing the RPD or percent difference values from laboratory duplicate analyses; MS/MSDs; and LCS/LCSDs. Ensure compliance with the precision goals listed in Worksheet #12 and 28.	Project chemist or data validators, Resolution Consultants	External
Validation (Steps IIa/IIb) Sample results for representativeness	Check that the laboratory recorded the temperature at sample receipt and the pH of the chemically preserved samples to ensure sample integrity from sample collection to analysis.	Project chemist or data validators, Resolution Consultants	External
Validation (Steps IIa/IIb) Project action limits	Assess and document the impact on matrix interferences or sample dilutions performed because of the high concentration of one or more contaminant, on the other target compounds reported as undetected.	Project chemist or data validators, Resolution Consultants	External
Validation (Steps IIa/IIb) Data quality assessment report	Summarize deviations from methods, procedures, or contracts. Qualify data results based on method or QC deviation and explain all the data qualifications. Present tabular qualified data and data qualifier codes and summarize data qualification outliers. Determine if the data met the measurement performance criteria and determine the impact of any deviations on the technical usability of the data.	Project chemist or data validators, Resolution Consultants	External
Validation (Steps IIa/IIb) SAP QC sample documentation	Ensure that all QC samples specified in the SAP were collected and analyzed and that the associated results were within acceptance limits.	Project chemist or data validators, Resolution Consultants	External
Validation (Step IIb) Analytical data deviations	Determine the impact of any deviation from sampling or analytical methods and SOPs requirements and matrix interferences effect on the analytical results.	Project chemist or data validators, Resolution Consultants	External
Validation (Step IIb) Project quantitation limits for sensitivity	Ensure that the project LOQs were achieved.	Project chemist or data validators, Resolution Consultants	External

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/External
Validation (Steps IIa/IIb) Groundwater — VOCs	SW-846 8260B method-specific criteria, the DoD QSM, and those listed in Worksheets # 12, 19, and 28 will be used to assess VOC data. The logic outlined in *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, (October 1999) will be used to apply qualifiers to data.	Project chemist or data validators, Resolution Consultants	External
Validation (Steps IIa/IIb) Groundwater — MNA Parameters Anions (sulfate, chloride, nitrate, nitrite), iron, manganese, BOD, COD, TOC, TN GRO, TN EPH hydrogen, methane, ethane, ethene, Census DNA	Method-specific criteria, the DoD QSM, and criteria listed in Worksheets #12, 19, and 28 will be used to assess MNA data. The logic *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, (October 2004) will be used to apply qualifiers to data to the extent possible. Validation for non-critical MNA parameters will be limited to the following elements: holding times, blank analyses, and laboratory control samples.	Project chemist or data validators, Resolution Consultants	External

Notes:

SAP	=	Sampling and analysis plan
FTL	=	Field team leader
QC	=	Quality control
RPD	=	Relative percent difference
MS/MSD	=	Matrix spike/Matrix Spike duplicate
LCS/LCSD	=	Laboratory control sample/laboratory control sample duplicate
SOP	=	Standard operating procedure
LOQ	=	Limit of quantitation
DoD QSM	=	*Department of Defense Quality Systems Manual for Environmental Laboratories*, Version 4.2, October 2010
VOC	=	Volatile organic compounds
GC/MS	=	Gas chromatography/mass spectrometry
BOD	=	Biochemical oxygen demand
COD	=	Chemical oxygen demand
TOC	=	Total organic carbon
TN GRO	=	Tennessee gasoline range organics method
TN EPH	=	Tennessee extractable range organics method
USEPA	=	U.S Environmental Protection Agency
MNA	=	Monitored natural attenuation

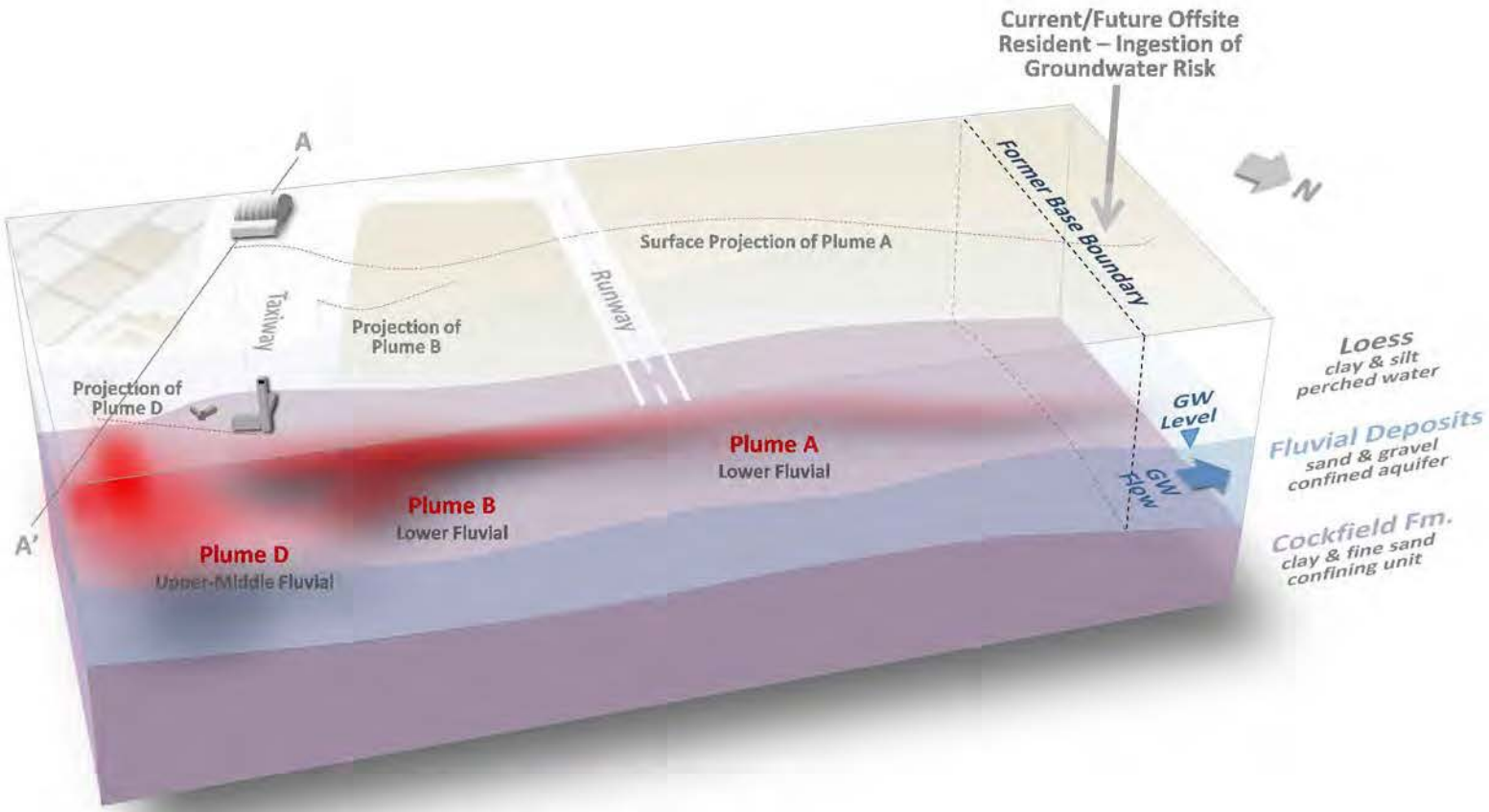
Appendix A
Figures

Figure 1:
Base Location Map
NSA Mid-South
Millington, TN

Primary Basemap: (c) 2010 Microsoft Corporation and its data suppliers. Inset Basemap: ESRI Data & Maps. 11/23/2011 \\bstcrystal\gis\projects\NsaMidSouth\arcgis_projects\BaseMap_AOCA2.mxd

Figure 2
AOC A Location Map
NSA Mid-South
Millington, TN

12/6/2011 \\bstcrystal\gis\projects\NsaMidSouth\arcgis_projects\aerial_sitemap.mxd



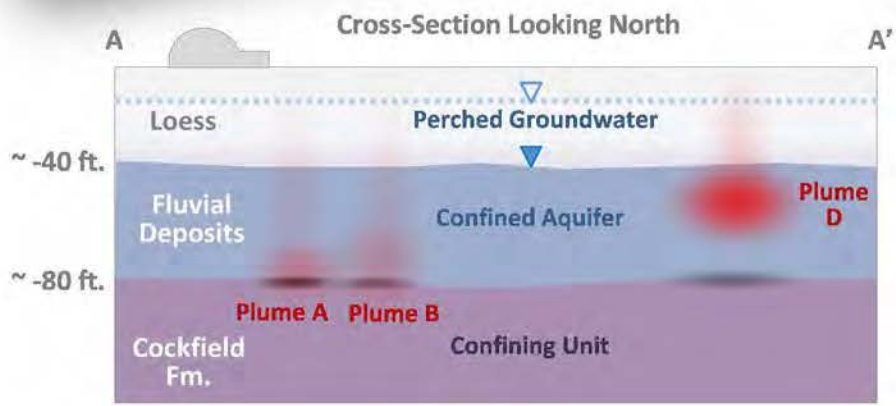


FIGURE 3
AOC A CONCEPTUAL SITE MODEL
NSA MID-SOUTH
MILLINGTON, TENNESSEE

REQUESTED BY: BEN B.	
DRAWN BY: BRONSON	
DWG DATE: 12/19/11	
DWG NO: 11501_B002	

NAVFAC Naval Facilities Engineering Command

I:\2011 PROJECTS BST\11501 NSA\PLANS\11501_B002_NSA_TN.DWG

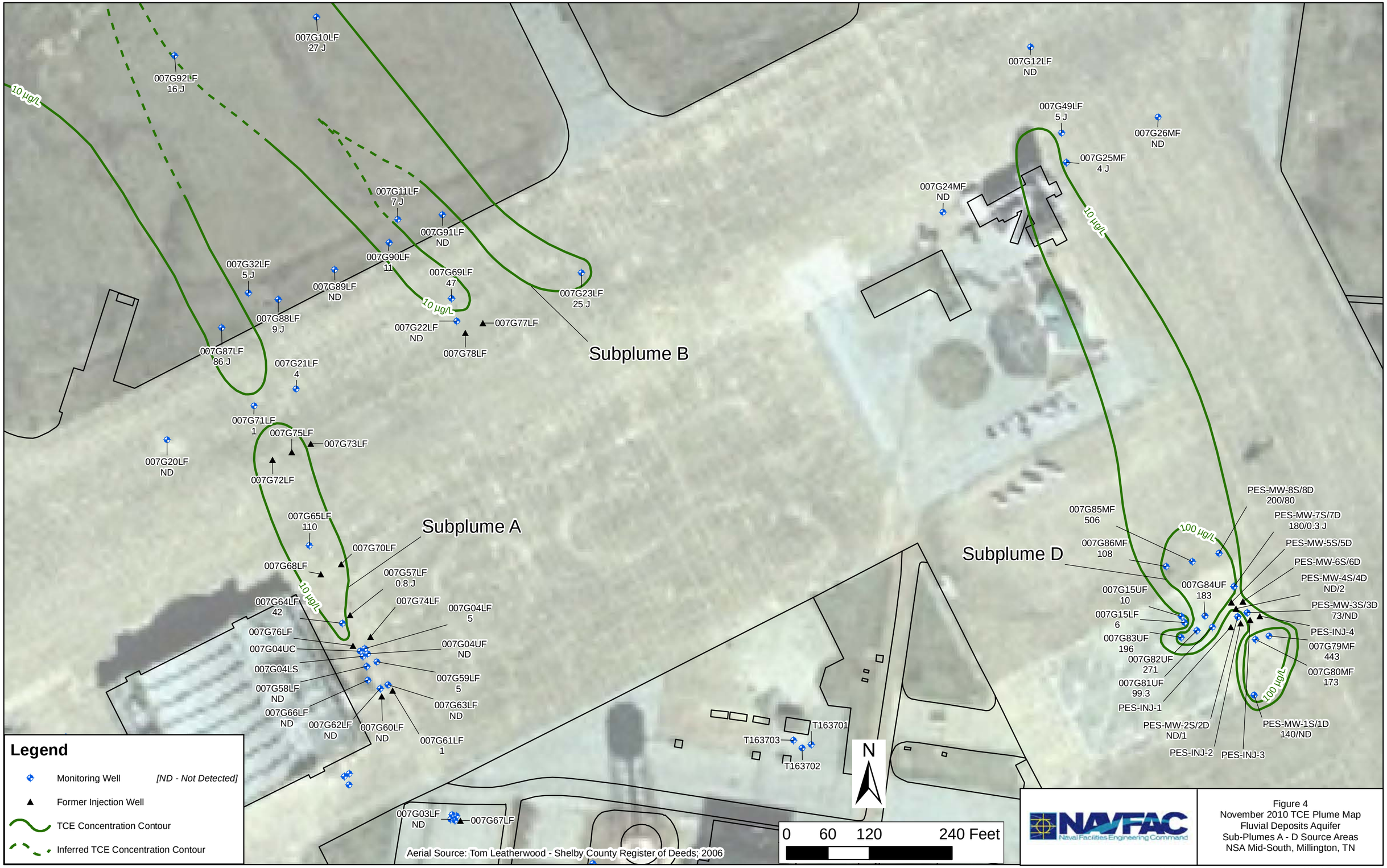
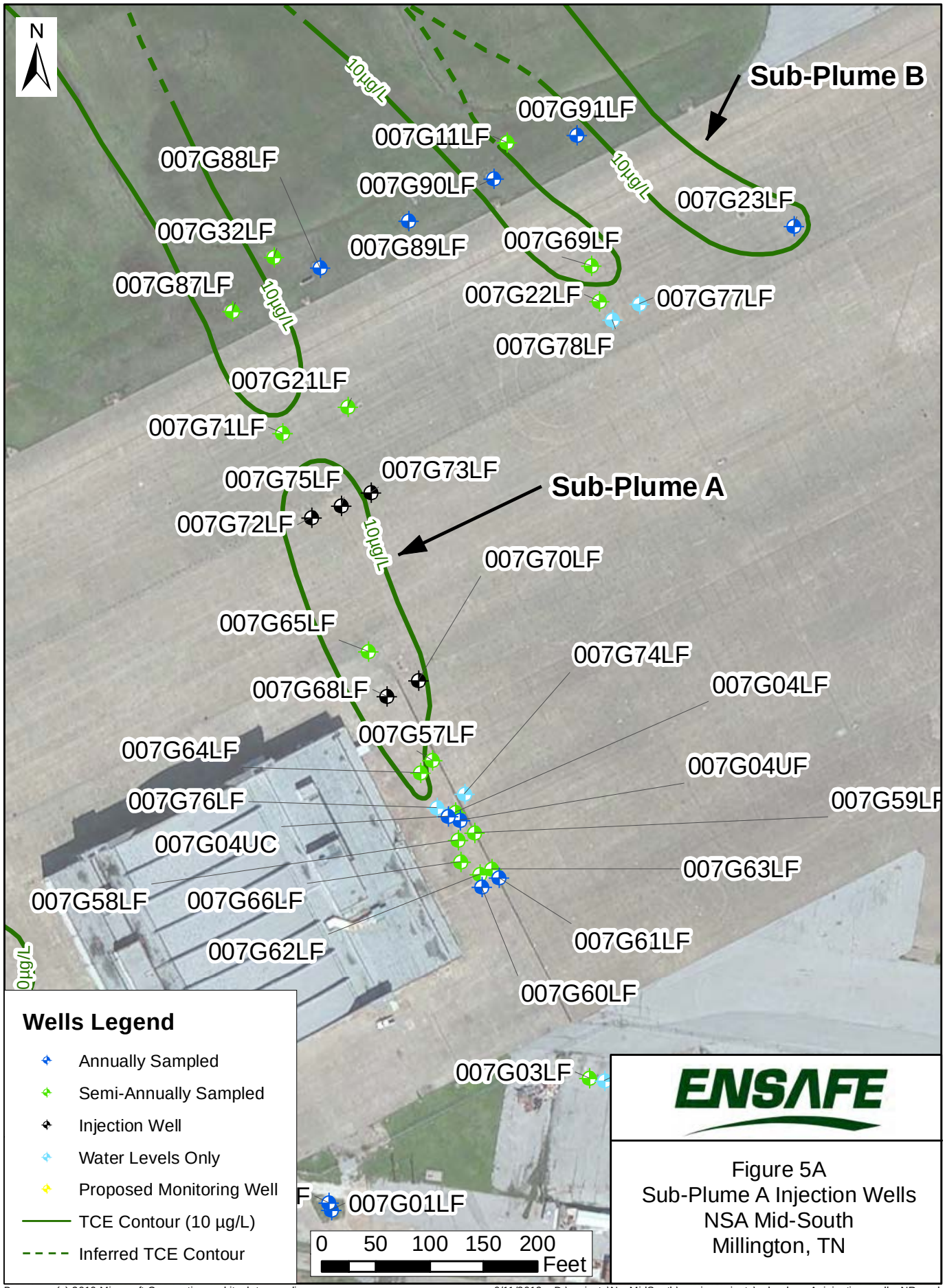


Figure 4
November 2010 TCE Plume Map
Fluvial Deposits Aquifer
Sub-Plumes A - D Source Areas
NSA Mid-South, Millington, TN

6/29/2012 D:\projects\NsaMidSouth\arcgis_projects\aoca_plumes_tce_1110_NR.mxd

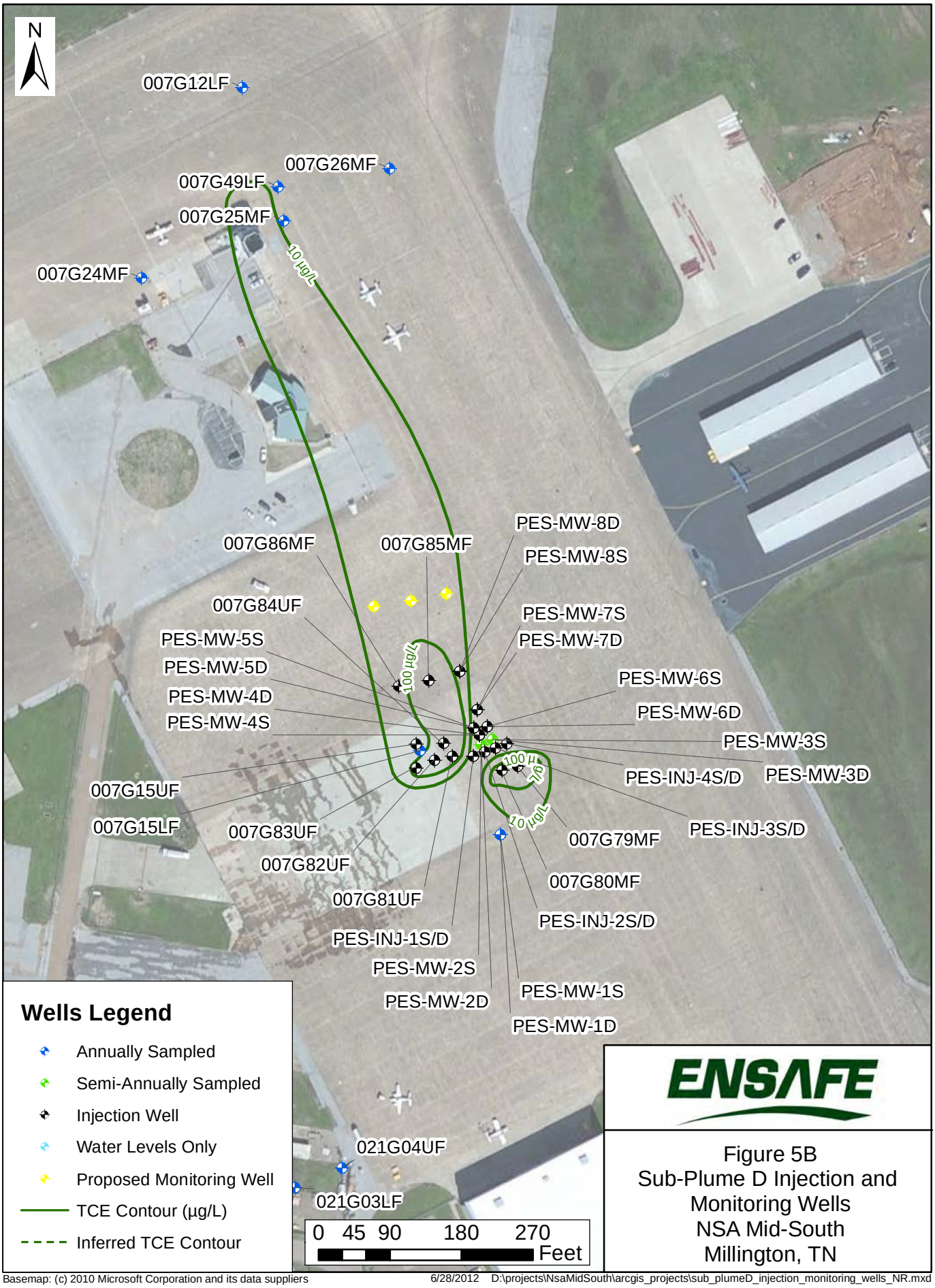


ENSAFE

Figure 5A
Sub-Plume A Injection Wells
NSA Mid-South
Millington, TN

Basemap: (c) 2010 Microsoft Corporation and its data suppliers

9/11/2012 D:\projects\NsaMidSouth\arcgis_projects\sub_plumeA_injection_wells_NR.mxd



ENSAFE

Figure 5B
Sub-Plume D Injection and Monitoring Wells
NSA Mid-South
Millington, TN

Basemap: (c) 2010 Microsoft Corporation and its data suppliers

6/28/2012 D:\projects\NsaMidSouth\arcgis_projects\sub_plumeD_injection_monitoring_wells_NR.mxd

Figure 5C
Perimeter Injection Wells and
Proposed Offsite Monitoring Wells
NSA Mid-South
Millington, TN

Basemap: (c) 2010 Microsoft Corporation and its data suppliers

6/25/2012 D:\projects\NsaMidSouth\arcgis_projects\TCEcontour_Perimeter_Inject_wells.mxd

10 µg/L
10 µg/L
10 µg/L
10 µg/L
Wells Legend
Annually Sampled
Semi-Annually Sampled
Injection Well
Water Levels Only
Proposed Monitoring Well
TCE Contour (10 µg/L)
Inferred TCE Contour
N
0
250
500
1,000 Feet
Aerial Source: (c) 2010 Microsoft Corporation and its data suppliers
NAVFAC
Figure 5D
AOC A Monitoring and Injection Wells
NSA Mid-South
Millington, TN

Figure 5E
AOC A Monitoring and Injection Wells
NSA Mid-South
Millington, TN

6/29/2012 G:\projects\NsaMidSouth\arcgis_projects\aaoca_wells_1111_NR_SE.mxd

Figure 6
SWMU 15 DPT Sample Locations
NSA Mid-South
Millington, TN

12/9/2011 \\bstcrystal\gis\projects\NsaMidSouth\arcgis_projects\swmu_15_benzene_1110.mxd

Appendix B
Standard Operating Procedures

Standard Operating Procedure SOP-3-01
Utility Clearance

1.0 PURPOSE

This standard operating procedure (SOP) describes the process for determining the presence of subsurface utilities and other cultural features at locations where planned site activities involve the physical disturbance of subsurface materials. The procedure applies to the following activities: soil gas surveying, excavating, trenching, borings and installation of monitoring, injection, and extraction wells, use of soil recovery or slide-hammer hand augers, and all other intrusive sampling activities. The primary purpose of the procedure is to minimize the potential for damage to underground utilities and other subsurface features, which could result in physical injury, disruption of utility service, or disturbance of other subsurface cultural features.

If there are applicable procedures from Resolution Consultants, State and/or Federal entities that are not addressed in this SOP, those procedures may be added as an appendix to the project specific Sampling and Analysis Plan.

2.0 SCOPE

This procedure shall serve as a management-approved professional guidance and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

3.0 DEFINITIONS

3.1 Utility

For this procedure, a utility is defined as a manmade underground line or conduit, cable, pipe, vault or tank that is, or was, used for the transmission of material or energy (e.g., gas, electrical, telephone, steam, water or sewage, product transfer lines, or underground storage tanks).

3.2 As-Built Plans

As-built plans are plans or blueprints depicting the locations of structures and associated utilities on a property.

3.3 One-Call

The Utility Notification Center is the one-call agency for nationwide 'call before you dig' activities. The Utility Notification Center is open 24 hours a day, and accepts calls from anyone planning to

dig. The phone number 811 is the designated call before you dig phone number for Tennessee that directly connects you to your local one call center. Additional information can be found at www.call811.com/.

Calling before you dig ensures that any publicly owned underground lines will be marked, so that you can dig around them safely. Having the utility lines marked not only prevents accidental damage to the lines, but prevents property damage and personal injuries that could result in breaking a line.

The following information will need to be provided when a call is placed to One-Call:

- Your name, phone number, company name (if applicable), and mailing address
- What type or work is being completed
- Who the work is being completed for
- The county and city the work is taking place in
- The address or the street where the work is taking place
- Marking instructions, (specific instructions as to where the work is taking place)

Under normal circumstances it takes between 2 days to 5 days from the time you call (not counting weekends or holidays) to have the underground lines marked. Because these laws vary from state to state, exactly how long it will take depends on where your worksite is located. You will be given an exact start time and date when your locate request is completed, which will comply with the laws in your area.

In the event of an emergency (any situation causing damage to life or property, or a service outage), lines can be marked sooner than the original given time if requested.

3.4 Toning

Toning is the process of surveying an area utilizing one or more surface geophysical methods to determine the presence or absence of underground utilities. Typically, toning is conducted after identifying the general location of utilities and carefully examining all available site utility plans. Each location is marked according to the type of utility being identified. In addition, areas cleared by toning are flagged or staked to indicate that all identified utilities in a given area have been toned. Toning is commonly conducted by the Utility Notification Center; however, private utility locating services are required in instances where the Utility Notification Center will not enter a

subject property, suspect utility lines not included by the Utility Notification Center may be present on the property, or utility maps or site personnel with utility information are not available.

4.0 RESPONSIBILITIES

The CTO Manager, or designee, is responsible for verifying that these utility locating procedures are performed prior to the initiation of active subsurface exploration. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks.

QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The onsite Field Manager (FM) is responsible for planning utility clearance and for locating and marking underground utilities according to this procedure.

Field personnel are responsible for the implementation of this procedure.

5.0 PROCEDURES

Follow the following steps at all sites where subsurface exploration will include excavations, drilling, or any other subsurface investigative method that could damage utilities at a site. In addition to the steps outlined below, always exercise caution while conducting subsurface exploratory work.

5.1 Prepare Preliminary Site Plan

Prepare a preliminary, scaled site plan depicting the proposed exploratory locations as part of the work plan. Include as many of the cultural and natural features as practical in this plan.

5.2 Review Background Information

Search existing plan files to review the as-built plans to identify the known location of utilities at the site. Plot the locations of utilities identified onto a preliminary, scaled site plan. Inform the CTO Manager if utilities lie within close proximity to a proposed exploration or excavation location. The CTO Manager will determine if it is necessary to relocate proposed sampling or excavation locations.

Include the utility location information gathered during investigation (e.g., remedial investigation or remedial site evaluation) work in the project design documents for removal or remedial actions. In

this manner, information regarding utility locations collected during implementation of a CTO can be shared with the other contractors during implementation of a particular task order. In many instances, this will help to reduce the amount of additional geophysical surveying work the other contractor may have to perform.

Conduct interviews with onsite and facility personnel familiar with the site to obtain additional information regarding the known and suspected locations of underground utilities. In addition, if appropriate, contact shall be made with local utility companies to request their help in locating underground lines. Pencil in the dimensions, orientation, and depth of utilities, other than those identified on the as-built plans, at their approximate locations on the preliminary plans. Enter the type of utility, the personnel who provided the information, and the date the information was provided into the field log.

During the pre-fieldwork interviewing process, the interviewer will determine which site personnel should be notified in the event of an incident involving damage to existing utilities. Record this information in the field logbook with the corresponding telephone numbers and addresses.

5.3 Site Visit — Locate Utilities — Toning

Prior to the initiation of field activities, the field task manager or similarly qualified staff personnel shall visit the site and note existing structures and evidence of associated utilities, such as fire hydrants, irrigation systems, manhole and vault box covers, standpipes, telephone switch boxes, free-standing light poles, gas or electric meters, pavement cuts, and linear depression. Compare notes of the actual site configuration to the preliminary site plan. Note deviations in the field logbook and on the preliminary site plan. Accurately locate or survey and clearly mark with stakes, pins, flags, paint, or other suitable devices all areas where subsurface exploration is proposed. These areas shall correspond with the locations drawn on the preliminary site plan.

Following the initial site visit by the FM, Utility One Call or a subcontracted utility locator will locate, identify, and or/tone all utilities in the areas slated for investigation. The locator should utilize appropriate sensing equipment to attempt to locate utilities that might not have appeared on the as-built plans. This may involve the use of surface geophysical methods. Use other appropriate surface geophysical methods, such as Ground Penetrating Radar, if non-metallic cultural features are likely to be present at the site. Proposed drilling/excavation areas should be clearly marked on the ground before the utility locator enters the property so locations can be cleared and utilities appropriately marked relative to proposed investigation areas. Any utilities identified on the site

that haven't been previously noted on site plans should be noted and transferred for subsequent reporting.

The FM shall refer to the site-specific health and safety plan to determine the safe distance to maintain from the known or suspected utility. It may be necessary to relocate proposed exploration or excavation areas. If this is required, the FM or a similarly qualified individual shall relocate them and clearly mark them using the methods described above. Completely remove the markings at the prior location. Plot the new locations on the site plan and delete the prior locations from the plan. In all proposed drilling instances, a hand auger or non-mechanical probing device (rebar, pipe, etc.) should be used to verify the absence of utilities.

5.4 Prepare Site Plan

Prior to the initiation of field activities, draft a final site plan that indicates the location of subsurface exploration areas and all known or suspected utilities present at the site. Provide copies of this site plan to the Navy Technical Representative (NTR), the CTO Manager, and the subcontractor who is to conduct the subsurface exploration/excavation work. Review the site plan with the NTR to verify its accuracy prior to initiating subsurface sampling activities.

6.0 RECORDS

Keep a bound field logbook detailing all utility locating procedures. The logbook will describe any changes and modifications made to the original investigation/exploration plan. Ticket reference numbers provided by Utility One Call should be maintained with the field records.

7.0 HEALTH AND SAFETY

Field and subcontractor personnel shall review and adhere to the site-specific health and safety plan prior to proceeding with any subsurface excavation activities.

8.0 REFERENCES

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

9.0 ATTACHMENTS

None.

Standard Operating Procedure SOP-3-02

Field Logbooks

1.0 PURPOSE

This standard operating procedure describes the activities and responsibilities pertaining to the identification, use, and control of logbooks and associated field data. If there are procedures from Resolution Consultants, state and/or federal that are not addressed in this Standard Operating Procedure (SOP) and are applicable to logbooks, then those procedures may be added as an appendix to the project-specific Sampling and Analysis Plan.

2.0 SCOPE

This procedure shall serve as management-approved professional guidance and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan Appendix A Section 1.4 *Field Documentation SOPs* (DoD, 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

3.0 DEFINITIONS

3.1 Logbook

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person assigned responsibility for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 Data Form

A data form is a predetermined format utilized for recording field data that may become, by reference, a part of the logbook (e.g., soil boring logs, trenching logs, surface soil sampling logs, groundwater sample logs, and well construction logs are data forms).

4.0 RESPONSIBILITIES

The CTO Manager, or designee, is responsible for determining which team members shall record information in field logbooks and for obtaining and maintaining control of the required logbooks. The CTO Manager, or designee, shall review the field logbook on at least a monthly basis. The CTO Manager, or designee, is responsible for reviewing logbook entries to determine compliance with this procedure and to ensure that the entries meet the project requirements.

A knowledgeable individual such as the Field Manager, CTO Manager, or QA Manager shall perform a technical review of each logbook at a frequency commensurate with the level of activity (weekly is suggested, or, at a minimum, monthly). Document these reviews by the dated signature of the reviewer on the last page or page immediately following the material reviewed.

The Field Manager is responsible for ensuring that all project field staff follows these procedures and that the logbook is completed properly and daily. The Field Manager is also responsible for submitting copies to the CTO Manager, who is responsible for filing them and submitting a copy to the Navy (if required by the CTO Statement of Work).

The logbook user is responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. The logbook user is also responsible for safeguarding the logbook while having custody of it.

Field personnel are responsible for the implementation of this procedure.

5.0 PROCEDURE

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct the applicable events. Store the logbook in a clean location and use it only when outer gloves used for personal protective equipment (PPE) have been removed.

Individual data forms may be generated to provide systematic data collection documentation. Entries on these forms shall meet the same requirements as entries in the logbook and shall be referenced in the applicable logbook entry. Individual data forms shall reference the applicable logbook and page number. At a minimum, include names and collection times of all samples collected in the logbook even if they are recorded elsewhere.

Enter field descriptions and observations into the logbook, as described in Attachment 1, using indelible black ink.

Typical information to be entered includes the following:

- Dates (month/day/year) and times (military) of all onsite activities and entries made in logbooks/forms

- Site name and description
- Site location by city, county, and longitude and latitude, if warranted
- Weather conditions, including approximate temperature
- Fieldwork documentation, including site entry and exit times
- Descriptions of, and rationale for, approved deviations from the work plan (WP) or field sampling plan
- Field instrumentation readings
- Names, job functions, and organizational affiliations of personnel onsite
- Photograph references
- Site sketches and diagrams made onsite
- Identification and description of sample morphology, collection locations and sample numbers as described in SOP 3-03, *Sample Labeling and Chain-of-Custody Procedures*
- Sample collection information, including dates (month/day/year) and times (military) of sample collections, sample collection methods and devices, station location numbers, sample collection depths/heights, sample preservation information, sample pH (if applicable), analysis requested (analytical groups), etc., as well as chain-of-custody (COC) information such as sample identification numbers cross-referenced to COC sample numbers
- Sample naming convention
- Field quality control (QC) sample information
- Site observations, field descriptions, equipment used, and field activities accomplished to reconstruct field operations

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- Meeting information
- Important times and dates of telephone conversations, correspondence, or deliverables
- Field calculations
- PPE level
- Calibration records
- Contractor and subcontractor information (address, names of personnel, job functions, organizational affiliations, contract number, contract name, and work assignment number)
- Equipment decontamination procedures and effectiveness
- Laboratories receiving samples and shipping information, such as carrier, shipment time, number of sample containers shipped, and analyses requested
- User signatures

The logbook shall reference data maintained in other logs, forms, etc. Correct entry errors by drawing a single line through the incorrect entry, then initialing and dating this change. Enter an explanation for the correction if the correction is more than for a mistake.

At least at the end of each shift, the person making the entry shall sign or initial each entry or group of entries. Enter logbook page numbers on each page to facilitate identification of photocopies. If a person's initials are used for identification, or if uncommon acronyms are used, identify these on a page at the beginning of the logbook.

6.0 RECORDS

Retain the field logbook as a permanent project record. If a particular CTO requires submittal of photocopies of logbooks, perform this as required.

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7.0 HEALTH AND SAFETY

In order to keep the logbook clean, store it in a clean location and use it only when outer gloves used for PPE have been removed.

8.0 REFERENCES

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U.S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/-ufp_qapp_v1_0305.pdf.

9.0 ATTACHMENTS

Attachment 1: Description of Logbook Entries

Attachment 1

Description of Logbook Entries

Logbook entries shall contain the following information, as applicable, for each activity recorded. Some of these details may be entered on data forms, as described previously, in lieu of recording in the logbook.

Name of Activity	For example, Groundwater Sampling, Carbon Substrate Injections, Aquifer Testing, Etc.
Task Team Members and Equipment	Name all members on the field team involved in the specified activity. List equipment used by serial number or other unique identification, including calibration information.
Activity Location	Indicate location of sampling area as indicated in the field sampling plan.
Weather	Indicate general weather and precipitation conditions.
Level of PPE	Record the level of PPE (e.g., Level D).
Methods	Indicate method or procedure number employed for the activity.
Sample Name	Indicate the unique name associated with the physical samples. Identify QC samples.
Sample Type and Volume	Indicate the medium, container type, preservative, and the volume for each sample.
Time and Date	Record the time and date when the activity was performed (e.g., 0830/08/OCT/89). Use the 24-hour clock for recording the time and two digits for recording the day of the month and the year.
Analyses	Indicate the appropriate code for analyses to be performed on each sample, as specified in the WP.
Field Measurements	Indicate measurements and field instrument readings taken during the activity. If this information is recorded on a field form, the logbook should reference it, as appropriate.
Chain of Custody and Distribution	Indicate chain-of-custody information for each sample collected and indicate to whom the samples are transferred and the destination.
References	If appropriate, indicate references to other logs or forms, drawings, or photographs employed in the activity.
Narrative (including time and location)	Create a factual, chronological record of the team's activities throughout the day including the time and location of each activity. Include descriptions of general problems encountered and their resolution. Provide the names and affiliations of non-field team personnel who visit the site, request changes in activity, impact the work schedule, request information, or observe team activities. Record any visual or other observations relevant to the activity, the contamination source, or the sample itself. It should be emphasized that logbook entries are for recording data and chronologies of events. The logbook author must include observations and descriptive notations, taking care to be objective and recording no opinions or subjective comments unless appropriate.
Recorded by	Include the signature of the individual responsible for the entries contained in the logbook and referenced forms.

Standard Operating Procedure 3-03
Sample Labeling and Chain of Custody Procedures

1.0 PURPOSE

The purpose of this standard operating procedure is to establish standard protocols for all field personnel for use in maintaining field and sampling activity records, labeling samples, ensuring that proper sample custody procedures are utilized, and completing chain-of-custody/analytical request forms. If there are procedures from Resolution Consultants, state and/or federal that are not addressed in this Standard Operating Procedure (SOP) and are applicable to sample handling, storage, and shipping then those procedures may be added as an appendix to the project specific Sampling and Analysis Plan (SAP).

2.0 SCOPE

This procedure shall serve as management-approved professional guidance and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

3.0 DEFINITIONS

3.1 Logbook

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person responsible for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 Chain-of-Custody

Chain-of-custody (COC) is documentation of the process of custody control. Custody control includes possession of a sample from the time of its collection in the field to its receipt by the analytical laboratory, and through analysis and storage prior to disposal.

4.0 RESPONSIBILITIES

The CTO Manager, or designee, is responsible for determining which team members shall record information in the field logbook and for checking sample logbooks and COC forms to ensure compliance with these procedures. The CTO Manager, or designee, shall review COC forms on a monthly basis at a minimum.

The CTO Manager and QA Manager or Technical Director are responsible for evaluating project compliance with the Project Procedures Manual. QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Laboratory is responsible for reporting any sample documentation or COC problems to the CTO Manager, or designee, within 24 hours of sample receipt.

The Field Manager is responsible for ensuring that all field personnel follow these procedures. The Project Chemist, or designee, is responsible for verifying that the COC/analytical request forms have been completed properly and match the sampling and analytical plan. The Project Chemist, or designee, is responsible for notifying the laboratory, data managers, and data validators in writing if analytical request changes are required as a corrective action. These small changes are different from change orders, which involve changes to the scope of the subcontract with the laboratory and must be made in accordance with a respective contract. Field personnel are responsible for following these procedures while conducting sampling activities. Field personnel are responsible for recording pertinent data onto the COC forms to satisfy project requirements and for attesting to the accuracy of the entries by dated signature.

5.0 PROCEDURES

This procedure provides standards for labeling the samples, documenting sample custody, and completing COC/analytical request forms. The standards presented in this section shall be followed to ensure that samples collected are maintained for their intended purpose and that the conditions encountered during field activities are documented.

5.1 Sample Labeling

Affix a waterproof sample label with adhesive backing to each individual sample container. Record the following information with a waterproof marker on each label:

- Project name or number (optional)
- COC sample number
- Date and time of collection
- Sampler's initials
- Matrix (optional)
- Sample preservatives (if applicable)
- Analysis to be performed on sample (This shall be identified by the method number or name identified in the subcontract with the laboratory)

These labels may be obtained from the analytical laboratory or printed from a computer file onto adhesive labels.

5.2 Custody Procedures

For samples intended for chemical analysis, sample custody procedures shall be followed through collection, transfer, analysis, and disposal to ensure that the integrity of the samples is maintained. A description of sample custody procedures is provided below.

Sample Collection Custody Procedures

According to the EPA guidelines, a sample is considered to be in custody if one of the following conditions is met:

- It is in one's actual physical possession or view
- It is in one's physical possession and has not been tampered with (i.e., it is under lock or official seal)
- It is retained in a secured area with restricted access
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal

Place custody seals on shipping coolers (and sample jars, if required) if the cooler/container is to be removed from the sampler's custody. Place a minimum of two custody seals in such a manner that they must be broken to open the containers or coolers. Label the custody seals with the following information:

- Sampler's name or initials
- Date and time that the sample/cooler was sealed

These seals are designed to enable detection of sample tampering. An example of a custody seal is shown in Attachment 1.

Field personnel shall also log individual samples onto COC forms (carbon copy or computer generated) when a sample is collected. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 0, indicating sample identification

number, matrix, date and time of collection, number of containers, analytical methods to be performed on the sample, and preservatives added (if any). The samplers will also sign the COC form signifying that they were the personnel who collected the samples. The COC form shall accompany the samples from the field to the laboratory. When a cooler is ready for shipment to the analytical laboratory, the person delivering the samples for transport will sign and indicate the date and time on the accompanying COC form. One copy of the COC form will be retained by the sampler and the remaining copies of the COC form shall be placed inside a self-sealing bag and taped to the inside of the cooler. Each cooler must be associated with a unique COC form. Whenever a transfer of custody takes place, both parties shall sign and date the accompanying carbon copy COC forms, and the individual relinquishing the samples shall retain a copy of each form. One exception is when the samples are shipped; the delivery service personnel will not sign or receive a copy because they do not open the coolers. The laboratory shall attach copies of the completed COC forms to the reports containing the results of the analytical tests. An example COC form is provided in Attachment 2.

5.3 Completing COC/Analytical Request Forms

COC form/analytical request form completion procedures are crucial in properly transferring the custody and responsibility of samples from field personnel to the laboratory. This form is important for accurately and concisely requesting analyses for each sample; it is essentially a release order from the analysis subcontract.

Attachment 2 is an example of a completed COC/analytical request form that may be used by field personnel, with box numbers identified and discussed in text below. Multiple copies may be tailored to each project so that much of the information described below need not be handwritten each time. Each record on the form (Attachment 2) is identified with a bold number corresponding to the instructions given below.

1. Record the project name, site location.

2. Record the site location, including the state.

3. Record the Contract Task Order number

4. Record the Resolution Consultants Task Order Manager

5. Record the sampler/site phone or cell number (if applicable).

6. Record the laboratory name where the samples were sent.

7. Record the requested turnaround time, in days. If a specific turnaround time is required to meet project objectives, but was not indicated on the laboratory service request form submitted to the purchasing department, the sampler, project manager, or site manager should contact the purchasing department so the laboratory contract can be modified.

8. Record the COC number that is defined by the sampler and should be unique throughout the project's history. An example would be to use the sampler's initials followed by the data. If multiple custodies are generated on a given day, use a unique sequential identifier. Example: CRC040105A, CRC040105B

9. Record the purchase order number provided by the purchasing department.

10. Record the page and total number of COC forms used in a shipment.

11. Record the project, and phase applicable to the sampling task.

12. Record the two-character code corresponding to the *chemical* preservation type, which is found on the bottom of the COC form. If no chemical preservation was added to the sample, the field should be left blank. Temperature preservation need not be documented at this location, but will be indicated elsewhere on the COC form (see 33).

13. List the requested analysis. Whenever possible, list the corresponding analytical method. (e.g., VOCs, 8260).

14. For Lab identification use only.

15. Record the full *unique* sample identification as detailed in the Site's Sampling and Analysis Plan.

16. Record the location identification, which is a shortened ID used for presentation and mapping, as detailed in the Site's Sampling and Analysis Plan.

17. Record the sample date using the format mm/dd/yy.

18. Record the sample time using the military format of hhmm.

19. Record the matrix code of the sample, which is located at the bottom of the COC form. The matrix code is a crucial element of the Navy's data management system. For simplicity, only typical matrix codes are listed on the bottom COC form, but below is a complete listing of all applicable Navy matrix codes:

Table 1
Navy Matrix Codes

Matrix Code	Matrix Code Description	Matrix Code	Matrix Code Description
AA	Ambient air	RK	Rock
AC	Composite air sample	SB	Bentonite
AD	Air - Drilling	SBS	Sub-surface soil (> 6")
AIN	Integrated air sample (under sample form of gas)	SC	Cement/Concrete
AQ	Air quality control matrix	SD	Drill cuttings - solid matrix
AQS	Aqueous	SE	Sediment
ASB	Asbestos	SEEP	SEEP
ASBF	Asbestos-Fibrous	SF	Filter sand pack
ASBNF	Asbestos-Non-Fibrous	SJ	Sand
AVE	Air-Vapor extraction, effluent	SK	Asphalt
AX	Air sample from unknown origin	SL	Sludge
BK	Brick	SM	Water filter (solid material used to filter water)
BS	Brackish sediment	SN	Miscellaneous solid/building materials
CA	Cinder ash	SO	Soil
CK	Caulk	SP	Casing (PVC, stainless steel, cast iron, iron pipe
CN	Container	SQ	Soil/Solid quality control matrix
CR	Carbon (usually for a remediation system)	SS	Scrapings
DF	Dust/Fallout	SSD	Subsurface sediment
DR	Debris/rubble	STKG	Stack gas
DS	Storm drain sediment	STPM	Stripper Tower Packing Media
DT	Trapped debris	SU	Surface soil (less than 6 inches)
EF	Emissions flux	SW	Swab or wipe
EW	Elutriate water	SZ	Wood
FB	Fibers	TA	Animal tissue
FL	Forest litter	TP	Plant tissue
GE	Soil gas effluent - stack gas (from system)	TQ	Tissue QC
GI	Soil gas influent (into system)	TX	Tissue
GL	Headspace of liquid sample	UNK	Unknown
GQ	Gaseous or Headspace QC	W	Water (not groundwater, unspecified)
GR	Gravel	WA	Drill cuttings - aqueous mix

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Table 1
Navy Matrix Codes

Matrix Code	Matrix Code Description	Matrix Code	Matrix Code Description
GS	Soil gas	WB	Brackish Water
GT	Grit	WC	Drilling water (used for well construction)
IC	IDW Concrete	WD	Well development water
IDD	IDW Solid	WF	Freshwater (not groundwater)
IDS	IDW soil	WG	Ground water
IDW	IDW Water	WH	Equipment wash water
IW	Interstitial water	WI	Ground water influent (into system)
LA	Aqueous phase of a multiphase liquid/soil	WL	Leachate
LF	Product (floating or free)	WM	Marine water
LQ	Organic liquid quality control matrix	WN	Pore water
MA	Mastic	WO	Ocean water
MO	Mortar	WP	Drinking water
MR	Marine sediment	WQ	Water for QC samples
MS	Metal shavings	WR	Ground water effluent (from system)
NS	Near-surface soil	WS	Surface water
PA	Paper	WT	Composite groundwater sample
PC	Paint Chips	WU	Storm water
PP	Precipitate	WW	Waste water
RE	Residue		

Field QC blanks will require matrix codes that identify the type of blank associated with parent sample. Aqueous field QC blanks are not automatically identified with a matrix code of "WQ," indicating a water quality control blank; they are only identified with a matrix code of "WQ" if the associated samples are also aqueous. Trip blanks, field blanks, and equipment rinsate blanks collected in association with ***soil*** samples will be identified with a matrix code of "SQ," even though the actual matrix is aqueous, because the blanks were collected to assess potential contamination imparted during decontamination activities or transport of ***soil*** samples.

20. Record the sample type code, which is located at the bottom of the COC form. The sample type is a crucial element of the EQuIS data management system. For simplicity, only typical sample type codes are listed on the bottom of the COC form, but below is a list of all applicable Navy field sample type codes:

Table 2
Navy Sample Type Codes

Sample Type Code	Sample Type Code Description
AB	Ambient condition blank
BIOCON	Bioassay control sample
BS	Blank spike
BSD	Blank spike duplicate
EB	Equipment blank
EBD	Equipment blank/rinsate duplicate
FB	Field blank
FD	Field duplicate
FS	Field spike
IDW	Purge and rinsate water
LB	Lab Blank
LR	Lab Replicate
MB	Material blank
MIS	Multi-Incremental Sample
MS	Matrix spike
N	Normal (Regular)
PE	Performance evaluation
PURGE	Purge water sample
RD	Regulatory duplicate
SB	Source blank
SBD	Source blank duplicate
SCREEN	Screening Sample
SD	Matrix spike duplicate
SPLIT	Sample split
SRM	Standard reference material
TB	Trip Blank
TBD	Trip blank duplicate
TBR	Trip blank replicate

Field duplicate samples — Field duplicates will be identified using the format detailed in the Site's Sampling and Analysis Plan. However, field duplicates will also be differentiated from the parent sample on the chain-of-custody form. The parent sample will have a sample type code of "N," for normal environmental sample; while its duplicate will have a sample type code of "FD."

21. Record whether the sample is field filtered with a "Y" or not field filtered with an "N." If a project requires collecting samples for both total and dissolved constituents, the same sample and location ID is used for both (see 15 and 16); however, the sampler will indicate whether the sample is field filtered at this location on the COC form. This field must always be filled out; even when soil samples are collected (where "N" appropriately applies, in most cases).

22. Record the total number of containers that are submitted for all of the tests. This must add up to the total number of containers listed for each individual test in 23.

23. Record the number of containers for each test. Do not use Xs, rather indicate the number of containers submitted for each test listed in 14. For example, Sample 010MW007002 requires analysis for VOCs (8260), and SVOCs (8270). Record 3 under the VOC analysis and 2 under the SVOC (assuming 3 containers were submitted for VOCs and 2 were submitted for SVOCs). The total number of containers in this example is 5, which should be the total number of containers listed in 22. Extra containers submitted for matrix spike/matrix spike duplicates (MS/MSDs) will be appropriately recorded.

24. Indicate if extra sample volume was included for MS/MSD analysis using an "X." Samples to be used for MS/MSDs will use the same sample ID and location ID (see 15 and 16), but will be collected in triplicate, particularly for liquid samples, to ensure the analytical laboratory receives sufficient volume for the analyses.

25. Indicate if the samples should be held by the laboratory for future testing using an "X."

26. Record any field comments.

27. Reserved for laboratory comments.

28. Indicate the total number of coolers in each shipment. *Note*: When multiple coolers are submitted, each should contain a COC form.

29. Signature(s) of the person(s) relinquishing sample custody.

30. Signature(s) of the person(s) receiving sample custody.

31. Indicate whether the samples are iced, by checking the appropriate response.

32. Indicate the method of shipment (e.g., FedEx, hand-delivered, laboratory courier).

33. Record the airbill number when a commercial courier is used. This is particularly important when multiple coolers are sent in the same shipment or when the laboratory is sent the COC form in advance of receiving samples because it aids in tracking lost coolers.

34. Record the date the coolers were shipped.

COC forms tailored to each CTO can be drafted and printed onto multiple forms. This eliminates the need to rewrite the analytical methods column headers each time. It also eliminates the need to write the project manager, name, and number; QC Level; turnaround time; and the same general comments each time.

Complete one COC form per cooler. Whenever possible, place all volatile organic analyte vials into one cooler in order to reduce the number of trip blanks. Complete all sections and be sure to sign and date the COC form. One copy of the COC form must remain with the field personnel.

6.0 RECORDS

The COC/analytical request form shall be faxed or emailed approximately daily to the Project Chemist, or designee for verification of accuracy. Following the completion of sampling activities, the sample logbook and COC forms will be transmitted to the CTO Manager for storage in project files. The original COC/analytical request form shall be submitted by the laboratory along with the data delivered. Any changes to the analytical requests that are required shall be made in writing to the laboratory. A copy of this written change shall be sent to the data validators and placed in the project files. The reason for the change shall be included in the project files so that recurring problems can be easily identified.

7.0 HEALTH AND SAFETY

Not applicable.

8.0 REFERENCES

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/-ufp_qapp_v1_0305.pdf.

9.0 ATTACHMENTS

Attachment 1: Chain-of-Custody Seal
Attachment 2: Generic Chain-of-Custody/Analytical Request Form

Attachment 1
Chain-of-Custody Seal

EXAMPLE CHAIN-OF-CUSTODY SEAL

<table>
<tr><td rowspan="3">[LABORATORY]</td><td>SAMPLE NO.</td><td>DATE</td><td>SEAL BROKEN BY</td></tr>
<tr><td colspan="2">SIGNATURE</td><td>DATE</td></tr>
<tr><td colspan="3">PRINT NAME AND TITLE (Inspector, Analyst or Technician</td></tr>
</table>

Attachment 2

Example Chain-of-Custody/Analytical Request Form

RESOLUTION CONSULTANTS

CHAIN OF CUSTODY AND ANALYTICAL REQUEST RECORD

COC No. 8 | Page of 10

Project Name: 1 | PO No. 9 | Project No. 11 | Phase

Site Location: 2 | **Sample Analysis Requested** (*Enter number of containers for each test*)

CTO No. 3 | RC Task Order Manager: 4

Sampler/Site Phone# 5

Lab Name: 6 | Turnaround Time(specify): 7

Lab ID	Sample ID (sys_samp_code)	Location ID (sys_loc_code)	Date (mm/dd/yy)	Time (Military) (hhmm)	Matrix Code (1)	Sample Type (2)	Field Filtered (Y/N)	Total No. of Containers											Extra Volume for MS/MSD	HOLD
								(3)→	12											
									13											
14	15	16	17	18	19	20	21	22	23										24	25

Field **Comments:** 26

Lab **Comments:** 27

Sample Shipment and Delivery Details

Number of coolers in shipment: 28

Relinquished by (signature)	Date	Time	Received by (signature)	Date	Time	
1 29			1 30			Samples Iced?(check) 31 Yes___ No____
						Method of Shipment: 32
2			2			Airbill No: 33
3			3			Date Shipped: 34

(1) **AA**=Ambient air, **AQ**=Air quality control, **ASB**=Asbestos, **CK**=Caulk, **DS**=Storm drain sediment, **GS**=Soil gas, **IC**=IDW Concrete, **IDD**=IDW Solid, **IDS**=IDW soil, **IDW**=IDW Water, **LF**=Free Product, **MA**=Mastic, **PC**=Paint Chips, **SC**=Cement/Concrete, **SE**=Sediment, **SL**=Sludge, **SO**=Soil, **SQ**=Soil/Solid quality control, **SSD**=Subsurface sediment, **SU**=Surface soil (<6 in), **SW**=Swab or wipe, **TA**=Animal tissue, **TP**=Plant tissue, **TQ**=Tissue quality control, **WG**=Ground water, **WL**=Leachate, **WO**=Ocean water, **WP**=Drinking water, **WQ**=Water quality control, **WR**=Ground water effluent, **WS**=Surface water, **WU**=Storm water, **WW**=Waste water

(2) **Sample Type: AB**=Ambient Blk, **EB**=Equipment Blk, **FB**=Field Blk, **FD**=Field Duplicate Sample, **IDW**=Investigative-Derived Waste, **MIS**=Incremental Sampling Methodology, **N**=Normal Environmental Sample, **TB**=Trip Blk

(3) **Preservative added: HA**=Hydrochloric Acid, **NI**=Nitric Acid, **SH**=Sodium Hydroxide, **SA**=Sulfuric Acid, **ME**=Methanol, **SB**=sodium bisulfate, **ST**=Sodium Thiosulfate If **NO preservative** added leave blank

Rev 5/12

Standard Operating Procedure SOP-03-04 (MS)
Sample Handling, Storage, and Shipping of Low Level Environmental Samples

1.0 PURPOSE

This Standard Operating Procedure (SOP) sets forth the methods for use by personnel engaged in handling, storing, and transporting low level environmental samples.

If there are procedures whether from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to sample handling, storage, and shipping, then those procedures may be added as an appendix to the project-specific Sampling and Analysis Plan.

2.0 SCOPE

In general, low-level environmental samples include drinking water, most groundwater and ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, biological specimens, and other samples not expected to be contaminated with high levels of hazardous materials. Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods and are not covered in this SOP, which is intended for handling and shipment of low-level environmental samples.

This procedure shall serve as management-approved professional guidance consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

The CTO Manager, or designee, and the laboratory Project Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future sample transport activities are in compliance with this procedure.

The Field Manager is responsible for ensuring that all samples are shipped according to this procedure. Field personnel are responsible for the implementation of this procedure. Personnel that are involved in packaging, shipping, and receipt of samples must be aware of

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Department of Transportation (DOT) regulations, know when to apply them, and know what procedures are needed to support this application.

The QA Manager or Technical Director is responsible for ensuring that sample handling, storage, and transport activities conducted during all CTOs are in compliance with this procedure.

5.0 PROCEDURES

5.1 Handling and Storage

Environmental samples should be packaged prior to shipment using the following procedures:

1. Allow sufficient headspace in all bottles (except volatile organic analysis containers with a septum seal) to compensate for any pressure and temperature changes (approximately 1 percent of the volume of the container).

2. Ensure that the lids on all bottles are tight (will not leak).

3. Glass bottles should be wrapped in bubble wrap — preferably sealable bubble wrap sample bags, if available. Place bottles in separate and appropriately-sized polyethylene bags and seal the bags.

4. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber or duct tape inside and outside. Line the cooler with a large heavy-duty plastic bag.

5. Place cushioning/absorbent material in the bottom of the cooler, if available, and then place the containers in the cooler with sufficient space to allow for the addition of cushioning between the containers.

6. Put "blue ice" (or ice that has been "double bagged" in heavy-duty polyethylene bags and properly sealed) on top of and/or between the containers. Fill all remaining space between the containers with bubble wrap or other suitable absorbent material.

7. Securely fasten the top of the large garbage bag with packaging tape.

8. Place the completed Chain-of-Custody (COC) Record into a sealed plastic bag, and tape the bag to the inner side of the cooler lid.

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9. Close the cooler and securely tape (preferably with fiber tape) the top of the cooler shut. COC seals should be affixed to opposing sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

5.2 Shipping

Follow all appropriate DOT regulations (e.g., 49 Code of Federal Regulations, Parts 171-179) for shipment of air, soil, water, and other samples. Elements of these procedures are summarized in the following subsections.

5.2.1 Non-hazardous Materials Shipment

If the samples are suspected to be non-hazardous based on previous site sample results, field screening results, or visual observations, if applicable, then samples may be shipped as non-hazardous.

When a cooler is ready for shipment to the laboratory, prepare standard air bill paperwork for shipment of the samples to the laboratory. Write the shippers tracking/airbill number on the COC form. Place two copies of the COC form inside a self-sealing bag and tape it to the inside of the cooler. Seal the cooler with waterproof tape and label it with "Fragile," "This-End-Up" (or directional arrows pointing up), or other appropriate notices. Affix a label stating the destination (laboratory address) to each cooler. Personnel should be aware of carrier weight or other policy restrictions.

5.2.1 Hazardous Materials Shipment

Shipment of Hazardous Material is not covered in this SOP; all samples handled under this SOP are anticipated to be non-hazardous or not dangerous goods. The CTO Manager, or designee, is responsible for determining if samples collected during a specific field investigation meet the definitions for dangerous goods. If a sample is collected of a material that is listed in the Dangerous Goods List, Section 4.2, of International Air Transport Authority (IATA), then that sample must be identified, packaged, marked, labeled, and shipped according to the instructions given for that material. If the composition of the collected sample(s) is unknown, and the project leader knows or suspects that it is a regulated material (dangerous goods), the sample may not be offered for air transport. If the composition and properties of a waste sample or a highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport.

6.0 RECORDS

Maintain records as required by implementing these procedures.

7.0 HEALTH AND SAFETY

Avoid lifting heavy coolers with back muscles; instead, use leg muscles or dollies.

Wear proper gloves, such as blue nitrile and latex, as defined in the site-specific project health and safety plan, when handling sample containers to avoid contacting any materials that may have spilled out of the sample containers.

8.0 REFERENCES

International Air Transport Authority (IATA). Dangerous Goods Regulations
http://www.iata.org/whatwedo/cargo/dangerous_goods/Documents/DGR52-significant-changes.pdf

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

9.0 ATTACHMENTS

None

Standard Operating Procedure SOP-3-05 (MS)
Investigation-Derived Waste Management

1.0 PURPOSE

The purpose of this procedure is to provide guidance for the minimization, handling, labeling, temporary storage, inventory, classification, and disposal of investigative derived waste (IDW) generated during all field activities, including:

- Personal protective equipment (i.e., gloves, Tyveks, spent respirators) and non-contaminated solid waste.
- Solid hazardous and non-hazardous waste (i.e., soil cuttings, drilling mud, contaminated equipment)
- Liquid hazardous and non-hazardous waste (i.e., purge/development water, rinse water from decontamination, free-phase product)

The waste handling procedures will vary according to project-specific and Facility requirements. Those specified in this SOP are unique to Naval Support Activity Mid-South in Millington, Tennessee. Additional procedures from Resolution Consultants, state and/or federal regulations that are not addressed in this Standard Operating Procedure (SOP) and that are applicable, may be added as an appendix to the project specific Sampling and Analysis Plan (SAP).

2.0 SCOPE

This procedure shall serve as management-approved professional guidance and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by both the Contract Task Order (CTO) Manager and the Quality Assurance (QA) Manager or Technical Director, and documented.

Solid, liquid, and PPE waste will be characterized for disposal through the use of client knowledge, laboratory analytical data created from soil or groundwater samples gathered during the field activities, and/or composite samples from individual containers.

All waste generated during field activities will be stored, transported, and disposed of according to applicable state, federal, and local regulations. While no hazardous waste generation is expected,

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any that is classified as hazardous will be disposed of at a licensed treatment storage and disposal facility.

All waste-disposal shall be carefully coordinated with NSA Mid-South Public Works personnel and the facility receiving the waste. Facilities receiving waste have specific requirements. Waste characterization shall be conducted to support both applicable regulations and Facility requirements.

3.0 RESPONSIBILITY

The CTO Manager is responsible for overseeing and ensuring that the IDW is properly managed in accordance with this SOP and any other facility or project-specific planning documents.

The Field Team Leader is responsible for understanding, overseeing, and documenting all field activities related to the implementation of this SOP.

4.0 PROCEDURES FOR WASTE DISPOSAL

The following procedures are to be used for handling IDW at NSA Mid-South

4.1 Soil and Mud Waste

Soil cuttings and drilling mud generated from drilling activities shall be collected in 55-gallon drums and staged next to the borehole/monitoring well until the conclusion of the drilling program. Drums shall be secured with bolt-on lids and labeled in accordance with this SOP. An inventory containing the source, volume, and description of generated soil/mud waste shall be logged in the field logbook. At the conclusion of the drilling program and consistent with recent RFI activities, NSA Mid-South Public Works personnel shall be contacted for access to SWMU 41 on the Southside of the facility where the soil waste will be thin-spread and temporarily staged while pending laboratory analysis. Straw bales will be placed around the soil placement area to ensure effective storm water controls. Soil and mud-waste should be spread to a thickness of 6-inches, after which one composite soil sample shall be collected for every 100 square feet of soil and submitted for total and toxicity characteristic leaching procedure (TCLP) analyses for the contaminants of concern. The analytical data will be used to verify whether a potential exposure risk is posed and whether the soil meets the characteristic hazardous waste criteria. If the contaminants of concern are unknown or could be multiple, then samples shall be analyzed for a full analytical suite using both methods (total and TCLP). Soil waste generated during investigating

AOC A shall be analyzed for the minimum constituents: TPH, VOCs, and TCLP-VOCs, and TCLP-RCRA Metals.

Following confirmation that no soil risk is posed by contaminants in the soil and it meets the non-hazardous criteria characteristics, the plastic sheeting will be removed, the soil will be seeded and covered with straw. The SWMU 41 soil disposal area is shown on Figure 1 (Attachment 1). Since the disposal area is located on the secured, Southside of NSA Mid-South, the drilling subcontractor will be required to complete Form 5530 (Attachment 2) and obtain a badge for accessing the NSA Mid-South Southside. Completed 5530 Forms should be submitted within 48-hours before needing access to Ms. Barbara Kaldenburg in Building 455. Completed forms may be hand delivered, e-mailed (barbara.kaldenburg@navy.mil), or faxed (901 874 7022).

A sketch of sample locations shall be made in the field logbook and upon receipt of the analytical data, a summary table of any detected contaminants shall be created with the appropriated screening/regulatory standards for documenting the final disposition of the soil IDW. A hits-only summary table and analytical data should be provided to the Navy in the project-specific report.

In the rare event waste is deemed hazardous or poses a residential risk based on detected contaminants, it must be containerized and arranged for disposed at an off-site facility. Transportation and disposal of any waste shall be coordinated directly with NSA Mid-South Public Works personnel who will sign all applications and waste manifests. NSA Mid-South Public Works personnel that should be contacted with all waste disposal issues are the following:

Debbie Zanot (Hazardous Waste Coord.)	(901) 874 5368
Rob Williamson	(901) 874 5399
Jim Heide (alternate)	(901) 874 5367

Should waste or waste water analysis indicate that the material must be disposed of as hazardous waste, disposal shall be coordinated with Debbie Zanot: (901) 874-5368.

4.2 Waste Water

Groundwater generated during monitoring well development, purging, and sampling has historically been released to the sanitary sewer after collecting waste profile data and authorization from the Millington Waste Water Treatment Plant. Typically, development/purge water is collected in totes,

drums and/or portable storage tanks provided by the drilling contractor and then transferred to a larger holding tank provided by NSA Mid-South Public Works personnel. Public works personnel must be contacted in advance of sampling/drilling activities so holding tanks can be staged at a pre-arranged location next to a sanitary sewer inlet and near the field-work area. The Millington Industrial Development Board or the Millington Airport Authority shall also be contacted regarding anticipated work activities and before the staging of any totes/vessels on their property. Any containers holding waste-water awaiting analysis must be labeled, properly secured, and staged until analysis is complete and authorization granted by the city of Millington to discharge the waste water to the sewer.

Before waste water can be discharged to the sanitary sewer, the City of Millington water treatment plant requires that the water-waste be characterized and data evaluated for the contaminants of concern. One water sample shall be collected per holding tank and analyzed for the contaminants of concern. Fisher Arnold Inc. is subcontracted by the waste water treatment plant for data evaluation and discharge approval. Upon receipt of the analytical data, approval for discharge must be requested via email from Mr. Jim Cox at jlcox@fisherarnold.com. The request will contain the following information:

- Analytical data for contaminant(s) of concern
- Volume of proposed discharge
- Schedule of anticipated discharge

Upon approval for discharging waste water, water will be released to the sanitary sewer and Public Works personnel will be contacted for the removal and transport of the emptied holding tank(s) to their designated storage area. Discharge dates, volumes, and analytical data shall be retained with the project files and incorporated into the appropriate project-specific reports. All copies of correspondence between RC and City of Millington shall be forwarded to the Public Works Environmental Division Director. In the event water waste is considered hazardous or approval to discharge to the sanitary sewer is not permitted by the city of Millington, the waste is to remain staged until alternate treatment and/or disposal options are evaluated with NSA Mid-South personnel.

4.3 Personal Protective Equipment (PPE)

Historically, low concentration solvents detected in AOC A groundwater has resulted in no special handling of PPE. Therefore, PPE and non-media solid waste (i.e., empty bags, supply containers,

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trash) that is generated during AOC A investigation activities shall be placed in plastic garbage bags and disposed of in designated dumpsters at NSA Mid-South. In the event PPE is generated from contact with suspect hazardous liquid or solid waste it shall be labeled, secured in a 55-gallon drum, and appropriately disposed pending the analytical results.

4.4 Soil Drum Handling

Soil and mud IDW shall be containerized using U.S. Department of Transportation-(DOT) approved drums. The drums shall be made of steel, have a 55-gallon capacity, be completely painted and have removable lids (i.e., United Nations Code 1A2 or 1H2). Lids must be able to securely closed. Recycled drums shall not be used for hazardous waste, polychlorinated byphenyls (PCBs) or other regulated shipments. For short-term storage of non-hazardous soil IDW, reconditioned drums are acceptable for use. Verify the integrity of the foam or rubber sealing ring located on the underside of some drum lids prior to sealing drums containing IDW liquids. If the ring is only partially attached to the drum lid, or if a portion of the ring is missing, select another drum lid with a sealing ring that is in sound condition.

To prepare IDW drums for labeling, wipe clean the outer wall surfaces and drum lids of all material that might prevent legible and permanent labeling. If potentially contaminated material adheres to the outer surface of a drum, wipe that material from the drum, and segregate the paper towel or rag used to remove the material with visibly soiled PPE and disposable sampling equipment. Label all IDW drums and place them on pallets for transport.

4.5 Drum Labeling

Two general conditions exist for labeling drums: 1) waste characteristics are known to be either hazardous or nonhazardous from previous studies or project-specific data; or 2) waste characteristics are unknown until additional data are obtained. In most cases waste generated in environmental investigations can be assumed to be non-hazardous; however, if waste is suspected to contain elevated contaminant mass based on staining, odors, or other indications, then the waste should be segregated and labeled while pending analysis followed with the below drum labeling instructions. In no case should waste be thin-spread at SWMU 41 (as discussed in Section 4.1) if there is any indication that contamination may be present in the waste.

The following labeling requirements shall be adhered to for nonhazardous waste containers that are generated and pending transportation/disposal:

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- Description of waste (i.e., purge water, soil cuttings)
- Contact information (i.e., contact name and telephone number)
- Date when the waste was first generated

The following information shall be placed on all hazardous waste labels:

- Description of waste (i.e., purge water, soil cuttings)
- Generator information (i.e., name, address, contact telephone number)
- EPA identification number (supplied by on-site client representative)
- Date when the waste was first accumulated

If waste data is suspected of being contaminated then the drums should be staged and labeled with the words "waste characterization pending analysis" and the following information included on the label:

- Description of waste (i.e., purge water, soil cuttings)
- Contact information (i.e., contact name and telephone number)
- Date when the waste was first accumulated

Once the waste has been characterized, the label should be changed as appropriate for a nonhazardous or hazardous waste. If the project-specific planning documents do not specify the sampling frequency, one composite sample shall be collected per set of drums generated at each monitoring well/soil boring.

Waste labels should be constructed of a weatherproof material and filled out with a permanent marker to prevent being washed off or becoming faded by sunlight. Waste labels shall be placed on the side of the container, since the top is more subject to weathering. However, when multiple containers are accumulated together, labels must also be placed on the top of the containers to facilitate organization and disposal.

4.6 Waste Accumulation On-Site

Solid, liquid, or PPE wastes generated during investigation activities that are classified as hazardous shall not be accumulated on-site longer than 90 days. All waste that is deemed as hazardous or drummed non-hazardous waste that requires off-site shipment, temporarily will be staged at Building 1694 while pending transport and disposal. Any waste requiring offsite disposal shall be

coordinated with Ms. Debbie Zanot (ph. 901 874 5368), the NSA Mid-South hazardous waste coordinator. At a minimum, the following requirements for the hazardous waste storage area must be implemented:

- Proper hazardous waste signs shall be posted as required by any state or federal statutes that may govern the labeling of waste;
- Secondary containment to contain spills;
- Spill containment equipment must be available;
- Fire extinguisher;
- Adequate aisle space for unobstructed movement of personnel.

RC will generate an inventory of all drums staged at 1694 at the conclusion of field activities and their classification (hazardous versus non-hazardous) and quantity will be provided to NSA Mid-South Public Works Environmental Division Director. Any transport of waste classified as hazardous will be conducted only by a state-certified hazardous waste hauler. Typically, the facility receiving any waste can coordinate a hauler to transport the waste. Shipped hazardous waste shall be disposed of in accordance with all RCRA/USEPA requirements. All waste manifests or bills of lading will be signed by the NSA Mid-South Public Works Environmental Division Director and copied to the project file.

5.0 REGULATORY REQUIREMENTS

The following federal and state regulations shall be used as resources for determining waste characteristics and requirements for waste storage, transportation, and disposal:

- Code of Federal Regulations (CFR), Title 40, Part 261;
- CFR, Title 49, Parts 172, 173, 178, and 179.

6.0 RECORDS

All containerized IDW shall be documented in the field logbook.

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7.0 REFERENCES

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Attachments

Attachment 1: Figure 1 — Soil/Mud Waste Disposal Area; Former SWMU 41 at NSA Mid-South Southside

Attachment 2: Form 5530 — NAVSUPPACT Mid-South Building CAC Access/Issue Application

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Figure 1 — Soil/Mud Waste Disposal Area; Former SWMU 41 at NSA Mid-South Southside

Attachment 2: Form 5530 for Base Access (Southside)

NAVSUPPACT MID-SOUTH BUILDING CAC ACCESS/ISSUE APPLICATION				
From: Robert Morrison **To:** Email to MILL_BADGE@NAVY.MIL **Subj:** Request for Identification Badge, and access to restricted spaces				
APPLICANT INFORMATION				
Name (Last, First, Middle Initial)	**Gender**	**Citizenship**	**SSN:**	
Command/Dep. **NAVFAC/PWD MIDSOUTH**	**Title:**		**Date of Birth:**	
Race:	**State Drivers License#:**			
Height:	**Weight:**	**Hair Color:**	**Eye Color:**	**Work Phone:**
Company Name: (Contractors):	**Contract Exp Date:**	**Contract Number:**		
COMMAND ACCESS REQUEST				
☒ **New Access**	☐ **Access Modification**	☐ **Non-CAC Contractor**		
REASON FOR BADGE ISSUANCE				
☒ **Initial Issue**	☐ **Renewal**	☐ **Replacement**		
EXTERNAL BUILDING ACCESS:				
External Building(s), Days, and Time for access(EX: 455, Mon-Fri, 0600-1800) **Building 455, Mon. – Fri, 0600 - 2400**				
RESTRICTED SPACE(s) ACCESS REQUIRED:				
Building(s), Room Number, Days, Time for access(EX: 769, Room 188, 24 X 7)				
ONLY COMMAND APPOINTED AUTHORIZED PERSONNEL CAN SIGN REQUEST				
Authorizing Official: (Last Name, First and Middle Initial)	**Telephone Number:**			
Authorizing Official Signature: (N/A when emailed, verified by email from authorizing official)	**Date:**			

Privacy Act Statement

AUTHORITY: 5 U.S.C. 301; EO 12356; EO 9397
PRINCIPAL PURPOSE: To facilitate verification of a personnel security clearance for an individual applying for building access in connection with their livelihood or official duties.
ROUTINE USES; Information may be furnished to Federal, state, or local agencies for regulatory and law enforcement purposes.
DISCLOSURE: Voluntary; however, refusal to furnish requested information may result in inability to verify essential personal information and approve requested building pass application.

Standard Operating Procedure SOP-3-06
Equipment Decontamination

1.0 PURPOSE

This standard operating procedure (SOP) describes methods of equipment decontamination for use during site activities by field personnel. If there are procedures from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to equipment decontamination, then those procedures may be added as an appendix to the project-specific Sampling and Analysis Plan (SAP).

2.0 SCOPE

This procedure shall serve as management-approved professional guidance for and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by both the Contract Task Order (CTO) Manager and the Quality Assurance (QA) Manager.

3.0 DEFINITIONS

3.1 Logbook

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person assigned responsibility for maintenance of the logbook, and the beginning and ending dates of the entries.

4.0 RESPONSIBILITIES

The CTO Manager is responsible for identifying instances of non-compliance with this procedure and ensuring that decontamination activities comply with this procedure. The CTO Manager is responsible for ensuring that all personnel involved in equipment decontamination shall have the appropriate education, experience, and training to perform their assigned tasks.

The QA Manager or CTO Manager is responsible for ensuring overall compliance with this procedure. The Field Manager is responsible for ensuring that all field equipment is decontaminated according to this procedure. Field personnel are responsible for the implementation of this procedure.

5.0 PROCEDURES

Decontamination of equipment used in soil/sediment sampling, groundwater monitoring, well drilling and well development, as well as equipment used to sample groundwater, surface water,

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sediment, waste, wipe, asbestos, and unsaturated zone is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program requires consideration of the following factors:

- The location where the decontamination procedures will be conducted
- The types of equipment requiring decontamination
- The frequency of equipment decontamination
- The cleaning technique and types of cleaning solutions appropriate to the contaminants of concern
- The method for containing the residual contaminants and wash water from the decontamination process
- The use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsection describes standards for decontamination, including the frequency of decontamination, cleaning solutions and techniques, containment of residual contaminants and cleaning solutions, and effectiveness.

5.1 Decontamination Area

Select an appropriate location for the decontamination area at a site based on the ability to control access to the area, the ability to control residual material removed from equipment, the need to store clean equipment, and the ability to restrict access to the area being investigated. Locate the decontamination area an adequate distance away and upwind from potential contaminant sources to avoid recontamination of clean equipment.

5.2 Types of Equipment

Drilling equipment that must be decontaminated includes drill bits, auger sections, drill-string tools, drill rods, split barrel samplers, tremie pipes, clamps, hand tools, and steel cable. Decontamination of monitoring well development and groundwater sampling equipment includes submersible pumps, bailers, interface probes, water level meters, bladder pumps, airlift pumps, peristaltic pumps,

and lysimeters. Other sampling equipment that requires decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless-steel spoons and bowls, soil sample liners and caps, wipe sampling templates, composite liquid waste samplers, and dippers. Equipment with a porous surface, such as bailing twine, rope, cloth hoses, and wooden blocks cannot be thoroughly decontaminated and shall be properly disposed after one use.

5.3 Frequency of Equipment Decontamination

Decontaminate down-hole drilling equipment and equipment used in monitoring well development and purging prior to initial use and between each borehole or well. Down-hole drilling equipment, however, may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, decontaminate the drilling tools prior to drilling deeper.

Initiate groundwater sampling from the monitoring well where the least contamination is suspected. Decontaminate groundwater, surface water, and soil sampling devices prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

5.4 Cleaning Solutions and Techniques

Decontamination is accomplished using a variety of techniques and fluids. The preferred method of decontaminating major equipment, such as drill bits, augers, drill string, and pump drop-pipe, is steam cleaning. To steam clean, use a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, thoroughly steam wash equipment, and rinse it with potable tap water to remove particulates and contaminants.

A rinse decontamination procedure is acceptable for small equipment such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following:

1. Wash with a non-phosphate detergent (alconox, liquinox, or other suitable detergent) and potable water solution.

2. Rinse with potable water.

3. Spray with laboratory-grade isopropyl alcohol or other appropriate solvent (if used).

4. Rinse with deionized or distilled water.

5. Spray with deionized or distilled water. If possible, disassemble equipment prior to cleaning. Add a second wash at the beginning of the process if equipment is very soiled.

Isopropyl alcohol may contribute to acetone formation; therefore, its use in decontamination of equipment used for sampling volatile organic compounds should be considered. Solvents other than isopropyl alcohol may be used, depending upon the contaminants involved. For example, if polychlorinated biphenyls or chlorinated pesticides are contaminants of concern, hexane may be used as the decontamination solvent. However, if samples are also to be analyzed for volatile organics, hexane shall not be used. In addition, some decontamination solvents have health effects that must be considered. Decontamination water shall consist of distilled or deionized water. Steam-distilled water shall not be used in the decontamination process as this type of water usually contains elevated concentrations of metals. Decontamination solvents to be used during field activities will be specified in CTO work plan (WP) or site-specific SAP.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. Decontaminate these pumps by washing and rinsing the outside surfaces using the procedure described for small equipment or by steam cleaning. Decontaminate the internal surfaces by recirculating fluids through the pump while it is operating. This recirculation may be done using a relatively long (typically 4-feet) large-diameter pipe (4-inch or greater) equipped with a bottom cap. Fill the pipe with the decontamination fluids, place the pump within the capped pipe, and operate the pump while recirculating the fluids back into the pipe. The decontamination sequence shall include:

1. Detergent and potable water,
2. Potable water rinse,
3. Potable water rinse, and
4. Deionized water rinse. Change the decontamination fluids after each decontamination cycle.

Rinse equipment used for measuring field parameters, such as pH (indicates the hydrogen ion concentration — acidity or basicity), temperature, specific conductivity, and turbidity with deionized

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or distilled water after each measurement. Also wash new, unused soil sample liners and caps with a fresh detergent solution and rinse them with potable water followed by distilled or deionized water to remove any dirt or cutting oils that might be on them prior to use.

5.5 Containment of Residual Contaminants and Cleaning Solutions

A decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water.

When contaminated material and cleaning fluids must be contained from heavy equipment, such as drill rigs and support vehicles, the area must be properly floored, preferably with a concrete pad that slopes toward a sump pit. If a concrete pad is impractical, planking can be used to construct solid flooring that is then covered by a nonporous surface and sloped toward a collection sump. If the decontamination area lacks a collection sump, use plastic sheeting and blocks or other objects to create a bermed area for collection of equipment decontamination water. Situate smaller items such as auger flights on metal stands or other similar equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers such as Department of Transportation (DOT)-approved drums, until their disposition is determined by laboratory analytical results.

Store clean equipment in a separate location to prevent recontamination.

Use wash buckets or tubs to catch fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices. Collect the decontamination fluids and store them onsite in secured containers, such as DOT-approved drums, until their disposition is determined by laboratory analytical results.

5.6 Effectiveness of Decontamination Procedures

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment blank samples or wipe testing. Equipment blanks consist of analyte-free water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a cloth over the surface of the equipment after cleaning. These quality control measures provide "after-the fact" information that may be useful in

determining whether or not cleaning methods were effective in removing the contaminants of concern.

6.0 RECORDS

Describe the decontamination process in the field logbook.

7.0 HEALTH AND SAFETY

It is the responsibility of the Site Safety Office (SSO) to set up the site zones (i.e., exclusion, transition, and clean) and decontamination areas. Generally, the decontamination area is located within the transition zone, upwind of intrusive activities, and serves as the washing area for both personnel and equipment to minimize the spread of contamination into the clean zone. For equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing solvents (if required) and distilled water are used for final rinsing of equipment. Depending on the nature of the hazards and the site location, decontamination of heavy equipment, such as augers, pump drop pipe, and vehicles, may be accomplished using a variety of techniques.

Personnel responsible for equipment decontamination must adhere to the site-specific health and safety plan (HASP) and must wear the personal protective equipment (PPE) specified in the site-specific HASP. Generally this includes, at a minimum, Tyvek coveralls, steel-toed boots with boot covers or steel-toed rubber boots, safety glasses, American National Standards Institute-standard hard hats, and hearing protection (if heavy equipment is in operation). Air monitoring by the SSO may result in an upgrade to the use of respirators and cartridges in the decontamination area; therefore, this equipment must be available onsite. If safe alternatives are not achievable, discontinue site activities immediately.

In addition to the aforementioned precautions, employ the following safe work practices:

Chemical Hazards Associated With Equipment Decontamination

- Avoid skin contact with and/or incidental ingestion of decontamination solutions and water.
- Utilize PPE as specified in the site-specific HASP to maximize splash protection.
- Refer to material safety data sheets, safety personnel, and/or consult sampling personnel regarding appropriate safety measures (i.e., handling, PPE including skin and respiratory).
- Take the necessary precautions when handling detergents and reagents.

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Physical Hazards Associated With Equipment Decontamination

- To avoid possible back strain, it is recommended to raise the decontamination area 1 to 2 feet above ground level.

- To avoid heat stress, over exertion, and exhaustion, it is recommended to rotate equipment decontamination among all site personnel.

- Take necessary precautions when handling field sampling equipment.

8.0 REFERENCES

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U.S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at:http://www.epa.gov/fedfac/pdf/-ufp_qapp_v1_0305.pdf.

9.0 ATTACHMENTS

None.

Standard Operating Procedure SOP-3-08 (MS)
Soil Classification

1.0 PURPOSE

This section sets forth standard operating procedures for soil classification. If there are procedures from Resolution Consultants, state and/or federal that are not addressed in this Standard Operating Procedure (SOP) and are applicable to soil and rock classification then those procedures may be added as an appendix to the project specific Sampling and Analysis Plan (SAP).

2.0 SCOPE

This procedure shall serve as management-approved professional guidance and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

The CTO Manager, or designee, is responsible for ensuring that these standard soil and rock classification procedures are followed and that a qualified individual conducts or supervises the projects. A qualified individual is defined as a person with a degree in geology, hydrogeology, soil science, or geotechnical/civil engineering with at least 1 year of experience classifying soil. Supervision is defined as onsite and continuous monitoring of the individual conducting soil classification. The CTO Manager is responsible for ensuring that all personnel involved in soil and rock classification shall have the appropriate education, experience, and training to perform their assigned tasks. The CTO Manager is responsible for reviewing copies of the field boring log forms on a monthly basis at a minimum.

QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5.0 SOIL CLASSIFICATION

The basic purpose of the classification of soil is to thoroughly describe the physical characteristics of the sample and to classify it according to an appropriate soil classification system. The Unified Soil Classification System (USCS) was developed so that soils could be described on a common basis by different investigators and serve as a "shorthand" description of soil. A classification of a soil in accordance with the USCS includes not only a group symbol and name, but also a complete word description.

Describing soil on a common basis is essential so that soil described by different site qualified personnel is comparable. Site individuals describing soil as part of site activities *must* use the classification system described herein to provide the most useful geologic database for all present and future subsurface investigations and remedial activities.

The site geologist or other qualified individual shall describe the soil and record the description in a boring log or logbook. The essential items in any written soil description are as follows:

- Classification group name (e.g., silty sand)
- Color, moisture, and odor
- Range of particle sizes and maximum particle size
- Approximate percentage of boulders, cobbles, gravel, sand, and fines
- Plasticity characteristics of the fines
- In-place conditions, such as consistency, density, and structure
- USCS classification symbol

The USCS serves as ”shorthand“ for classifying soil into 15 basic groups:

- GW[1] Well graded (poorly sorted) gravel (>50 percent gravel, <5percent fines)
- GP[1] Poorly graded (well sorted) gravel (>50percent gravel, <5percent fines)
- GM[1] Silty gravel (>50 percent gravel, >15 percent silt)
- GC[1] Clayey gravel (>50 percent gravel, >15 percent clay)
- SW[1] Well graded (poorly sorted) sand (>50 percent sand, <5 percent fines)
- SP[1] Poorly graded (well sorted) sand (>50 percent sand, <5 percent fines)

[1] If percentage of fine is 5 percent to 15 percent, a dual identification shall be given (e.g., a soil with more than 50 percent poorly sorted gravel and 10 percent clay is designated GW-GC.

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- SM[1] Silty sand (>50 percent sand, >15 percent silt)
- SC[1] Clayey sand (>50 percent sand, >15 percent clay)
- ML[2] Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness, and plasticity)
- CL[2] Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)
- MH[2] Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)
- CH[2] Inorganic, high plasticity (fat) clay (no dilatancy, high toughness, and plasticity)
- OL Organic low plasticity silt or organic silty clay
- OH Organic high plasticity clay or silt
- PT Peat and other highly organic soil

Figure 1 defines the terminology of the USCS. Flow charts presented in Figure 2 and Figure 3 indicate the process for describing soil. The particle size distribution and the plasticity of the fines are the two properties of soil used for classification. In some cases, it may be appropriate to use a borderline classification (e.g., SC/CL) if the soil has been identified as having properties that do not distinctly place the soil into one group.

5.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. Being proficient in estimating this factor requires extensive practice and frequent checking. The steps involved in determining particle size distribution are listed below:

1. Select a representative sample (approximately 1/2 of a 6-inch long by 2.5-inch diameter sample liner).

2. Remove all particles larger than 3 inches from the sample. Estimate and record the percent by volume of these particles. Only the fraction of the sample smaller than 3 inches is classified.

[2] If the soil is estimated to have 15 percent to 25 percent sand or gravel, or both, the words "with sand" or "with gravel" (whichever predominates) shall be added to the group name (e.g., clay with sand, CL; or silt with gravel, ML). If the soil is estimated to have 30 percent or more sand or gravel, or both, the words "sandy" or "gravely" (whichever predominates) shall be added to the group name (e.g., sandy clay, CL). If the percentage of sand is equal to the percent gravel, use "sandy."

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DEFINITION OF TERMS

MAJOR DIVISIONS			SYMBOLS	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More Than Half of Material is Larger Than No. 200 Sieve Size	GRAVELS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	CLEAN GRAVELS (Less than 6% Fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS With Fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	CLEAN SANDS (Less than 6% Fines)	SW	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SANDS With Fines	SM	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More Than Half of Material is Smaller Than No. 200 Sieve Size	SILTS AND CLAYS Liquid Limit is Less Than 50%		ML	Inorganic silts, rock flour, fine sandy silts or clays, and clayey silts with non- or slightly-plastic fines
			CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limit is Greater Than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, clayey silt
			CH	inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils

GRAIN SIZES

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

200 40 10 4 3/4" 3" 12"

U.S. STANDARD SERIES SIEVE — CLEAR SQUARE SIEVE OPENINGS

Figure 1: Unclassified Soil Classification System (USCS)

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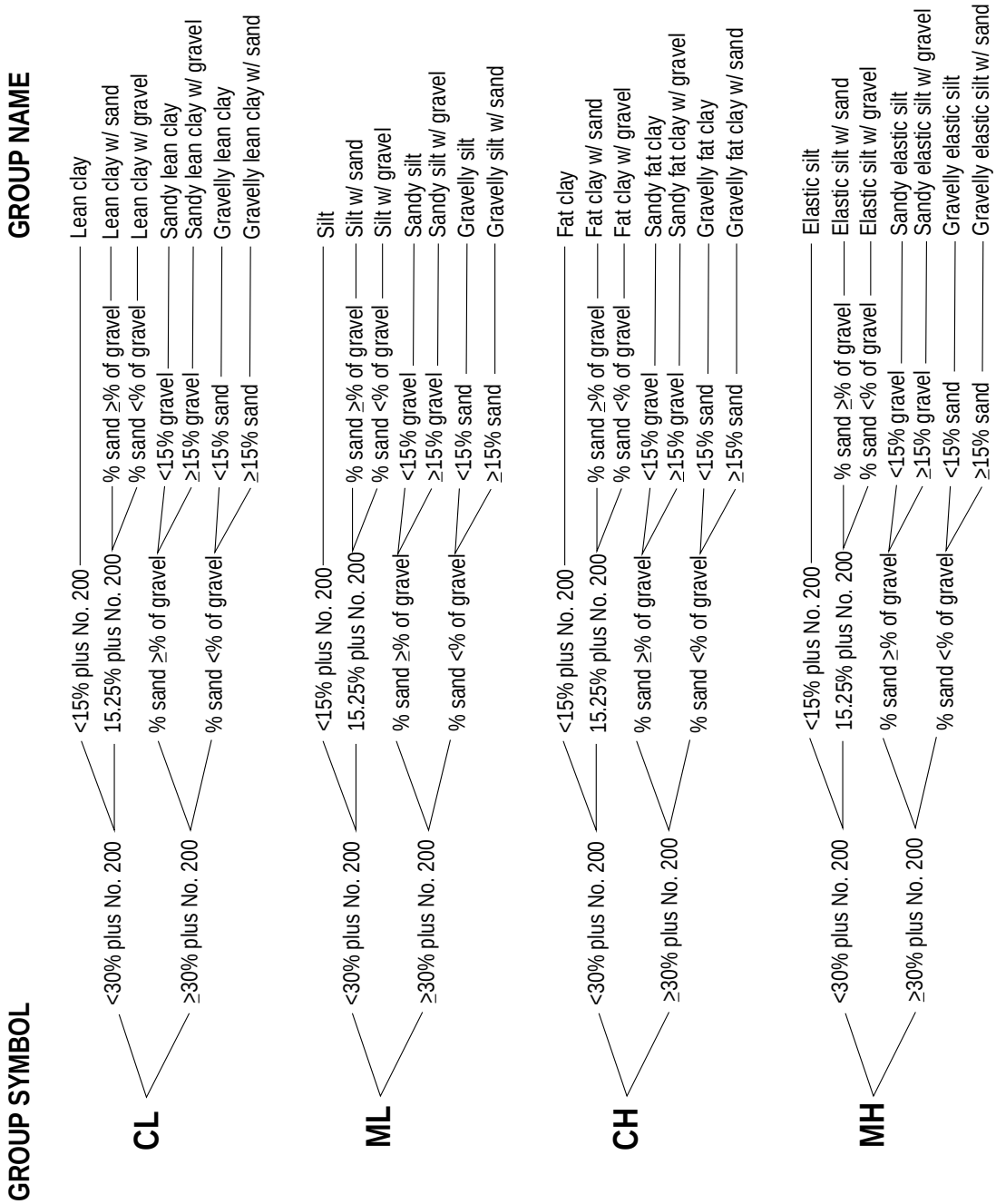

Figure 2: Flow Chart for Fine Grain Soil Classification

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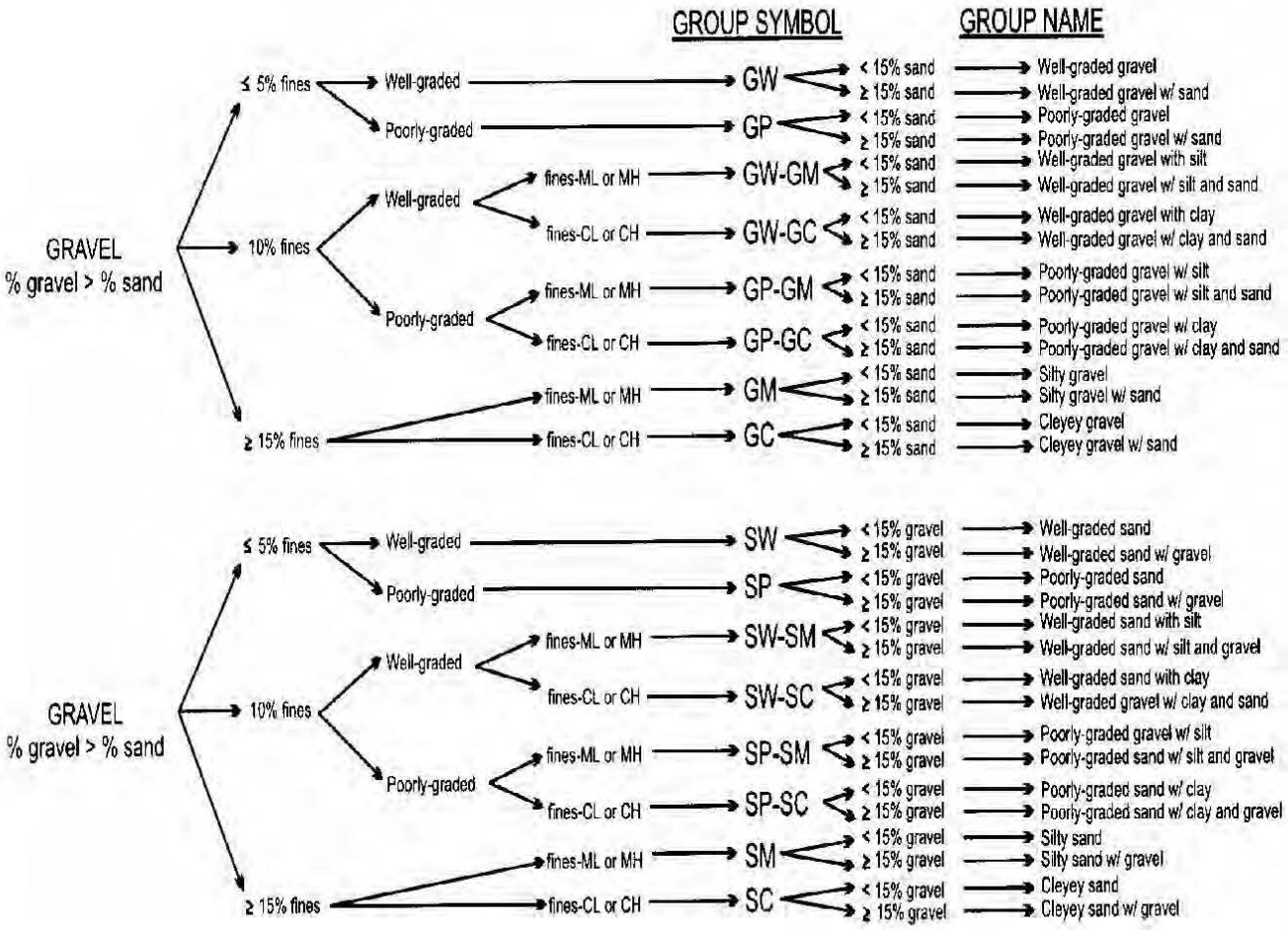

Figure 3: Flow Chart for Soil with Gravel

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3. Estimate and record the percentage of dry mass of gravel (less than 3 inches and greater than 1/4 inch).

4. Considering the rest of the sample, estimate, and record the percentage of dry mass of sand particles (about the smallest particle visible to the unaided eye).

5. Estimate and record the percentage of dry mass of fines in the sample (do not attempt to separate silts from clays).

6. Estimate percentages to the nearest 5 percent. If one of the components is present in a quantity considered less than 5 percent, indicate its presence by the term "trace".

7. The percentages of gravel, sand, and fines must add up to 100 percent. "Trace" is not included in the 100 percent total.

5.2 Soil Dilatancy, Toughness, and Plasticity

5.2.1 Dilatancy

To evaluate dilatancy, follow these procedures:

1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 millimeters [mm]) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

2. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against 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 note the reaction as none, slow, or rapid in accordance with the criteria in Table 1. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Table 1
Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in 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.

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5.2.2 Toughness

Following the completion of the dilatancy test, shape the test specimen into an elongated pat and roll it 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, spread it into a thin layer and allow it to lose some water by evaporation.) Fold the sample threads and re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble at a diameter of 1/8 inch when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, lump the pieces together and knead it until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 2.

Table 2
Criteria for Describing Toughness

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

5.2.3 Plasticity

The plasticity of a soil is defined by the ability of the soil to deform without cracking, the range of moisture content over which the soil remains in a plastic state, and the degree of cohesiveness at the plastic limit. The plasticity characteristic of clays and other cohesive materials is defined by the liquid limit and plastic limit. The liquid limit is defined as the soil moisture content at which soil passes from the liquid to the plastic state as moisture is removed. The test for the liquid limit is a laboratory, not a field, analysis.

The plastic limit is the soil moisture content at which a soil passes from the plastic to the semi-solid state as moisture is removed. The plastic limit test can be performed in the field and is indicated by the ability to roll a 1/8-inch (0.125-inch) diameter thread of fines, the time required to roll the thread, and the number of times the thread can be re-rolled when approaching the plastic limit.

The plasticity tests are not based on natural soil moisture content, but on soil that has been thoroughly mixed with water. If a soil sample is too dry in the field, add water prior to performing

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classification. If a soil sample is too sticky, spread the sample thin and allow it to lose some soil moisture.

Table 3 presents the criteria for describing plasticity in the field using the rolled thread method.

Table 3
Criteria for Describing Plasticity

Description	Criteria
Non-Plastic	A 1/8-inch thread cannot be rolled.
Low Plasticity	The thread can barely be rolled.
Medium Plasticity	The thread is easy to roll and not much time is required to reach the plastic limit.
High Plasticity	It takes considerable time rolling the thread to reach the plastic limit.

5.2.4 Angularity

The following criteria describe the angularity of the coarse sand and gravel particles:

- **Rounded** particles have smoothly-curved sides and no edges.
- **Subrounded** particles have nearly plane sides, but have well-rounded corners and edges.
- **Subangular** particles are similar to angular, but have somewhat rounded or smooth edgesand.
- **Angular** particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

5.2.5 Color, Moisture, and Odor

The natural moisture content of soil is very important. Table 4 shows the terms for describing the moisture condition and the criteria for each.

Table 4
Soil Moisture Content Qualifiers

Qualifier	Criteria
Dry	Absence of moisture, dry to the touch
Moist	Damp but no visible water
Wet	Visible water, usually soil is below water table

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Color is described by hue and chroma using the Munsell Soil Color Chart (Munsell 2000). For uniformity, all site geologists shall utilize this chart for soil classification. Doing so will facilitate correlation of geologic units between boreholes logged by different geologists The Munsell Color Chart is a small booklet of numbered color chips with names like "5YR 5/6, yellowish-red." Note mottling or banding of colors. It is particularly important to note and describe staining because it may indicate contamination.

In general, wear a respirator if strong organic odors are present. If odors are noted, describe them if they are unusual or suspected to result from contamination. An organic odor may have the distinctive smell of decaying vegetation. Unusual odors may be related to hydrocarbons, solvents, or other chemicals in the subsurface. An organic vapor analyzer may be used to detect the presence of volatile organic contaminants.

5.2.6 In-Place Conditions

Describe the conditions of undisturbed soil samples in terms of their density/consistency (i.e., compactness), cementation, and structure utilizing the following guidelines:

5.2.6.1 Density/Consistency

Density and consistency describe a physical property that reflects the relative resistance of a soil to penetration. The term "density" is commonly applied to coarse to medium-grained sediments (i.e., gravels, sands), whereas the term "consistency" is normally applied to fine-grained sediments (i.e., silts, clays). There are separate standards of measure for both density and consistency that are used to describe the properties of a soil.

The density or consistency of a soil is determined by observing the number of blows required to drive a 1 3/8-inch (35 mm) diameter split barrel sampler 18 inches using a drive hammer weighing 140 lbs (63.5 kilograms [kg]) dropped over a distance of 30 inches (0.76 meters). Record the number of blows required to penetrate each 6 inches of soil in the field boring log during sampling. The first 6 inches of penetration is considered to be a seating drive; therefore, the blow count associated with this seating drive is recorded, but not used in determining the soil density/consistency. The sum of the number of blows required for the second and third 6 inches of penetration is termed the "standard penetration resistance," or the "N-value." The observed number of blow counts must be corrected by an appropriate factor if a different type of sampling device (e.g., Modified California Sampler with liners) is used. For a 2 3/8-inch inner diameter (I.D.) Modified California Sampler equipped with brass or stainless steel liners and penetrating a

cohesionless soil (sand/gravel), the N-value from the Modified California Sampler must be divided by 1.43 to provide data that can be compared to the 1 3/8-inch diameter sampler data.

For a cohesive soil (silt/clay), the N-value for the Modified California Sampler should be divided by a factor of 1.13 for comparison with 1 3/8-inch diameter sampler data.

Drive the sampler and record blow counts for each 6-inch increment of penetration until one of the following occurs:

- A total of 50 blows have been applied during any one of the three 6-inch increments; a 50-blow count occurrence shall be termed "refusal" and noted as such on the boring log.
- A total of 150 blows have been applied.
- The sampler is advanced the complete 18 inches without the limiting blow counts occurring, as described above.

If the sampler is driven less than 18 inches, record the number of blows per partial increment on the boring log. If refusal occurs during the first 6 inches of penetration, the number of blows will represent the N-value for this sampling interval. Table 5 and Table 6 present representative descriptions of soil density/consistency vs. N-values.

Table 5
Measuring Soil Density with a California Sample — Relative Density (Sands, Gravels)

	Field Criteria (N-Value)	
Description	**1 3/8 in. ID Sampler**	**2 in. ID Sampler using 1.43 factor**
Very Loose	0–4	0–6
Loose	4–10	6–14
Medium Dense	10–30	14–43
Dense	30–50	43–71
Very Dense	> 50	> 71

Table 6
Measuring Soil Density with a California Sampler — Fine Grained Cohesive Soil

Description	Field Criteria (N-Value)	
	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.13 factor
Very Soft	0–2	0–2
Soft	2–4	2–4
Medium Stiff	4–8	4–9
Stiff	8–16	9–18
Very Stiff	16–32	18–36
Hard	> 32	> 36

For undisturbed fine-grained soil samples, it is also possible to measure consistency with a hand-held penetrometer. The measurement is made by placing the tip of the penetrometer against the surface of the soil contained within the sampling liner or shelby tube, pushing the penetrometer into the soil a distance specified by the penetrometer manufacturer, and recording the pressure resistance reading in pounds per square foot (psf). The values are as follows (Table 7):

Table 7
Measuring Soil Consistency with a Hand-Held Penetrometer

Description	Pocket Penetrometer Reading (psf)
Very Soft	0–250
Soft	250–500
Medium Stiff	500–1000
Stiff	1000–2000
Very Stiff	2000–4000
Hard	>4000

Consistency can also be estimated using thumb pressure using Table 8.

Table 8
Measuring Soil Consistency Using Thumb Pressure

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will penetrate soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

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5.2.6.2 Cementation

Cementation is used to describe the friability of a soil. Cements are chemical precipitates that provide important information as to conditions that prevailed at the time of deposition, or conversely, diagenetic effects that occurred following deposition. Seven types of chemical cements are recognized by Folk (1980). They are as follows:

1. Quartz — siliceous

2. Chert — chert-cemented or chalcedonic

3. Opal — opaline

4. Carbonate — calcitic, dolomitic, sideritic (if in doubt, calcareous should be used)

5. Iron oxides — hematitic, limonitic (if in doubt, ferruginous should be used)

6. Clay minerals — if the clay minerals are detrital or have formed by recrystallization of a previous clay matrix, they are not considered to be a cement. Only if they are chemical precipitates, filling previous pore space (usually in the form of accordion-like stacks or fringing radial crusts) should they be included as "kaolin-cemented," "chlorite-cemented," etc.

7. Miscellaneous minerals — pyritic, collophane-cemented, glauconite-cemented, gypsiferous, anhydrite-cemented, baritic, feldspar-cemented, etc.

The degree of cementation of a soil is determined qualitatively by utilizing finger pressure on the soil in one of the sample liners to disrupt the gross soil fabric. The three cementation descriptors are as follows:

1. Weak — friable; crumbles or breaks with handling or slight finger pressure
2. Moderate — friable; crumbles or breaks with considerable finger pressure
3. Strong — not friable; will not crumble or break with finger pressure

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5.2.6.3 Structure

This variable is used to qualitatively describe physical characteristics of soil that are important to incorporate into hydrogeological and/or geotechnical descriptions of soil at a site. Appropriate soil structure descriptors are as follows:

- Granular — spherically shaped aggregates with faces that do not accommodate adjoining faces

- Stratified — alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness

- Laminated — alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness

- Blocky — cohesive soil that can be broken down into small angular or subangular lumps that resist further breakdown

- Lensed — inclusion of a small pocket of different soil, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soil are present, the soil being described can be termed homogeneous if the description of the lenses is included

- Prismatic or Columnar — particles arranged about a vertical line, ped is bounded by planar, vertical faces that accommodate adjoining faces; prismatic has a flat top; columnar has a rounded top

- Platy — particles are arranged about a horizontal plane

5.2.6.4 Other Features

- Mottled — soil that appears to consist of material of two or more colors in blotchy distribution

- Fissured — breaks along definite planes of fracture with little resistance to fracturing (determined by applying moderate pressure to sample using thumb and index finger)

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- Slickensided — fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)

5.2.7 Development of Soil Description

Develop standard soil descriptions according to the following examples. There are three principal categories under which all soil can be classified. They are described below.

5.2.7.1 Coarse-grained Soil

Coarse-grained soil is divided into sands and gravels. A soil is classified as a sand if over 50 percent of the coarse fraction is "sand-sized." It is classified as a gravel if over 50 percent of the coarse fraction is composed of "gravel-sized" particles.

The written description of a coarse-grained soil shall contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); grain size of coarse fraction; Munsell color and color number; moisture content; relative density; sorting; angularity; other features, such as stratification (sedimentary structures) and cementation, possible formational name, primary USCS classification, secondary USCS classification (when necessary), and approximate percentages of minor constituents (i.e., sand, gravel, shell fragments, rip-up clasts) in parentheses.

Example: <u>POORLY-SORTED SAND WITH SILT</u>, medium- to coarse-grained, light olive gray, 5Y 6/2, saturated, loose, poorly sorted, subrounded clasts, SW/SM (minor silt with approximately 20 percent coarse-grained sand-sized shell fragments, and 80 percent medium-grained quartz sand, and 5 percent to 15 percent ML).

5.2.7.2 Fine-grained Soil

Fine-grained soil is further subdivided into clays and silts according to its plasticity. Clays are rather plastic, while silts have little or no plasticity.

The written description of a fine-grained soil should contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); Munsell color; moisture content; consistency; plasticity; other features, such as stratification, possible formation name, primary USCS classification, secondary USCS classification (when necessary), and the percentage of minor constituents in parentheses.

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Example: SANDY LEAN CLAY, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70 percent fines, 30 percent sand, with minor amounts of disarticulated bivalves [about 5 percent]).

5.2.7.3 Organic Soil

For highly organic soil, describe the types of organic materials present as well as the type of soil constituents present using the methods described above. Identify the soil as an organic soil, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soil usually has a dark brown to black color and may have an organic odor. Often, organic soils will change color, (e.g., from black to brown) when exposed to air. Some organic soils will lighten in color significantly when air-dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

Example: ORGANIC CLAY, black, 2.5Y, 2.5/1, wet, soft, low plasticity, organic odor, OL (100 percent fines), weak reaction to HCl.

6.0 RECORDS

Document soil classification information collected during soil sampling onto the field boring logs, field trench logs, and into the field notebook. Copies of this information shall be placed in the project files.

7.0 HEALTH AND SAFETY

Observe standard health and safety practices according to the CTO-specific health and safety plan. Monitoring during excavation activities should determine contaminant concentrations and any required personal protective equipment (PPE) that may be necessary.

Suggested minimum protection during soil and rock classification activities in conjunction with field excavations shall include disposable nitrile gloves, steel-toed boots and overboots, safety glasses, hearing protection, and an American National Standards Institute-standard hard hat. Respirators and cartridges may be necessary depending on the contaminant concentrations and shall always be available on site. At no time during classification activities are personnel to reach for debris near machinery that is in operation, place any samples in their mouth, or come in contact with the soils/rocks without the use of gloves.

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In addition to the aforementioned precautions, employ the following safe work practices:

Physical Hazards Associated With Soil Classification:

- To avoid lifting injuries associated with large specimens, use the large muscles of the legs, not the back.
- Be wary of uneven terrain to avoid slip/trip/fall conditions.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1-2 cups/hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- Be aware of restricted mobility due to PPE.

8.0 REFERENCES

American Society for Testing and Materials (ASTM). 2000. *Standard Practice for Description and Identification of Soils (Visual, Manual Procedure)*. D 2488-00. West Conshohocken, PA.

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Folk, Robert L. 1980. *Petrology of Sedimentary Rocks*. Austin, TX: Hemphill Publishing Company.

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9.0 ATTACHMENTS

None.

Standard Operating Procedure SOP-3-12MS
Resonant Sonic Drilling/Well Installation and Development

1.0 PURPOSE

This standard operating procedure describes the methods to be used by Resolution Consultants (RC) personnel during the installation of groundwater monitoring and/or injection wells using resonant sonic drilling methods. If there are additional procedures from Resolution Consultants, state and/or federal that are not addressed in this Standard Operating Procedure (SOP) and are applicable to monitoring well installation then those procedures may be added as an appendix to the project specific Sampling and Analysis Plan (SAP).

2.0 SCOPE

This procedure shall serve as management-approved professional guidance and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD, 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

The following aspects should be addressed before implementing any field activities:

- Well permits required by local/state water Board/Districts, etc.
- Waste generation and handling (drums, storage vessels, tanks, etc.)
- Water availability
- Site/location access
- Health and safety issues associated with chemical and physical hazards
- Locating subsurface and overhead utilities before drilling activities and adjust locations as necessary to account for impediments and obstacles

The procedure outlined in this SOP describes the installation, development, and documentation procedures for installing and developing monitoring wells. The employed drilling method will depend on the physical nature of the subsurface material, drilling depth, confining pressures, well-data objective, and the specifications of the project-specific planning documents. The project-specific planning documents should contain, at a minimum, the following information:

- Well locations
- Monitoring well design specifications, required materials, diameter, thickness, lengths

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- Anticipated well depths
- Screened lengths
- Screen length(s)
- Well completion specifications.

The drilling contractor shall be a licensed driller, in accordance with local and state requirements, and qualified for installation of groundwater monitoring wells for environmental investigations.

3.0 RESPONSIBILITIES

The CTO Manager is responsible for ensuring that the project involving monitoring well installation is properly planned and executed and that the safety of personnel from chemical and physical hazards associated with drilling and well installation is ensured.

The Field Geologist is responsible for directly overseeing the construction and installation of monitoring wells by the driller and to ensure that the well-installation specifications defined in the project-specific planning documents are followed and that pertinent data are recorded on appropriate forms and in the field notebook. Monitoring well construction and boring completion will be conducted under the supervision of an appropriately qualified and registered person as defined by local regulations.

The Site Safety Officer (SSO) is responsible for overseeing the health and safety of employees and for stopping work if necessary to address and mitigate unsafe conditions observed in the field. If a subcontracted firm conducts installation and documentation activities, then the firm will be responsible for appointing a SSO.

4.0 PROCEDURES

4.1 Rotosonic Drilling Method

Rotosonic drilling combines rotational and high frequency vibrational forces to advance an inner and outer casing with individual drill bit cutting heads into the subsurface. The core/sampler is advanced with the inner casing and is 4 to 6-inch in diameter and can be advanced in 5, 10, 15, or 20 foot increments, depending on the sample barrel length. Upon reaching the desired soil sampling depth, the larger diameter outer casing (6- to 8-inches outside diameter [OD]), is advanced over the inner core barrel to the bottom of the sample depth. The inner casing containing the soil sample is retrieved to the surface and the larger casing is left in place to keep the borehole open. At the surface, the sample barrel is rotated to a 45 degree angle to the drill

mast and the sampler is vibrated to allow the soil sample exit the sampler. The soil sample is collected into a plastic sleeve and placed in the sample are for lithologic description or soil sampling by the field geologist. The core barrel is then rinsed with water from both the inside and outside, and water is collected in a wash tub that is centered over borehole. The process is then repeated until the desired sample depth is reached.

The **advantages** of rotosonic drilling are the following:

- The outer casing serves to hold the borehole open for installation of monitoring wells, enabling clean delivery of sand pack and bentonite for well construction. The outer drill casing which may be 6-inches or 8-inches OD to allow ample space to construct either 2-inch or 4-inch diameter wells.

- With near 100% soil recovery, a precise and detailed stratigraphic profile is enabled of any overburden conditions including dry or wet saturated sands and gravels, cobbles and boulders, clays, silts and hard tills.

- The outer casing provides a continuous casing while drilling and inherently safeguards against the downward migration of shallower, contaminated soil and groundwater.

- Generates minimal soil/mud waste.

The **disadvantages** of rotosonic drilling are:

- Localized compaction of formation adjacent to well, possibly resulting in reduced soil permeability and well yield. Additional water usage that is necessary for drilling in fine and/or heaving sands which may cause groundwater sample concentrations to be biased low. As such, additional effort is required during well development so that the injected water is recovered and representative groundwater samples are collected. Water usage should be tracked and recovered during well development.

- The typical set up requires two large trucks positioned end-to-end, so site access and space issues must be considered. Alternatively, smaller more maneuverable trailer, skid mounted, and mini sonic rigs are available where access is limited.

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4.2 Borehole Logging

Soil cuttings collected from the inner core barrel will be used for lithologic description for a continuous profile of the subsurface geology. Soil classification will be conducted per the SOP for soil classification and should be included in the soil boring log (see Attachment 2 for a soil boring log) with other relevant information including the boring/monitoring well I.D., sample depths, sample length, length of recovered sample, start and finish times, dates, boring location relative to land features, and any other relevant field information.

Upon reaching the desired soil boring depth, the field geologist will measure the open borehole from the inside of the outer casing using a calibrated tape measure, document the depth, and decide on the well completion depth based on lithologic units, water bearing units, or the project specific objectives that should be described in the appropriate planning documents.

4.3 Monitoring Well Design

Monitoring wells will be constructed in accordance with local and state agency requirements and the project specific planning documents. The following components are included in all monitoring well construction:

- Backfill material
- Well screens and casing
- Filter pack
- Well sealing materials
- Surface completions

4.3.1 Backfilling Material

Commonly a borehole is overdrilled beyond the completion of the monitoring well, requiring the backfilling of the borehole with either bentonite grout, bentonite pellets, filter pack sand, or formation material. The selected backfill material will depend on the lithology and site-specific conditions associated with the contaminants. Generally a minimum of 6-inches sand should be in place between the bottom of the well screen for a footing, to prevent the well screen from resting on bentonite that seals the bottom of the hole. Sealing the bottom of the borehole is particularly important if it penetrates a permeable sand and/or gravel unit that could be a conduit for vertical migration of shallow contaminants to deeper zones below the well. If bentonite pellets or grout are used, typically a 24-hour hydration time is necessary before well construction can begin. The set-up time should be based on manufacture specifications.

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Bentonite pellets are generally easier to place than bentonite chips because pellets have a coating that allows for a short delay before they begin to hydrate, hence pellets are the preferred method for small backfill jobs where significant confining zones have not been breached. Care should be exercised by carefully dropping the pellets into the borehole to minimize the risk of sticking to the side of the outer casing wall when dropped through a water column. Vibrating the outer casing while retrieving it will generally loosen the bentonite chips that may adhere to the casing wall. Frequent measurements inside the casing should be conducted when adding bentonite to ensure the casing is not lifted beyond the height of the bentonite before sealing the zone of interest. If bentonite grout is used, a tremie pipe will be necessary for placement at the bottom of the borehole and grout should be injected while retrieving the outer casings. Frequent measurements of the borehole will be required when adding grout or bentonite and the thickness recorded.

4.3.2 Well Casing and Screen

The selection of an appropriate casing diameter is also important. Wells greater than 150 feet in depth may require diameters larger than 4 inches to ensure that development and sampling equipment can be moved easily through the well. In addition, wells designed for groundwater extraction or carbon substrate injection may have a casing diameter large enough to accommodate a pump capable of achieving the appropriate pumping rate. The borehole in which the well is to be installed shall be a minimum of 4 inches larger in diameter than the OD of the well casing.

Well Materials:

Monitoring well casings and screens must be clean, free of rust, grease, oil or contaminants and be composed of materials that will not affect the quality of the water sample. All casing shall be watertight. The casing shall be centered in the borehole, be free of any obstructions and allow sampling devices to be lowered into the well. The well string shall be hung in the borehole during installation so that the well is sufficiently plumbed and straight after completion. Wells deeper than 100 feet below grade (or as specified by State or local requirements) should have centralizers to keep the well casing plume and straight in the borehole. Centralizers should be placed in the middle of the well screen interval and at 40 foot intervals throughout the blank casing interval.

Typical well screens and casings are constructed of polyvinyl chloride (PVC) but may also be constructed of Teflon or stainless steel depending on the subsurface conditions or potential site contaminants. If free-phase aromatic compounds (benzene, toluene, ethylbenzene, and xylenes) are present on groundwater, Schedule 40, rigid, Type 1 PVC casing and screens are compatible; however, in the presence of free-phase chlorinated solvents stainless steel well materials should be

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used. Experiments have shown 10% of the solubility limit of methylene chloride (or 1,300 mg/L) will soften PVC whereas 60% of the TCE solubility limit (or 600 mg/L) will soften PVC. If highly contaminated groundwater is identified or suspected at a site that could possibly degrade well construction materials, the U.S.EPA's chemical compatibility table provided in *Non-aqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation* (EPA, 1995) should be consulted at http://www.epa.gov/tio/tsp/download/napl.pdf.

Besides chemical compatibility, a second consideration for specification of casing materials is the depth of the monitoring well. Well installations greater than 150 feet deep require casing materials of greater structural strength. In the case of PVC casing, Schedule 80 PVC rather than Schedule 40 may be required to prevent over-stressing of the casing couplings and compressing the well screen. The build-up of heat during grout setup might adversely affect some plastic materials. Only flush threaded couplings with O-ring seals should be used for joining individual sections of screen and casings (some States require the removal of the O-rings since they are composed of rubber. Verify with your State or local agency as to whether use of O-rings are permissible). Solvent, glue, or anti-seize compounds will not be used on the joints.

Monitoring Well Screen Design:

The screened section of the monitoring well allows groundwater to flow freely into the well, while retarding movement of fine-grained lithologic materials into the well. When designing a well screen, consider important factors, such as type of well screen material, length of the screened section, location of the screened section, the intake opening size, the type of intake opening (i.e., slot, continuous wire-wrap, etc.), and size of filter pack to be utilized.

Selection of the screen length depends on its primary use(s). Most monitoring wells function as both groundwater sampling points and piezometers. Shorter-screened sections provide more specific data on vertically distributed contaminants, hydraulic head, and flow, and are generally preferred to longer-screened lengths. Saturated sections in groundwater monitoring wells shall be limited to between 5 and 10 feet in length; however, longer intervals may be justified in certain circumstances with approval of the CTO Manager, QA Manager or Technical Director.

Placement of the screened interval depends primarily upon two factors: the type of contaminants to be monitored and the discrete interval that is to be monitored which is based on hydraulic characteristics of the water bearing zone (i.e., confined or unconfined), confining units, and the characteristics of the contaminants to be monitored (i.e., light, non-aqueous phase liquid [LNAPL];

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dense, non-aqueous phase liquid [DNAPL]). The project-specific planning documents should specify the monitoring zone interval and the associated data objectives. If an unconfined zone is being monitored for LNAPL (e.g., gasoline, diesel, waste oil), place 3 to 5 feet of the well screen interval above the highest level of the water table to allow for fluctuations in water elevations and to ensure that contaminant phases less dense than water can be observed. Conversely, if an unconfined zone is being monitored for DNALP (e.g., chlorinated solvents), place approximately 5 feet of screened interval (maximum) just above the confining unit at the base of the water-bearing zone to facilitate detection of the dense-phase contaminants.

4.3.3 Filter Pack

The filter pack will consist of sand or gravel and is required for monitoring wells constructed within unconsolidated material. In investigations where there are limited data on site conditions prior to monitoring well installation, the filter pack should be selected based on available lithologic data. If no data are available, use finer filter pack sizes if fine-grained formations are anticipated to be present, and use coarser-grained filter packs if coarser-grained lithologies or consolidated formations are expected.

Sizing of the filter pack material is often conducted using sieve analysis and following interpretative procedures outlined in Driscoll (1986). If available, use the sieve data for the finest lithology identified in the interval to be monitored for establishing filter pack size. The screen slot size should be sized to match the screen slot size to prevent filter pack sand from entering the well. Table 2 provides a comparison of typical filter pack grain-sizes and appropriate screen size openings:

Table 2
Comparison of Screen Slot Size and Filter Pack

Screen Size Opening (inch)	Screen Size Slot Number	Typical Sand Pack Mesh Size (U.S. Standard Sieve Number)
0.005	5	100
0.010	10	20 to 40
0.020	20	10 to 20
0.030	30	10 to 20

Crushed limestone, dolomite, or any material containing clay or any other material that will adversely affect the performance of the monitoring well shall not be used as filter pack. The sand or gravel shall be free of clay, dust, and organic material.

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The filter pack will extend a maximum of six (6) inches below the bottom of the screen to two (2) to three (3) feet above the top of screen. If DNAP is suspected, then the well screen should directly rest on the bottom of borehole. The filter pack material may be poured at the surface through the annular space between the well pipe and outer casing. Using resonance sonic technique, the outer casing may be vibrated to minimize the risk of voids in the filter pack due to bridging. However, in all cases, filter pack material should be added carefully with continuous measurements by the field geologist to prevent bridging of the filter pack material.

4.3.4 Annular Seal

The annular seal is placed directly above the filter pack in the annulus between the borehole and the well casing. The annular space must be sealed to prevent the migration of water and contaminants along the outside of the well casing. Hydrated bentonite chips or pellets are typically used as an annular seal with a minimum thickness of 2 feet. The bentonite may be poured at the surface through the annular space between the well pipe and outer casing. Using resonance sonic technique, the outer casing may be vibrated to minimize the risk of voids in the seal due to bridging. Once the bentonite is in place and if the top of the bentonite seal is above the water table/saturated zone, add approximately 5 gallons of water to hydrate the bentonite. Refer to the manufactures instructions for the appropriate hydration time. A minimum of 15 minutes is required for hydration of the bentonite seal once it is installed.

Following the bentonite seal, emplace the remaining annular seal. The annular seal shall be either a grout slurry consisting of 7 to 9 gallons of water per 94-pound bag of Portland cement Type I or II and with a minimum of 3 to 5 percent bentonite (1/4 to 1/2 bags of bentonite powder per five bags of Portland cement) or a mixture of high-solids bentonite. Thoroughly mix the grout to ensure the proper consistency with no visible lumps of dehydrated powder. Place the bottom of the tremie pipe about 5 to 10 feet above the bentonite seal, depending on the stability of the hole and impact velocity of the grout. Emplace the annular grout seal by pumping in one continuous pour, from the top of the transition seal to the ground surface, when possible. The rate at which the outer casing is withdrawn and the slurry added will be such that the level of the grout within the well annulus is just below the lowermost outer casing. Installing the grout seal using resonance sonic allows for vibration to remove air pockets that may be present in the grout.

A minimum of 24 hours should lapse before development of the well. Likewise, the concrete slab, traffic box, and/or casing riser of the surface completion shall not be poured and constructed until

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the grout seal has set. Top off any settlement of the grout seal as soon as possible after it sets. Record all pertinent data on the well construction log.

4.3.5 Surface Completion

The surface of a groundwater monitoring well shall be either an above-ground completion or as a flush-to-ground completion. Regardless of the method, each monitoring well shall have, at a minimum, a casing cap, concrete slab and annular seal, and a locking protective casing or locking vault.

In an above-ground completion, the protective casing is installed around the top of the well casing within a concrete surface seal. Type 1 Portland concrete, which meets the requirements of CLASS A standard, is used for the surface seal and well pad. A 2-foot-long by 2-foot-wide concrete pad with a minimum thickness of 4 inches is constructed around the protective casing. Inspect the protective casing prior to installation to ensure that no oils, wet paint coatings, or chemicals are present. Once installed, maintain the protective casing in a plumb position with 2 to 3 inches of clearance between the top of the well casing and the lid of the monument. The monument shall extend at least 18 inches above grade and at least 12 inches below grade. In areas where frost heaving is considered a factor, the casing shall extend below the frost depth. Construct a minimum of three concrete-filled posts around the well to protect it from vehicular damage.

Inside the monument, cut or scribe two permanent survey marks, approximately 0.25 inches apart, into the top of the well casing, and also permanently mark the well with its identification number. Ideally a well tag should be on the outside of the well casing; however, the well I.D. can also be etched into the concrete pad before it dries. Cover the top of the well casing with a slip cap or locking cap to prevent debris from entering the well. Fit the monument with a casehardened lock to prevent unauthorized entry.

In a flush-to-ground completion, the protective casing or traffic box is installed around the top of the well casing, which has been cut off slightly below grade. The traffic box has a lid that is held firmly in place by bolts and has a flexible O-ring or rubber gasket to prevent water from entering the box. The traffic box is set within a cement surface seal slightly above grade to deflect surface water flow away from the well. The surface seal extends to a minimum of 4 inches from the outer rim of the traffic box. Type 1 Portland concrete, which meets the requirements of CLASS A standard, is used for the surface seal and 2-foot square well pad. Inspect the traffic box prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed,

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maintain the traffic box in a level position that leaves 2 to 3 inches of clearance between the top of the well casing and the lid of the traffic box. Cover the top of the well casing with a lockable cap to prevent debris from entering the well. Also, fit the lockable cap with a casehardened lock to prevent unauthorized entry.

4.4 Well Construction Record Keeping Procedures

A written well completion record detailing the timing, amount of materials, and methods of installation/construction for each step of monitoring well construction shall be prepared during construction of each monitoring well by the field geologist. Construction records shall be kept in a hard-bound field notebook dedicated to the CTO. An "as-built" drawing illustrating the placement location and amounts of all materials used in construction of each monitoring well shall be prepared in the field at the time of construction. The well construction record shall be filled out with indelible ink. Construction records shall include the date/time and quantities of materials used at each of the following stages of monitoring well construction, including:

- Drilling
  - Drill rig type
  - Drilling method/coring method
  - Drill bit/core barrel length diameter (hole diameter)
  - Drill company, driller, helper(s)
  - Field geologist
  - Dates/times start and finish drilling hole, interval drilling rates
  - Total depth of hole
  - Drilling location, surveyed ground elevation
- Borehole abandonment — type, volume, and surface seal
- Casing material — type
- Casing decontamination — document process and equipment used
- Casing diameter — nominal I.D. of casing
- Screen material
  - Type
  - Top and bottom of section as actually installed
  - Length
  - Slot type, size, shape
  - Type of bottom plug and/or cap used

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- Filter pack material
  - Composition and size gradation
  - Manufacturer
  - Actual volume and depth of top and bottom of filter pack
  - Calculated volume versus actual volume used and explanation of discrepancies
- Bentonite seal (chips, pellets)
  - Composition and depth of top and bottom of seal
  - Size (or gradation) or material used (e.g., pellets, granulated, or powdered)
  - Time allowed for hydration prior to emplacement of annular grout slurry seal
- Annular slurry seal
  - Type and actual volume of seal
  - Set time allowed prior to commencement of additional work
- Surface completion
  - Type of construction
  - Nature of materials used for surface completion
  - Date/time of completion

4.5 Well Development

Monitoring well development is necessary to ensure that complete hydraulic connection is made and maintained between the well and the aquifer material surrounding the well screen and filter pack. The appropriate development method will be selected for each project on the basis of the circumstances, objectives, and requirements of that project.

Well development should begin no sooner than 24 hours after well installation. However, if drilling muds are used during well installation, well development should occur approximately 24 hours following well installation so that the drilling mud does not set up in the well screen section.

The methods available for the development of monitoring wells include: (1) mechanical surging with a surge block or swab, and (2) surge pumping. Development methods using air or jetting of water into the well are generally inappropriate for development of monitoring wells due to the potential for affecting water quality. Well development will continue until the water in the well clarifies and monitoring parameters such as pH, specific conductance, and temperature stabilize as defined in the project-specific planning documents. Containerize and appropriately label all

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development water, unless it is permissible to discharge it on site. More detailed descriptions of appropriate development methods are presented below.

4.5.1 Mechanical Surging and Bailing

For mechanical surging and bailing, a surge block or swab is operated either manually or by a drill rig. The surge block or swab should be vented and be of sufficient weight to free-fall through the water in the well and create a vigorous outward surge. The equipment lifting the tool must be strong enough to extract it rapidly. A bailer is then used to remove fine-grained sediment and groundwater from the well.

Procedures:

- Properly decontaminate all equipment entering the well.
- Record the static water level and the total well depth.
- Lower the surge block or swab to the top of the screened interval.
- Operate in a pumping action with a typical stroke of approximately 3 feet.
- Gradually work the surging downward through the screened interval during each cycle.
- Surge for approximately 10 to 15 minutes per cycle.
- Remove the surge block and attach the bailer in its place.
- Bail to remove fines loosened by surging until the water appears clear.
- Repeat the cycle of surging and bailing at least three times or until turbidity is reduced and stabilization of water quality parameters occurs.
- The surging shall initially be gentle and the energy of the action should gradually increase during the development process.

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- The advantages (+) and disadvantages (–) of this method are listed below:

  + Reversing the direction of flow reduces bridging between large particles, and the inflow then moves the fine material into the well for withdrawal.

  + It affects the entire screened interval.

  + It effectively removes fines from the formation and the filter pack.

  – It might cause upward movement of water in the filter pack that could disrupt the seal.

  – Potential exists for damaging a screen with a tight-fitting surge block or with long surge strokes.

4.5.2 Surge Pumping

Procedures:

1. Properly decontaminate all equipment entering the well.

2. Record the static water level and the total well depth.

3. Lower a submersible pump or airlift pump without a check valve to a depth within 1 to 2 feet of the bottom of the screened section.

4. Start pumping and increase discharge rate to maximum capacity (overpumping), causing rapid drawdown of water in the well.

5. Periodically stop and start the pump, allowing the water in the drop pipe to fall back into the well and surge the formation (backwashing), thus loosening particulates.

6. The pump intake shall be moved up the screened interval in increments appropriate to the total screen length.

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7. At each pump position, the well shall be pumped, overpumped, and backwashed alternately until satisfactory development has been attained as demonstrated by reduction in turbidity and stabilization of water quality parameters.

The advantages (+) and disadvantages (–) of this method are listed below:

+ Reversing the direction of flow reduces bridging between large particles, and the inflow then moves the fine material into the well for withdrawal.

+ It effectively removes fines from the well screen and the filter pack.

– The pump position or suction line must be changed to cover the entire screen length.

– Submersible pumps suitable to perform these operations may not be available for small diameter (2 inches or less) monitoring wells.

– It is not possible to remove sediment from the well unless particle size is small enough to move through the pump.

For additional information on well development, consult the references included in Section 8 of this procedure.

4.5.3 Well Development Record Keeping

Throughout the well development process, maintain a development record by completing the well development log. An example well development log is presented in Attachment 1 of this SOP. The record should include the following information:

General:

- Well name/number and location
- Date, time, and weather conditions
- Names of personnel involved

Development volume:

- Initial and final water level
- Casing total depth and diameter

- Borehole diameter
- Casing volume, filter pack pore volume, total well volume
- Volume of water to be evacuated
- Method and rate of removal
- Appearance of water before and after development

Monitoring data for each sample point:

- Date, time, elapsed time
- Cumulative gallons removed, removal method, removal rate
- Temperature, pH (indicates the hydrogen ion concentration — acidity or basicity), specific conductivity, turbidity, dissolved oxygen, and redox potential

4.6 Monitoring Well Location and Surveying

Each well will be surveyed by a licensed surveyor in the state where the well has been installed and tied to an established state or county benchmark, site conditions permitting. The vertical survey will be accurate to 0.01 foot relative to the North American Vertical Datum 1988 or other, as specified in the project-specific planning documents. Both the top of casing and ground surface elevation near the well will be surveyed for vertical control. The "V" notch cut on the north side of each well casing will be used as the surveyor's reference mark. For horizontal control, each well will be tied to an existing site coordinate system for the site (i.e., North American Datum [NAD] 27, 83, State Plane or Universal Transverse Mercator ([UTM]) and will be surveyed to a horizontal accuracy of 0.1 foot.

4.7 Disposal and Decontamination

All drill cuttings and fluids generated during well installation and development will be containerized pending analytical results and determination of disposal options as outlined in the Investigation-Derived Waste Handling SOP unless project-specific requirements specify otherwise. Waste containment and disposal will occur in a manner that will not result in contamination of the immediate area or result in a hazard to individuals who may come in contact with these materials. All drilling and well construction equipment that comes into contact with the borehole will be decontaminated by following the Equipment Decontamination SOP.

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4.8 Well Abandonment/Destruction

Once a monitoring well is no longer needed as part of an investigation, or has been damaged to the extent that it cannot be repaired, it is essential that it be properly abandoned. The proper abandonment of a monitoring well ensures that the underlying groundwater supply is protected and preserved. In addition, proper well abandonment eliminates a potential physical hazard and liability. An additional permit and/or inspection may be required for abandonment by local, state or federal regulations.

The first step in abandoning a groundwater monitoring well is to remove the surface completion from around the top of the well casing. This is normally accomplished using a jackhammer to break the surface cement seal, and then removing the monument or traffic box. When the surface seal and the wellhead cover have been removed, the well can be abandoned by either over drilling or grouting the inside of the well pipe as specified in local and State ordinances and the project-specific planning documents. If the well is to be overdrilled, typically, a hollow-stem auger (HSA) is used to drill over the top of the well to its completion depth and removal of the casing and screen from the borehole. Then completely backfill the borehole with a grout seal. Typically, the grout seal is emplaced as slurry of Portland cement grout, which contains a minimum of 3 to 5 percent bentonite as described in above. Emplace the slurry through the HSAs. The rates at which the augers are withdrawn and the slurry is added shall be such that the level of the slurry within the borehole is in the bottom of the lead auger. The borehole seal shall extend from the total depth of the borehole to a depth of approximately 1 foot bgs. Then repair the surface to prior conditions and grade.

If the monitoring well casing cannot be pulled or drilled out and closure in place is acceptable, lower a tremie pipe to the bottom of well and inject under pressure bentonite grout to fill the well screen and riser until grout fills the well to grade level. Remove the uppermost section of casing by unthreading counterclockwise, and pour a cement cap on top of the abandoned well to near grade. Finish the remaining portion of the excavation to match the surrounding surface (concrete, asphalt).

5.0 RECORDS

Soil boring logs, monitoring well construction logs, and well development forms shall be collected by the Field Team leader and kept with the field notebook for the CTO. The Field Team leader should provide a copy of the records to the CTO Manager and maintain them for the project files.

6.0 REFERENCES

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/-ufp_qapp_v1_0305.pdf.

Driscoll, F.G., Ph.D. 1986. *Ground Water and Wells*. St. Paul, MN: Johnson Division.

Environmental Protection Agency (EPA). 1995. *Non-aqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation* (EPA, 1995). EPA 540/S-95/503.

Environmental Protection Agency, United States (EPA). 1987. *A Compendium of Superfund Field Operations Methods*. Office of Solid Waste and Emergency Response. EPA540/P-87/001.

— 1990 *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*. EPA/600/4-89/034. Office of Research and Development, Washington. March.

— 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

7.0 ATTACHMENTS

Attachment 1: Well Completion Form
Attachment 2: Soil Boring Logs
Attachment 3: Well Development Logs

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Attachment 1
Well Completion Form

Well Construction Form

Facility/Project Name:

Well ID.:

Facility License Number:

Type of Well:
Ground Water Monitoring ☐
Piezometer ☐ Injection ☐
Other_____

Date Well Installed:

Location of well relative to waste source:
Upgradient ☐ Downgradient ☐ Side-gradient ☐ Unknown ☐

Well Installed By:

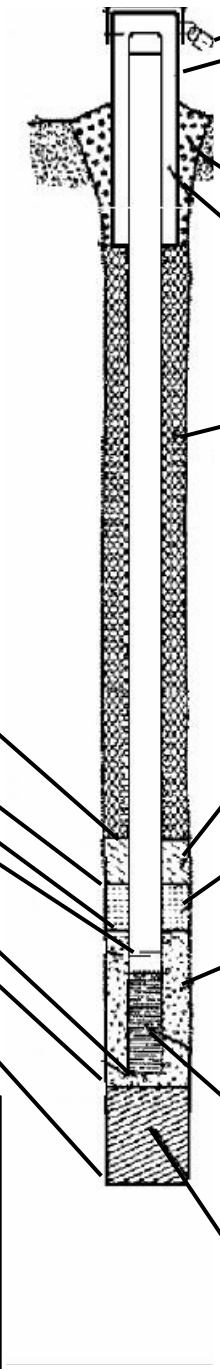
Well Driller License Number:

Geologist:

A. Protective pipe: ft. above grade
B. Well casing, top elevation: ft. MSL
C. Land Surface Elevation: ft. MSL
D. Surface seal, bottom: ft.below grade

12. USCS classification of soil near screen:
GP☐ GM ☐ GC ☐ GW ☐ SP ☐ SM ☐
SC☐ SW☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐
13. Sieve analysis attached? Yes ☐ No ☐
14. Drilling method used: Rotary ☐ HSA ☐
Other:
15. Drilling fluid used:
Water☐ Air ☐ Drilling Mud ☐ None ☐
16. Drilling additives used? Yes ☐ No ☐
Specify:
17: Source of water:

E. Bentonite seal: top ft. (depth)
F. Fine sand: top ft. (depth)
G. Filter pack: top ft. (depth)
H. Screen joint top: ft. (depth)
I. Well bottom: f t. (depth)
J. Filter pack: bottom ft. (depth)
K. Borehole: bottom . ft.(depth)
Borehole diameter: in.



1. Cap and lock? ☐ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: in.
b. Length: ft.
c. Material: *Steel* ☐ *Other*
3. Surface seal: *Bentonite* ☐ *Concrete* ☐
Other:
4. Material blw. well casing and protective pipe:
Bentonite ☐ *Annular space seal* ☐
Other:
5. Annular space seal: *(Manufacturer name)*
a. Granular bentonite ☐
b. Bentonite/Cement slurry ☐
% bentonite ……. Bentonite/cement grout ☐
Lbs/gal mud weight … bentonite slurry ☐
c. How installed: *Tremie* ☐ *Tremie pumped* ☐
Gravity ☐
6. Bentonite seal: *(Manufacturer, product name)*
Bentonite granules ☐
☐ *¼ in.* ☐ *3/8 in.* ☐ *½ in.* *Bentonite pellets* ☐
Other:
7. Fine sand material: *(Manufacturer, product name, mesh size)*
Volume added: ft^3
8. Filter pack material: *(Manufacturer, product name, mesh size)*
Volume added: ft^3
9. Well casing: Flush-threaded Sch 40 PVC☐
Flush-threaded Sch 80 PVC☐
Other:
10. Screen material:
a. Screen type: factory cut ☐ continuous slot ☐
Other:
b. Manufacturer:
c. Slot size: 0. in.
d. Slotted length: ft.
11. Backfill material: *or* None ☐

CERTIFICATION:
I hereby certify that the information on this form is true and correct to the best of my knowledge:

_____
(Signature)

_____
(Company Name)

Attachment 2
Soil Boring Log

ENSAFE

LOCATION OF BORING	JOB NO.	CLIENT	LOCATION

DRILLING METHOD:	BORING NO.
	SHEET OF
SAMPLING METHOD:	DRILLING
	START / FINISH
WATER LEVEL	TIME / TIME
TIME	
DATE	DATE / DATE
CASING DEPTH	

DATUM ELEVATION

SURFACE CONDITIONS:

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	DEPTH OF CASING	SAMPLE NO. / SAMPLE DEPTH	BLOWS/FT SAMPLER	VAPOR CONCENTRATIONS (PPM)	DEPTH IN FEET	SOIL GRAPH
						0	
						1	
						2	
						3	
						4	
						5	
						6	
						7	
						8	
						9	
						0	
						1	
						2	
						3	
						4	
						5	
						6	
						7	
						8	
						9	
						0	

DRILLING CONTR. _____

BY _____ DATE _____ CHK'D BY _____

Attachment 3
Well Development Record

WELL DEVELOPMENT LOG

PROJECT	WELL NO.	SITE	PREPARED BY

METHOD
- OVERPUMPAGE ☐
- BAILER ☐
- SURGE BLOCK ☐
- AIR LIFT ☐
- OTHER _____

INITIAL WATER LEVEL

FINAL WATER LEVEL

REMARKS:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

1" - 0.012

2" - 0.16
4" - 0.65
6" - 0.1.47

VOLUME BETWEEN CASING AND HOLE (GALLONS/LINEAR FOOT) (ASSUMING 40% POROSITY)

1" CASING AND 2" HOLE - 0.013

2" CASING AND 6" HOLE - 0.52
2" CASING AND 8" HOLE - 0.98
4" CASING AND 10" HOLE - 1.37
4" CASING AND 12" HOLE - 2.09

HOLE DIAMETER d_h =

WELL CASING INSIDE DIAMETER $d_w ID$ =

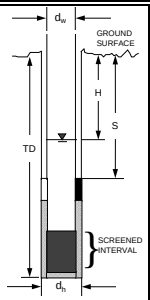
OUTSIDE DIAMETER $d_w OD$ = _____

DEPTH TO: WATER LEVEL H =

BASE OF SEAL S = _____

BASE OF WELL TD =

EST. FILTER PACK POROSITY P = _____



WELL VOLUME CALCULATION :

$$\text{CASING VOLUME} = V_c = \Pi\left(\frac{d_w ID}{2}\right)^2 (TD - H) = 3.14\left(\frac{___}{2}\right)^2 (___ - ___) = ____$$

$$\text{FILTER PACK PORE VOLUME} = V_f = \Pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_w OD}{2}\right)^2\right](TD - (S \text{ or } H^*))(P) = ____$$

(* if S > H, use S; if S < H, use H)

$$= 3.14\left[\left(\frac{___}{2}\right)^2 - \left(\frac{___}{2}\right)^2\right](___ - ___)(___) = ___$$

TOTAL WELL VOLUME = VT = Vc + Vf = ____ + ____ = _____ $ft.^3$ x 7.48 = _____ gal.

DEVELOPMENT LOG:

DATE	TIME BEGIN/END	METHOD	ELAPSED TIME	FLOW RATE (gpm)	CUMULATIVE WATER REMOVED GALLONS	WATER QUALITY pH	TEMP	CONDUC-TIVITY	D.O. *	REDOX	TURBID-ITY	COMMENTS

* = Dissolved Oxygen

Standard Operating Procedure SOP-3-14
Monitoring Well Sampling

1.0 PURPOSE

This standard operating procedure (SOP) describes the monitoring well sampling procedures. If there are procedures from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to monitoring well sampling, then those procedures may be added as an appendix to the project-specific sampling and analysis plan (SAP).

2.0 SCOPE

This procedure shall serve as management-approved professional guidance consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

The CTO Manager is responsible for ensuring that these standard groundwater sampling activities are followed during projects. The CTO Manager or designee shall review all groundwater sampling forms for completeness. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1c (DON 2007). The QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure. The Field Manager is responsible for ensuring that all project field staff follow these procedures.

5.0 PROCEDURES

5.1 Site Background Information

Establish a thorough understanding of the purposes of the sampling event prior to field activities. Conduct a review of all available data obtained from the site and pertinent to the water sampling. Review well historical data including, but not limited to, well locations, sampling history, purging rates, turbidity problems, previously used purging methods, well installation methods, well completion records, well development methods, previous analytical results, presence of immiscible phases, historical water levels, and general hydrogeologic conditions.

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To help minimize the potential for cross-contamination, well purging, sampling, and water level measurement collection shall proceed from the least contaminated to the most contaminated as indicated in previous analytical results or expected contaminant transport. This order may be changed in the field if conditions warrant it, particularly if dedicated sampling equipment is used. A review of prior sampling procedures and results may also identify which purging and sampling techniques are appropriate for the parameters to be tested under a given set of field conditions.

5.2 Groundwater Analysis Selection

Establish the requisite field and laboratory analyses prior to water sampling. Determine the appropriate and required types and numbers of QA/quality control (QC) samples to be collected (if not specified in the SAP), as well as the type and volume of sample preservatives, the number of sample shipping containers (e.g., coolers), and the quantity of ice or other chilling materials. The sampling personnel shall ensure that the appropriate number and size sample containers are brought to the site, including extras in case of breakage or unexpected field conditions. The analytical requirements for groundwater analyses should be specified in the project-specific work plan or SAP.

5.3 Sampling Methods

The utilized sampling methodology shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration during collection and transfer to sample containers. A variety of methods exist including submersible pumps, bladder pumps, peristaltic pumps, and bailers. Dedicated tubing should be used if at all possible and sampling equipment should be constructed of inert material consisting of either stainless steel, polyethylene, Teflon, or polyvinyl chloride. The selected pump type must take into account water depth, total depth of well, and the lift capacity of pump — typically available from the pump manufacturer. If depth to water is greater than 50 feet, then the pumps performance curves should be evaluated to ensure a sustained pumping rate can be maintained for continual flow. Sampling materials must be compatible with site contaminants and dedicated tubing should always be used, if possible. The various types of sampling devices, their advantages and disadvantages are described in the following paragraphs.

Bailers

A single- or double-check valve Teflon or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages,

including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, mixing, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, bailers should be used for groundwater sampling only when other types of sampling devices cannot be utilized for technical or logistical reasons. The QA Manager or Technical Director must approve the use of bailers for groundwater sampling in advance, or as approved in a SAP.

Bailers must be constructed of materials compatible with the analytes of interest. Use disposable bailers when sampling grossly contaminated sample sources. Lanyards must be made of non-reactive, non-leachable material. They may be cotton twine, nylon, stainless steel, or may be coated with Teflon, Polyethylene or Polypropylene.

Plastic sheeting must be placed around the well so that the bailer lanyard or rope is not in contact with ground. Bailers are lowered into the top of the water column, allowed to fill, and removed. Bailer samples are collected by slowly and gently lowering the bailer down the well until the top of the bailer is below the groundwater surface. Care should be taken to avoid sample disturbance and to minimize aeration of samples or groundwater in the well. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. Do not allow any bailer to fall freely into the well; minimize contact with the well sides and avoid contact with the bottom since this may allow any attached or settled out sediments to be incorporated into the samples. Retrieve the bailer slowly. Carefully empty groundwater samples directly into the appropriate containers.

New bailer rope should be attached to the bailer between samples and after decontamination, if non-disposable bailers are used. If a bailer was used to purge the well, it may also be used to sample the well and new bailer rope is not required between purging and sampling.

Bladder Pumps

A gas-operated Teflon or stainless steel bladder pump with adjustable flow control and equipped with Teflon-lined tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge. If a

bladder pump is utilized for the well purging process, the same bladder pump can also be utilized for sample collection after purging is complete.

When using a compressor, take several precautions. First, position any fuel-operated compressor downwind of the well and point of sample collection. Second, ensure the purge water exiting the well is collected into a drum or bucket. Finally, connect the compression hose from the well pump to the control box. Do not connect the compression hose from the compressor to the control box until after the engine has been started.

When all precautions are completed and the engine has been started, connect the compression hose to the control box. Slowly adjust the control knobs so as to discharge water in the shortest amount of time but maintaining a near constant flow. This does not mean that the compressor must be set so as to discharge the water as hard as possible. The optimal setting is one that produces the largest volume of purge water per minute (not per purge cycle) while maintaining a near constant flow rate.

Prior to sampling, adjust the flow or purge rate to yield 100 to 300 milliliters/minute (mL/min). Avoid settings that produce pulsating streams of water instead of a steady stream. Operate the pump at this low flow rate for several minutes to ensure that the groundwater being sampled is being withdrawn at a low extraction rate. The flow rate of 100 mL/min must be obtained so as not to cause fluctuation in pH, pH-sensitive analytes, and the loss of volatile constituents. Higher flow rates can be used once the samples for the analysis of volatile components have been collected. At no time shall the sample flow rate exceed the flow rate used while purging. Preserve the natural conditions of the groundwater, as defined by pH, dissolved oxygen (DO), specific conductance, temperature, turbidity, and oxidation/reduction potential (ORP).

For those samples requiring filtration, it is recommended to use in-line high capacity filter after all nonfiltered samples have been collected.

Passive Diffusion Bags

Passive diffusion bag samplers are bags comprised of low-density polyethylene plastic and containing analyte-free water, preferably with no headspace. The bags are deployed, with stainless steel weights, to the desired sample interval and are allowed to equilibrate with the water at the point of deployment in the well. A deployment period of a minimum of 14 days is recommended to ensure equilibration prior to removal.

After 14 days, the bags are removed and opened with a puncture device or other cutting implement and the contents transferred to containers for sampling or field measurement.

Peristaltic Pumps

A peristaltic pump is a type of positive displacement pump that lifts the water in a well by vacuum. The sample tubing is connected to flexible silicon hose fitted between rotating cams inside the pump casing that compresses the flexible tube as the rotor turns, creating a vacuum within the tube which lifts the water. In peristaltic pumps, no moving part of the pump is in contact with the water, thus forgoing the need for pump decontamination. The pumps are simple to operate, generally trouble free and quite inexpensive requiring only a 12-volt battery to power.

Peristaltic pumps may use a vacuum-trap method to collect non-volatile organic compound (VOC) samples. In this method, a pre-cleaned "transfer bottle" is connected between the peristaltic pump and the Teflon intake tubing installed in the well. As the pump evacuates air from the transfer bottle, the vacuum created causes the transfer bottle to fill with groundwater avoiding water contact with the flexible silicon tubing. The water aliquot in the transfer bottle is used to fill the appropriate sample containers.

Using a peristaltic pump to collect samples for VOCs requires special technique. The intake tube in the well is allowed to fill, the pump is shutoff and the tubing is retrieved from the well. In some cases, an inline valve is placed before the pump and is closed to ensure the sample does not drain from the intake tubing while it is being withdrawn from the well. Alternatively, the intake tubing may be crimped to retain the water. Sample containers should be filled by draining the water from the bottom of the intake tube by either breaking the vacuum or reversing the pump flow direction. Special care should be taken if the pump is reversed so that water that contacted the silicon tubing is not collected as part of the sample or that water from the purge collection container is not siphoned into sample container. Groundwater contact with the pump's silicon tubing should be avoided as the tubing may strip low level VOCs from the sample or components of the silicon tubing may interfere with the sampling results.

If depth to water in the well is greater than 28 to 30 feet, the peristaltic pump will not lift the water and an alternate sampling device will be necessary.

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Submersible Pumps

When operated under low-flow rate conditions (mL/min or less), submersible pumps are as effective as bladder pumps in acquiring samples for volatile organic analysis as well as other analytes. The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and Teflon, sample discharge lines composed of Teflon) and must have a controller mechanism allowing the required low flow rate. Ensure the purge water exiting the well is collected into a drum or bucket. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low flow rate. Higher pumping rates than 100 to 300 mL/min may be used when collecting samples to be analyzed for non-volatile constituents, if significant drawdown does not occur.

5.4 Groundwater Sampling Procedures

5.4.1 Measurement of Static Water Level and Purge Volume Calculations

Verify the identification of the monitoring well by examining markings, sign plates, placards or other designations. Remove the well cover and remove all standing water around the top of the well casing (manhole) before opening the well cap. Inspect the exterior protective casing of the monitoring well for damage and document the results of the inspection if there is a problem. It is recommended that you place a protective ground covering (like plastic sheeting) around the well head. Replace the covering if it becomes soiled or ripped. Inspect the well lock and determine whether the cap fits tightly. Replace the cap if necessary. Document all observations in the logbook.

Use an electronic probe to determine the water level. Decontaminate all equipment before use per SOP 3-06, Equipment Decontamination. Measure the depth to groundwater from the top of well casing to the nearest 0.01 foot and always measure from the same reference point or survey datum mark on the well casing. If there is no reference mark, measure from the north side of the casing. Record the measurement and the reference point in the logbook.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. An electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an electronic interface probe should be used to determine the presence of light, non-aqueous phase liquids (LNAPLs) and/or

dense, non-aqueous phase liquids (DNAPLs). Measurements should be from the top and the bottom of the product. Water levels containing LNAPL must be corrected for density effects to accurately determine the elevation of the water table.

If well development or drilling data indicates a potential for immiscible phase layers in groundwater, complete the following steps for detecting the presence of LNAPL and DNAPL before the well is evacuated for conventional sampling:

1. Carefully remove the well cap and release any pressure that may have accumulated from possible gasses or pressure changes between the inside and outside of well.

2. Sample the headspace in the wellhead immediately after the well is opened for organic vapors using an organic vapor analyzer such as a photoionization detector or flame-ionization detector, and record the measurements in the logbook.

3. Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements in the logbook.

4. Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.

If the well contains an immiscible phase, it may be desirable to sample this phase separately. It may not be meaningful to conduct water sample analysis of water obtained from a well containing LNAPLs or DNAPLs. Consult the CTO Manager and QA Manager or Technical Director if this situation is encountered.

5.4.2 Water Column Determination

If the total well depth is not available, the well should be sounded using a decontaminated weighted tape. A water level probe should not be used for sounding a well as the meter will be short circuited due to excessive head pressures overcoming the probe's seals. Note that wells which have not been sampled for a long period could be sufficiently silted-in to require re-development prior to sampling. It is therefore recommended that sufficient planning be included in a work activity to allow at least 24 hours to sound any wells to be sampled and redevelop for which a layer of silt at the bottom of the well screen may be present.

Subtract the depth to the top of the water column from the total well depth to determine the length of the water column. Calculate the total volume of water in gallons in the well using the following equation:

$$v = (0.041)d^2h$$

Where:
v = volume in gallons
d = well diameter in inches
h = height of the water column in feet

The total volume of water in the well may also be determined with the following equation by using a casing volume per foot factor (gallons per foot of water) for the appropriate diameter well:

$$v = (\text{gallons per foot of water})h$$

Where:
v = volume in gallons
h = height of the water column in feet

Table 1
Well Purging Volumes for Variable Well Casing Diameters

Casing Internal Diameter (inches)	Approximate Gallons per Foot of Water
0.75	0.02
1	0.04
1.25	0.06
2	0.16
3	0.37
4	0.65
5	1.02
6	1.47
12	5.88

5.5 Low Flow Purging and Water Quality Parameter Monitoring

The low-flow purging is the method of choice for collecting representative groundwater and offers the advantage over traditional three-well volume purges in that it generates minimal

investigation-derived waste and commonly generates a higher quality groundwater sample. This method is based on the procedure described in *Low-Flow (Minimal Drawdown), Ground-Water Sampling Procedures*, (Puls and Barcelona, USEPA, April 1996).

This procedure is typically accomplished by measuring field parameters at periodic intervals during purging with a flow-through cell container that allows field personnel to constantly monitor field water quality parameters such as temperature, pH, dissolved oxygen, and specific conductance. Other techniques or containers can be used to collect samples for periodic measurements, provided that periodic and representative samples can be collected.

Low-flow purging does not require the calculation of the water volume in the well, since purging is based solely on indicator parameter stabilization. Instead, the volume of the pump and discharge tubing are used to determine field measurement frequency and/or the minimum purge volume. Pump chamber or bladder volumes can be obtained from the manufacturer. Volumes of the sample tubing can be calculated or taken from Table 2.

Table 2
Equipment Volumes for Variable Tube Diameters

Discharge Tubing Volumes

Tubing Diameter (inches)	Volume per foot
1/2 OD and 3/8 ID	20 mL
3/8 OD and 1/4 ID	10 mL
1/4 OD and 1/8 ID	5 mL

Notes:
OD = outer diameter
ID = inner diameter
mL = milliliter

Well casing volumes should still be calculated and recorded on field information forms in the event parameter stabilization is not achieved after a three-casing-volume purge (see following subsection).

Sampling equipment volumes are calculated and recorded for use in determining the frequency of field measurements. Depending on the equipment configuration, calculate and record the volume of the pump and sample tubing using the methodology previously described (the volumes are typically converted to liters). The frequency of field readings is based on the time required to

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purge at least one volume of the pump and tubing system. For example, a pump and tubing volume of 500 mL purged at a rate of 250 mL/min will be purged in 2 minutes; readings should be at least 2 minutes apart.

The purging process removes sufficient water from within the well screen zone to obtain a sample that is representative of actual aquifer conditions adjacent to the well. The pump intake location is established for dedicated pumps. For non-dedicated pumps, the intake is placed within the screened interval, typically in the center of the screen. If the water column in the screen is shorter than the overall screen length, the pump should be placed lower in the screen but no lower than about 6 to 12 inches from the bottom of the screen to avoid picking up any settled solids in the well.

Typically, a pumping rate less than 1,000 mL/min is used and it is dependent on site-specific conditions. The pumping rate should be established based on where drawdown achieves stabilization and not an arbitrary drawdown limit. Excessive pumping rates (more than 1,000 mL/min) should be avoided so as to avoid turbidity as a result of aquifer shearing and water cascading through the well screen and potentially stripping VOCs. Flow rate is determined by measuring the time it takes to fill a calibrated container. Drawdown is monitored by measuring the water level below the top of the well casing with a water level indicator or similar device (e.g., transducer) while pumping. Flow rates and drawdown are recorded on a field logbook, field data form or with a data logger.

- Measure water level prior to initiating purging;
- Calculate well volumes, if required by permit;
- Calculate sampling system volume and determine indicator parameter measurement frequency;
- Connect the flow-through cell to the discharge tube from the pump;
- Begin purge at a rate of 100 to 200 mL/min (or at a rate determined from prior events);
- Check drawdown with a water level monitor while pumping;

- If drawdown stabilizes quickly, increase the pumping rate in increments of 100 mL/min until drawdown increases, then reduce the rate slightly after a few minutes to achieve a stable pumping water level;

- If the water level continues to drop, reduce purge rate by 100 mL/min increments until the water level stabilizes;

- Once water level stabilization is achieved, proceed to indicator parameter stabilization. Attempts should be made to avoid purging well to dryness, which can usually be accomplished by slowing the purge rate. If after continued reductions in the flow rate the well goes dry, the well should be sampled immediately after a sufficient volume of water has recovered in the well.

- If, after three well volumes have been removed, the chemical parameters have not stabilized according to the above criteria, the sampling team may elect to collect a sample.

Parameter Stabilization

Parameter stabilization ensures that the well is adequately purged and sampled groundwater is representative of formation water. In order to determine when a well has been adequately purged, samplers should:

- Monitor pH, specific conductance, DO, ORP, temperature, and turbidity of the groundwater removed during purging.

- Ensure stabilization is achieved by measuring three consecutive measurements, no sooner than 3 to 5 minutes apart, for the six parameters and criteria listed in Table 3 are achieved.

- Observe and record the water level drawdown.

- Record the purge rate and note the volume of water removed if required by guidance or permit.

Make every attempt to satisfy the parameter criteria in Table 3. Match the pumping rate with the recharge rate of the well by ensuring water level in well is stable before evaluating the purging criteria and document on the groundwater sampling form.

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Table 3
Water Quality Parameters and Stability Criteria

Parameter	Stability Limit
Temperature	± 0.2 °C
pH	± 0.2 Standard Units
Specific Conductance	± 5.0% of reading
Oxygen Reduction Potential	± 10.0% of reading
Dissolved Oxygen	≤20% Saturation
Turbidity	≤10 NTU

Notes:
°C = degrees Celsius
NTU = nephelometric turbidity units

If the criteria for dissolved oxygen and/or turbidity cannot be met, the range between the highest and the lowest values for the last three measurements cannot exceed the stated limits in Table 4.

Table 4
Default Criteria for Dissolved Oxygen and Turbidity
if Stabilization Criteria is Not Achieved

Parameter	Stability Limit
Temperature	± 0.2 °C
pH	± 0.2 Standard Units
Specific Conductance	± 5.0% of reading
Oxygen Reduction Potential	± 10.0% of reading
Dissolved Oxygen	± 0.2 mg/L or 10%, whichever is greater
Turbidity	± 5 NTUs or 10%, whichever is greater

Notes:
°C = degrees Celsius
mg/L = milligrams per liter
NTU = nephelometric turbidity units

If the stabilization parameters described cannot be met, and all attempts have been made to minimize the drawdown, check the instrument condition and calibration, purging flow rate and all tubing connections to determine if they might be affecting the ability to achieve stable measurements. All measurements that were made during the attempt must be documented, as well as a description pertaining to why the dissolved oxygen and/or turbidity were requirements were not achieved, and associated pertinent information. The sampling team leader may decide

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whether or not to collect a sample or to continue purging after three well volumes have been removed from the well.

5.6 Groundwater Sampling

Wells should be sampled immediately upon completion of purging operations. Once the water level stabilizes, the pumping rate should remain constant during low-flow sampling (generally less than 500 mL/min). For VOCs, lower sampling rates (100 to 200 mL/min) may be required.

- Record field parameters prior to sampling.
- Record depth to water levels prior to sampling (note if the well has not stabilized).
- Record the flow rate determined using a calibrated measuring device.
- Disconnect the flow-through cell and other equipment from the pump discharge tube.
- Collect samples from the pump discharge tube (or if using a peristaltic pump, by the method described in Section 5.3).
- Collect sample in the order cited in Section 5.8.

If, after three well volumes have been removed, the chemical parameters have not stabilized according to the criteria, the sampling team may elect to collect a sample. In most cases, after removing three well volumes of water, it may be assumed that fresh formation water is being collected by the pump intake. However, all site-specific data should be considered in determining whether sample collection is appropriate in a given situation. The conditions of sampling should be noted in the field log or field information form.

Low Yield Formations

In some situations, even with very slow purge rates, the well drawdown may not stabilize. In this case, sampling the water within the well screen zone provides the best opportunity to determine the formation water chemistry, as well purging can greatly affect sample chemistry through changes in dissolved gas levels, dissolved metals and VOCs.

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Attempts should be made to avoid purging wells to dryness. This can usually be accomplished by slowing the purge rate. If the well is evacuated during the purging procedures listed, the sample may be collected as soon as a sufficient volume of water has recovered in the well. If the well goes dry repeatedly (i.e., over multiple monitoring events) prior to sampling, then a minimum purge or "passive" sampling approach should be used in lieu of well evacuation.

In the case of a fully dry purge (not recommended): This criterion applies only if purging was attempted as described, and if it is impossible to balance the pumping rate with the rate of recharge at very low pumping rates (less than 100 mL/min). If wells have previously and consistently purged dry and the current depth to groundwater indicates that the well will purge dry during the sampling, minimize the amount of water removed from the well before collecting the sample:

- Place the pump or tubing intake within the well screened interval.
- Use 1/4-inch OD diameter Teflon, polyethylene, or polypropylene tubing and the smallest possible pump chamber volume to minimize the total volume of water pumped from the well and to reduce drawdown.
- Select tubing that is thick enough to minimize oxygen transfer through the tubing walls while pumping.
- Pump at the lowest possible rate (100 mL/min or less) to reduce drawdown to a minimum.
- Purge at least two volumes of the pumping system (pump, tubing and flow-through cell, if used).
- Measure pH, specific conductance, temperature, ORP, DO and turbidity and begin to collect the samples.

<u>Collect samples immediately after purging is complete</u>. If adequate volume is available upon completion of purging, the well must be sampled immediately. If sample collection does not occur within one hour of purging completion, re-measure the field parameters just prior to collecting the sample. If the measured values are not within the stability criteria re-purge the well (the exception is for "dry" wells). If well must recover prior to sampling, sample the well as soon

as adequate volume has recovered. Sampling of wells which have a slow recovery should be scheduled so that they can be purged and sampled in the same day, after adequate volume has recovered. Wells of this type should not be purged at the end of one day and sampled the following day.

5.7 Groundwater Sampling Using Peristaltic Pump/Vacuum Jug Assembly

Some states and/or regions discourage organic sample collection through peristaltic pump flexible tubing used in the pump head. In these instances, when collecting samples for organic compound analyses it may be necessary to use a vacuum container, placed between the pump and the well for sample collection. Figure 1 shows the vacuum/jug assembly apparatus.

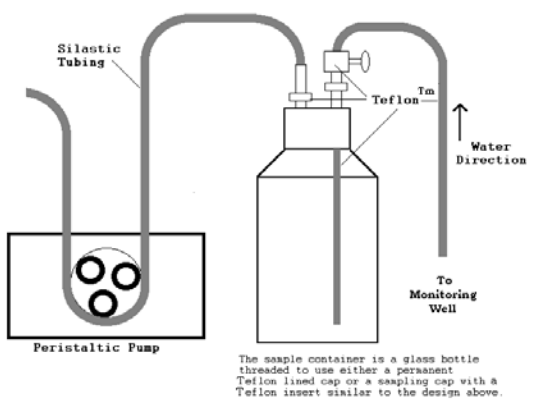

Figure 5-1
Vacuum Jug/Assembly Apparatus

The following step-by-step procedures, obtained from the U.S. Environmental Protection Agency (USEPA) Region 4 SOP, *Groundwater Sampling*, describe the process of sampling with a peristaltic pump and vacuum jug (see note following these procedures for collection of VOC samples):

1. Disconnect the purge tubing from the pump after low flow is established. Make sure the tubing is securely attached to the protective casing or other secure object.

2. Insert the tubing into one of the ferrule nut fittings of a Teflon vacuum container transfer cap assembly.

3. Place a suitable length of Teflon tubing between the remaining transfer cap assembly ferrule nut fitting and the vacuum side of the flexible tubing in the peristaltic pump head. Securely hand-tighten both fittings.

4. Turn the pump on. Water should begin to collect in the transfer container (typically a 1-liter sample container) within a few minutes. If water does not begin to flow into the container within several minutes, check the transfer cap fittings and make sure the assembly is tightly attached to the container. It may be necessary to tighten the ferrule nuts with a wrench or pliers to achieve a vacuum in the system, particularly when approaching the maximum head difference between the pump and water table (limit of suction).

5. When the transfer container is nearly full, turn off the pump, remove the transfer cap assembly, and pour the sample into the appropriate containers.

6. If additional sample volume is needed, replace the transfer cap assembly, turn the pump on, and collect additional volume. The use of Teflon valves or ball check devices to retain the water column in the sample delivery tubing during the transfer phase, when large volumes of sample are required, is acceptable. These devices, however, must be constructed so that they may be completely disassembled and cleaned.

NOTE: Samples for volatile organic compound analyses cannot be collected using this method. If samples for VOC analyses are required, they must be collected with a Teflon or stainless steel bailer or by other approved methods, such as the "soda straw" method. The "soda straw" method involves allowing the tubing to fill, by either (A) lowering it into the water column or (B) by filling it via suction applied by the pump head. If method (A) is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vial. If method (B) is used, after running the pump and filling the tubing with sample, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials. Avoid completely emptying the tubing when filling the sample vials when using method (B) to prevent introducing water that was in contact with the flexible pump head tubing. Either method is repeated, as necessary, until all vials are filled.

5.8 Sample Handling and Preservation

The laboratory will supply the necessary sample bottles and required preservatives. In some cases, the field team may add preservatives in the field. Improper sample handling may alter the

analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the laboratory provided containers as described above and in the project-specific planning documents.

It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens
2. Dissolved gases, total organic carbon, total fuel hydrocarbons
3. Semi-volatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Turbidity
10. Nitrate and ammonia
11. Radionuclides

When sampling for VOCs, collect water samples in the laboratory pre-preserved vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to dislodge air bubbles that may adhere to the sample cap or wall of sample vial. Sometimes it is not possible to collect a sample without air bubbles, particularly water that is aerated. In these cases, the investigator shall note the problem to account for possible error. Cooling samples may also produce headspace, but this will typically disappear once the sample is warmed prior to analysis. In addition, if the samples are shipped by air, air bubbles

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may form. Field logs should note any headspace in the sample container(s) at the time of collection.

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 mL of 1:1 nitric acid added to 500 mL of groundwater will produce a pH less than 2. Certain matrices that have alkaline pH (greater than 7) may require more preservative. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. The introduction of preservatives will dilute samples, and may require normalization of results. Calcium rich groundwater will react with the hydrochloric acid preservative and effervesce in VOC vials. In such instances, the laboratory should be contacted for possible removal of the preservative and reduction in the sample holding time. Guidance for the preservation of environmental samples can be found in the USEPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (USEPA 1982). Additional guidance can be found in other USEPA documents (USEPA 1992, 1996).

5.9 Quality Assurance/Quality Control Samples

The accuracy and precision of the field methods and laboratory analytical procedures are assessed through QA/QC samples collected during the sampling program. QA/QC samples may be labeled with QA/QC identification numbers or fictitious identification numbers if blind submittal is desired, and are sent to the laboratory with the other samples for analyses. The frequency, types, and locations of QA/QC samples should be specified in the SAP. Examples of QA samples include, but are not limited to, equipment rinsate blanks, field blanks, trip blanks, filter blanks, duplicate samples, and matrix spike (MS)/matrix spike duplicate (MSD) samples.

5.9.1 Equipment Rinsate Blanks

Equipment rinsate blanks are intended to check if decontamination procedures have been effective and to assess potential contamination resulting from containers, preservatives, sample handling and laboratory analysis. Procedures for collection are as follows:

1. Select a piece of sampling equipment that has been decontaminated onsite per the site-specific requirements.

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2. Rinse the decontaminated sampling apparatus with deionized water. Allow the rinsate to drain from the sampling apparatus directly into the sample bottle or into a secondary container which is then poured into the sample bottle;

3. Specify on the chain-of-custody (COC) form the same analytical methods for rinsate samples as is specified for the groundwater samples;

4. Assign the rinsate sample an identification number and label as rinsate samples; and

5. Place the rinsate sample in a chilled cooler and ship it to the laboratory with the other samples.

5.9.2 Field Blanks

Field blanks are used to assess the contamination of samples during sample collection and are prepared at a sampling location by pouring decontamination source water into the sample bottle. The field blank sample should be analyzed by the same methods as the groundwater samples. An identification number/sample name shall be assigned and recorded in the logbook and the groundwater sample location where the field blank was prepared should also be recorded. The frequency of the field blank samples will be identified in the project SAP.

5.9.3 Trip Blanks

Trip blanks are volatile organic samples that are prepared in the laboratory using analyte-free water. Trip blanks are analyzed to assess VOC contamination of samples during transport and are used only when VOCs are suspected and being analyzed in the groundwater samples. One trip blank will be included for each cooler that contains samples for VOC analysis. At no time should the trip blanks be opened by field personnel.

5.9.4 Field Duplicate Samples

Field duplicate samples are collected to assess the precision of field and laboratory components of field samples. When collecting a duplicate groundwater sample, the original and duplicate sample containers should be filled simultaneously, or as close to simultaneous as possible, by moving the discharge tubing or bailer back and forth over each container until they are full.

The duplicate sample is handled and preserved in the same manner as the primary sample and assigned a sample number, stored in a chilled cooler, and shipped to the laboratory with the

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other samples. Whenever possible, the sample identification numbers for the investigation sample and its duplicate are independent such that the receiving laboratory is not able to distinguish which samples are duplicates prior to analysis. The frequency of the field duplicate samples will be identified in the project SAP.

5.9.5 Matrix Spike/Matrix Spike Duplicate Samples

An extra volume of sample media may be collected during the sampling event for performance of MS/MSD or MS/lab duplicate analyses by the laboratory to assess laboratory accuracy, precision, and matrix interference. Aqueous MS/MSDs are collected in triplicate volume using the same sample procedures as field duplicates. MS/MSDs must be identified using the same identification as the parent sample and must be identified on the COC form to inform the laboratory that the sample is intended to be used for spiking. Samples chosen for spiking should be representative of the matrix indicative of site conditions. MS/MSDs are collected, preserved, transported, and documented in the same manner as the samples. The frequency of the MS/MSD samples will be identified in the project SAP.

6.0 RECORDS

Document information collected during groundwater sampling in logbooks or on the groundwater sampling form provided in Attachment 1. Information to be recorded includes the following:

- Identification of well
- Well depth
- Static water level depth
- Purge volume and pumping rate
- Stable water level during sampling
- Time that the well was purged
- Sample name/identification numbers
- Well purging/sampling equipment
- Date and time of collection
- Field observations
- Name of personnel
- Weather conditions

Copies of the groundwater sampling forms should be maintained by the Field Team Leader through the duration of field sampling activities and provided to the CTO Manager at the completion of the

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groundwater sampling event. Groundwater sampling forms for each sampling event should be maintained with the permanent site records.

7.0 HEALTH AND SAFETY

Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. Review the site-specific health and safety plan (HASP) paying particular attention to the control measures planned for the well sampling tasks. Conduct preliminary area monitoring of wells to determine the potential hazard to sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

Safety glasses with splash shields or goggles, disposable gloves, and steel-toe boots shall be worn during all groundwater sampling events, unless a higher level of personal protective equipment (PPE) is designated in the site-specific HASP.

Groundwater monitoring wells may be located in overgrown and/or wooded areas. Biological hazards such as poison ivy may be present. Such wells should be approached and opened with caution, in case insects or a snake have nested inside a well's protective casing.

Depending upon the type of contaminant expected or determined in previous sampling efforts, employ the following safe work practices:

- Avoid skin contact with and/or incidental ingestion of purge water.
- Wear long-sleeved protective gloves and splash protection (i.e., Saranex or splash suits and face shields) as warranted.
- Use eye protection and gloves when handling acid or caustic preservatives.
- Avoid breathing constituents venting from the well by approaching upwind, and/or by use of respiratory protection.
- If historical knowledge or evidence of free-phase is present, evaluate the well headspace with a flame or photo ionization detector prior to sampling.

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- If monitoring results indicate organic vapors that exceed action levels as specified in the HASP, sampling activities may need to be conducted in Level C protection. The site safety officer and/or field manager should be notified and a determination made based on protocols in the HASP for proper PPE or to use other methods to mitigate potential exposure during sampling. At a minimum, use skin protection, such as Tyvek or other media that is protective against the encountered media.

8.0 REFERENCES

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United States Environmental Protection Agency. 1982. *Handbook for Sampling and Sample Preservation of Water and Wastewater.* EPA-600/4-82-029. Cincinnati: EPA Office of Research and Development, Environmental Monitoring and Support Laboratory.

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9.0 ATTACHMENTS

Attachment 1 Groundwater Sampling Form

Attachment 1

Example Well Development and Groundwater Sampling Form

Attachment 1: Example Groundwater Sampling Form

DATE:	JOB NUMBER:	PHASE:	TASK:
PROJECT:	EVENT:		
WELL ID:	LOCATION:		
WEATHER CONDITIONS:	AMBIENT TEMP:		
REVIEWED BY:	PERSONNEL:		

WELL DIA:	WELL DEVELOPMENT	
TOTAL DEPTH from TOC (ft.):	START:	FINISH:
DEPTH TO WATER from TOC (ft.):	VOLUME PURGED (gal):	
LENGTH OF WATER COL. (ft.):	GROUNDWATER SAMPLING	
1 VOLUME OF WATER (gal):	START:	FINISH:
3 VOLUMES OF WATER (gal):	VOLUME PURGED (gal):	
	ANALYSIS:	

MNA FIELD RESULTS

FERROUS IRON	mg/L	CHLORIDE	mg/L		mg/L
SULFIDE	mg/L	ALKALINITY	mg/L		mg/L
SULFATE	mg/L	CO_2	mg/L		mg/L

IN-SITU TESTING

Circle one: DEVELOPMENT SAMPLING ☐ Bailer ☐ Pump Description:

Time (hh:mm):												
pH (units):												
Conductivity (mS/cm):												
Turbidity (NTU):												
DO (mg/L): Horiba												
YSI												
Temperature (C°):												
ORP (mV):												
Volume Purged (gal):												
Depth to Water (ft):												
Orion ORP: mV												
E_H												
Rel mV												
								Well Goes Dry While Purging ☐				

SAMPLE DATA

☐ Bailer ☐ Pump Description:

Sample ID	Date (m/d/y)	Time (hh:mm)	Bottles (total to lab)	Filtered (0.45 μm)	Remarks

Purging/Sampling Device Decon Process:

COMMENTS:

Purge water placed in drum#_____

Standard Operating Procedure SOP-3-17
Water Quality Parameter Testing for Groundwater Sampling

1.0 PURPOSE

This standard operating procedure (SOP) represents minimum standard of practice. State and federal requirements may vary, and this SOP does not replace state and federal requirements that must be consulted before work begins. Further, if a project-specific work plan has been created, the work plan should be considered the ruling document. This SOP may be modified to meet specific regulatory, client, or project specific criteria.

If there are procedures whether it be from Resolution Consultants, state and/or federal that are not addressed in this SOP and are applicable to water quality parameter testing, then those procedures may be added as an appendix to the project-specific Sampling and Analysis Plan (SAP).

2.0 SCOPE

This procedure provides guidance for expected sampling methods and protocols by all personnel related to the measurement of water quality parameters.

Field measurements of water quality parameters are commonly performed to evaluate surface water and groundwater. These tests are often performed to evaluate basic water quality parameters, to evaluate natural attenuation parameters, and to assess the presence of pore water entering a well.

As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

3.0 DEFINITIONS

3.1 Barometric Pressure (BP)

The density of the atmosphere, which varies according to altitude and weather conditions.

3.2 Conductivity/Specific Conductance

A measure of the ability of water to pass electrical current, which increases with the amount of dissolved ionic substances (i.e., salts). Conductivity is inversely related to the resistance of a solution and is measured in units of mhos per centimeter (mhos/cm) (inverse ohms/cm, Siemens/cm). The conductivity of water increases with increasing temperature.

Specific Conductance is corrected for 25 degrees Celsius (°C); for this reason, it is best to record Specific Conductance. If Conductivity is recorded, the temperature of the sample MUST recorded.

3.3 Dissolved Oxygen (DO)

The amount of oxygen present in water and available for respiration. DO is typically measured in milligrams per liter (mg/L). Oxygen is less soluble in warm and salty waters, so the instrument compensates the apparent percent saturation for changes in temperature and conductivity. Most probes measure the current resulting from the electrochemical reduction of oxygen (at a gold cathode) diffusing through a selective membrane. Because oxygen is being removed from the sample to perform the measurement, sample flow is required to prevent false low readings due to depletion of oxygen in the solution in front of the probe. Optical DO probes do not remove oxygen from the sample and are less affected by salts. The common range of DO in groundwater is 0.0 to 3.0 mg/L. Measurements outside of this range suggest that the meter may not be operating correctly.

3.4 Nephelometric Turbidity Unit (NTU)

The measurement of light passing through a sample based on the scattering of light caused by suspended particles.

3.5 pH

A measure of acidity and alkalinity of a solution using a logarithmic scale on which a value of 7 represents neutrality, lower numbers indicate increasing acidity, and higher numbers are increasingly basic.

3.6 Oxidation-Reduction Potential (ORP)

Also known as redox or eH, ORP is a measurement of the potential for a reaction to occur, which generally indicates the oxygen status of a sample. The probe consists of a platinum electrode, the potential of which is measured with respect to a reference electrode that rapidly equilibrates with the potential of the sample solution. A positive value indicates that oxygen is present. A negative value indicates an anaerobic environment or reducing condition. For this reason, negative ORP readings should be associated with DO readings of less than 0.5 mg/l; with negative ORP readings the water may exhibit a sulfur odor or gray color. Positive ORP readings should be associated with DO readings greater than 0.5 mg/L and lack of sulfur odors. Because of the complex relationship between ORP and temperature, no compensation is attempted; it is thus best to report both the ORP and temperature of a water sample.

3.7 Total Dissolved Solids

A measure of the quantity of materials in water that are either dissolved or too small to be filtered.

3.8 Turbidity

Measure of the clarity of water in NTUs. Potable water typically has NTU values between 0.0 and 0.3 NTUs, depending on the state or regulatory program.

4.0 RESPONSIBILITIES

The CTO Manager, or designee, is responsible for ensuring that these standard groundwater sampling activities are followed and shall review all groundwater sampling forms at the conclusion of a sampling event. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks. The QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure. The Field Manager is responsible for ensuring that all project field staff follows these procedures.

Field sampling personnel are responsible for the implementation of this procedure. Personnel are required to be knowledgeable of the procedures in this SOP. Training and familiarization with this SOP shall be documented in the training file for each employee. The field sampler and/or Field Manager is responsible for directly supervising the calibration procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the CTO Manager, QA Manager, or Technical Director and then documented in the field logbook and associated report or equivalent document.

5.0 PROCEDURES

5.1 Purpose

The procedures will vary depending on parameters being measured, method of sampling, and the method of measurement used. The information here is a general guidance and the site-specific documents and manufacturer manuals supersede these procedures.

5.2 Cautions

Improper use of water quality testing equipment could result in equipment damage or compromised sampling results. Personnel should be trained to operate the test equipment being used for a field operation and should be trained in the proper techniques for collecting and

logging water quality parameters. Personnel should also be able to recognize problems with test equipment and have someone available for basic troubleshooting and repair.

5.3 Interferences

During field testing, water quality data that is documented from field testing equipment may be influenced by certain outside factors that are unrelated to the actual site water quality. Such parameters and equipment include the following:

pH Meters

- Coatings of oils, greases, and particles may impair the electrode's response. Pat the electrode bulb dry with lint-free paper or cloth and rinse with de-ionized water. For cleaning hard-to-remove films, use isopropyl alcohol very sparingly so that the electronic surface is not damaged.

- Poorly buffered solutions with low specific conductance (less than 200 microsiemens per centimeter) may cause fluctuations in the pH readings. Equilibrate electrode by immersing in several aliquots of sample before taking pH.

Dissolved Oxygen

- Dissolved gases (e.g., hydrogen sulfide, halogens, sulfur dioxide) are a factor with the performance of DO probes. The effect is less pronounced on optical DO meters. Meter type and potential interferences should be considered based on potential sulfate/sulfide or nitrate/nitrite reducing environments.

- Exposure of the sample to the atmosphere will cause elevated DO measurements.

Turbidity Meter

- If the weather is warm and humidity is high, condensation may collect on the cuvet. To avoid this, allow the sample to warm and dry the outside of the cuvet before making the measurement. One method used to accomplish this is to place the cuvet against one's body (armpits work well).

Temperature

- Sample temperature will change rapidly when there are significant differences between the sample and ambient air.

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5.4 Apparatus and Materials

Field personnel shall consult the site work plan and SAP to review the equipment requirements for the sampling procedures to be followed during the sampling effort. The specific apparatus and materials required will depend on the water quality parameters being monitored. Table 1 shows the common equipment used in water quality parameter testing.

Table 1
Water Quality Parameter Testing — Common Equipment

Water Quality Parameter Instrument	Calibration Standards Required	Other Equipment
pH Meter	Yes - 2 or 3 Point Standards depending on groundwater range. Calibration must cover the range to be measured. If samples are above or below typical buffer standards (4, 7 and 10), special order buffers that fall outside groundwater pH range.	Container or flow thru cell for holding sample
Specific Conductance	Yes	Container or flow thru cell for holding sample
ORP Meter	Yes	Container or flow thru cell for holding sample
Turbidity Meter	Yes	Container or flow thru cell for holding sample
DO	No	Container or flow thru cell for holding sample
Thermometer	No	Container or flow thru cell for holding sample
Flow Rate	No	Calibrated Container

Notes:
ORP = Oxidation-Reduction Potential
DO = Dissolved Oxygen

5.5 Instrument or Method Calibration

Most monitoring instruments require calibration before use, and this calibration must be conducted in the field under the ambient climatic conditions that will be present during field sampling. Calibration of monitoring instruments shall be performed in accordance with the manufacturer's specifications and recorded in the provided form in Attachment 1. Site-specific instrument calibration requirements should be specified in the SAP. The following minimum calibration requirements apply to the various types of meters used to gather water quality measurements.

Initial Calibration (IC): Before use, the instrument or meter electronics are adjusted (manually or automatically) to a theoretical value (e.g., DO saturation) or a known value of a

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calibration standard. An IC is performed in preparation for the first use of an instrument or if a calibration verification does not meet acceptance criteria.

Initial Calibration Verification (ICV): The instrument or meter calibration is checked or verified directly following IC by measuring a calibration standard of known value as if it were a sample and comparing the measured result to the calibration acceptance criteria for the instrument/parameter. If an ICV fails to meet acceptance criteria, immediately recalibrate the instrument using the applicable initial calibration procedure or remove it from service.

Continuing Calibration Verification (CCV): After use, the instrument or meter calibration is checked or verified by measuring a calibration standard of known value as if it were a sample and comparing the measured result to the calibration acceptance criteria for the instrument/parameter.

5.5.1 Calibration Checks

Calibration checks are conducted by measuring a known standard. They must be completed after calibration and should be performed at least one other time (i.e., after lunch) and anytime suspect measurements are encountered. Table 2 provides general acceptance ranges to be used during calibration checks. If a meter is found to be outside of the acceptance range, the meter **must** be recalibrated. If the meter remains out of range, the project manager and/or the supplier of the meter should be contacted to determine alternative measures.

Table 2
Calibration Check Acceptance Limits

Parameter	Acceptance Criteria
Dissolved Oxygen	±0.3 mg/L of the theoretical oxygen solubility
Oxidation-Reduction Potential	±10 mv from the theoretical standard value at that temperature
pH	±0.2 Standard pH Units
Specific Conductance	±5% of the standard
Turbidity	0.1 to 10 NTU: ±10% of the standard 11 to 40 NTU: ±8% of the standard 41 to 100 NTU: ±6.5% of the standard

Notes:
mg/L = milligrams per liter
mv = millivolts
NTU = nephelometric turbidity units

5.5.2 Possible and Suspected Ranges

The concentration for each parameter range should be known so that concentrations outside of the range can be noted. Table 3 presents the maximum range of the parameter in groundwater. The table also presents the suspected range. Measurements outside of the maximum/minimum range should be considered in error and the measurement method should be checked. Concentrations outside the normal range should be treated as suspect but may be the result of contaminant impact. For example, a pH of 2.0 would be out of the normally suspected range for groundwater but not at a site impacted with an acid.

Table 3
Minimum and Maximum Result Ranges

Parameter	Units	Possible Min	Possible Max	Normal Min	Normal Max	Notes
Dissolved Oxygen	mg/L	0.0	14.6 (0°C) 10.1 (15°C) 8.3 (2°C)	0.0	5	The colder the sample, the higher the DO reading. DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron and/or gray color. DO less than 1 mg/L, ORP negative, may have sulfur odor, sulfide, ferrous iron and/or gray color.
pH	SU	0	14	5	9	pH values exceeding 10 could indicate grout contamination
ORP	mv					DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron and/or gray color. DO less than 1 mg/L, ORP negative, may have sulfur odor, sulfide, ferrous iron and/or gray color.
Specific Conductance	µS/cm			varies	varies	
Temperature	°C	0	100	5	30	
Turbidity	NTU	0	Greater than 1,000	0	Greater than 1,000	50 NTU or greater suggests cloudiness.

Notes:

mg/L = milligrams per liter
°C = degrees Celsius
DO = dissolved oxygen
SU = standard units
ORP = oxidation reduction potential
mv = millivolts
mS/cm = micro Siemens per cm
NTU = nephelometric turbidity units

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5.5.3 Field Instruments and Calibration Criteria

The calibration acceptance criteria for each instrument are summarized in Table 4 along with special considerations related to each field instrument.

Table 4
Calibration Check Acceptance Limits

Parameter	Acceptance Criteria
Dissolved Oxygen	±0.3 mg/L of the theoretical oxygen solubility.
Oxidation-Reduction Potential	±10 mv from the theoretical standard value at that temperature.
pH	±0.2 Standard pH Units
Specific Conductance	±5% of the standard
Turbidity	0.1 to 10 NTU: ±10% of the standard 11 to 40 NTU: ±8% of the standard 41 to 100 NTU: ±6.5% of the standard

Notes:
mg/L = milligrams per liter
mv = millivolts
NTU = nephelometric turbidity units

pH Meters

- For the most accurate of pH measurements, pH meters should receive a three-point calibration. However, if a two-point calibration will bracket the groundwater pH of the site, a two-point calibration is acceptable. Three-point calibrations typically include calibrating to solutions of pH 7.00, 4.00, and 10.00. If groundwater pH is outside the calibration range of the solution standards, special buffers must be ordered to bracket the pH. Some meters will report the slope of the calibration and this may be used in checking the meter calibration (refer to the meter's manual). When performing an ICV, the result must be within +/- 0.2 pH units of the stated buffer value.

- pH meters should be calibrated across the range of values to be measured. The maximum and minimum calibration solutions shall be outside the range of anticipated values. For example, if the expected range is between 7.50 and 9.00, the 7.00 and the 10.00 standard should be used for calibration. Perform the IC using at least two buffers, and always use the pH 7.00 buffer first. A reading that is above the maximum (or below the minimum) calibration standard is an estimate only and is not valid. This condition requires obtaining a new standard that is above (or below) the reported value, depending on the measurement.

- A percent slope of less than 90 percent indicates a bad electrode that must be changed or repaired. If percent slope cannot be determined, or the manufacturer's optimum specifications are different, follow the manufacturer's recommendation for maintaining optimum meter performance.

Specific Conductivity Meters

- For IC, when the sample measurements are expected to be 100 microsiemens per centimeter (µS/cm) or greater, use two standard potassium chloride (KCl) solutions that bracket the range of expected sample conductivities. Calibrate the instrument with the first standard. Verify the calibration of the instrument with the second standard, bracketing the range of expected sample values.

- If the instrument can be calibrated with more than one standard, choose additional calibration standards within the range of expected sample values.

- When the sample measurements are expected to be less than 100 µS/cm, a lower bracket is not required, but one standard (KCl) solution that is within the range of expected measurements must be used for the IC and the ICV.

- Accept the calibration if the meter reads within +/- 5 percent of the value of any calibration standard used to verify the calibration.

- Most field instruments read conductivity directly. Record all readings and calculations in the calibration records.

- For CCV, check the meter with at least one KCl standard with a specific conductance in the range of conductivity measured in environmental samples. The reading for the calibration verification must also be within +/- 5 percent of the standard value.

- If new environmental samples are encountered outside the range of the IC, verify the instrument calibration with two standards bracketing the range of sample values. If these calibration verifications fail, recalibrate the instrument.

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Dissolved Oxygen Meters

- Before calibrating, check the probe membrane for bubbles, tears, or wrinkles. These conditions require replacement of the membrane in accordance with the manufacturer's directions.

- If the meter provides readings that are off-scale, will not calibrate, or drift, check the leads, contacts, etc., for corrosion and/or short circuits. These conditions require replacement maintenance in accordance with the manufacturer's directions.
- Most DO meters must be calibrated based on an environment of 100 percent humidity and a known elevation and barometric pressure (BP).

- For 100 percent humidity, place the probe in the calibration container with a moist towel and allow the probe to remain, undisturbed, for 10 to 20 minutes.

- The IC is an air calibration at 100% saturation. Before use, verify the meter calibration in water-saturated air to make sure it is properly calibrated and operating correctly. Make a similar verification at the end of the day or sampling event. Follow the manufacturer's instructions for your specific instrument. Allow an appropriate warm up period before IC. Wet the inside of the calibration chamber with water, pour out the excess water (leave a few drops), wipe any droplets off the membrane/sensor and insert the sensor into the chamber (this ensures 100 percent humidity). Allow adequate time for the DO sensor and the air inside the calibration chamber to equilibrate. Once the probe/calibration chamber is stable at ambient temperature, check the air temperature and determine, from the DO versus temperature table (see Attachment 2) what DO should measure. The acceptance criterion for DO ICV is +/- 0.3 mg/L.

- Use the same procedure as above for CCV.

ORP Meters

- Verify electrode response before use in the field.

- Equilibrate the standard solution to the temperature of the sample. The standard solution is based on a 25°C temperature; however, the calibration solution standard's value will require adjustment based on the temperature.

- Immerse the electrodes and gently stir the standard solution in a beaker (or flow cell). Turn the meter on, placing the function switch in the millivolt (mv) mode.

- Let the electrode equilibrate and record the reading to the nearest millivolt. The reading must be within ±10 mv from the theoretical redox standard value at that temperature. If not, determine the problem and correct it before proceeding. Switch to temperature display and read the value.

- Record the mv reading and temperature in the field notebook or in form. Rinse the electrode with distilled water and proceed with the sample measurement, unless using a flow cell. If a flow cell is used, rinse between sample locations.

Turbidity Meters

- Perform an initial calibration using at least two primary standards.

- If the instrument cannot be calibrated with two standards, calibrate the instrument with one standard and verify with a second standard.

- Perform an ICV by reading at least one primary standard as a sample. The acceptance criterion for the ICV depends on the range of turbidity of the standard value:

    1. Standard Value = 0.1 to 10 NTU: the response must be within 10 percent of the standard;

    2. Standard Value = 11 to 40 NTU: the response must be within 8 percent of the standard;

    3. Standard Value = 41 to 100 NTU: the response must be within 6.5 percent of the standard; and

    4. Standard Value greater than 100 NTU: the response must be within 5 percent of the standard.

- Determining the Values of Secondary Standards: Use only those certified by the manufacturer for a specific instrument. Secondary standards may be used for CCVs.

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To initially determine the value of a secondary standard, assign the value that is determined immediately after an ICV or verification with primary standards. This is done by reading the secondary standard as a sample. This result must be within the manufacturer's stated tolerance range and +/- 10 percent of the assigned standard value. If the +/- 10 percent criterion is not met, assign this reading as the value of the standard. If the reading is outside the manufacturer's stated tolerance range, discard the secondary standard.

- CCV: Perform a CCV using at least one primary or secondary standard. The calibration acceptance criteria are the same as those for an ICV.

5.6 Direct Measurements

Direct measurements with meters are the most common methods and can be accomplished by placing a sample in a container with the probe or by allowing the water to flow past the probe in a flow cell. The use of a flow-through cell improves measurement quality by allowing the constant flow of water over the probes and reduces interaction of the sample with the atmosphere. Sample cups should be avoided. The quantity of samples, timing, and methodology should be described in the project SAP.

Following calibration of required probes, connect the bottom flow-cell port to the discharge line of the pump. Connect the top port to a discharge line directed to a bucket to collect the purge water. Allow the flow cell to completely fill. As the water flows over the probe, record the measurements. Continue to record the measurements at regular intervals, as specified in the SAP.

When the ambient air temperatures are much higher or lower than the temperature of the water sample, it is best to keep the length of tubing between the wellhead and the flow cell as short as possible to prevent heating or cooling of the water. Tubing and flow-through cell should not be exposed to direct sunlight, particularly in the summer, if at all possible, to avoid heating of water samples.

5.7 Data Acquisitions, Calculations, and Data Reduction

5.7.1 Specific Conductivity Correction Factions

If the meter does not automatically correct for temperature (i.e., read Specific Conductivity) record Conductivity and adjust for temperature upon returning to the office. The following equation can be used to convert Conductivity to Specific Conductivity.

$$K = \frac{(Km)(C))}{1 + 0.0191(\mathrm{T} - 25)}$$

Where:

K	=	Conductivity in μmhos/cm at 25°C
Km	=	Measured conductivity in μmhos/cm at T degrees Celsius
C	=	Cell constant
T	=	Measured temperature of the sample in degrees Celsius;

If the cell constant is 1, the formula for determining conductivity becomes:

$$K = \frac{(Km)}{1 + 0.0191(\mathrm{T} - 25)}$$

5.7.2 Percentage Difference Calculation

For evaluating slope of readings from either a flow cell or a sample cup.

$$\%Difference = \frac{(Highest\ Value - Lowest\ Value)}{(Highest\ Value)}\ x\ 100$$

5.7.3 Convert mm mercury (mmHG) to inches mercury (inHG)

$$mmHG = inHG\ x\ 25.4$$

5.7.4 True Barometric Pressure

For converting BP obtained from a public domain source that is expressed in BP at sea level to BP at the subject site.

$$TrueBP = (BP) - \frac{(2.5\ x\ [Local\ Altitude])}{100}$$

Where: BP is in mmHG and Local Altitude is in feet

Example: BP at site A is 30.49 inHg and elevation is 544 feet, calculate TrueBP

Convert inHG to mmgHG:

mmHg = 30.49 inHg x 25.4 = 774.4 mmHg

Calculate True BP:

TrueBP = (774.4 mmHg) – [2.5 * (544 /100)] = 774.4-13.6 = 760.8 mmHg

6.0 RECORDS

Data will be recorded promptly, legibly, and in indelible ink on the appropriate logbooks and forms. At the completion of a field effort, all logbooks, field data forms, and calibration logs shall be scanned and made electronically available to the project team. The original field forms, calibrations logs, and log book will be maintained in the project file.

7.0 HEALTH AND SAFETY

Detailed Health and Safety requirements can be found in the site specific Health and Safety Plan. Ensure that a Safe Work Assessment and Permit form is filled out daily prior to any work in the field and reviewed with all project personnel in a daily safety brief.

Safety glasses with side shields or goggles and disposable gloves shall be worn during calibration activities.

8.0 REFERENCES

None

9.0 ATTACHMENTS

Attachment 1: Example Field Instrument Calibration Form
Attachment 2: Solubility of Oxygen at Given Temperatures
Attachment 3: Example Field Data Form

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Attachment 1

Example Field Instrument Calibration Form

Field Instrument Calibration Form

Calibrated by: _____ Equipment (Make/Model/Serial#): _____

Date: _____ Equipment (Make/Model/Serial#): _____

pH (su) — Standard: ± 0.2 standard units

	Initial Calibration		Initial Calibration Verification	
	Hach SL	Reading	Pine SL	Reading
pH7				
pH4				

Continuing Calibration Verification

	Hach SL	Reading	Deviation	Acceptable Variance (Y/N)
pH7				
pH4				

DO (mg/L) — Standard: ± 0.3 mg/L of theoretical*

IC (Temp:)		ICV (Temp:)	
Saturation (%)	Reading (%)	Theoretical (mg/L)	Reading (mg/L)
100			

CCV (Temp:)

Saturation (%)	Reading (%)	Deviation	Acceptable Variance (Y/N)
100			

Theoretical (mg/L)	Reading (mg/L)	Deviation	Acceptable Variance (Y/N)

ORP (mV) — Standard: NA

IC (Zobell SL:)		ICV (Pine SL:)	
TCS (Std/Temp)	Reading	TCS (Std/Temp)	Reading

CCV (Zobell SL:)

TCS (Std/Temp)	Reading	Deviation	Acceptable Variance (Y/N)

Turbidity (ntu) — Standard: ±10% of Standard

Initial Calibration

Standard	Reading

Continuing Calibration Verification

Standard	Reading	Deviation	Acceptable Variance (Y/N)

Conductivity (ms^{C}/cm) — Standard: ± 5% of standard value

IC (YSI SL:)		ICV (Pine SL:)	
Standard	Reading	Standard	Reading

CCV (YSI SL:)

Standard	Reading	Deviation	Acceptable Variance (Y/N)

Comments:

_____

_____

_____

_____

Notes:

SL	solution lot	su	standard units	ntu	Nephelometric Turbidity Units
TCS	temperature corrected standard	mV	millivolts	°C	degrees Celsius
Std	standard	%	percent	ms°/cm	millisiemens per centimeter (temperature corrected)
Temp	temperature	mg/L	milligrams per liter	*	Theoretical value

Attachment 2

Solubility of Oxygen at Given Temperatures

Field Measurement of Dissolved Oxygen

Solubility of Oxygen in Water at Atmospheric Pressure			
Temperature	**Oxygen Solubility**	**Temperature**	**Oxygen Solubility**
°C	**mg/L**	**°C**	**mg/L**
0.0	14.621	26.0	8.113
1.0	14.216	27.0	7.968
2.0	13.829	28.0	7.827
3.0	13.460	29.0	7.691
4.0	13.107	30.0	7.559
5.0	12.770	31.0	7.430
6.0	12.447	32.0	7.305
7.0	12.139	33.0	7.183
8.0	11.843	34.0	7.065
9.0	11.559	35.0	6.950
10.0	11.288	36.0	6.837
11.0	11.027	37.0	6.727
12.0	10.777	38.0	6.620
13.0	10.537	39.0	6.515
14.0	10.306	40.0	6.412
15.0	10.084	41.0	6.312
16.0	9.870	42.0	6.213
17.0	9.665	43.0	6.116
18.0	9.467	44.0	6.021
19.0	9.276	45.0	5.927
20.0	9.092	46.0	5.835
21.0	8.915	47.0	5.744
22.0	8.743	48.0	5.654
23.0	8.578	49.0	5.565
24.0	8.418	50.0	5.477
25.0	8.263		

Notes:

The table provides three decimals to aid interpolation

Under equilibrium conditions, the partial pressure of oxygen in air-saturated water is equal to that of the oxygen in water saturated

°C = degrees Celsius

mg/L = milligrams per liter

Attachment 3
Example Field Data Form

WELL DEVELOPMENT & GROUNDWATER SAMPLING FORM

DATE:	JOB NUMBER:	EQUIPMENT (Make/Model #/Serial #):
PROJECT:	EVENT:	/ /
WELL ID:	LOCATION:	/ /
WEATHER CONDITIONS:	AMBIENT TEMP:	/ /
REVIEWED BY:	PERSONNEL:	/ /

WELL DIA:	**WELL DEVELOPMENT**	
TOTAL DEPTH from TOC (ft.):	START:	FINISH:
DEPTH TO WATER from TOC (ft.):	VOLUME PURGED (gal):	
LENGTH OF WATER COL. (ft.):	**GROUNDWATER SAMPLING**	
1 VOLUME OF WATER (gal):	START:	FINISH:
3 VOLUMES OF WATER (gal):	VOLUME PURGED (gal):	
	ANALYSIS:	

WELL DEVELOPMENT PARAMETERS		GW SAMPLING PARAMETERS	
Temperature:	± 1.0° C	Temperature:	± 0.2° C
pH:	± 0.5 standard units	pH:	± 0.2 standard units
Specific Conductance:	± 10% of the past measurement	Specific Conductance:	± 5% of the past measurement
Turbidity:	relatively stable	DO:	≤ 20% saturation
		ORP:	± 10 millivolts
		Turbidity:	≤ 10 NTU

IN-SITU TESTING

Circle one: DEVELOPMENT SAMPLING ☐ Bailer ☐ Pump Description:

Time (hh:mm):												
pH (units):												
Conductivity (mS/cm):												
Turbidity (NTU):												
DO (mg/L): YSI 556												
DO (mg/L): YSI 550												
Temperature (C°):												
ORP (mV):												
Volume Purged (gal):												
Depth to Water (ft):												
								Well Goes Dry While Purging ☐				

SAMPLE DATA

☐ Bailer ☐ Pump Description:

Sample ID	Date (m/d/y)	Time (hh:mm)	Bottles (total to lab)	Filtered (0.45 µm)	Remarks
Purging/Sampling Device Decon Process:					

COMMENTS:

Purge water placed in drum#_____

Standard Operating Procedures SOP-3-18 (MS)
Direct Push Sampling Techniques

1.0 PURPOSE

This standard operating procedure provides procedures for use of direct push sampling methods for collecting soil and groundwater samples. If there are additional procedures required by state and/or federal that are not addressed in this Standard Operating Procedure (SOP) and are applicable to direct push sampling then those procedures may be added as an appendix to the project specific Sampling and Analysis Plan.

2.0 SCOPE

This procedure shall serve as management-approved professional guidance and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

The physical nature of the subsurface materials, water depth, regulatory buy in, data quality objectives, and other issues will play an important part in deciding whether direct push methods are suitable for the project and should be discussed in the project-specific planning documents. Before field implementation of direct push methods, the following aspects will need to be considered:

- Permits required by local/state water Board/Districts, etc.
- Waste generation and handling
- Health and safety issues associated with chemical and physical hazards
- Locating subsurface and overhead utilities before field activities and adjust locations as necessary to account for impediments and obstacles.

If direct push methods are used for constructing small diameter monitoring wells, the following aspects should also be considered:

- Well locations and depths
- Permanent or temporary wells
- Screen length(s)
- Well completion specifications.

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3.0 RESPONSIBILITIES

The CTO Manager is responsible for ensuring that the described direct push methods are followed and that all field personnel involved shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1c (DON 2007).

QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for implementing or ensuring that all project field staff follow these procedures.

4.0 BACKGROUND

4.1 Direct Push Techniques

Direct push techniques (DPT) rely on use of hydraulically powered machines that utilize static and percussion forces to advance various tools in the subsurface for a variety of uses including soil and groundwater sampling, logging, grouting and materials injections. The machines are very portable and their small size makes them ideal for working inside buildings and confined areas. They are also very fast and generate very little investigative derived waste resulting in direct push methods being a very cost-effective sampling approach compared to traditional drilling methods. A variety of systems are available under several trade names, such as Geoprobe and Strataprobe. Equipment may be skid-mounted, trailered, or mounted directly on the frame of a vehicle. Major limitations of direct push techniques are their inability to penetrate rock or cobbles and a shallow maximum depth of penetration. The capabilities of direct push systems vary significantly among vendors. Consider these differences in capabilities when evaluating the method for a subsurface exploration program.

5.0 PROCEDURES

5.1 Soil Sampling

Vendors of direct push equipment offer a variety of sampling systems designed specifically for their equipment. Both continuous and discreet soil samples may be obtained using direct push sampling equipment and there are generally two methods for soil sampling, using either an open-tube sampler or closed-point sampler. The open tube sampler enables the continuous collection of soil

cores from the ground surface to a depth dependent on the core hole staying open. Upon retrieving the sampler, the plastic liner and soil core are removed, the sampler properly decontaminated, reassembled with a new liner and inserted back down the same hole to collect the next soil core. The plastic liners are split lengthwise and the soil core within is described, screened and/or sampled as specified in the project-specific planning documents. Since a new liner is used with each sampler, the potential cross-contamination risk is minimized, resulting in an inherently safe soil sampling method.

Sandy soils or material collapsing from the probe side wall can make it difficult to collect representative soil cores from significant depths with an open tube sampler. A closed-point sampler (or piston sampler) seals the leading end of the sampler with a point assembly that is held in place with a center rod. Once the sampler is advanced to the top of the sampling interval, the probe rod string is removed which disengages the piston point, allowing soil to enter the sampler. The sampler is retrieved, the plastic liner and soil core are removed and the process is repeated until reaching the desired completion depth.

5.2 Groundwater Sampling

Groundwater samples and can be collected in-situ using a groundwater sampling device or through constructing small diameter (< 1.5 inch) monitoring wells, either permanent or temporary.

In-situ Groundwater Sampling

1. Place a drive cap on the assembled direct push sampler and drive it into the subsurface.

2. Continue driving by adding probe rods until the sampler tip has been driven about one foot below the target sampling depth.

3. After reaching the groundwater depth, disengage the expendable drive point by pulling the rods back a distance of about 2 feet and remove the drive cap.

4. Lower the sensor of an electric water level indicator until the audio signal sounds and record the depth to groundwater. The measurement tape scale (0.01 ft intervals) on the water level indicator wire is read at the top of the probe rod after pulling the tape out and extending it to the ground surface.

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5. After recording the water level depth measurement, the indicator sensor is removed from the probe rods.

6. Lower a 0.25 to 0.375-inch OD polyethylene or Teflon tube inside the probe rods and evacuate groundwater with a peristaltic pump. When lowering tubing inside the rod string, ensure that it enters the screen interval. The leading end of the tubing will sometimes catch at the screen head giving the illusion that the bottom of the screen has been reached. An up-and-down motion combined with rotation helps move the tubing past the lip and into the screen.

7. Retrieve the sampler, clean all parts thoroughly, replace the O-rings, and prepare for the next sample.

Typically less than a gallon of water is purged until turbidity levels are stable and sampling follows. Since in-situ groundwater samples are usually collected as "screening" data and are a means to focus permanent monitoring wells, water quality parameters (pH, conductivity, turbidity, temperature) are not normally collected; however, field personnel should defer to the requirements of the project-specific planning documents. If sampling for volatile organic compounds (VOCs), the sample should not be circulated through the peristaltic pump since low level VOCs may be stripped from the sample, causing low bias in analyses. The methods described in SOP 7, *Monitoring Well Sampling* for sampling with a peristaltic pump should be adhered to.

In cases where the water depth is greater than 28 feet and the water cannot be lifted, groundwater samples may also be collected by attaching a check valve (with check ball) to the bottom end of the tubing and oscillating the tubing up and down until water exits the top of the tube.

Monitoring Well Installations with Direct Push Methods

1. Place a drive cap on the first section of 2.125-in. probe rod with an expendable drive point installed and advance the rod into the ground.

2. Continue driving by adding probe rods, with O-ring seals between each rod, until the sampler tip reaches approximately one foot below the screen installation depth.

3. After reaching the installation depth, the PVC well screen is lowered into the probe rods while adding threaded lengths of PVC riser pipe as needed. Care must be taken to tighten the threaded sections to prevent leakage at the joints. New, clean, rubber gloves are worn while handling all well screen and riser pipe materials to provide the highest quality samples from the well after installation.

4. After the screen and riser are set at the installation depth, the probe rods are retracted slightly while holding down pressure on the riser pipe. This disengages the expendable point from the bottom section of drive rod.

5. After disengaging the drive point, the screen is exposed to the aquifer. Before proceeding with the well installation, it is prudent to measure the static water level in the well. This allows for adjustment of the proper screen depth if required.

6. After assuring the proper installation depth, if pre-packed screens are not used, filter-pack sand is slowly poured within the annular space between the well screen and probe rods.

7. Filter sand is added, while retracting the probe rods, until the sand reaches approximately two feet above the screen length.

8. If the native formation is well-sorted sand, coarse enough to filter and not pass through the well screen filter sand may be unnecessary. Retracting the probe rods to approximately two feet above the top of the screen will allow collapse of the native formation around the screen.

9. Above the filter pack, a minimum two-foot thick bentonite seal is installed to prevent any infiltration from above reaching the sand pack and/or well screen. The bentonite seal is tremied from the bottom (top of the filter pack), with the high-pressure grout pump while retracting the probe rods.

10. A bentonite slurry can be used to grout the entire well annulus, or alternatively above the required minimum two-foot thick bentonite seal, the annulus can be grouted with neat cement.

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11. Following 24 hours, the development and sampling of the well can proceed as for typical larger diameter wells.

Small-diameter (3/4 — 1 inch) monitoring wells can be installed using direct push methods and are commonly considered permanent, depending upon local and State regulations. The limitations and abilities of wells constructed should be thoroughly understood and before using direct push methods, it should be confirmed that:

1. The method effectively protects the well screen from exposure to contaminated overburden soils during installation

2. Effective filter packing is placed around the well screen (commercially available pre-packed well screens ensure adequate filter packing around well screen).

3. The well screen to be effectively sealed against the downward infiltration of overlying groundwater or surface precipitation

4. Well materials are compatible with the intended sampling and analysis goals of the project

5. The well screen is properly sized and slotted for the needs of the project

The project-specific planning documents should evaluate the appropriateness of direct push systems and whether collected data will meet the project objectives. As part of this evaluation, regulatory concurrence/approval should also be sought.

5.3 Equipment Decontamination

To avoid cross-contamination, thoroughly decontaminate equipment used for direct push exploration and sampling. Decontaminate sampling tools and downhole equipment between each sampling event and between penetration points. At a minimum, steam clean or wash and rinse the equipment with a combination of soapy water and a double rinse of clean water. The inside of the of the sample roads is cleaned with nylon brushes and extension rods. Use clean water and phosphate-free soap, cycle the brush inside the probe rod or sample tube to remove contaminants. Rinse with clean water and allow to air dry.

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5.4 Borehole Abandonment

Some direct push boreholes will close naturally as the drive rods and sampling tools are withdrawn. This may occur in loose, unconsolidated soils, such as sands. Close all boreholes using one of the procedures described in this procedure, unless natural caving precludes such closure.
The three methods for closing direct push boreholes are:

1. Add granulated or pelletized bentonite and hydrate in layers, proceeding from the bottom of the hole to the surface.

2. Pour premixed cement/water (or cement/water/bentonite) mixture into the hole.

3. Fill the entire hole with granular or pelletized bentonite and hydrate by means of a previously emplaced water tube that is gradually withdrawn as water is supplied to the bentonite.

For shallow holes less than 10 feet in depth, pour a cement/water/bentonite mix directly into the opening using a funnel. For deeper holes, use a conductor (tremie) pipe to carry the grout mix to the far reaches of the borehole. Lower the conductor pipe to within 2 inches of the bottom and gradually withdraw it as grout is added, keeping the lower end of the pipe submerged in grout at all times. Seal boreholes to within 0.5 to 2.0 feet of the surface. Inspect the abandoned borehole after 24 hours to ensure that grout shrinkage does not occur. If significant shrinkage has occurred, re-grout the borehole. Fill the remaining portion of the hole with local topsoil or appropriate paving materials.

6.0 RECORDS

Record all DPT field activities in the appropriate field log book. Depending on the project objectives, soil classification may or may not be required. If it is required, complete a soil boring log as provided in Attachment 1. Monitoring wells constructed with direct push methods require both a well construction log and groundwater sampling log which are also provided in Attachments 2 and 3. Field personnel should provide copies of all completed forms to the Field Team Leader who is responsible for forwarding the forms to the CTO Manager who will review them for completeness before incorporating them into the project files.

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7.0 HEALTH AND SAFETY

The primary hazards associated with direct push sampling are the mechanical hazards associated with machinery. Only qualified personnel should operate the equipment and field personnel should always maintain a safe distance from it. The minimum personal protective equipment (PPE) is safety glasses, hearing protection, steel-toed boots, and a hard hat. Depending upon the site-specific contaminants, additional PPE requirements may be required as designated in the site-specific HASP.

Employ the following safe work practices:

- Avoid skin contact with and/or incidental ingestion of purge water.
- Position DPT machine downwind of bore
- Use eye protection and gloves when handling acid or caustic preservatives.
- Avoid breathing constituents venting from the borehole by positioning rig upwind between field personnel/operators and the borehole.
- If historical knowledge or evidence of free-phase is present, use a flame or photo ionization detector to ensure the breathing zone is safe.
- If monitoring results indicate organic vapors that exceed action levels as specified in the HSP, be prepared to upgrade PPE to Level C protection.

8.0 REFERENCES

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/-ufp_qapp_v1_0305.pdf.

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9.0 ATTACHMENTS

Attachment 1 Soil Boring Log

Attachment 2 Well Construction Form

Attachment 3 Groundwater Sampling Form

Attachment 4 Geoprobe Screen Point 22 Groundwater Sampler

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Attachment 1
Soil Boring Log

ENSAFE

LOCATION OF BORING	JOB NO.	CLIENT	LOCATION

DRILLING METHOD:	BORING NO.
	SHEET OF
SAMPLING METHOD:	DRILLING
	START / FINISH
WATER LEVEL	TIME / TIME
TIME	
DATE	DATE / DATE
CASING DEPTH	

DATUM ELEVATION

SURFACE CONDITIONS:

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	DEPTH OF CASING	SAMPLE NO. / SAMPLE DEPTH	BLOWS/FT SAMPLER	VAPOR CONCENTRATIONS (PPM)	DEPTH IN FEET	SOIL GRAPH
						0	
						1	
						2	
						3	
						4	
						5	
						6	
						7	
						8	
						9	
						0	
						1	
						2	
						3	
						4	
						5	
						6	
						7	
						8	
						9	
						0	

DRILLING CONTR. _____

BY _____ DATE _____ CHK'D BY _____

Attachment 2
Well Construction Form

Well Construction Form

Facility/Project Name:

Well ID.:

Facility License Number:

Type of Well:
Ground Water Monitoring ☐
Piezometer ☐ Injection ☐
Other_____

Date Well Installed:

Location of well relative to waste source:
Upgradient ☐ Downgradient ☐ Side-gradient ☐ Unknown ☐

Well Installed By:

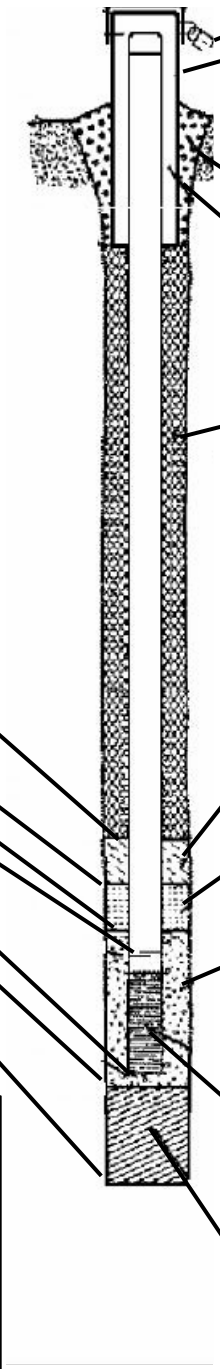
Well Driller License Number:

Geologist:

A. Protective pipe: ft. above grade
B. Well casing, top elevation: ft. MSL
C. Land Surface Elevation: ft. MSL
D. Surface seal, bottom: ft.below grade

12. USCS classification of soil near screen:
GP☐ GM ☐ GC ☐ GW ☐ SP ☐ SM ☐
SC☐ SW☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐
13. Sieve analysis attached? Yes ☐ No ☐
14. Drilling method used: Rotary ☐ HSA ☐
Other:
15. Drilling fluid used:
Water☐ Air ☐ Drilling Mud ☐ None ☐
16. Drilling additives used? Yes ☐ No ☐
Specify:
17: Source of water:

E. Bentonite seal: top ft. (depth)
F. Fine sand: top ft. (depth)
G. Filter pack: top ft. (depth)
H. Screen joint top: ft. (depth)
I. Well bottom: f t. (depth)
J. Filter pack: bottom ft. (depth)
K. Borehole: bottom . ft.(depth)
Borehole diameter: in.



1. Cap and lock? ☐ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: in.
b. Length: ft.
c. Material: *Steel* ☐ *Other*
3. Surface seal: *Bentonite* ☐ *Concrete* ☐
Other:
4. Material blw. well casing and protective pipe:
Bentonite ☐ *Annular space seal* ☐
Other:
5. Annular space seal: *(Manufacturer name)*
a. Granular bentonite ☐
b. Bentonite/Cement slurry ☐
% bentonite ……. Bentonite/cement grout ☐
Lbs/gal mud weight … bentonite slurry ☐
c. How installed: *Tremie* ☐ *Tremie pumped* ☐
Gravity ☐
6. Bentonite seal: *(Manufacturer, product name)*
Bentonite granules ☐
☐ *¼ in.* ☐ *3/8 in.* ☐ *½ in.* *Bentonite pellets* ☐
Other:
7. Fine sand material: *(Manufacturer, product name, mesh size)*
Volume added: ft^3
8. Filter pack material: *(Manufacturer, product name, mesh size)*
Volume added: ft^3
9. Well casing: Flush-threaded Sch 40 PVC☐
Flush-threaded Sch 80 PVC☐
Other:
10. Screen material:
a. Screen type: factory cut ☐ continuous slot ☐
Other:
b. Manufacturer:
c. Slot size: 0. in.
d. Slotted length: ft.
11. Backfill material: *or* None ☐

CERTIFICATION:
I hereby certify that the information on this form is true and correct to the best of my knowledge:

_____
(Signature)

_____
(Company Name)

Attachment 3
Groundwater Sampling Form

ENSAFE

WELL DEVELOPMENT & GROUNDWATER SAMPLING FORM

DATE:	JOB NUMBER:	EQUIPMENT (Make/Model #/Serial #):
PROJECT:	EVENT:	/ /
WELL ID:	LOCATION:	/ /
WEATHER CONDITIONS:	AMBIENT TEMP:	/ /
REVIEWED BY:	PERSONNEL:	/ /

WELL DIA:	WELL DEVELOPMENT	
TOTAL DEPTH from TOC (ft.):	START:	FINISH:
DEPTH TO WATER from TOC (ft.):	VOLUME PURGED (gal):	
LENGTH OF WATER COL. (ft.):	GROUNDWATER SAMPLING	
1 VOLUME OF WATER (gal):	START:	FINISH:
3 VOLUMES OF WATER (gal):	VOLUME PURGED (gal):	
	ANALYSIS:	

WELL DEVELOPMENT PARAMETERS		GW SAMPLING PARAMETERS	
Temperature:	± 1.0° C	Temperature:	± 0.2° C
pH:	± 0.5 standard units	pH:	± 0.2 standard units
Specific Conductance:	± 10% of the past measurement	Specific Conductance:	± 5% of the past measurement
Turbidity:	relatively stable	DO:	≤ 20% saturation
		ORP:	± 10 millivolts
		Turbidity:	≤ 10 NTU

IN-SITU TESTING

Circle one: DEVELOPMENT SAMPLING ☐ Bailer ☐ Pump Description:

Time (hh:mm):												
pH (units):												
Conductivity (mS/cm):												
Turbidity (NTU):												
DO (mg/L): YSI 556												
DO (mg/L): YSI 550												
Temperature (C°):												
ORP (mV):												
Volume Purged (gal):												
Depth to Water (ft):												
								Well Goes Dry While Purging ☐				

SAMPLE DATA

☐ Bailer ☐ Pump Description:

Sample ID	Date (m/d/y)	Time (hh:mm)	Bottles (total to lab)	Filtered (0.45 μm)	Remarks

Purging/Sampling Device Decon Process:

COMMENTS:

Purge water placed in drum#_____

Attachment 4

Geoprobe Screen Point 22 Groundwater Sampler

Standard Operating Procedure SOP-3-19 (MS)
Substrate Injection

1.0 PURPOSE

The procedure is for the delivery of a carbon substrate into an aquifer via monitoring/injection wells or through use of direct-push technology is to stimulate the in-situ biological degradation of contaminants. If there are procedures in addition to these specified, as required by State and/or federal entities that are not addressed in this Standard Operating Procedure (SOP) and are applicable to substrate injection then those procedures may be added as an appendix to the project specific Sampling and Analysis Plan (SAP).

2.0 SCOPE

This procedure shall serve as management-approved professional guidance and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Contract Task Order (CTO) Manager or the Quality Assurance (QA) Manager, and documented.

This procedure is intended to provide a general approach for injecting carbon substrate into the subsurface as part of a remediation approach. Specific delivery quantities, mixtures, and procedures will depend on subsurface conditions and the remedial objectives in the project-specific planning documents. The following aspects should be addressed before implementing any field activities:

- Injection permits from local/state water Board/Districts, etc.
- Seasonal temperature and whether heating of injectate solution will be necessary for mixing.
- Aquifer properties and capacity, contingencies for slow material acceptance.
- Whether materials will be injected via wells or direct-push methods.
- Whether materials be delivered using pressure or gravity draining.
- Verification testing of proposed injection radius.

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- Water availability.
- Health and safety issues associated with materials and equipment.

- Ensure all subsurface and overhead utilities have been located and clearly marked before any subsurface injection/drilling activities and adjust locations as necessary to account for impediments and obstacles.

The injection contractor should be experienced with handling all types of carbon substrate, particularly the one specified in the project-specific planning documents. The contractor will also be required to have all mixing tanks/vessels, pumps, trailers, packers, couplings, gauges, and any ancillary equipment to ensure smooth, uninterrupted delivery of the carbon substrate once the project has begun. The contractor is responsible for all material handling, mixing, delivery, and site cleanup; however, oversight of all injection activities is required. Using an appropriate pump to install the injectate product is very critical to the success of the application as well as the overall success of the project. It is strongly recommended that a pump has a pressure rating of at least 1,000 pounds per square-inch (psi) and a delivery rate of at least 3 gallons per minute be used.

3.0 RESPONSIBILITIES

The CTO Manager, or designee, is responsible for ensuring that the carbon substrate injection is properly planned and executed and that personnel are properly protected from chemical and physical hazards associated with material handling.

The Field Manager is responsible for supervising the subcontractor and ensuring that the specifications in the project-planning documents are met. He/she is also responsible for documenting all pertinent data associated with injection activities. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the CTO Manager or QA Manager, and documented.

4.0 REQUIRED MATERIALS

At a minimum, the following equipment will be needed for delivering carbon substrate:

- Centrifugal pump

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- Appropriate hose assembly including fittings that link pump to well casing and/or direct-push rods
- Two or more tanks/vessel with a minimum of 500 gallon capacity (one for mixing one for water)
- Rotary transfer pump (or equivalent) with appropriate hosing to connect from water vessel to mixing tank
- Compressed nitrogen gas tank and appropriate regulators if pressurized application is selected. The compressed gas tank must be mounted vertically and properly secured to protect the tank for falling over and to protect the valve from damage.
- Pressure washer (or equivalent) for cleaning
- Carbon substrate materials
- Proper personnel protective equipment (PPE) for all personnel potentially exposed to the carbon substrate materials or contaminated groundwater.

5.0 METHODS

Two methods are used for delivering carbon substrate and the selection will depend on the material used for injection, targeted treatment area, hydrogeologic conditions, and other variables that should be addressed in the project-specific planning documents. One method is through gravity flow where the injectate material is pumped directly into a well and allowed to filter out via the well screen. Packers may be used to isolate sections of the well screen, if necessary. The second method is through use of pressure injection using pressurized air or water to deliver the medium. Pressurized injections can be through a well or more commonly through use of a direct-push device (i.e., Geoprobe ®) which enables the strategic delivery of carbon substrate over multiple locations and various depth intervals. Using pressurized air or water enables the delivery of the materials over a wider area compared to gravity draining. The treatment area will depend on the aquifer properties, material viscosity, injection pressure, and overall remedial objectives which all should be detailed in the project-planning documents. Direct-push delivery methods are commonly limited to shallow applications or sites that can be

penetrated with direct-push methods. If repeated applications of carbon substrate are anticipated and direct-push methods are a viable delivery option, a cost analysis between permanent injection wells and direct-push methods should be conducted to determine the optimal method.

Substrate Injection Using Wells

1. Mix the carbon substrate and water per the manufactured or project-specific scoping documents in the appropriate vessel/tank or drum. Ensure mixture requirements are met and material quantities are appropriate documented.

2. Insert the pump intake hose into the bottom of the tank/vessel or connect to the bottom of the tank valve. Attach it in place so it remains fixed while pumping the mixture from the vessel into the well.

3. If pumping with pressure, connect the output hose from the pump to the connector fitting at the top of well casing. Ensure that the seal is tight and adequate for withstanding pumping pressures. Using an appropriate pump to install the injectate product is very critical to the success of pressurized injections. It is strongly recommended that a pump that has a pressure rating of at least 1,000 psi and a delivery rate of at least 3 gallons per minute be used.

4. Start pumping the injection solution. The initial volume of solution will displace the water inside the well casing and screen. Monitor the pressure gauge to evaluate injectate delivery.

5. If gravity feeding, monitor the fluid level in the well to make sure aquifer capacity is not exceeded. Slow down the drain/pump rate, as necessary, to avoid spillage. If the aquifer capacity is less than the delivery rate, it may be more effective to inject alternatively at two or more locations simultaneously.

6. If injecting under pressure, caution should be exercised to ensure excessive back flow pressure does not release injectate material on personnel, equipment or the ground. Indications of excessive pressure include pump noise or application pressure spikes (e.g., squealing), bulging hoses, etc. Pressure gauges should be continuously monitored

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during the delivery and if formation acceptance is less than delivery rate slow down the pump rate or stop pumping to allow the materials to equilibrate with the aquifer.

7. Once the appropriate quantity is delivered, disconnect the hoses and fittings from the well and record the delivered volume/mass.

8. Repeat the process at the next well.

9. Record all calculations or measurements performed in the field in the Field Logbook or on field forms.

There are various configurations for carbon substrate delivery systems and they will vary with contractors, mixing requirements of injectate material, and available equipment. A typical configuration of an injection system is provided in the schematic below.

Substrate Injection Using Pressure (Direct-Push Methods)

1. Mix the carbon substrate and water per the manufactured or project-specific scoping documents. Ensure mixture requirements are met and material quantities are appropriate documented.

2. The leading drive rod assembly should be fitted with a disposable tip as it is driven to the desired maximum injection depth.

3. A sub-assembly connecting the delivery hose to the drive rods and pump should be used. The sub-assembly should be constructed in a manner that allows for the drive rods to be withdrawn while the material is being pumped.

4. After the drive rods have been pushed to the desired depth, the rod assembly should be withdrawn six inches so that the disposable tip disconnects from the drive rods and an open borehole section is created. If an injection tool is used instead of an expendable tip, the application of material can take place without any preliminary withdrawal of the rods.

5. Fill the annular space of the drive rods with water to minimize the amount of air introduced to the aquifer.

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6. Connect the discharge hose from the pump to the drive rod assembly.

7. Insert the pump intake hose into the bottom of the tank/vessel or mixing drum. Secure the intake hose so that the inlet remains in place while pumping the mixture from the vessel.

8. Start pumping the injectate solution.

9. The initial volume of solution pumped should only be enough to displace the water within the drive rods. Once this is done the actual injection can start.

10. Withdraw the drive rods and start pumping the solution simultaneously. The injection dosage should be as specified in the project-specific planning documents and the rod withdrawal rate should be such that it allows the appropriate quantity of material to be injected into the targeted interval.

11. There may difficulty injecting in less permeable soils such as clays and silts which may require use of higher pressure and/or a stepped application approach where the rods are withdrawn in one-foot increments, the material is injected, and the process repeated over the targeted interval.

12. Look for any indications of aquifer refusal such as:

    - Excessive pump noise or pressure gauge spikes

    - Surfacing of material through injection point. If acceptance appears to be an issue it is critical that the aquifer is given enough time to equilibrate before breaking down the drive rods and/or removing the hose. The failure to do this can lead to excessive back flow of the injectate material on personnel, equipment, and the ground surface.

13. Complete the delivery of injectate solution at the designated application rate across the entire targeted vertical interval.

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14. After the injection is completed, a bentonite seal of pellets or chips should be installed above the treated interval to prevent any surface contaminants from migrating into the borehole. Sealing the borehole may require conformance with local regulations.

15. Complete the borehole at the surface as appropriate using concrete or asphalt.

16. Repeat the above steps until the entire application has been completed.

6.0 HEALTH AND SAFETY

The site-specific health and safety plan should be consulted for site-specific hazards associated with substrate injections. The CTO Manager is responsible to ensure all field personnel have read the Material Safety Data Sheets and any chemical specific hazards/handling procedures are understood before initiating any field activities so that appropriate health and safety measures are employed in advance to field work. PPE should be maintained at all times with minimum protection requirements including nitrile gloves, hearing protection, Tyvek coveralls, steel-toed boots and full face-splash shields (for personnel mixing), safety glasses, and an American National Standards Institute-standard hard hat. Additional precautionary measures may be necessary depending on the selected injectate materials.

7.0 RECORDS

At the completion of a field effort, all logbooks and field forms shall be given to the site or project manager to be maintained as part of the project file. Information to be recorded during a carbon substrate injection event should include the following, as a minimum:

- Date
- Time
- Sample Location
- Depth Interval
- Proposed Pounds/Gallons of Carbon Substrate
- Actual Pounds/Gallons of Carbon Substrate
- Gallons Water

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8.0 REFERENCES

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/-ufp_qapp_v1_0305.pdf.

9.0 ATTACHMENTS

Attachment 1 – 3D Micro-emulsion (3DMe) Installation Instructions

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Attachment 1
3-D Microemulsion (3DMe)
Installation Procedures

3-D Microemulsion (3DMe)™

INSTALLATION INSTRUCTIONS

High-Volume, Wide-Area, Micro-Emulsion Application

Introduction

3-D Microemulsion (3DMe)™, a form of HRC Advanced®, should ONLY be applied as a high-volume, micro-emulsion. In this form it offers greater physical distribution of the 3DMe material across a larger potential radius from a single injection point. The production of a 3DMe emulsion involves the on-site, volumetric mixing of 10 parts water with 1 part delivered 3DMe concentrate to form the injection-ready 3DMe micro-emulsion. This micro-emulsion suspension can then be injected directly or further diluted to a predetermined ratio of 3DMe to water. The following instructions provide details in the production and installation of the 3DMe micro-emulsion.

Material Overview Handling and Safety

3DMe concentrate is shipped and delivered in 4.25-gallon buckets. Each bucket has a gross weight of approximately 32 pounds. Each bucket contains 30 pounds of 3DMe concentrate (net weight) and a nominal volume of 3.7 gallons. At room temperature, 3DMe concentrate is a liquid material with a viscosity of approximately 500 centipoise, roughly the equivalent of pancake syrup. The viscosity of 3DMe is not temperature sensitive above 50 ºF (10 ºC). However, below 50 ºF the viscosity may increase significantly. If the user plans to apply the product in cold weather, consideration should be given to heating the material to above 60 ºF so that it can be easily handled. 3DMe concentrate should be stored in a warm, dry place that is protected from direct sunlight. It is common for stored 3DMe concentrate to settle somewhat in the bucket, a quick pre-mix stir by a hand held drill with a paint or "jiffy mixer" attachment will rapidly re-homogenize the material. 3DMe concentrate is non-toxic, however field personnel should take precautions while handling and applying the material. Field personnel should use appropriate personal protection equipment (PPE) including eye protection. Gloves should be used as appropriate based on the exposure duration and field conditions. A Material Safety Data Sheet is provided with each shipment. Personnel who operate field equipment during the installation process should have appropriate training, supervision, and experience and should review the MSDS prior to site operations.

Micro-Emulsion Production 3DMe to Water Ratio

3DMe concentrate should be mixed with water on a volume to volume (v/v) basis to produce a micro-emulsion starting at 10 parts water: 1 part 3DMe. Although micro-emulsions can be easily produced using greater water volumes than 10 parts, e.g. 20 to 50 parts water to 1 part 3DMe, the initial micro-emulsion should never be produced below a ratio of less than 10 parts water: 1 part 3DMe v/v. **WARNING: Do not attempt to produce a micro-emulsion at less than 10 parts water to 1 part 3DMe ratio v/v. This will produce an undesirable and unstable solution.**

The field production of 3DMe micro-emulsion is a very simple procedure; however, it is critical that the user follow the mixing directions outlined below. Never attempt to add water to the 3DMe as this will produce an undesirable and unstable large emulsion. Always add the 3DMe to a large volume of water.

As indicated previously the 10:1 ratio of water to 3DMe v/v is the minimum water ratio that can be used, a greater ratio (more dilute solution) can easily be achieved and is governed by: A) the volume of 3DMe required to treat the estimated contaminant mass, B) the pore volume in which the material is applied, C) the time available for installation (gallons/pump rate), and C) the estimated volume of 3DMe micro-emulsion that the target zone will accept over the time period allocated for installation.

Conceptually, although a higher volume of water to volume of 3DMe will produce a larger volume of the suspension, it will lower the concentration of 3DMe per gallon of solution. Thus, the benefit of using a high water/3DMe v/v ratio in order to affect a greater pore volume of the subsurface aquifer is offset by the dilution of the 3DMe per unit volume of suspension as well as by the limitations of the subsurface hydraulic conductivity and effective porosity (capacity of the aquifer to accept the volume of 3DMe micro-emulsion).

It is important that the user plan in advance the v/v 3DMe/water ratio to be employed at a project site. The resulting volume of solution will dictate the site water requirements and the time required for injection, etc. If upon injection of greater than 10:1 3DMe micro-emulsion, the subsurface does not readily accept the volume of solution as designed, the user can adjust downward the v/v water to 3DMe ratio until a more concentrated suspension is produced (this solution should never drop below the required 10 parts water:1 part 3DMe v/v production ratio). For more information on designing a 3DMe/water ratios to meet specific site conditions, please contact Regenesis Technical Services.

Direct Push Application Requirements

One of the best methods to deliver the 3DMe micro-emulsion into the subsurface is to pressure inject the solution through direct-push rods using hydraulic equipment, or to pressure inject/gravity feed the micro-emulsion into the dedicated injection wells. The use of low cost push points or temporary injection points allows the applier to more cost effectively distribute the 3DMe material across shallow sites by employing multiple points per site. In the case of treating deep aquifer sites, the use of the micro-emulsion applied via dedicated injection wells is likely to be the most cost effective remediation approach. Please note that this set of instructions

is specific to direct-push equipment. Please contact Regenesis Technical Services to assist you with dedicated injection well applications.

In general, Regenesis strongly recommends application of the 3DMe micro-emulsion using an injection pump with a minimum delivery rate of three gallons per minute (gpm) and a pressure rating of between 150 to 200 pounds per square inch (psi). **Note: the injection pump requirements are different than the requirements of the mixing pump (see Mixing to Generate 3DMe Micro-emulsion).** High pressure, positive displacement pumps and progressive cavity pumps are appropriate for injecting 3DMe. For low permeability lithologies (clay, silt) higher pressure pumps (800-1600 psi) may be necessary, while for more permeable lithologies (gravel, sand) a lower pressure pump may be adequate. Examples of appropriate pumps are: Rupe Models 6-2200, 9-1500 and 9-1600 (positive displacement), Geoprobe® GS-2000 (positive displacement) and DP-800 (progressive cavity), Yamada (air diaphragm), Moyno (progressive cavity), and Wilden (air diaphragm). Delivery rate is a critical factor in managing installation time and costs. Generally, higher delivery rates (>6 gpm) are more cost effective for these types of applications but pump selection should be on a site specific basis and account for the volume of 3DMe solution and specific aquifer conditions present at the site.

The installation of the 3DMe micro-emulsion should span the entire vertical contaminated saturated thickness. If the vertical extent of the application is confined to a limited interval, then the micro-emulsion should be placed across a vertical zone extending a minimum of one-foot above and one-foot below the screened interval of monitoring wells that are being used to evaluate the performance of the project.

Producing the 3DMe Micro-Emulsion

The application of 3DMe requires the creation of a micro-emulsion. Technically the optimal suspension is an 3DMe-in-water suspension containing micro-emulsions. Before beginning the mixing procedure the user should have in mind the desired water to 3DMe ratio v/v desired.

It is critical that the micro-emulsion be produced using a high-shear apparatus such as a high speed centrifugal pump. The shearing provided by the vanes in these types of pumps is sufficient to form and maintain a homogeneous milky emulsion. **This pump will be a different pump than that used to inject the 3DMe micro-emulsion into the subsurface.** If the user is uncertain as to requirements for the pump or the applicability of a certain pump, please contact Regenesis Technical Services. Regenesis typically suggests using a water trailer/pump apparatus commonly found at equipment rental facilities. Regenesis recommends using a Magnum Products LLC model MWT500 or equivalent water trailer (fitted with centrifugal recirculation pump). This “trash pump” or transfer pump is an ideal high shear pump and the water tank (400 gallons) serves as an excellent mixing tank.

To ensure that proper micro-emulsion suspension is generated Regenesis suggests a two-step process that simply requires mixing at least 10 parts water to 1 part 3DMe concentrate using water at a temperature $\geq 60^{o}$F.

Step 1) Regenesis recommends that the 3DMe concentrate in each bucket be re-homogenized using a drill equipped with a paint or "jiffy" mixer attachment as minor settling may have occurred during shipment.

Step 2) to calculate the volume of water necessary to produce a 10:1 v/v micro-emulsion, each bucket of 3DMe concentrate containing 3.7 gallons of material should be mixed with 37 gallons of water.

Example: 6 buckets x 3.7 gallons 3DMe concentrate/bucket yields a total of 22.2 gallons of 3DMe concentrate. Thus, a 10:1 v/v solution will require 222 gallons of water (22.2 gallons 3DMe concentrate x 10 gallons water yields 222 gallons of water). A nominal total volume micro-emulsion would result from the summation of the 3DMe concentrate volume (22.2 gallons) and the water volume (222 gallons). This yields a total fluids delivery volume of approximately 244 gallons.

The previously calculated water volume (222 gallons) should be transferred into an appropriately sized mixing tank. The water should be circulated by the high shear centrifugal pump and each of the six 3DMe buckets slowly poured into the tank. Each bucket of 3DMe concentrate should be poured at a slow rate (approx. 1 minute per bucket) and the contents of the tank continually recirculated using the high hear centrifugal pump. A period of 1-2 minutes should be allowed between addition of each subsequent bucket of 3DMe concentrate to allow the centrifugal pump to continue to shear and mix the water/3DMe concentrate. Upon addition of the entire volume of 3DMe concentrate the pump should remain on to allow the solution mixture to recirulate. The recirculation of the 3DMe micro-emulsion should continue until the material is injected to maintain micro-emulsion consistency.

Application of Micro-Emulsion Using Direct-Push Methods

1) Prior to the installation of the micro-emulsion, any surface or overhead impediments should be identified as well as the location of all underground structures. Underground structures include but are not limited to: utility lines, tanks, distribution piping, sewers, drains, and landscape irrigation systems.

2) The planned installation locations should be adjusted to account for all impediments and obstacles.

3) Pre-mark the installation locations, noting any points that may have different vertical application requirements or total depth.

4) Set up the direct-push unit over each specific point and follow the manufacturer's standard operating procedures (SOP). Care should be taken to assure that probe holes remain vertical.

5) For most applications, Regenesis suggests using drive rods with an O.D. of at least 1.25-inches and an I.D. of at least 0.625-inches I.D (Geoprobe or equivalent). However, the lithologic conditions at some sites may warrant the use of larger 2.125-inch O.D./1.5-inch I.D. drive rods.

6) The most typical type of sub-assembly currently being used is designed for 1.25-inch direct-push rods and is manufactured by Geoprobe. Other brands of drive rods can also be used but require the fabrication of a sub-assembly that allows for a connection between the pump and drive rod.

7) For mixing large volumes of the micro-emulsion, Regenesis recommends using a Magnum Products LLC model MWT500 water trailer (fitted with centrifugal recirculation pump) or equivalent unit. However, single large volume poly tanks are adequate. We suggest filling the tank with an appropriate quantity (e.g. from the example above 222 gallons) of water before start of mixing operations. The tank should be configured so that both a hose and a fire hydrant or larger water tank can be connected to it simultaneously and filled with water quickly and easily. This will dramatically reduce the time needed to fill the tank with mixing water.

8) Regenesis highly recommends preparing the micro-emulsion before pushing any drive rods into the subsurface. NOTE: it is best if the micro-emulsion is produced a single day application volumes.

9) After the micro-emulsion mixing/shearing step has been completed as described above, the micro-emulsion is ready to be applied. Check to see if a hose has already been attached to the inlet side of the centrifugal pump. If this has not been done, do so now.

10) If a non-water trailer tank is being used for mixing the micro-emulsion a stand alone centrifugal pump and hose system should be used for the shearing and mixing operations.

11) Advance drive rods through the ground surface, as necessary, following SOP.

12) Push the drive rod assembly with an expendable tip to the desired maximum depth. Regenesis suggests pre-counting the number of drive rods needed to reach depth prior to starting injection activities to avoid any miscalculations.

13) After the drive rods have been pushed to the desired depth, the rod assembly should be withdrawn three to six inches. The expendable tip can be dropped from the drive rods, following SOP.

14) If an injection tool is used instead of a direct-push rod with an expendable tip, the application of material can take place without any preliminary withdrawal of the rods.

15) In some cases, introduction of a large column of air may be problematic. This is particularly the case in deep injections (>50 ft) with large diameter rods (>1.5-inch O.D.). To prevent the injection of air into the aquifer during the application, fill the drive rods with 3DMe emulsion after they have been pushed to the desired depth and before the disposable tip has been dropped or before the injection tip is operational.

16) Transfer the appropriate quantity of the micro-emulsion from the water trailer to the working/application pump hopper or associated holding tank.

17) A volume check should be performed prior to the injection of the micro-emulsion. Determining the volume discharged per unit time/stroke using a graduated bucket and stopwatch or stroke counter.

18) Start the pump and use the graduated bucket to determine how many gallons of micro-emulsion are delivered each minute or stroke per unit volume.

19) Connect the 1.25-inch O.D., 1-inch I.D. delivery hose to the pump outlet and the appropriate sub-assembly. Circulate the micro-emulsion through the hose and the sub-assembly to displace any air present in the system.

20) Connect the sub-assembly to the drive rod. After confirming that all of the connections are secure, pump the micro-emulsion through the delivery system to displace any water or other fluids in the rods.

21) The pump engine RPM and hydraulic settings should remain constant throughout the day to maintain a constant discharge rate.

22) The material is now ready to be installed in the subsurface. Use the pumps discharge rate as calculated in step 18 to determine the withdrawal rate of the drive rods needed for the application.

23) Slowly withdraw the drive rods using Geoprobe Rod Grip or Pull Plate Assembly (Part AT1222-For 1.25-inch drive rods). While slowly withdrawing single lengths of drive rod (three or four feet), pump the pre-determined volume of micro-emulsion into the aquifer across the desired treatment interval.

24) Remove one or two sections of the drive rod at a time. The drive rod may contain some residual material so Regenesis suggests placing it in a clean, empty bucket and allowing the material to drain. Eventually, the material recovered in the bucket should be returned to the pump hopper for reuse.

25) Observe any indications of aquifer refusal such as “surfacing” around the injection rods or previously installed injection points. If aquifer acceptance appears to be low, allow enough time for the aquifer to equilibrate prior to removing the drive rod.

26) Repeat steps 19 through 25 until treatment of the entire contaminated vertical zone has been achieved.

27) Install an appropriate seal, such as bentonite, above the micro-emulsion injection zone. The seal should span across the entire vadose zone. Depending on soil conditions and local regulations, a bentonite seal using chips or pellets can be used. If the injection hole remains open more than three or four feet below the ground surface sand can be used to fill the hole and provide a base for the bentonite seal. The installation of an appropriate seal assures that

the micro-emulsion remains properly placed and prevents contaminant migration from the surface. If the micro-emulsion continues to "surface" up the direct-push borehole, an oversized disposable drive tip or wood plug/stake can be used to temporarily plug the hole until the aquifer equilibrates and the material stops surfacing.

28) Remove and clean the drive rods as necessary.

29) Finish the borehole at the surface as appropriate (concrete or asphalt cap, if necessary).

30) Periodically compare the pre- and post-injection discharge rates of the micro-emulsion in the pump hopper or holding tank using any pre-marked volume levels. If volume level indicators are not on the pumps hopper or holding tank use a pre-marked dipstick or alternatively temporary mark the hopper or holding tank with known quantities/volumes of water using a carpenter's grease pencil (Kiel crayon).

31) Move to the next probe point, repeating steps 11 through 29.

Helpful Hints

1) *Application in Cold Weather Settings*

As discussed in the Material Overview, Handling, and Safety section, cold weather tends to increase the viscosity of 3DMe as well as decrease the ease of micro-emulsion formation. To optimize an application in cold weather settings Regenesis recommends maintaining the 3DMe concentrate and the associated water at a temperature ≥60°F (16°C). The following procedures can be used to facilitate the production and installation of a 10:1 v/v 3DMe micro-emulsion.

- Raise and maintain the temperature of the HRC-A to at least 60°F (16°C) prior to mixing with water. A hot water bath can be used to heat up the 3DMe concentrate buckets. A Rubbermaid fiberglass Farm Trough Stock Tank (Model 4242-00-GRAY) has been used for this process. This trough can hold up to 16 buckets of 3DMe concentrate.
- Hot water (approximately 130-170°F or 54-77°C) should be added to the tank after the buckets of 3DMe have been placed inside. The hot water should be delivered from a heated pressure washer (Hotsy® Model No. 444 or equivalent) or steam cleaner unit.
- It is equally critical that a moderate water temperature (>60°F or 16°C) be used in the production of the micro-emulsion. If on-site water supply is below 60°F use a hot water or steam cleaner to generate a small volume (e.g. 5-10% of total water volume) of hot water (130–170°F/54-77°C). This small volume of hot water should be added to remaining cold water volume to raise the total volume temperature to >60°F. When the 3DMe concentrate and water each reach a minimum temperature of 60°F or 16°C the two materials are ready for mixing.
- Upon achieving a minimum temperature of 60°F or 16°C (approximately 10-20 minutes). When the 3DMe and the associated water volumes have reached a minimum temperature of 60°F or 16°C (approximately 10-20 minutes) they are ready for mixing.
- In exceptionally harsh winter temperature settings use of a separate insulated pump containment structure and insulated delivery hoses may be necessary.

- Use a pump with a heater unit.
- Periodically check the temperature of the material in the hopper.
- Re-circulate the 3DMe micro-emulsion through the pump and hose to maintain temperature adequate temperatures.
- Care should be taken to avoid the re-circulation of material volumes that exceed the volume of the pump hopper or holding tank.

Table 1: Equipment Volume and 3DMe Micro-Emulsion Weight per Unit Length of Hose (Feet)

Equipment	Volume	Product Weight
1-inch OD; 0.625-inch ID hose (10 feet)	0.2 gallon	1.6 lbs.
1.25-inch OD; 0.625-inch ID drive rod (3 feet):	0.05 gallon	0.4 lbs.
1.25-inch OD; 0.625-inch ID drive rod (4 feet):	0.06 gallon	0.5 lbs.

2) Pump Cleaning

For best results, use a heated pressure washer to clean equipment and rods periodically throughout the day. Internal pump mechanisms and hoses can be easily cleaned by re-circulating a solution of hot water and a biodegradable cleaner such as Simple Green through the pump and delivery hose. Further cleaning and decontamination (if necessary due to subsurface conditions) should be performed according to the equipment supplier's standard procedures and local regulatory requirements.

NOTE:

Before using the Rupe Pump, check the following:

- Fuel level prior to engaging in pumping activities (it would be best to start with a full tank)
- Remote control/pump stroke counter LCD display [if no display is present, the electronic counter will need to be replaced (Grainger Stock No. 2A540)]

Monitor pump strokes by observing the proximity switches (these are located on the top of the piston).

3) *Bedrock Applications*

When contaminants are present in competent bedrock aquifers, the use of direct-push technology as a delivery method is not possible. *Regenesis is in the process of developing methods for applying 3DMe via boreholes drilled using conventional rotary techniques.* To develop the best installation strategy for a particular bedrock site, it is critical that our customers call the Technical Services department at Regenesis early in the design process.

The micro-emulsion can be applied into a bedrock aquifer in cased and uncased boreholes. The micro-emulsion can be delivered by simply filling the borehole without pressure or by using a

single or straddle packer system to inject the material under pressure. Selection of the appropriate delivery method is predicated on site-specific conditions. The following issues should be considered in developing a delivery strategy:

- Is the aquifer's hydraulic conductivity controlled by fractures?
- Backfilling may be the better delivery method in massive, unfractured bedrock. This is particularly true in an aquifer setting with high permeability and little fracturing (such as that found in massive sandstone).
- Down-hole packer systems may be more advantageous in fractured bedrock aquifers.
    - In this case the fracture type, trends, and interconnections should be evaluated and identified.
- Are the injection wells and monitoring wells connected by the same fractures?
- Determine if it is likely that the injection zone is connected to the proposed monitoring points.
- If pressure injection via straddle packers is desired, consideration should be given to the well construction. Specific issues to be considered are:
    - Diameter of the uncased borehole (*will casing diameter allow a packer system to be used under high pressures*?).
    - Diameter of the casing (*same as above*).
    - Strength of the casing (*can it withstand the delivery pressures?*).
    - Length of screened interval (*screened intervals greater than 10 feet will require a straddle packer system*).

For further assistance or questions please contact Regenesis Technical Services at 949-366-8000.

3-D MicroEmulsion™
HRC ADVANCED®

Standard Operating Procedure SOP-SM-9

Bubble Strip

Microseeps, Inc.

Gas Stripping Cell Instructions

Technical Guidance from Microseeps

Sampling Questions?

Call 800-659-2887 Mon. - Fri. 9 -5 EST

Installation and Operation

To place the gas stripping cell into service:

1. Remove one of the cell assemblies from the packing carton. Refer to Figure 1 (following pages) to become familiar with the parts of the cell.

2. Connect the inlet tube of the cell to the outlet of your pump. The inlet tube is designed to connect to ¼ inch O.D. hard tubing. Secure the connection (nylon wire ties are recommended).

3. Insert the drain tube of the cell into a waste container, keeping the end of the tube at the bottom of the container. Any waste container of suitable size may be used. A 2-liter soda pop bottle may be placed in the waste container to determine pumping flow rate.

4. Secure the cell assembly so that the housing cover is above the glass housing (*i.e.* upright). A ring stand and clamp are recommended for this purpose.

5. Turn the pump on and check for leaks. If any leaks are found seal them before proceeding. Measure, in ml per minute, the flow rate of the pump. If a 2-liter soda pop bottle was used, the flow rate can be determined by measuring how many minutes it takes to fill the bottle, then substituting the measured time into the following equation.

Flow = 2000 ml/time to fill in minutes

Consult table to determine the equilibrium time needed to gas strip at this flow rate.

Flow rate (ml/min)	Sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

NOTE: Use a flow rate between 100 ml/min and 350 ml/min. Do not turn off the pump.

6. Unclamp the cell assembly, invert it and re-secure the assembly in the inverted position. Make sure the drain tube is still in the waste container and the end of the drain tube is near the bottom of the bottle.

7. Connect the (supplied) stopcock to the syringe and the (supplied) needle to the stopcock. Place the stopcock in the open position (*i.e.* so that the stopcock handle is in-line with the syringe). Draw the plunger back on the syringe to the 20.0-mL mark. Keeping the cell in the inverted position, insert the needle into the needle guide. Pierce the septum and inject the air into the cell. Then remove the needle and syringe from the assembly and carefully cover the needle. Do not discard the syringe apparatus.

8. Start timing and let the ground water pump through the cell for the time specified in Table 1 for your particular pumping speed. Meanwhile, be sure that the sample vial is properly labeled and that the flow rate and any other relevant field data are recorded in the field log.

   NOTE: Be sure to keep the end of the drain tube at the bottom of the waste container. This will insure that outside air is not drawn into the cell. Failure to do this will invalidate the sample.

9. When the equilibration time is up, turn off the pump, unclamp the cell and re-clamp it in its upright position. Verify that the plunger of the syringe is pushed all the way in and that the stopcock is in the open position, then insert the needle into the needle guide and pierce the septum. Withdraw 1-mL of gas by pulling back on the syringe plunger while holding the syringe body in place, remove the syringe from the cell and expel the sample. Immediately re-insert the needle into the needle guide and pierce the septum. Withdraw a 15-mL sample of gas and, with the needle still through the septum, close the stopcock. Rapidly withdraw the needle from the septum and place it through septum on the sample vial (see Figure 2, next page). Open the stopcock and completely depress the syringe barrel. With the syringe barrel completely depressed, separate the sample vial and the syringe with a quick pull. Discard the syringe apparatus according to Local, State and Federal regulations.

Gas Stripping Cell Instructions

Technical Guidance from Microseeps

Sampling Questions?

Call 800-659-2887 Mon. - Fri. 9 -5 EST

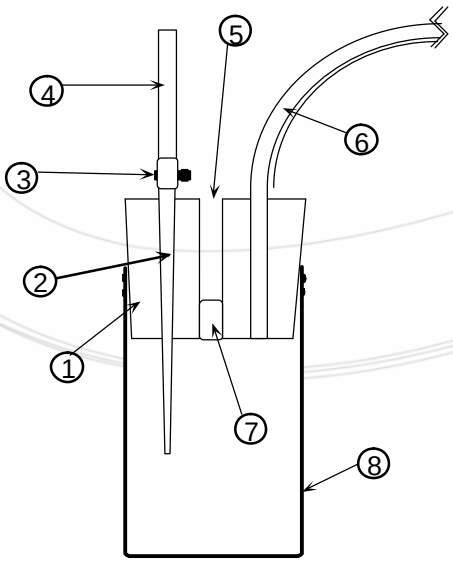
Decontamination/Cleaning

Pump at least 1 liter of potable water through the cell. The cell assembly is now ready for re-use.

The only expendable part of the cell is the sampling septum (part 7). Normally, each septum may be used for the collection of 5-10 samples. If bubbles are seen rising up from the septum when the cell is inverted the septum MUST be replaced.

Figure 1.
Cross section of Microseeps Gas Stripping Cell

1. Housing Cover
2. Jet Spray Nozzle
3. Nylon Tie
4. Inlet Tube
5. Needle Guide Port
6. Drain Tube
7. Replaceable Septum
8. Glass Housing



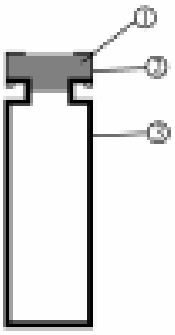


Figure 2.
Cross section of septum bottle

1. Septum
2. Metal Closure
3. Glass vial

Replacing the Sampling Port Septum

All part numbers refer to Figure 1.

1. Remove the housing cover (part 1) from the glass housing (part 8).

2. Use a handy, blunt tipped object to push the replaceable septum (part 7) out of the housing cover. The cover to a needle works well for this purpose, but be sure that the needle is NOT in the cover. Discard the old septum.

3. Take a new septum and wet both the new septum and the housing cover with potable water.

4. Carefully using the same blunt instrument used in step three above, slide the new septum into the hole from which the old septum was removed. The bottom of the new septum must be flush with the narrow end of the housing cover.

5. If the housing cover is not still wet, wet it again with potable water. Place the bottom end of the housing cover into the glass housing and push it in until less than 3/8" are above the rim of the glass housing. This may require some force.

6. Follow the cleaning procedures described above to prepare the cell for a return to service.

Microseeps Gas Stripping Cell Instructions

Back to Microseeps Homepage

Choosing Sampling Pumps for Hydrogen from Deep Wells

INSTALLATION AND OPERATION

To place the gas stripping cell into service:

1. Remove one of the cell assemblies from the packing carton. See Figure 1.

Image 1.

2. **Image 1.** Connect the inlet tube of the cell to the outlet of your pump. The inlet tube is designed to connect to 1/4 O.D. hard tubing. Secure the connection using binder clips or cable ties.

3. Insert the drain tube of the cell into a waste container, keeping the end of the tube at the bottom of the container. Any waste container of suitable size may be used. A 2-Liter soda pop bottle may be placed in the waste container to determine pumping flow rate.

Back to step 11

4. Secure the cell assembly so that the housing cover (stopper) is above the glass housing (i.e. upright). A ring stand and clamp are recommended for this purpose.

5. Turn the pump on and check for leaks. If any leaks are found, seal them before proceeding.

Image 2.

6. **Image 2.** Measure, in mL per minute, the flow rate of the pump. If a 2-Liter soda pop bottle is used, the flow rate can be determined by measuring how many minutes it takes to fill the bottle and substituting the measured time into the following equation:

Flow = 2000 mL/Time to fill (in minutes)

Consult Table 1 to determine the equilibrium time needed to bubble strip at this flow rate.

Note: Use a flow rate between 100 mL/min. and 500 mL/min. **Do not turn off the pump.**

Table 1.

Flow rate (ml/min)	Sampling time (min)
100-120	30
130-150	25
160-200	20
210-300	15
>300	10

Return to Step 6

Return to Step 10

Image 3.

7. **Image 3.** Unclamp the cell assembly, invert it, and re-secure the assembly in the inverted position. Make sure the drain tube is still in the waste container and the end of the drain tube is near the bottom of the bottle.

Image 4.

8. **Image 4.** Connect the stopcock to the syringe and the needle to the stopcock (zoom in on image). Place the stopcock in the open position (so that the stopcock handle is in-line with the syringe). Draw the plunger back on the syringe to the 20.0 mL mark pulling ambient air into the syringe.

Image 5.

9. **Image 5.** Keeping the cell in the inverted position, insert the needle into the needle guide. Pierce the septum and inject the air into the cell creating the bubble. Withdraw the needle from the assembly and carefully place the needle into the cover. Do not discard the syringe apparatus.

10. Start timing and let the groundwater pump through the cell for time specified in Table 1 for your particular pumping speed. Meanwhile, be sure that the sample vial is properly labeled and that the flow rate and any other relevant field data are recorded in the field log.

Note: Be sure to keep the end of the drain tube at the bottom of the waste container. This will insure that outside air is not drawn into the cell. **Failure to do this will invalidate the sample.**

11. When equilibration time is up, **turn off the pump,** unclamp the cell, and re-clamp it in its upright position. See Image 1. Verify that the plunger of the syringe is pushed all the way in and that the stopcock is in the open position.

Image 6.

12. **Image 6.** Insert the needle into the needle guide and pierce the septum. Withdraw 1 mL of gas by pulling back on the syringe plunger while holding the syringe body in place. Remove the syringe from the cell and expel the sample.

13. Immediately re-insert the needle into the needle guide and pierce the septum. Withdraw a 15 mL sample of gas (being careful not to pull any water into the syringe). With the needle still through the septum, close the stopcock and withdraw the needle from the septum.

Image 7.

14. **Image 7.** Immediately insert the needle through the septum on the sample vial. Keeping the syringe and vial "in line", open the stopcock and completely depress the syringe plunger injecting the entire sample into the vial.

Image 8.

15. **Image 8.** Keeping the plunger depressed, quickly remove the vial from the needle. Your sample is now ready to be packaged and shipped back to Microseeps for analysis. Do not cool the samples.

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Decontamination/Cleaning

Pump at least 1 liter of potable water through the cell. The cell assembly is now ready for re-use.

The only expendable part of the cell is the sampling septum (part 7). Normally, each septum may be used for the collection of up to 5 samples. If bubbles are seen rising up from the septum when the cell is inverted the septum MUST be replaced. Instructions for replacing the septum are provided below.

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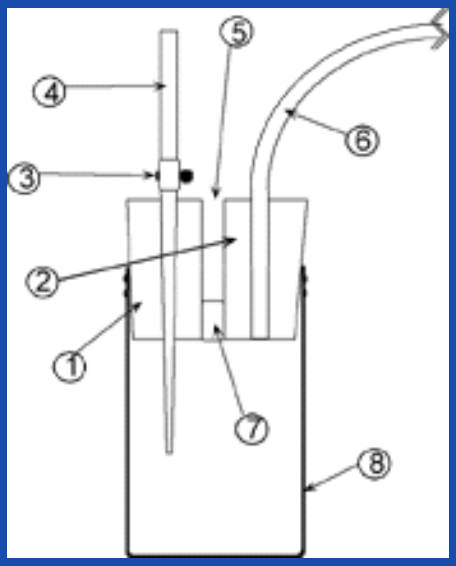
Figure 1. Cross section of Microseeps Gas Stripping Cell



1. Housing Cover

2. Jet Spray Nozzle

3. Nylon Tie

4. Inlet Tube

5. Needle Guide Port

6. Drain Tube

7. Replaceable Septum

8. Glass Housing

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Replacing the Sampling Port Septum

All part numbers refer to Figure 1.

1. Remove the housing cover (part 1) from the glass housing (part 8).

2. Use a handy, blunt tipped object to push the replaceable septum (part 7) out of the housing cover. The cover to a needle works well for this purpose, but be sure that the needle is **NOT** in the cover. Discard the old septum.

4. Take a new septum and wet both the new septum and the housing cover with potable water.

5. Carefully using the same blunt instrument used in step three above, slide the new septum into the hole from which the old septum was removed. The bottom of the new septum must be flush with the narrow end of the housing cover.

6. If the housing cover is not still wet, wet it again with potable water. Place the bottom end of the housing cover into the glass housing and push it in until less than 3/8" are above the rim of the glass housing. This may require some force.

7. Follow the cleaning procedures described above to prepare the cell for a return to service.

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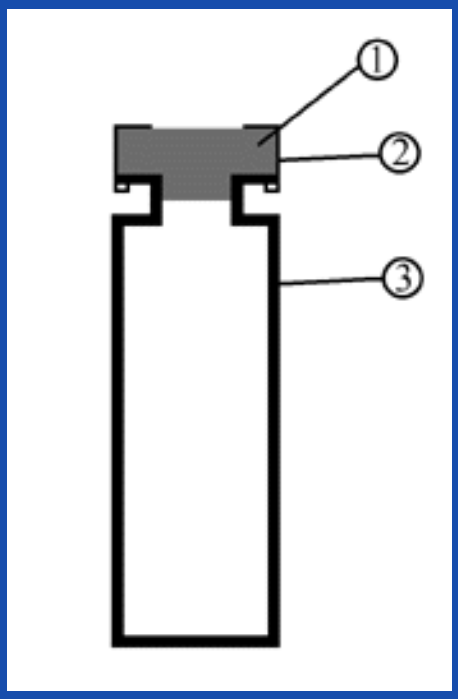


Figure 2. Cross section of septum bottle

1. Septum

2. Metal Closure

3. Glass vial

SAMPLING QUESTIONS?

CALL MICROSEEPS AT **1-412-826-5245**

MON.- FRI. 7:30 AM TO 6 PM EST

Back to Microseeps Homepage

Appendix C
Field Forms

ENSAFE

LOCATION OF BORING	JOB NO.	CLIENT	LOCATION

DRILLING METHOD:	BORING NO.
	SHEET OF
SAMPLING METHOD:	DRILLING
	START / FINISH
WATER LEVEL	TIME / TIME
TIME	
DATE	DATE / DATE
CASING DEPTH	

DATUM ELEVATION

SURFACE CONDITIONS:

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	DEPTH OF CASING	SAMPLE NO. / SAMPLE DEPTH	BLOWS/FT SAMPLER	VAPOR CONCENTRATIONS (PPM)	DEPTH IN FEET	SOIL GRAPH
						0	
						1	
						2	
						3	
						4	
						5	
						6	
						7	
						8	
						9	
						0	
						1	
						2	
						3	
						4	
						5	
						6	
						7	
						8	
						9	
						0	

DRILLING CONTR. _____

BY _____ DATE _____ CHK'D BY _____

Field Instrument Calibration Form

Calibrated by: _____ **Equipment (Make/Model/Serial#):** _____

Date: _____ **Equipment (Make/Model/Serial#):** _____

pH (su) — Standard: ± 0.2 standard units

Initial Calibration / Initial Calibration Verification

	Hach SL	Reading	Pine SL	Reading
pH7				
pH4				

Continuing Calibration Verification

	Hach SL	Reading	Deviation	Acceptable Variance (Y/N)
pH7				
pH4				

DO (mg/L) — Standard: ± 0.3 mg/L of theoretical*

IC (Temp:) / ICV (Temp:)

Saturation (%)	Reading (%)	Theoretical (mg/L)	Reading (mg/L)
100			

CCV (Temp:)

Saturation (%)	Reading (%)	Deviation	Acceptable Variance (Y/N)
100			

Theoretical (mg/L)	Reading (mg/L)	Deviation	Acceptable Variance (Y/N)

ORP (mV) — Standard: NA

IC (Zobell SL:) / ICV (Pine SL:)

TCS (Std/Temp)	Reading	TCS (Std/Temp)	Reading

CCV (Zobell SL:)

TCS (Std/Temp)	Reading	Deviation	Acceptable Variance (Y/N)

Turbidity (ntu) — Standard: ±10% of Standard

Initial Calibration

Standard	Reading

Continuing Calibration Verification

Standard	Reading	Deviation	Acceptable Variance (Y/N)

Conductivity (ms^C/cm) — Standard: ± 5% of standard value

IC (YSI SL:) / ICV (Pine SL:)

Standard	Reading	Standard	Reading

CCV (YSI SL:)

Standard	Reading	Deviation	Acceptable Variance (Y/N)

Comments:

_____

_____

_____

_____

Notes:

SL	solution lot	su	standard units	ntu	Nephelometric Turbidity Units
TCS	temperature corrected standard	mV	millivolts	°C	degrees Celsius
Std	standard	%	percent	ms^C/cm	millisiemens per centimeter (temperature corrected)
Temp	temperature	mg/L	milligrams per liter	*	Theoretical value listed on Table FT 1500-1 (attached)

ENSAFE

WELL DEVELOPMENT & GROUNDWATER SAMPLING FORM

DATE:	JOB NUMBER:	EQUIPMENT (Make/Model #/Serial #):
PROJECT:	EVENT:	/ /
WELL ID:	LOCATION:	/ /
WEATHER CONDITIONS:	AMBIENT TEMP:	/ /
REVIEWED BY:	PERSONNEL:	/ /

WELL DIA:	WELL DEVELOPMENT	
TOTAL DEPTH from TOC (ft.):	START:	FINISH:
DEPTH TO WATER from TOC (ft.):	VOLUME PURGED (gal):	
LENGTH OF WATER COL. (ft.):	GROUNDWATER SAMPLING	
1 VOLUME OF WATER (gal):	START:	FINISH:
3 VOLUMES OF WATER (gal):	VOLUME PURGED (gal):	
	ANALYSIS:	

WELL DEVELOPMENT PARAMETERS		GW SAMPLING PARAMETERS	
Temperature:	± 1.0° C	Temperature:	± 0.2° C
pH:	± 0.5 standard units	pH:	± 0.2 standard units
Specific Conductance:	± 10% of the past measurement	Specific Conductance:	± 5% of the past measurement
Turbidity:	relatively stable	DO:	≤ 20% saturation
		ORP:	± 10 millivolts
		Turbidity:	≤ 10 NTU

IN-SITU TESTING

Circle one: DEVELOPMENT SAMPLING ☐ Bailer ☐ Pump Description:

Time (hh:mm):												
pH (units):												
Conductivity (mS/cm):												
Turbidity (NTU):												
DO (mg/L): YSI 556												
DO (mg/L): YSI 550												
Temperature (C°):												
ORP (mV):												
Volume Purged (gal):												
Depth to Water (ft):												
								Well Goes Dry While Purging ☐				

SAMPLE DATA

☐ Bailer ☐ Pump Description:

Sample ID	Date (m/d/y)	Time (hh:mm)	Bottles (total to lab)	Filtered (0.45 μm)	Remarks

Purging/Sampling Device Decon Process:

COMMENTS:

Purge water placed in drum#_____

NAVSUPPACT MID-SOUTH BUILDING
CAC ACCESS / ISSUE APPLICATION

From: Robert Morrison
To: Email to MILL_BADGE@NAVY.MIL
Subj: Request for Identification Badge, and access to restricted spaces

APPLICANT INFORMATION

Name (Last, First, Middle Initial)	Gender	Citizenship	SSN:
Command/Dep. NAVFAC/PWD MIDSOUTH	Title:		Date of Birth:
Race:	State Drivers License#:		

Height:	Weight:	Hair Color:	Eye Color:	Work Phone:

Company Name: (Contractors):	Contract Exp Date:	Contract Number:

COMMAND ACCESS REQUEST

☒ New Access	☐ Access Modification	☐ Non-CAC Contractor

REASON FOR BADGE ISSUANCE

☒ Initial Issue	☐ Renewal	☐ Replacement

EXTERNAL BUILDING ACCESS:

External Building(s), Days, and Time for access(EX: 455, Mon-Fri, 0600-1800)
Building 455, Mon. – Fri, 0600 - 2400

RESTRICTED SPACE(s) ACCESS REQUIRED:

Building(s), Room Number, Days, Time for access(EX: 769, Room 188, 24 X 7)

ONLY COMMAND APPOINTED AUTHORIZED PERSONNEL CAN SIGN REQUEST

Authorizing Official: (Last Name, First and Middle Initial)	Telephone Number:
Authorizing Official Signature: (N/A when emailed, verified by email from authorizing official)	Date:

Privacy Act Statement

AUTHORITY: 5 U.S.C. 301; EO 12356; EO 9397
PRINCIPAL PURPOSE: To facilitate verification of a personnel security clearance for an individual applying for building access in connection with their livelihood or official duties.
ROUTINE USES; Information may be furnished to Federal, state, or local agencies for regulatory and law enforcement purposes.
DISCLOSURE: Voluntary; however, refusal to furnish requested information may result in inability to verify essential personal information and approve requested building pass application.

RESOLUTION CONSULTANTS

CHAIN OF CUSTODY AND ANALYTICAL REQUEST RECORD

COC No.	Page of
PO No.	Project No. Phase

Project Name:

Site Location:

CTO No. RC Task Order Manager:

Sampler/Site Phone#

Lab Name: Turnaround Time(specify):

Sample Analysis Requested (*Enter number of containers for each test*)

Lab ID	Sample ID (sys_samp_code)	Location ID (sys_loc_code)	Date (mm/dd/yy)	Time (Military) (hhmm)	Matrix Code **(1)**	Sample Type **(2)**	Field Filtered (Y/N)	Total No. of Containers	(3)→											Extra Volume for MS/MSD	HOLD

***Field* Comments:**

***Lab* Comments:**

Sample Shipment and Delivery Details

Number of coolers in shipment:

Relinquished by (signature)	Date	Time	Received by (signature)	Date	Time
1			1		
2			2		
3			3		

Samples Iced?(check) Yes_____ No_____

Method of Shipment:

Airbill No:

Date Shipped:

(1) AA=Ambient air, **AQ**=Air quality control, **ASB**=Asbestos, **CK**=Caulk, **DS**=Storm drain sediment, **GS**=Soil gas, **IC**=IDW Concrete, **IDD**=IDW Solid, **IDS**=IDW soil, **IDW**=IDW Water, **LF**=Free Product, **MA**=Mastic, **PC**=Paint Chips, **SC**=Cement/Concrete, **SE**=Sediment, **SL**=Sludge, **SO**=Soil, **SQ**=Soil/Solid quality control, **SSD**=Subsurface sediment, **SU**=Surface soil (<6 in), **SW**=Swab or wipe, **TA**=Animal tissue, **TP**=Plant tissue, **TQ**=Tissue quality control, **WG**=Ground water, **WL**=Leachate, **WO**=Ocean water, **WP**=Drinking water, **WQ**=Water quality control, **WR**=Ground water effluent, **WS**=Surface water, **WU**=Storm water, **WW**=Waste water

(2) Sample Type: AB=Ambient Blk, **EB**=Equipment Blk, **FB**=Field Blk, **FD**=Field Duplicate Sample, **IDW**=Investigative-Derived Waste, **MIS**=Incremental Sampling Methodology, **N**=Normal Environmental Sample, **TB**=Trip Blk

(3) Preservative added: **HA**=Hydrochloric Acid, **NI**=Nitric Acid, **SH**=Sodium Hydroxide, **SA**=Sulfuric Acid, **ME**=Methanol, **SB**=sodium bisulfate, **ST**=Sodium Thiosulfate If **NO preservativ**e added leave blank

Rev

Field Measurement of Dissolved Oxygen

Solubility of Oxygen in Water at Atmospheric Pressure1,2			
Temperature oC	Oxygen Solubility mg/L	Temperature oC	Oxygen Solubility mg/L
0.0	14.621	26.0	8.113
1.0	14.216	27.0	7.968
2.0	13.829	28.0	7.827
3.0	13.460	29.0	7.691
4.0	13.107	30.0	7.559
5.0	12.770	31.0	7.430
6.0	12.447	32.0	7.305
7.0	12.139	33.0	7.183
8.0	11.843	34.0	7.065
9.0	11.559	35.0	6.950
10.0	11.288	36.0	6.837
11.0	11.027	37.0	6.727
12.0	10.777	38.0	6.620
13.0	10.537	39.0	6.515
14.0	10.306	40.0	6.412
15.0	10.084	41.0	6.312
16.0	9.870	42.0	6.213
17.0	9.665	43.0	6.116
18.0	9.467	44.0	6.021
19.0	9.276	45.0	5.927
20.0	9.092	46.0	5.835
21.0	8.915	47.0	5.744
22.0	8.743	48.0	5.654
23.0	8.578	49.0	5.565
24.0	8.418	50.0	5.477
25.0	8.263		

1. The table provides three decimals to aid interpolation

2. Under equilibrium conditions, the partial pressure of oxygen in air-saturated water is equal to that of the oxygen in water saturated

Well Construction Form

Facility/Project Name:

Well ID.:

Facility License Number:

Type of Well:
Ground Water Monitoring ☐
Piezometer ☐ Injection ☐
Other_____

Date Well Installed:

Location of well relative to waste source:
Upgradient ☐ Downgradient ☐ Side-gradient ☐ Unknown ☐

Well Installed By:

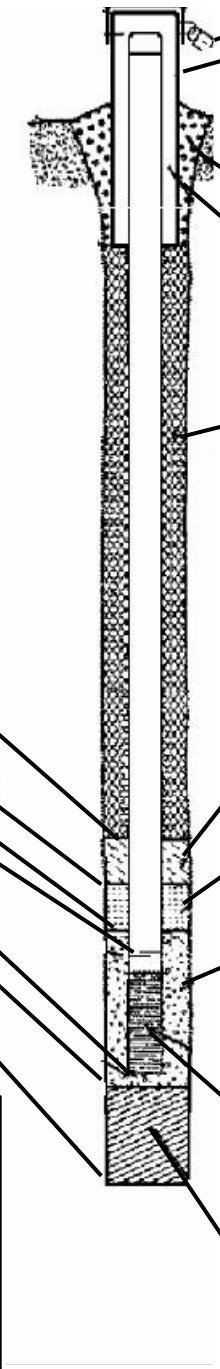
Well Driller License Number:

Geologist:

A. Protective pipe: ft. above grade
B. Well casing, top elevation: ft. MSL
C. Land Surface Elevation: ft. MSL
D. Surface seal, bottom: ft.below grade

12. USCS classification of soil near screen:
GP☐ GM ☐ GC ☐ GW ☐ SP ☐ SM ☐
SC☐ SW☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐
13. Sieve analysis attached? Yes ☐ No ☐
14. Drilling method used: Rotary ☐ HSA ☐
Other:
15. Drilling fluid used:
Water☐ Air ☐ Drilling Mud ☐ None ☐
16. Drilling additives used? Yes ☐ No ☐
Specify:
17: Source of water:

E. Bentonite seal: top ft. (depth)
F. Fine sand: top ft. (depth)
G. Filter pack: top ft. (depth)
H. Screen joint top: ft. (depth)
I. Well bottom: f t. (depth)
J. Filter pack: bottom ft. (depth)
K. Borehole: bottom . ft.(depth)
Borehole diameter: in.



1. Cap and lock? ☐ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: in.
b. Length: ft.
c. Material: *Steel* ☐ *Other*
3. Surface seal: *Bentonite* ☐ *Concrete* ☐
Other:
4. Material blw. well casing and protective pipe:
Bentonite ☐ *Annular space seal* ☐
Other:
5. Annular space seal: *(Manufacturer name)*
a. Granular bentonite ☐
b. Bentonite/Cement slurry ☐
% bentonite ……. Bentonite/cement grout ☐
Lbs/gal mud weight … bentonite slurry ☐
c. How installed: *Tremie* ☐ *Tremie pumped* ☐
Gravity ☐
6. Bentonite seal: *(Manufacturer, product name)*
Bentonite granules ☐
☐ *¼ in.* ☐ *3/8 in.* ☐ *½ in.* *Bentonite pellets* ☐
Other:
7. Fine sand material: *(Manufacturer, product name, mesh size)*
Volume added: ft^3
8. Filter pack material: *(Manufacturer, product name, mesh size)*
Volume added: ft^3
9. Well casing: Flush-threaded Sch 40 PVC☐
Flush-threaded Sch 80 PVC☐
Other:
10. Screen material:
a. Screen type: factory cut ☐ continuous slot ☐
Other:
b. Manufacturer:
c. Slot size: 0. in.
d. Slotted length: ft.
11. Backfill material: *or* None ☐

CERTIFICATION:
I hereby certify that the information on this form is true and correct to the best of my knowledge:

_____
(Signature)

_____
(Company Name)

Appendix B
Standard Operating Procedures

Headspace Screening for Total VOCs

Procedure 3-19

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the basic techniques for using headspace analysis to screen for volatile organics in contaminated soils using a portable Photo Ionization Detector (PID) or Flame Ionization Detector (FID).

1.2 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP will be addressed in the project Health and Safety Plan (HASP). In the absence of a HASP, work will be conducted according to the Contract Task Order (CTO) Work Plan (WP) and/or direction from the **Site Safety Officer (SSO)**. Note that headspace screening usually requires Level D personal protection unless there is a potential for airborne exposure to site contaminants. Under circumstances where potential airborne exposure is possible respiratory protective equipment may be required based on personal air monitoring results. Upgrades to Level C will be coordinated with the Site Safety Officer (SSO) or **CTO Manager**.

2.2 Health and safety hazards and corresponding precautions include, but are not limited to, the following:

2.2.1 Dermal contact with contaminated soil. Personnel should treat all soil as potentially contaminated and wear chemically impervious gloves. Minimize skin contact with soil by using sampling instruments such as stainless steel spades or spoons. Do not touch any exposed skin with contaminated gloves.

2.2.2 Inhalation hazards. Appropriate air monitoring should be conducted to ensure that organic vapor concentrations in the breathing zone do not exceed action levels as specified in the Site-Specific HASP. When ambient temperatures are low enough to require warming samples using the vehicle heater, the vehicle's windows should be opened enough to prevent the build-up of any organic vapors. Use the PID or FID to verify the airborne concentrations in the vehicle remain below applicable action levels. Note that many volatile organic compounds (VOCs) are flammable and all precautions must be observed to eliminate any potential ignition sources.

2.2.3 Shipping limitations. Follow applicable regulations when shipping FID/PID equipment. When shipping an FID by air, the hydrogen tank must be bled dry. Calibration gas canisters are considered dangerous goods and must be shipped according to IATA and DOT regulations. Consult your EHS Coordinator and check with your shipping company to determine the correct shipping procedures

3.0 Terms and Definitions

None.

4.0 Interferences

4.1 Regardless of which gas is used for calibration, the instrument will respond to all analytes present in the sample that can be detected by the type of lamp used in the PID.

4.2 Moisture will generate a positive interference in the concentration measured for a PID and is characterized by a slow increase in the reading as the measurement is made. Care must be taken to

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minimize uptake of moisture to the extent possible. Refer to the manufacturers' instructions for care, cleaning, and maintenance.

4.3 Uptake of soil into the PID must be avoided as it will compromise instrument performance by blocking the probe, causing a positive interference, or dirtying the PID lamp. Refer to the manufacturers' instructions for care, cleaning, and maintenance.

4.4 The user should listen to the pitch of the sampling pump. Any changes in pitch may indicate a blockage and corrective action should be initiated.

5.0 Training and Qualifications

5.1 **Qualifications and Training**

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 **Responsibilities**

5.2.1 The CTO Manager is responsible for ensuring that the collection of headspace readings comply with this procedure. The CTO Manager is responsible for ensuring that all personnel involved in the collection of headspace readings shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The Program Quality Manager is responsible for ensuring overall compliance with this procedure.

5.2.3 The Field Manager is responsible for ensuring that all headspace readings are conducted according to this procedure as well as verifying that the PID/FID is in proper operating condition prior to use and for implementing the calibration.

5.2.4 All Field Personnel are responsible for the implementation of this procedure.

6.0 Equipment and Supplies

6.1 The following materials must be on hand in good operating condition and/or in sufficient quantity to ensure that proper field analysis procedures may be followed:

- Calibrated PID/FID instrument;
- Top-sealing "Zip-Loc" type plastic bags – or – 16 ounces of soil or "mason-" type glass jars and aluminum foil;
- Project field book and/or boring logs;
- Personal Protective Equipment (PPE) as specified in the project HASP; and
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants.

7.0 Procedure

7.1 **Preparation**

Review available project information to determine the types of organic vapors that will likely be encountered to select the right instrument. The two basic types of instruments are FIDs and PIDs.

FIDs work well with organic compounds that have relatively lightweight molecules, but may have problems detecting halogenated compounds or heavier organic compounds; FIDs can detect methane for example. Since the FID uses a flame to measure organic compounds, ensure that work is conducted in an atmosphere, which is free of combustible vapors. If ambient temperatures are below 40°F, the flame of the FID may be difficult to light.

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When using a PID, select an instrument that can measure the ionization potential of the anticipated contaminants of concern. PIDs work well with a range of organic compounds and can detect some halogenated hydrocarbons; PIDs cannot detect methane. The correct ultraviolet (UV) light bulb must be selected according to the types of organic vapors that will likely be encountered. The energy of the UV light must equal or exceed the ionization potential of the organic molecules that the PID will measure. The NIOSH Pocket Guide to Chemical Hazards is one source for determining ionization potentials for different chemicals. Bulbs available for PIDs include 9.4 eV, 10.6 (or 10.2) eV, and 11.7 eV bulbs. The 10.6 eV bulb is most commonly used as it detects a fairly large range of organic molecules and does not burn out as easily as the 11.7 eV bulb. The 9.4 eV bulb is the most rugged, but detects only a limited range of compounds. Under very humid or very cold ambient conditions, the window covering the UV light may fog up, causing inaccurate readings. Ask the **SSO** about correction factors when high humidity conditions exist.

After selecting the correct instrument, calibrate the PID/FID according to the manufacturer's instructions. Record background/ambient levels of organic vapors measured on the PID/FID after calibration and make sure to subtract the background concentration (if any) from your readings. Check the PID/FID readings against the calibration standard every 20 readings or at any time when readings are suspected to be inaccurate, and recalibrate, if necessary. Be aware that, after measuring highly contaminated soil samples, the PID/FID may give artificially high readings for a time.

7.2 Top-Sealing Plastic Bag

Place a quantity of soil in a top-sealing plastic bag and seal the bag immediately. The volume of soil to be used should be determined by the **CTO Manager** or **Field Manager**. The volume of soil may vary between projects but should be consistent for all samples collected for one project. Ideally, the bag should be at least 1/10th-filled with soil and no more than half-filled with soil. Once the bag is sealed, shake the bag to distribute the soil evenly. If the soil is hard or clumpy, use your fingers to gently work the soil (through the bag) to break up the clumps. Do not use a sampling instrument or a rock hammer since this may create small holes in the plastic bag and allow organic vapors to escape. Alternatively, the sample may be broken up before it is placed in the bag. Use a permanent marker to record the following information on the outside of the bag:

- Site identification information (i.e., borehole number);
- Depth interval; and
- Time the sample was collected. For example: "SS-12, 2-4 ft, @1425".

Headspace should be allowed to develop before organic vapors are measured with a PID/FID. The amount of time required for sufficient headspace development will be determined by the project-specific sampling plan and the ambient temperature. Equilibration time should be the same for all samples to allow an accurate comparison of organic vapor levels between samples. However, adjustments to equilibration times may be necessary when there are large variations in ambient temperature from day to day. When ambient temperatures are below 32°F, headspace development should be within a heated building or vehicle. When heating samples, be sure there is adequate ventilation to prevent the build-up or organic vapors above action levels.

Following headspace development, open a small opening in the seal of the plastic bag. Insert the probe of a PID/FID and seal the bag back up around the probe as tightly as possible. Alternatively, the probe can be inserted through the bag to avoid loss of volatiles. Since PIDs and FIDs are sensitive to moisture, avoid touching the probe to the soil or any condensation that has accumulated inside of the bag. Since the PID/FID consumes organic vapors, gently agitate the soil sample during the reading to release fresh organic vapors from the sample. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case, headspace data should be discounted. Record the highest reading on the field form or in the field notebook as described in Section 9.

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7.3 **Jar and Aluminum Foil (Alternate Method)**

Half-fill a clean glass jar with the soil sample to be screened. Quickly cover the jar's opening with one to two sheets of clean aluminum foil and apply the screw cap to tightly seal the jar. Allow headspace development for at least ten minutes. Vigorously shake the jar for 15 seconds, both at the beginning and at the end of the headspace development period. Where ambient temperatures are below 32°F (0°C), headspace development should be within a heated area. When heating samples, be sure there is adequate ventilation to prevent the build-up of organic vapors above action levels.

Subsequent to headspace development, remove the jar lid and expose the foil seal. Quickly puncture the foil seal with the instrument sampling probe, to a point about one-half of the headspace depth. Exercise care to avoid uptake of water droplets or soil particulates. As an alternative, use a syringe to withdraw a headspace sample, and then inject the sample into the instrument probe or septum-fitted inlet. This method is acceptable contingent upon verification of methodology accuracy using a test gas standard. Following probe insertion through the foil seal or sample injection to probe, record the highest meter response on the field form or in the field notebook. Using foil seal/probe insertion method, maximum response should occur between two and five seconds. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case, headspace data should be discounted.

8.0 Quality Control and Assurance

Quality Assurance/Quality Control (QA/QC) will include the collection of duplicate samples. In general, one duplicate will be collected per 20 samples. Organic vapor concentrations measured in the primary and duplicate samples should be similar within plus or minus 20 percent. The frequency of headspace duplicate collection will be determined by the project manager/task manager. The PID/FID instrument must be calibrated according to the manufacturer's instructions before beginning screening, and checked or recalibrated every 20 analyses or when readings are suspected to be inaccurate. Record ambient organic vapor levels in the field notebook and on the field form. Periodically check ambient organic vapor levels. If ambient levels have changed more than 20 percent, recalibrate the PID/FID. Make sure readings are not collected near a vehicle exhaust or downwind of a drill rig exhaust. If grossly contaminated soil is encountered, decontaminate sampling instruments between samples and/or change contaminated gloves to avoid cross contaminating less contaminated samples.

9.0 Records, Data Analysis, Calculations

9.1 All data generated (results and duplicate comparisons) will be recorded in the field notebook and/or on the field form. Any deviation from the outlined procedure will also be noted. Field conditions (ambient temperature, wind, etc.) should also be recorded in the field notebook.

9.2 Readings may be recorded in a field notebook, on a boring log, or on an appropriate form specific to the project. The form should include the following information:

- When the PID/FID was calibrated (date/time) and calibration standard used;
- Background/ambient concentrations measured after PID/FID calibration;
- Location of sample (i.e., bore-hole number);
- Depth interval of sample measured;
- Lithology of material measured; and
- PID/FID reading and units of measure.

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9.3 Note that if PID/FID measurements are recorded on a boring log, it is not necessary to duplicate information in the column where the PID/FID readings are recorded (e.g., borehole number, depth interval, lithology type).

9.4 All documentation will be stored in the project files and retained following completion of the project.

10.0 Attachments or References

SOP 3-20 Operation and Calibration of a Photoionization Detector

Author	Reviewer	Revisions (Technical or Editorial)
Robert Shoemaker Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)

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Surface and Subsurface Soil Sampling Procedures

Procedure 3-21

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the procedures for soil sampling. The procedure includes surface and subsurface sampling by various methods using hand auguring, test pit, direct-push, and split-spoon equipment.

1.2 The procedure includes soil sampling for volatile organic compounds (VOCs). For project specific information (e.g. sampling depths, equipment to be used, and frequency of sampling), refer to the Sampling and Analysis Plan (SAP), which takes precedence over these procedures. Surface soil sampling, typically considered to be up to two feet below ground surface by EPA standards, is typically accomplished using hand tools such as shovels or hand augers. Test pit samples are considered subsurface samples, although normally collected via hand tools similar to surface soil sampling or by excavation machinery. Direct-push and split-spoon sampling offer the benefit of collecting soil samples from a discrete or isolated subsurface interval, without the need of extracting excess material above the target depth. These methods dramatically reduce time and cost associated with disposal of material from soil cuttings when compared to test pit sampling. In addition, direct-push and split-spoon sampling methods can obtain samples at targeted intervals greater than 15 feet in depth, allowing for discrete depth soil sampling while speeding up the sampling process. Direct-push methods work best in medium to fine-grained cohesive materials such as medium to fine sands, silts, and silty clay soils. Split-spoon sampling works well in all types of soil, but is somewhat slower than direct-push methods. Samples are composited so that each sample contains a homogenized representative portion of the sample interval. Due to potential loss of analytes, samples for volatile analysis are not composited. Samples for chemical analysis can be collected by any of the above-mentioned sampling methods, as disturbed soil samples. Undisturbed samples are collected, sealed, and sent directly to the laboratory for analysis. For undisturbed samples, the samples are not homogenized.

2.0 Safety

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the project Health and Safety Plan (HASP). In the absence of a HASP, work will be conducted according to the Contract Task Order (CTO) Work Plan (WP) and/or direction from the **Site Safety Officer (SSO)**.

2.2 Before soil sampling commences, appropriate entities (e.g. DigSafe, local public works departments, company facilities) must be contacted to assure the anticipated soil sampling locations are marked for utilities, including electrical, telecommunications, water, sewer, and gas.

3.0 Terms and Definitions

None.

4.0 Interferences

4.1 Low recovery of soil from sampling equipment will prevent an adequate representation of the soil profile and sufficient amount of soil sample. If low recovery is a problem, the hole may be offset and re-advanced, terminated, or continued using a larger diameter sampler.

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4.2 Asphalt in soil samples can cause false positive results for hydrocarbons. To ensure samples are free of asphalt, do not collect samples that may contain asphalt. If the collection of samples potentially containing asphalt is unavoidable, note the sampling depths at which the presence of asphalt are suspected.

4.3 Instrumentation interferences addressed in SOPs for Calibration of the Photoionization Detector (PID), Headspace Screening for Total Volatile Organics, and Equipment Decontamination must also be considered.

4.4 Cross contamination from sampling equipment must be prevented by using sampling equipment constructed of stainless steel that is adequately decontaminated between samples.

5.0 Training and Qualifications

5.1 Qualifications and Training

The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

5.2.1 The CTO Manager is responsible for ensuring that soil sampling activities comply with this procedure. The CTO Manager is responsible for ensuring that all personnel involved in soil sampling shall have the appropriate education, experience, and training to perform their assigned tasks.

5.2.2 The Program Quality Manager is responsible for ensuring overall compliance with this procedure.

5.2.3 The Field Manager is responsible for ensuring that all soil sampling activities are conducted according to this procedure.

5.2.4 All Field Personnel are responsible for the implementation of this procedure.

6.0 Equipment and Supplies

The depth at which samples will be collected and the anticipated method of sample collection (direct-push, split-spoon, hand auger, shovel, or test pits) will be presented in the SAP. The following details equipment typically needed for soil sampling, based on the various methods. See the SAP for specific detail of equipment and supply needs.

6.1 Depending on the nature of suspected contamination, field screening instrumentation may be used for direct sampling. Appropriate instrumentation and calibration standards should be available. If volatile organic contaminants are suspected and a PID will be used, refer to the equipment and instrumentation listed in SOP 3-20 Operation and Calibration of a Photoionization Detector. Equipment in this SOP includes but is not limited to:

- PID/FID;
- Calibration gas; and
- Tedlar® gas bags (for calibration).

6.2 If field screening methods include jar headspace screening for volatile organics, refer to the equipment and procedure in SOP 3-19 Headspace Screening for Total VOCs. Equipment in this SOP includes but is not limited to:

- Clean soil ("drillers jars") jars; and
- Aluminium foil.

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6.3 Appropriate decontamination procedures must be followed for sampling equipment. Refer to SOP 3-06 Equipment Decontamination. Equipment in this SOP includes but is not limited to:

- Phosphate-free detergent;
- Isopropyl Alcohol;
- Tap water;
- Deionized Ultra-Filtered (DIUF) Water;
- Plastic buckets or washbasins;
- Brushes; and
- Polyethylene sheeting.

6.4 The following general equipment is needed for all soil sampling, regardless of method:

- Stainless steel bowls;
- Stainless steel trowels;
- Appropriate sample containers for laboratory analysis;
- Personal Protective Equipment (PPE);
- Logbook;
- Cooler and ice for preservation; and
- Stakes and flagging to document sampling location.

6.5 The following additional equipment is needed for volatile organic sampling:

- Electronic pan scale and weights for calibration; and
- Syringes or other discrete soil core samplers.

6.6 The following additional equipment may be needed for surface and test pit soil sampling:

- Hand Auger

6.7 The following additional equipment may be needed for soil sampling from direct push and/or split-spoon equipment:

- Tape measure or folding carpenter's rule for recording the length of soil recovered.

Note: All subsurface drilling equipment will be provided and maintained by the subcontractor.

7.0 Procedure

7.1 General Soil Sampling Procedure for All Soil Sampling Methods

7.1.1 Record the weather conditions and other relevant on-site conditions.

7.1.2 Select the soil sampling location, clear vegetation if necessary, and record the sampling location identification number and pertinent location details.

7.1.3 Verify that the sampling equipment is properly decontaminated, in working order, and situated at the intended sampling location.

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7.1.4 Place polyethylene sheeting on the ground and assemble all necessary sampling equipment on top of it. Cover surfaces onto which soils or sampling equipment will be placed (i.e. tables with polyethylene sheeting).

7.1.5 Follow the appropriate procedures listed below for either surface, split-spoon, direct push, or test pit sample collection (7.2, 7.3, 7.4, and 7.5 respectively).

7.1.6 Collect soil samples according to procedures listed in Section 7.6 depending on project specific analyses.

7.1.7 Record date/time, sample ID, and sample descriptions in the field logbook or field form. A sketch or description of the location may also be recorded so the sample location can be re-constructed, especially if the location will not be recorded using global positioning satellite (GPS) equipment.

7.1.8 Immediately label the sample containers and place them on ice, if required for preservation. Complete the chain-of-custody form(s) as soon as possible.

7.1.9 Dispose of all excess excavated soil in accordance with the SAP.

7.1.10 If required, mark the sample location with a clearly labelled wooden stake or pin flag. If the location is on a paved surface, the location may be marked with spray paint.

7.1.11 Decontaminate the sampling equipment according to SOP 3-06 Equipment Decontamination.

7.2 Surface Sampling

7.2.1 The criteria used for selecting surface soil locations for sampling may include the following:

- Visual observations (soil staining, fill materials);
- Other relevant soil characteristics;
- Site features;
- Screening results;
- Predetermined sampling approach (i.e. grid or random); and
- Sampling objectives as provided in the SAP.

7.2.2 The following procedures are to be used to collect surface soil samples. Surface soils are considered to be soils that are up to two feet below ground surface, though state regulations and project objectives may define surface soils differently; therefore, the SAP should be consulted for direction on the depth from which to collect the surface soil samples. Sampling and other pertinent data and information will be recorded in the field logbook and/or on field forms. Photographs may be taken as needed or as specified in the SAP.

1. Gently scrape any vegetative covering until soil is exposed. Completely remove any pavement.
2. Remove soil from the exposed sampling area with a trowel, hand auger, or shovel. Put soils within the sampling interval in a stainless steel bowl for homogenizing. Monitor the breathing zone and sampling area as required in the HASP.
3. For VOC analyses, collect representative soil samples directly from the recently-exposed soil using a syringe or other soil coring device (e.g., TerraCore®, EnCore®). Follow procedures in Section 7.6.1 for VOC sampling.
4. Collect sufficient soil to fill all remaining sample jars into a stainless steel bowl. Homogenize the soil samples to obtain a uniform soil composition which is representative of the total soil sample collected according to the following procedure:
   a) Remove all rocks and non-soil objects using a stainless steel spoon or scoop.

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b) Form a cone shaped mound with the sample material, then flatten the cone and split the sample into quarters.

c) Use the stainless steel spoon/scoop to mix the quarter samples that are opposite.

d) After mixing the opposite quarters, reform the cone shaped mound.

e) Repeat this procedure a minimum of five (5) times, removing any non-soil objects and breaking apart any clumps.

7.3 Split-Spoon Sampling

7.3.1 At each boring location, the frequency and depth of split-spoon samples will be determined from the SAP. Split-spoon samples may be collected continuously, intermittently, or from predetermined depths.

7.3.2 Split-spoon samplers shall be driven into undisturbed soil by driving the spoon ahead of the drill augers/casing. In cohesive soils, or soils where the borehole remains open (does not collapse), two split-spoon samples may be taken prior to advancing the augers/casing.

7.3.3 After split-spoons are retrieved, open the split-spoon and measure the recovery of soil. If a PID will be used for screening, immediately scan the recovered sample for VOCs using the PID. Scan the recovered soil boring by making a hole in the soil with a decontaminated trowel and placing the PID inlet very close to the hole. Be very careful not to get soil on the tip of the PID. Take PID readings every 6 inches along the split-spoon and/or in any areas of stained or disturbed soil. Record the highest PID reading and the depth at which it was observed along with all other pertinent observations. If required in the SAP, VOC and headspace samples should be collected (see Section 7.6.1) prior to logging the sample.

7.3.4 If headspace screening for VOCs is required in the SAP, collect a soil sample (as defined in the SAP) and perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.

7.3.5 Soils collected using the split-spoon sampler will be logged by the field representative using the procedure required in the SAP.

7.3.6 Collect the remainder of the sample volume required into a stainless steel bowl. Homogenize the soil so the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.

7.3.7 The SAP may specify that intervals to be sent to the laboratory be determined by visual observation and/or highest PID screening or headspace results, which can only be determined once the boring is complete. In this instance, a VOC sample should be collected at each interval. The remainder of the soil from that interval will be set aside in a clearly labelled stainless steel bowl covered with aluminium foil. Once the boring has been completed and the sample interval has been determined, the remainder of the soil can be homogenized according to Section 7.2 and submitted for laboratory analysis.

7.3.8 Once a boring is complete and all required samples have been collected, the boring must be completed as specified in the SAP (e.g., completed as a monitoring well, backfilled with bentonite, etc).

7.4 Direct Push Sampling

At each boring location, the frequency of direct-push samples will be determined from the SAP. Typically, samples with direct-push equipment are collected in 4 foot (ft) intervals, but smaller (e.g., 2 ft) and larger (e.g., 5 ft) intervals are also possible.

1. Sample using Macro-Core samplers with acetate liners to obtain discrete soil samples at the depths specified in the SAP.

2. Cut open the acetate liner. If required in the SAP, immediately scan the recovered soil boring for VOCs using a PID by making a hole in the soil with a decontaminated trowel and placing the PID inlet very close to the hole. Be very careful not to get soil on the tip of the PID. Take PID readings every 6 inches along the split-spoon and/or in any areas of stained or disturbed soil. Record the

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highest PID reading and the depth at which it was observed along with all other pertinent observations. VOC and headspace samples, if required in the SAP should be collected (see Section 7.6.1) prior to logging the sample.

3. If required in the SAP, collect a soil sample (as defined in the SAP) and perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.
4. Soils collected using the direct-push sampler will be logged by the by the field representative using the procedure required in the SAP.
5. Collect the remainder of the sample into a stainless steel bowl. Homogenize the soil collected so that the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.
6. Once a boring is complete and all required samples have been collected, the boring must be completed as specified in the SAP (e.g., completed as a monitoring well, backfilled with bentonite, etc).

7.5 Test Pit Sampling

7.5.1 Excavate the test pit to the desired depth.

7.5.2 Using the excavator bucket, collect soil samples as specified in the SAP. Collect a sample and perform screening analyses as required by the SAP. If VOCs contamination is suspected, perform headspace screening according to SOP 3-19 Headspace Screening for Total VOCs.

7.5.3 Collect the sample from center of the bucket to avoid potential contamination from the bucket.

7.5.4 VOC samples should also be collected from an undisturbed section soil in the excavator bucket. The top layer of exposed soil should be scraped away just prior to collecting the VOC samples.

7.5.5 Collect the remainder of the sample volume required into a stainless steel bowl. Homogenize the soil so the material is uniform in composition and representative of the total soil sample collected. Follow homogenizing techniques as described in Section 7.2.

7.5.6 Dispose of all excavated soil according to the SAP.

7.6 Sample Collection Methods

7.6.1 Volatile Organics Sampling

For soils collected for analyses of volatile organics, including Volatile Petroleum Hydrocarbons (VPH) or other purgable compounds, a closed system is maintained. From collection through analysis, the sample bottles are not opened. The bottle kit for a routine field sample for these analyses will typically include three 40-mL VOA vials and one soil jar. Two 40-mL VOA vials will contain either 5 mL reagent water or 5 mL sodium bisulfate and magnetic stir bars (i.e., low level vials). The third VOA vial will contain 15 mL methanol with no magnetic stir bar (i.e., high level vial). These vials are usually provided by the laboratory and are pre-weighed, with the tare weight recorded on the affixed sample label. No additional sample labels are affixed to the VOA vials, as addition of a label would alter the vial weight. All information is recorded directly on the sample label using an indelible marker. The soil jar is provided for percent solids determination. For VOC or VPH analyses, samples are collected prior to sample homogenization. Collect the VOC sample in accordance with the procedure described below.

1. Determine the soil volume necessary for the required sample weight, typically 5 grams:
   a) Prepare a 5 mL sampling corer (e.g., Terra Core®) or cut-off plastic syringe.
   b) Tare the sampler by placing it on the scale, and zeroing the scale.
   c) Draw back the plunger to the 5 gram mark or 5mL (5cc) mark on cut-off syringe, and insert the open end of the sampler into an undisturbed area of soil with a twisting motion, filling the

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sampler with soil. Note the location of the plunger with respect to the milliliter (cc) or other graduation printed on the sampler.

d) Weigh the filled sampler, and remove or add soil until the desired weight is obtained. Note the location of the plunger which corresponds to this weight. Do not use this sample for laboratory analysis.

2. Once the required soil volume has been determined, pull the plunger back to this mark and hold it there while filling the syringe for each sample.

3. Collect 5 grams of soil using the cut-off syringe or Terra Core® sample device. Extrude the 5-grams of soil into one of the low level 40-mL VOA vials. Quickly wipe any soil from the threads of the VOA vial with a clean Kimwipe® and immediately close the vial. It is imperative that the threads be free from soil or other debris prior to replacing the cap on the vial in order to maintain the closed system necessary for the analysis.

4. Gently swirl the vial so that all of the soil is fully wetted with the preservative.

5. Fill the other low level 40 mL VOA vial in this manner.

6. Repeat the process for the high level VOA vials, only for the high level VOA vial three 5 gram aliquots (i.e., 15 grams total) should be extruded into the high level VOA vial.

   NOTE: Depending on the laboratory, some high level VOA vials only contain 5 mL or 10 mL of methanol. If this is the case, either 5 grams total or 10 grams total, respectively, should be extruded into the high level VOA vial. In other words, the mass of soil in grams should be identical to the volume of methanol in mL (i.e., 1:1 ratio of soil to methanol).

7. Collect any additional QC sample collected (e.g., field duplicate, MS, and MSD) in the same manner as above.

8. Fill the 4-oz glass jar with soil from the same area for percent moisture determination.

7.6.2 Soil Sampling Method (All other analyses except VOC/VPH)

When all the required soil for a sampling location has been obtained, the soil can be homogenized as described in section 7.2. Collect sufficient volume to fill all of the remaining sample containers at least ¾ full for all other analyses. Homogenize the soil in a decontaminated stainless steel bowl, removing rocks, sticks, or other non-soil objects and breaking apart any lumps of soil prior to filling the remaining sample containers.

NOTE: Soil samples must contain greater than 30% solids for the data to be considered valid.

8.0 Quality Control and Assurance

8.1 Sampling personnel should follow specific quality assurance guidelines as outlined in the SAP. Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements outlined in the SAP typically suggest the collection of a sufficient quantity of field duplicate, field blank, and other samples.

8.2 Quality control requirements are dependent on project-specific sampling objectives. The SAP will provide requirements for equipment decontamination (frequency and materials), sample preservation and holding times, sample container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

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9.0 Records, Data Analysis, Calculations

All data and information (e.g., sample collection method used) must be documented on field data sheets, boring logs, or within site logbooks with permanent ink. Data recorded may include the following:

- Weather conditions;
- Arrival and departure time of persons on site;
- Instrument type, lamp (PID), make, model and serial number;
- Calibration gas used;
- Date, time and results of instrument calibration and calibration checks;
- Sampling date and time;
- Sampling location;
- Samples collected;
- Sampling depth and soil type;
- Deviations from the procedure as written; and
- Readings obtained.

10.0 Attachments or References

SOP 3-06, *Equipment Decontamination*

SOP 3-19, *Headspace Screening for Total VOCs*

SOP 3-20, *Operation and Calibration of a Photoionization Detector*

Author	Reviewer	Revisions (Technical or Editorial)
Robert Shoemaker Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)

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