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FINAL SAMPLING AND ANALYSIS PLAN SOLID WASTE MANAGEMENT UNIT 10 (SWMU
10) ROCKEYE NSA CRANE IN
06/01/2014
RESOLUTION CONSULTANTS

**FINAL
SAMPLING AND ANALYSIS PLAN**

**SOLID WASTE MANAGEMENT UNIT 10 — ROCKEYE
NAVAL SUPPORT ACTIVITY CRANE
CRANE, INDIANA**

Revision Number: 0

Prepared For:



**Department of the Navy
Naval Facilities Engineering Command Midwest
201 Decatur Avenue, Building 1-A
Great Lakes, Illinois 60088-2801**

Prepared By:



**Resolution Consultants
A Joint Venture of AECOM & EnSafe
1500 Wells Fargo Building
440 Monticello Avenue
Norfolk, Virginia 23510**

**Contract Number: N62470-11-D-8013
Contract Task Order: F27E**

June 2014

SAP WORKSHEET #1: TITLE AND APPROVAL PAGE
(UFP-QAPP Manual Section 2.1)

SAMPLING AND ANALYSIS PLAN

**SOLID WASTE MANAGEMENT UNIT 10 — ROCKEYE
NAVAL SUPPORT ACTIVITY CRANE
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June 2014

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Remedial Project Manager Date

EXECUTIVE SUMMARY

Resolution Consultants has prepared this Sampling and Analysis Plan for Long-Term Monitoring at Naval Facilities Engineering Command Midwest, Naval Support Activity Crane in Crane, Indiana, under the Comprehensive Long-Term Environmental Action Navy Contract No. N62470-11-D-8013, Contract Task Order F27E.

A long-term monitoring program is in-place for Naval Support Activity Crane, Solid Waste Management Unit (SWMU) 10, Rockeye, as part of the corrective action monitoring required by the facility's Resource Conservation and Recovery Act permit. Groundwater sampling is required biennially and samples are analyzed for a prescribed chemical list to confirm that explosives-related contamination concentrations are reduced to less than media cleanup standards via natural attenuation mechanisms, to verify that the explosives-related groundwater contamination plume is not migrating, and to ensure that the land-use controls remain effective at preventing human exposure to contaminated groundwater. Limited surface water monitoring is also conducted to verify whether groundwater contamination is entering a stream downgradient of the SWMU 10 source area. If groundwater or surface water contamination concentrations are not reduced to less than media cleanup standards within 20 years (i.e., by 2028), then the remedy should be re-evaluated to ensure it remains protective of human health and the environment.

Fourteen wells, screened in three different water-bearing zones, and seven surface water locations are sampled as part of the SWMU 10 biennial monitoring program. Eight wells are in the source area: 10-07, 10-08, 10-17, 10-18, 10-21, 10C49, 10C55P2, and 10C55. The remaining wells are downgradient of the source area: 10-01, 10-02, 10C48, 10C49P2, 10C56, and 10C57. Seven surface water sample locations are downgradient of SWMU 10: 10SW09, 10SW11, 10SW12, 10SW13, 10SW14, 10SW15, and 10SW16.

Activities described in this Sampling and Analysis Plan also include replacement of existing well 10C55P2, which will be abandoned in accordance with state regulations and replaced with a new well labeled 10R62.

The goal of this project is to conduct the necessary fieldwork (including project planning, groundwater sampling, surface water sampling, data validation, and reporting) to comply with corrective action monitoring requirements for SWMU 10, Rockeye.

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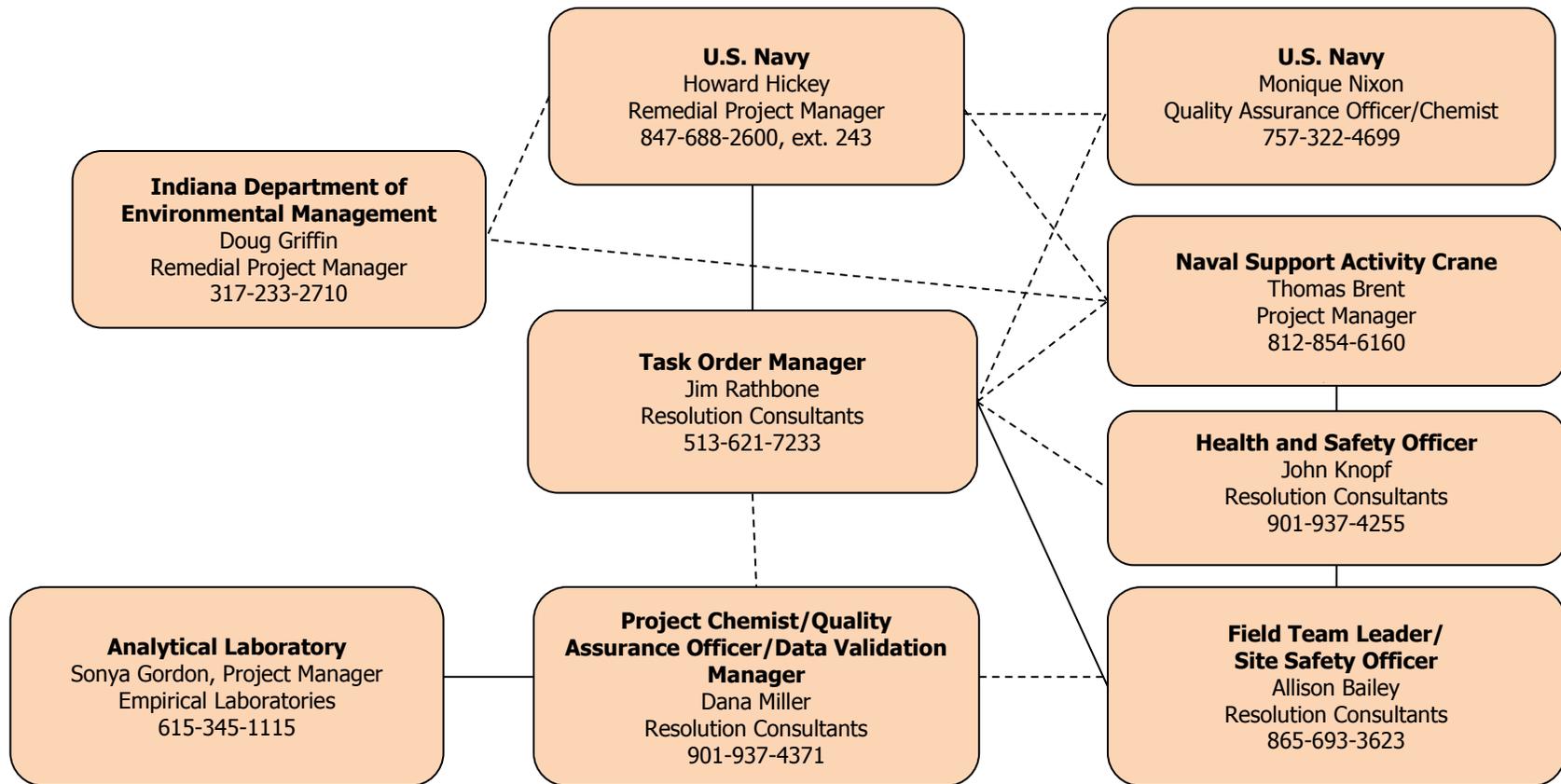
°C	Degrees Celsius
CAS	Chemical Abstract Services
CCV	Continuing calibration verification
DO	Dissolved oxygen
DoD	Department of Defense
DoD QSM	Department of Defense Quality Systems Manual
DVA	Data validation assistant
EICP	Extracted ion current profile
eQAPP	Electronic quality assurance project plan
ELAP	Environmental Laboratory Accreditation Program
FTL	Field team leader
GW	Groundwater
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HSO	Health and safety officer
ICAL	Initial calibration
IDEM	Indiana Department of Environmental Management
LCS	Laboratory control sample
LCSD	Laboratory control sample duplicate
LOD	Limit of detection
LOQ	Limit of quantitation
LTM	Long-term monitoring
LUCs	Land-use controls
MCS	Media cleanup standard
mL	Milliliter
MPC	Measurement performance criteria
MS/MSD	Matrix spike/matrix spike duplicate
µg/L	Micrograms per liter
NA	Not applicable
NAVFAC	Naval Facilities Engineering Command
NIRIS	Naval Installation Restoration Information Solution
NSA	Naval Support Activity
ORP	Oxidation reduction potential
PDF	Portable document format
PM	Project manager
QA	Quality assurance
QAO	Quality assurance officer
QC	Quality control

%R	Percent recovery
RCRA	Resource Conservation and Recovery Act
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
RPD	Relative percent difference
RPM	Remedial project manager
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SSO	Site safety officer
SVOC	Semivolatile organic compound
SW	Surface water
SWMU	Solid waste management unit
TBD	To be determined
Tetryl	Methyl-2,4,6-trinitrophenylnitramine
TOM	Task order manager
UFP-QAPP	Uniform Federal Policy-quality assurance project plan
U.S. EPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound



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 Naval Support Activity (NSA) Crane, Sampling and Analysis Plan (SAP) are shown below. Communications described in this worksheet will be documented in the appropriate format for the specific interaction. Appropriate forms of documentation include, but are not limited to: email, telephone logs, field logbook notations, field forms, audit reports, and formal memoranda, or as described below.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Regulatory Agency Interface	NSA Crane PM	Thomas Brent	812-854-6160	The NSA Crane PM informs regulatory agency of work progress on a periodic basis.
Progress Reports	Resolution Consultants FTL/SSO Resolution Consultants TOM Navy RPM	Allison Bailey Jim Rathbone Howard Hickey	865-693-3623 513-621-7233 847-688-2600, ext. 243	The Resolution Consultants FTL will verbally inform the Resolution Consultants TOM on a daily basis of field updates. The TOM will provide a weekly update to the Navy RPM by phone message and/or e-mail each Friday afternoon field activities are taking place.
Gaining Site Access	Resolution Consultants FTL NSA Crane PM	Allison Bailey Thomas Brent	865-693-3623 812-854-6160	The Resolution Consultants FTL will contact the NSA Crane PM verbally or via e-mail at least one week before commencement of fieldwork to arrange for access to the site for all field personnel.
Obtaining Utility Clearances for Intrusive Activities	Resolution Consultants FTL NSA Crane PM	Allison Bailey Thomas Brent	865-693-3623 812-854-6160	The Resolution Consultants FTL will coordinate verbally or via e-mail with NSA Crane PM at least 14 days in advance of site access to initiate the utility clearance process for all intrusive sampling locations.
Stop Work due to Safety Issues	Resolution Consultants FTL/SSO Resolution Consultants TOM Resolution Consultants HSO Navy RPM NSA Crane PM	Allison Bailey Jim Rathbone John Knopf Howard Hickey Thomas Brent	865-693-3623 513-621-7233 901-937-4255 847-688-2600, ext. 243 812-854-6160	Any field team member who observes an unsafe situation has the authority to stop work. If Resolution Consultants is the responsible party for a stop-work command, the Resolution Consultants SSO will inform onsite personnel, subcontractors, TOM, HSO, and the NSA Crane PM within 1 hour (verbally or by e-mail). The HSO will notify the Navy RPM within 24 of notification from the SSO. If a subcontractor is the responsible party, the subcontractor PM must verbally inform the Resolution Consultants SSO within 15 minutes, and the Resolution Consultants SSO will then follow the procedure listed above.



Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
SAP Changes before Field/Laboratory work	Resolution Consultants TOM Navy RPM IDEM RPM Resolution Consultants QAO	Jim Rathbone Howard Hickey Doug Griffin Dana Miller	513-621-7233 847-688-2600, ext. 243 317-233-2710 901-937-4371	The Resolution Consultants FTL will verbally inform the TOM upon realizing a need for a SAP modification. The FTL or TOM will document the proposed changes via a SAP modification form within five days and send it to the project QAO/chemist. The project QAO/chemist will assess whether: (a) The modification has the potential to affect the project's ability to achieve data quality objectives, b) The modification requires a change in field or laboratory methods which may affect project schedule or cost, or c) The modification does not affect DQOs, schedule, or cost and is for documentation purposes only. SAP modifications potentially affecting DQOs will be submitted to the Navy RPM and Project Team for review and consideration and may require SAP amendments and approval. Modifications in laboratory/field methods, project schedule or cost will be submitted to the Navy for review and consideration. Minor modifications not affecting DQOs, schedule or cost will be documented in the project file.
SAP Changes in the Field	Resolution Consultants FTL/SSO Resolution Consultants TOM Navy RPM IDEM RPM	Allison Bailey Jim Rathbone Howard Hickey Doug Griffin	865-693-3623 513-621-7233 847-688-2600, ext. 243 317-233-2710	The Resolution Consultants FTL will inform the TOM verbally within same day of the need for a SAP change in the field. The TOM will inform the Navy RPM by e-mail within 24 hours; the TOM sends a concurrence letter to the Navy RPM, if warranted, within 7 calendar days and the RPM signs the letter within 5 business days of receipt. Scope change is to be implemented before work is executed. Document the change on a field task modification request form (within 2 business days) or SAP amendment (within timeframe agreed to by Project Team). The Navy will notify IDEM of any significant SAP field changes within 5 business days. Any change of the approved SAP affecting the scope or implementation of the sampling program will be made only upon authorization of the Navy RPM and regulatory agency.
Field Corrective Actions	Resolution Consultants FTL/SSO Resolution Consultants TOM Navy RPM IDEM RPM	Allison Bailey Jim Rathbone Howard Hickey Doug Griffin	865-693-3623 513-621-7233 847-688-2600, ext. 243 317-233-2710	The Resolution Consultants FTL will inform the TOM verbally within same day of field corrective actions. The TOM will inform the Navy RPM by e-mail within 24 hours that corrective actions have been implemented. Corrective actions will be documented in weekly progress reports. The Navy RPM will notify IDEM of any significant corrective actions taken within 5 business days.
Recommendations to stop work and initiate work upon corrective action	Resolution Consultants FTL/SSO Resolution Consultants TOM Resolution Consultants QAO Navy RPM	Allison Bailey Jim Rathbone Dana Miller Howard Hickey	865-693-3623 513-621-7233 901-937-4371 847-688-2600, ext. 243	Responsible party verbally informs the Resolution Consultants TOM, FTL, and subcontractors within 1 hour of recommendation to stop work and within 24 hours of recommendation to restart work. Responsible party follows verbal notification with an e-mail to the Project Team within 24 hours.



Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Sample Receipt and Laboratory Quality Variances	Empirical Laboratories PM Resolution Consultants FTL Resolution Consultants TOM	Sonya Gordon Allison Bailey Jim Rathbone	615-345-1115 865-693-3623 513-621-7233	<p>The analytical laboratory PM will notify verbally or by e-mail the Resolution Consultants FTL immediately upon receipt of any chain-of-custody/sample receipt variances for clarification or direction from the FTL.</p> <p>The Resolution Consultants FTL will notify verbally or by e-mail the Resolution Consultants TOM within 1 business day, if corrective action is required.</p> <p>The Resolution Consultants TOM will notify verbally or by e-mail the analytical laboratory PM and the Resolution Consultants FTL within 1 business day of any required corrective action.</p>
Analytical Corrective Actions	Empirical Laboratories PM Resolution Consultants Project Chemist	Sonya Gordon Dana Miller	615-345-1115 901-937-4371	<p>The analytical laboratory PM shall notify the Resolution Consultants Project Chemist of any analytical data anomaly within 1 business day of discovery. After the analytical laboratory receives guidance from the Resolution Consultants Project Chemist, the laboratory shall initiate any corrective action to prevent further anomalies.</p>
Analytical Data Quality Issues	Empirical Laboratories PM Resolution Consultants Project Chemist Resolution Consultants TOM Navy RPM	Sonya Gordon Dana Miller Jim Rathbone Howard Hickey	615-345-1115 901-937-4371 513-621-7233 847-688-2600, ext. 243	<p>The analytical laboratory PM will notify verbally or by e-mail the Resolution Consultants Project Chemist within 1 business day of when an issue related to analytical laboratory data is discovered. The Resolution Consultants Project Chemist will notify the Resolution Consultants TOM within 1 business day.</p> <p>The Resolution Consultants Project Chemist will notify the Resolution Consultants TOM verbally or by e-mail within 48 hours of validation completion that a non-routine and significant analytical laboratory quality deficiency has been detected that could affect this project and/or other projects. The Resolution Consultants TOM will verbally advise the Navy RPM within 24 hours of notification from the Project Chemist. The Navy RPM will take corrective action appropriate for the identified deficiency. If there are significant data quality or non-useable data issues, the Navy QAO/Chemist will be contacted to ensure the issues do not have the potential to impact other Navy projects.</p>
Reporting Data Validation Issues/ Data Validation Corrective Actions	Resolution Consultants Project Chemist Resolution Consultants TOM	Dana Miller Jim Rathbone	901-937-4371 513-621-7233	<p>The Resolution Consultants Project Chemist or Data Validator will perform validation as specified in Worksheets #34, #35, and #36, and will contact the analytical laboratory as soon as possible if issues are found that require corrective action.</p> <p>If the Resolution Consultants Project Chemist or Data Validator identifies non-usable data during the data validation process that requires corrective action, the Resolution Consultants TOM will coordinate with the Project Chemist to take corrective action appropriate for the identified deficiency to ensure the project objectives are met. Corrective action may include resampling and/or reanalyzing the affected samples, as determined by the TOM.</p>



Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Notification of Non-Usable Data	Empirical Laboratories PM Resolution Consultants Project Chemist Resolution Consultants TOM Navy RPM IDEM RPM	Sonya Gordon Dana Miller Jim Rathbone Howard Hickey Doug Griffin	615-345-1115 901-937-4371 513-621-7233 847-688-2600, ext. 243 317-233-2710	<p>If the analytical laboratory determines that any data they have generated is non-usable, the analytical laboratory PM will notify verbally or by e-mail the Resolution Consultants Project Chemist within 1 business day of when the issue is discovered.</p> <p>The Resolution Consultants Project Chemist will notify verbally or by e-mail the TOM within 1 business day of the need for corrective action, if the non-usable data is a significant issue (i.e., critical sample data). Corrective action may include resampling and/or reanalyzing the affected samples.</p> <p>If a Resolution Consultants Project Chemist or Data Validator identifies non-usable data during the data validation process, the TOM will be notified verbally or via e-mail within 48 hours of validation completion that a non-routine and significant analytical laboratory quality deficiency has resulted in non-usable data.</p> <p>The Resolution Consultants TOM will take corrective action appropriate for the identified deficiency to ensure the project objectives are met. The TOM will notify the Navy RPM verbally or by email on any problems with the analytical laboratory or analysis that could significantly affect the usability of the data or project failures that impact the ability to complete the scope of work. The Navy RPM, may, at his discretion, contact the Navy QAO/Chemist for assistance in problem resolution. Such notification will be made within 1 business day of when the issue is discovered. The Navy RPM will notify IDEM when any significant corrective action is taken.</p>

Notes:

- DQO = Data quality objective
- FTL = Field team leader
- HSO = Health and safety officer
- IDEM = Indiana Department of Environmental Management
- NSA = Naval Support Activity
- PM = Project Manager
- QAO = Quality assurance officer
- RPM = Remedial project manager
- SAP = Sampling and Analysis Plan
- SSO = Site safety officer
- TOM = Task order manager



SAP WORKSHEET #9: PROJECT PLANNING SESSION PARTICIPANTS SHEET

(UFP-QAPP Manual Section 2.5.1)

NSA Crane, Solid Waste Management Unit (SWMU) 10 is under a long-term monitoring (LTM) program covered by Resource Conservation and Recovery Act (RCRA) Permit IN5170023498 which has oversight from the Indiana Department of Environmental Management (IDEM). A project planning session was not required for this SAP.



SAP WORKSHEET #10: CONCEPTUAL SITE MODEL

(UFP-QAPP Manual Section 2.5.2 — Worksheet #10)

10.1 Background/Site History

NSA Crane is located in a rural, sparsely populated region of south-central Indiana (Figure 10-1). Most of the facility is located in Martin County, and a small portion is distributed among Greene, Daviess, and Lawrence Counties. NSA Crane encompasses approximately 62,463 acres and most is forested; the surrounding area is wooded or farmland. The facility was opened in 1941 as the Naval Ammunition Depot, to serve as an inland munitions production and storage center.

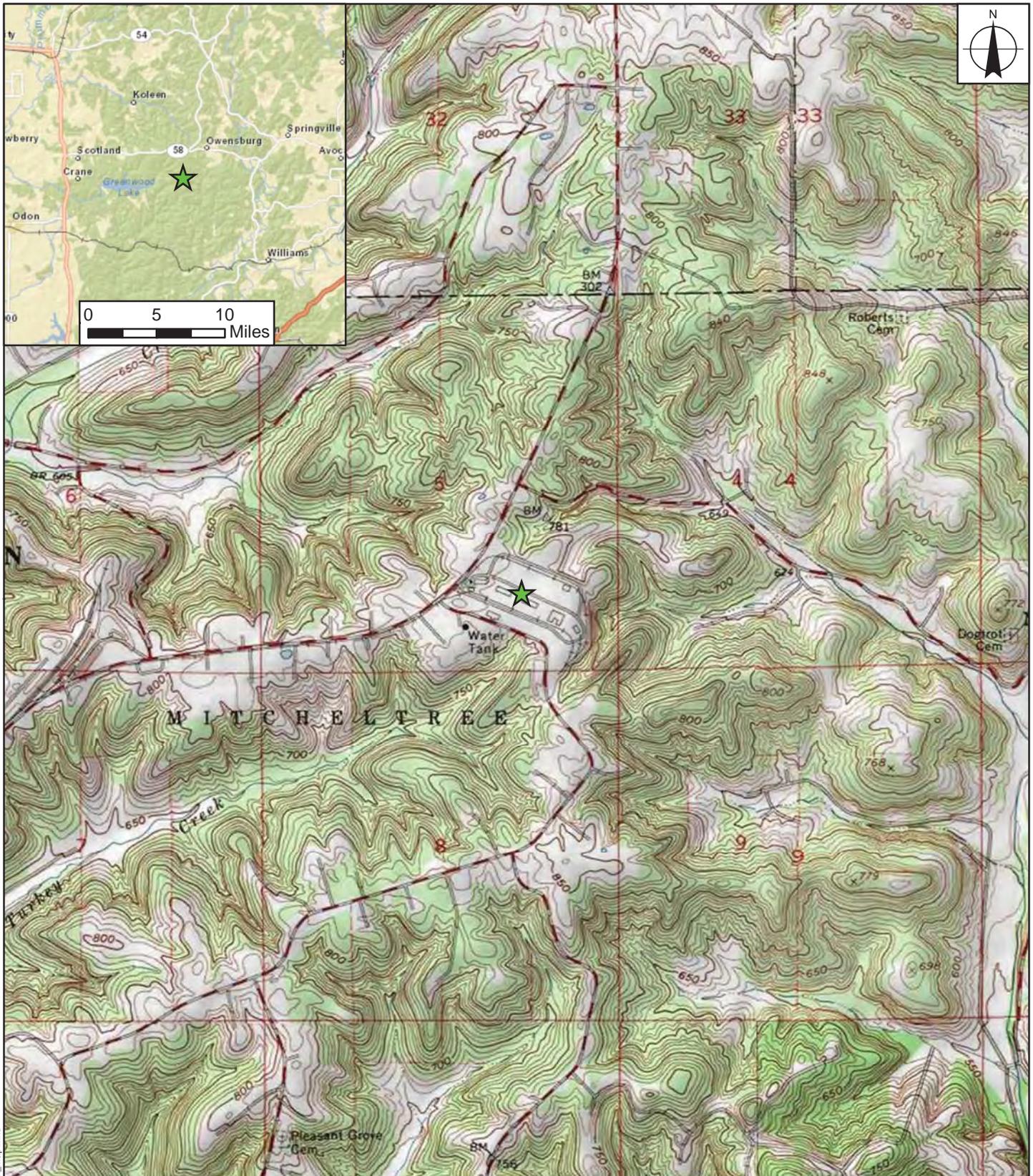
10.1.1 SWMU 10, Rockeye

SWMU 10 is located just east of and adjacent to Highway 45 in the northeastern quadrant of NSA Crane (Figure 10-2). The SWMU is relatively flat and spans an area of about 10 acres. To the northeast, east, and south the terrain recedes sharply to lower elevations. Drainage ditches in SWMU 10 ultimately lead to either Sulphur Creek, located east of the SWMU, or Turkey Creek, which is located west of the SWMU. The closest distance from SWMU 10 to the NSA Crane property boundary is approximately 1 mile to the northeast.

The Rockeye facility opened in the mid-1950s as a press loading operation for 3-inch projectiles, for which Composition A-3 (RDX and wax) was used.¹ This was changed in the late 1960s to case filling operations for Rockeye cluster bombs, which contained a blend of Octol Type II and Composition B high explosives. Current operations include loading, assembling, and packing of cast-load explosive items, renovation and painting of projectiles, and disassembly/demilitarization of munitions. Explosives-contaminated water is currently treated onsite to remove contamination. However, in the past, wastewater was collected in sumps for offsite treatment, and occasional overload of the sumps discharged wastewater to tributaries of nearby creeks; these discharges were eliminated in 1978 after installation of the onsite treatment facility.

Past operations at SWMU 10 resulted in the release of explosives, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs) to soil, sediments, and groundwater. Interim measures activities removed the identified source of contamination — soil and sediment.

¹ RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine



Legend

★ SITE LOCATION

1 inch = 2,000 feet



FIGURE 10-1
 SITE LOCATION MAP
 SWMU 10 - ROCKEYE
 NAVAL SUPPORT ACTIVITY CRANE
 CRANE, INDIANA



REQUESTED BY: L. HUGHES

DATE: 4/16/2014

DRAWN BY: B. LIPSCOMB

PROJECT: 0888815047

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To Inset →

FIGURE 10-2
 SITE MAP
 SWMU 10 - ROCKEYE
 NAVAL SUPPORT ACTIVITY CRANE
 CRANE, INDIANA

REQUESTED BY: L. HUGHES
 DRAWN BY: B. LIPSCOMB
 DATE: 4/25/2014
 PROJECT NO: 0888815047



- Legend**
- Downgradient Wells (Lower Pennsylvanian or Golconda/Haney)
 - Upper-Middle Pennsylvanian Aquifer Well
 - Lower Pennsylvanian Aquifer Well
 - Mississippian Big Clifty Aquifer Well
 - Unconsolidated Aquifer Well
 - Monitoring Well; Aquifer Not Identified
 - Wells to Be Sampled
 - Surface Water to Be Sampled
 - Installation Boundary
 - Road
 - Surface Water Sample Location

Some well aquifer data were not available.
 Other aquifer data were available but
 contained discrepancies in previous documents



X:\Navy\NSA_Crane\Wells_To_Be_Sampled_V2.mxd

The *Corrective Measures Implementation Plan/Quality Assurance Project Plan for SWMU 10 — Rockeye* (SAIC 2010) indicates groundwater corrective measures which must be conducted include:

- LTM of groundwater. Groundwater is monitored to confirm that explosives-related contamination concentrations are reduced to less than media cleanup standards (MCSs) via natural attenuation mechanisms, to verify the explosives-related groundwater contaminant plume is not migrating, and to ensure the land-use controls (LUCs) remain effective at preventing human exposure to contaminated groundwater. If groundwater or surface water contamination concentrations are not reduced to less than MCSs within 20 years (i.e., 2028), then the remedy should be re-evaluated to ensure it remains protective of human health and the environment. Preliminary estimations indicated the remediation timeframe may be greater than 100 years.
- Limited surface water monitoring is also required to determine if contaminants are entering the stream downgradient of the former SWMU 10 contaminant source.
- LUCs have been implemented for SWMU 10.
- Periodic site reviews. Seven-year site reviews will be conducted to verify the long-term reliability and effectiveness of this corrective action and to provide direction for potential further remedial action. The first seven-year review is due in 2015; see Worksheet #14 for details.

Sampling at SWMU 10 is conducted biennially and samples are analyzed using a prescribed chemical list for explosives of concern. The NSA Crane RCRA Permit number is IN5170023498.

10.2 Site Geology and Hydrology

The subsurface geology at NSA Crane is generally characterized by thin overburden deposits overlying bedrock. The overburden deposits range in depth from the ground surface down to approximately 5 to 20 feet below ground surface and generally consist of two types: Pleistocene-age unconsolidated deposits and unconsolidated residual soils derived from the decomposition of underlying bedrock. This portion of Indiana was not glaciated, so there are no glacial deposits in evidence at NSA Crane. Bedrock underlying NSA Crane consists of sedimentary rocks from the Lower Pennsylvanian and the Upper Mississippian.

The bedrock underlying SWMU 10 consists of Pennsylvanian shale, sandstone, siltstone, and coal in thin, laterally discontinuous layers, overlaying the massive Mississippian sandstone and limestone units. The natural unconsolidated material overlying the bedrock consists of weathered Pennsylvanian soils and averages ten feet in thickness.

Groundwater occurs between approximately 6 and 25 feet beneath SWMU 10. Groundwater is encountered in three distinct units: clay overburden, shale, and sandstone. Wells included in the LTM program are installed in the Upper/Middle Pennsylvanian, Lower Pennsylvanian, and Big Clifty (Mississippian). A Lower Pennsylvanian well is the deepest well included in the LTM program and it has a total depth of 78.5 feet deep. The Big Clifty wells are approximately 3,000 feet downstream of the northeast end of the contaminant plume.

The flow direction in the Upper/Middle Pennsylvanian aquifer is to the east and southeast. The flow direction for the Lower Pennsylvanian aquifer is mainly to the northeast. The flow direction in the Big Clifty is not known because there are only two wells. Explosives contamination in groundwater extends in a triangular-shaped pattern from the northeast perimeter of SWMU 10 starting near well 10C33P2 and extending to the northeast slightly beyond wells 10C56 and 10C57 (Figure 10-2).

A surficial drainage channel bisects the SWMU 10 groundwater plume area from southwest to northeast; contaminated surface water has the potential to migrate rapidly downstream and contaminate groundwater further downstream where the topography flattens and surface water percolates into the ground. The surface water, with its potential explosives contamination, migrates downstream to the area near Big Clifty wells 10-01 and 10-02 (Figure 10-2). The LTM program surface water sample locations are spread around SWMU 10 in steeply banked drainage ditches or downstream in Sulphur Creek. During the 2012 LTM sampling event, six of the seven surface water sample locations were dry.

10.3 Groundwater Conceptual Site Model

The conceptual site model for SWMU 10 is shown on Figure 10-3. A monitoring well network is in place to assess impacts to groundwater and includes wells screened in multiple zones (Upper/Middle Pennsylvanian, Lower Pennsylvanian, and Big Clifty). The network includes wells in the source area and downgradient of the source area. The aquifer units and locations with respect to the source area for the SWMU 10 wells are:

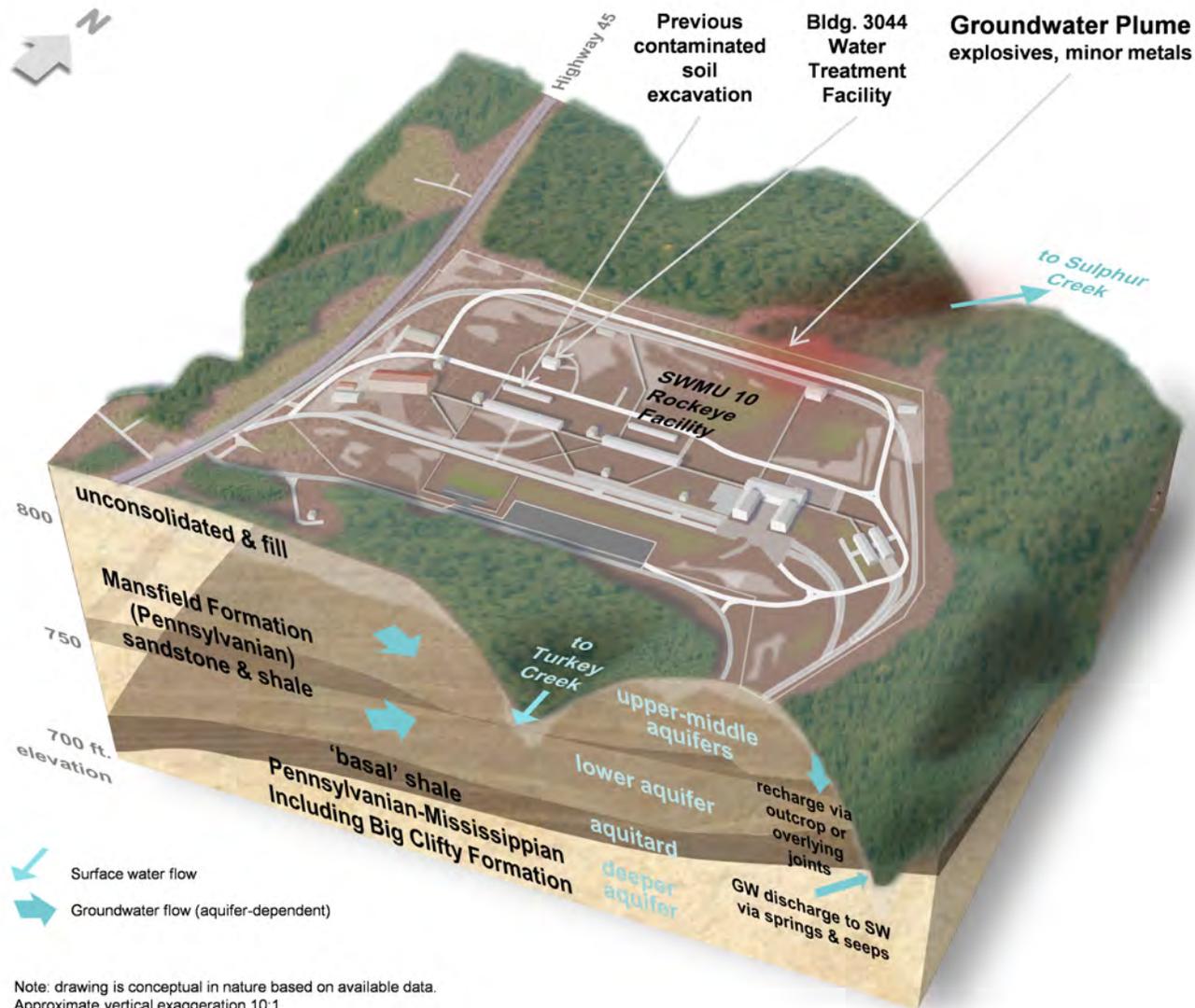


FIGURE 10-3
 SWMU 10 SITE CONCEPTUAL MODEL
 NAVAL SUPPORT ACTIVITY CRANE
 CRANE, INDIANA



REQUESTED BY: L. HUGHES

DATE: 4/22/2014

DRAWN BY: L. HUGHES

PROJECT: 0888815047



Area	Upper/Middle Pennsylvanian	Lower Pennsylvanian	Big Clifty
Source Area	10-07, 10-08, 10-17, 10-18, 10-21, 10C55P2 ^[1]	10C49, 10C55	
Downgradient	10C49P2	10C48, 10C56, 10C57	10-01, 10-02

Note:

¹ Existing well 10C55P2 will be abandoned and a new well labeled 10R62 will be installed.

10.4 Exposure Pathways and Potential Receptors

Past operations at SWMU 10 resulted in the release of explosives, VOCs, and SVOCs to soil and groundwater. Since contaminated soil and sediment have been removed, groundwater and surface water are the primary media of interest to monitor to determine if explosives-related contamination is reduced to less than MCSs, to verify the groundwater contaminant plume is not migrating, and to ensure LUCs are effective at preventing human exposure to contaminated groundwater. Groundwater contamination is limited to an area in the northeast portion of SWMU 10.

NSA Crane is currently surrounded by a chain-link-fence and is accessible only through vehicular traffic gates. SWMU 10 is approximately one mile southwest of the nearest NSA Crane property boundary. The current industrial land-use is expected to remain unchanged in the near future. Potential receptors (base workers, authorized base visitors, temporary residents, construction/maintenance workers, and permitted game hunters) have no known exposure to the groundwater. Unacceptable levels of risk have been identified for select hypothetical human receptors using groundwater as potable water; however, it is unlikely groundwater at SWMU 10 would be used as a potable water source.

Contaminated surface water at SWMU 10 has the potential to migrate rapidly downstream and to contaminate groundwater further downstream, where the topography flattens and surface water percolates more readily into the ground. Evidence of this potential was observed in the early 1990s at Big Clifty wells 10-01 and 10-02. These wells are far downstream of SWMU 10, yet they exhibited detectable concentrations of RDX in 1992. To date, surface water at SWMU 10 has not been identified as posing unacceptable levels of risk to human or ecological receptors.

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

(UFP-QAPP Manual Section 2.6.1)

11.1 Problem Statement

Groundwater corrective measures at NSA Crane SWMU 10 include LTM of groundwater, LUCs, and periodic site reviews. Groundwater is monitored to confirm that explosives-related contamination concentrations are reduced to less than MCSs via natural attenuation mechanisms, to verify the explosives-related groundwater contaminant plume is not migrating, and to ensure the LUCs remain effective at preventing human exposure to contaminated groundwater. Additionally, limited surface water monitoring is conducted to determine if contaminants are entering the stream downgradient of the former SWMU 10 contaminant source. If groundwater or surface water contamination concentrations are not reduced to less than MCSs within 20 years (i.e., by 2028), then the remedy should be re-evaluated to ensure it remains protective of human health and the environment.

11.2 Identify the Objectives of the Study

The objectives of the study include monitoring groundwater wells and surface water locations:

- Monitor fourteen groundwater wells for explosives
- Monitor seven surface water locations for explosives
- Measure field parameters prior to collecting groundwater well samples to ensure stability
- Measure field parameters prior to collecting surface water well samples
- Measure and record groundwater levels to a precision of 0.01 foot in all wells in the same day

Table 11-1 provides a summary of the groundwater and surface water monitoring requirements.



Table 11-1

Summary of Groundwater and Surface Water Biennial Monitoring Requirements

Type of Program	Analytical Program (All Wells)			Monitoring Points		
Sampling/Objective	Parameter Type	Target Constituents	Objectives	Locations	Objectives	Evaluations to be Performed
Type: Corrective Action Monitoring Objectives: <ul style="list-style-type: none"> • Monitor groundwater to determine concentrations of explosives. • Monitor surface water to determine concentrations of explosives. 	Field	Groundwater and Surface Water <ul style="list-style-type: none"> • pH • Specific conductance • Dissolved oxygen • Oxidation-reduction potential • Temperature • Turbidity 	For groundwater, determine if the well water is equivalent to formation water (i.e., stability). For surface water, document conditions at the time of sample collection.	Source Area Wells: <ul style="list-style-type: none"> • 10-07, 10-08, 10-17, 10-18, 10-21, 10C49, 10C55P2 ^[2], 10C55 Downgradient Wells: <ul style="list-style-type: none"> • 10-01, 10-02, 10C48, 10C49P2, 10C56, 10C57 Surface Water Locations: <ul style="list-style-type: none"> • 10SW09, 10SW11, 10SW12, 10SW13, 10SW14, 10SW15, 10SW16 	Monitor quality of groundwater in three aquifers beneath or downgradient of SWMU 10. Monitor quality of surface water in the creeks and streams near SWMU 10 which represent the greatest potential for downgradient migration of the contaminant source.	Compare concentrations of target analytes to media cleanup standards for groundwater or surface water which were established in the <i>Corrective Measures Implementation Plan/Quality Assurance Project Plan for SWMU 10 — Rockeye</i> (SAIC 2010).
		Groundwater <ul style="list-style-type: none"> • Water level measurements 	Determine groundwater flow rate, direction, and aquifer characteristics.			
	Laboratory	Groundwater Wells <ul style="list-style-type: none"> • Explosives ^[a] 	Monitor constituents in groundwater indicating the presence of chemicals attributable to operations.			
	Surface Water <ul style="list-style-type: none"> • Explosives ^[1] 	Monitor constituents in surface water indicating the presence of chemicals attributable to operations.				

Notes:

¹ Explosive analyte list may be found in Worksheet #15. Analytical methods for all analytes may be found in Worksheet #19.

² Existing well 10C55P2 will be abandoned and a new well labeled 10R62 will be installed.

SWMU = Solid waste management unit

11.3 Inputs to Problem Resolution

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

1. Chemical Data — Biennial data for the analytes listed in Table 11-2 and Worksheet #15 from the monitoring wells and surface water locations listed in Worksheet #18 and shown on Figure 10-2. The relevant standard operating procedures (SOPs) for sampling monitoring wells and surface water are presented in Worksheet #21.
2. Groundwater Well Stabilization Parameters (using a water quality meter) — pH, specific conductance, dissolved oxygen (DO), oxidation-reduction potential (ORP), temperature, and turbidity.
3. Groundwater Level Measurements — Groundwater level measurements from each well and sampling event will be measured to a precision of 0.01 foot. Water levels will be collected from 14 monitoring wells during the biennial monitoring event within a 24-hour period.
4. Surface Water Quality Parameters (using a water quality meter) — pH, specific conductance, DO, ORP, temperature, and turbidity.
5. MCS and Project Action Levels — As indicated in Worksheet #10, MCSs have been developed for explosives in groundwater and surface water. These are shown in Table 11-2. Groundwater and surface water data will be compared to MCSs for data evaluation using the decision rules described in Section 11.5.

Table 11-2 Media Cleanup Standards — Groundwater and Surface Water			
Analyte	CAS Number	Media Cleanup Standards (micrograms per liter)	
		Groundwater	Surface Water
1,3,5-Trinitrobenzene	99-35-4	1100	11
1,3-Dinitrobenzene	99-65-0	1	1
2,4,6-Trinitrotoluene	118-96-7	2	2
2,4-Dinitrotoluene	121-14-2	73	1.1
2,6-Dinitrotoluene	606-20-2	5	5
2-Amino-4,6-Dinitrotoluene	35572-78-2	7.3	11
2-Nitrotoluene	88-72-2	0.049	71
3-Nitrotoluene	99-08-1	120	42
4-Amino-2,6-Dinitrotoluene	19406-51-0	7.3	18
4-Nitrotoluene	99-99-0	0.66	46
HMX	2691-41-0	400	220



Analyte	CAS Number	Media Cleanup Standards (micrograms per liter)	
		Groundwater	Surface Water
Nitrobenzene	98-95-3	3.4	17
RDX	121-82-4	2	2
Tetryl	479-45-8	360	360

Notes:

Media cleanup standards for groundwater and surface water were established in the *Corrective Measures Implementation Plan/Quality Assurance Project Plan for SWMU 10 — Rockeye* (SAIC 2010).

- µg/L = Micrograms per liter
- HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
- RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine
- Tetryl = Methyl-2,4,6-trinitrophenylnitramine

Worksheet #15 identifies the project action levels (PALs) currently identified based on the criteria defined above. The laboratory selected for current work and any laboratories selected for future work are expected to achieve limits of quantitation (LOQs) that are low enough to measure constituent concentrations less than the Worksheet #15 PAL. Analytical data reported by the laboratory will use the following reporting conventions:

- All concentrations less than the LOQ will be considered non-detects and will be reported as the LOQ value with a “U” qualifier.
- Concentrations between the limit of detection (LOD) and LOQ will be reported as estimated values with a “J” qualifier.
- In the event a target analyte has a Worksheet #15 PAL between the LOD and LOQ, the “J” flagged data will be accepted to achieve project goals.
- The inability to quantify select analytes to Worksheet #15 PALs with confidence will be addressed in the final report.

The complete list of applicable PALs are presented in Worksheet #15 and are identified to ensure laboratory sensitivity is sufficient to meet current standards.

11.4 Define the Study Boundaries

Spatial Boundaries: SWMU 10 covers 10 acres near the northeast boundary of NSA Crane (Figure 10-2). Groundwater of interest is the Upper/Middle Pennsylvanian, Lower Pennsylvanian, and Big Clifty aquifers. The groundwater intervals monitored during the study range from approximately 6 to 57 feet below ground surface. For surface water, the monitoring zone reach includes six sample locations within 3,000 feet of SWMU 10 and one sample location nearly 3.5 miles downstream of SWMU 10 at the NSA Crane property boundary. The designated surface water sampling points are shown on Figure 10-2.

Temporal Boundaries: Target analyte concentrations should be measured at all groundwater monitoring wells at approximately the same time to ensure samples are representative of the same timeframe. Groundwater conditions and target analytes are not expected to change significantly during a sampling event. The LTM program requires biennial groundwater and surface water sample collection. This LTM program will continue indefinitely as long as groundwater and surface water contaminants exceed MCSs. Evaluation of groundwater and surface water data will involve comparisons of target analyte concentrations to the MCSs found in Table 11-2.

11.5 Analytic Approach

Changes in target analyte concentrations will be monitored to determine whether continued monitoring or some other action is necessary. A direct comparison will be made of target analyte concentrations to MCSs, which are detailed in Table 11-2. All decision rules listed below must be evaluated after each round of sampling.

Decision Rule #1

IF all target analyte concentrations in every LTM well and surface water sampling location, as represented by the 80 percent upper confidence interval on the well-specific predictive trend lines, are less than MCSs and remain less than MCSs for four consecutive monitoring periods, **THEN** stop monitoring and proceed to site closure with IDEM approval. Otherwise continue monitoring. Trending methodology is discussed in Section 11.7. Detection limit values will be replaced by one-half the detection limit value to provide surrogate values for numerical calculations.

Decision Rule #2

IF target analyte concentration trends for LTM wells and surface water sampling locations begin to increase at any location by the first seven-year review and subsequent seven-year reviews, **THEN** re-evaluate the remedy. This evaluation requires at least six data points are available for any

individual well. The 2014 sampling event will be the fourth round of LTM at SWMU 10 and the first seven-year review will be conducted in 2015. Factors to consider for this evaluation include the following:

- What is the potential for imminent threat to human health and the environment? If threats are not imminent, there may be little reason to implement a change to the remedy.
- What is the expected future concentration trend? If a target analyte concentration trend appears to be increasing, consideration should be given to the amount of increase expected during the next seven-year monitoring period. Large increases will be stronger evidence than smaller increases that a change in the sampling program is warranted. Projections will be based on data analyses described in Section 11.7. If a transient spike is identified but the overall trend is expected to be decreasing to the MCSs, the need to implement a change in the remedy is lessened.
- Examine the potential for increasing trends to impact media other than groundwater.
- The changes likely to be considered for implementation include enhanced natural attenuation and other measures that can reverse increasing concentration trends.

Decision Rule #3

After the sixth sampling round (including Year 1, which is the first round), evaluate sampling frequencies. The objective will be to determine whether sampling frequency should be increased or decreased. **IF** data indicate a change is necessary, **THEN** change the sampling frequency.

Decision Rule #4

IF SWMU 10 land use changes in a manner to cause increased potential for exposure of humans or the environment to groundwater or surface water, **THEN** consider changes in LUCs and/or re-evaluate the remedy to determine whether the rates of target analyte concentration decreases can be enhanced. Changes to LUCs might, for example, limit the rate of groundwater usage.

Decision Rule #5

IF LUCs are determined to be ineffective at preventing human exposure to contaminated groundwater or surface water, **THEN** improve the effectiveness of the LUCs by adding more LUCs or changing

existing LUCs. **IF** changes in LUCs will not prevent this human exposure, **THEN** alter the remedy to be more protective of human health and the environment. Examples of such alterations include enhanced natural attenuation in the most highly contaminated areas of the groundwater plume.

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

Sampling Strategy

The sampling strategy at SWMU 10 is to monitor contamination in groundwater and surface water by collecting samples biennially from existing groundwater wells or surface water locations.

Sources of Error

Sources of error in the site investigations 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. 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.

Managing Decision Error

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

- Use standard field sampling methodologies
- Use applicable analytical methods and SOPs for sample analysis by a competent analytical laboratory certified by the Department of Defense (DoD) Environmental Laboratory Accreditation Program (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

Sampling Methodologies and Procedures

Possible decision errors generated by sampling errors will be minimized during the sampling events by applying standardized field sampling methodologies and SOPs listed on Worksheet #21 and provided in Appendix A.

Field Data Logs

All sample information will be transcribed into a field logbook and/or onto field datasheets.

Analytical Laboratory Sample Management

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 samples. Designated samples will be used to obtain necessary sub-samples for laboratory quality control (QC) measurements (i.e., analytical sample duplicates and sample matrix spike/matrix spike duplicates [MS/MSD]). Tasks will be completed using the laboratory SOPs, which will be available upon request.

Resolution Consultants will provide data validation services to verify and evaluate the usability of the data as identified in Worksheets #34 through #36.

PDF copies of all analytical data packages will be electronically stored and archived in the Naval Facilities Engineering Command (NAVFAC) Midwest Administrative Record. All other data generated in the field and reports generated for the project will be stored as computer readable data files by Resolution Consultants.

11.7 Sampling Design

Groundwater and surface water locations and the analyses to be conducted on each well are provided on Worksheets #18 and #15, respectively. The sampling program for the LTM program is biased to assess explosives concentrations in existing groundwater wells within and around the SWMU 10 plume. Given the biased sampling design, the following analysis approach has been developed to support the decision rules outlined in Section 11.5:

- Groundwater target analyte concentrations will be graphed over time to demonstrate temporal concentration trends. As discussed in Decision Rule #2, a minimum of six data points are required to obtain initial estimates of trends. All target analyte concentrations will be trended unless the results are predominantly below DLs. Trends for each well in the LTM program will be identified via visual inspection and best professional judgment, and



usually the detection of trends will not require the use of statistical or other tools. If the Navy and IDEM determine Mann-Kendall trend evaluations should be used, standard statistical references will be consulted for proper implementation.

- Target analyte degradation rates may be computed using the best-fit line through the analyte concentration data plotted against sampling date. Selection of linear or non-linear models will depend on whether the data appear to be non-linear as determined by the data analyst.
- Target analyte concentrations will be compared to MCSs to assess whether SWMU 10 data meet cleanup criteria. An 80 percent upper confidence interval for predictive trends will be used to estimate the time required to achieve MCSs by projecting the trend forward until the line intersects the MCS value. The decay rate will be obtained as a parameter of the best fit. The Navy will consult with IDEM to agree on the best trending methods and interpretations for the data associated with SWMU 10.



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	Measurement Performance Criteria
Equipment Rinsate Blanks	All	One per 20 field samples per matrix per sampling equipment ⁽¹⁾	Accuracy/Bias/Contamination	No analytes > 1/2 LOQ, except common lab contaminants, which must be < LOQ
Field Duplicates	All	One per 20 field samples	Precision	Values > 5X LOQ: RPD must be ≤ 30
Matrix Spike/Matrix Spike Duplicate	All	One per 20 field samples	Accuracy/Bias/Precision	Percent recoveries — DoD QSM Limits RPD must be ≤ 30
Cooler Temperature Indicator	All	One per cooler	Representativeness	Temperature less than 6 degrees Celsius

Notes:

- ¹ Equipment rinsate blanks will be collected if decontamination is required and will not apply if only dedicated equipment is used
- LOQ = Limit of quantitation
- DoD QSM = Department of Defense Quality Systems Manual
- QC = Quality control
- RPD = Relative percent difference



SAP WORKSHEET #17: SAMPLING DESIGN AND RATIONALE

(UFP-QAPP Manual Section 3.1.1)

Groundwater and surface water samples will be collected biennially at SWMU 10 as required by corrective action monitoring under the NSA Crane RCRA permit. The following is a summary of the sampling program:

- Fourteen groundwater monitoring wells will be sampled along with associated QC samples as shown on Worksheet #18.
- Seven surface water locations will be sampled.
- All samples will be analyzed for explosives. Worksheet #15 provides the specific analyte list to be analyzed by the laboratory.
- The following measurements will be performed in the field while purging groundwater monitoring wells and sampling surface water: pH, specific conductance, DO, ORP, temperature, and turbidity.
- Groundwater and surface water monitoring is required biennially.

Groundwater wells and surface water sample locations are shown on Figure 10-2.

All groundwater monitoring wells will be sampled using micropurge (low flow/low stress) sampling techniques as detailed in Resolution Consultants SOP-3-14 provided in Appendix A. This will generally include using a bladder pump to pump the well at a rate that will minimize drawdown; purge parameters are monitored concurrently for stabilization. Worksheet #19 specifies the required bottle types, preservation, target analytes, analytical methods, and holding times.

All surface water samples will be collected using a dip or grab sample method as detailed in Resolution Consultants SOP-3-10 provided in Appendix A. This will generally involve the use of a sample container or sampling device constructed of a nonreactive material. Worksheet #14 further discusses surface water sample collection techniques. Worksheet #19 specifies the required bottle types, preservation, target analytes, analytical methods, and holding times.

Monitoring well 10C55P2, which is about 11 feet deep, will be abandoned in accordance with 312 Indiana Administrative Code 13-10-2(e)(6) and performed by an Indiana licensed-well driller (Indiana Code



25-39-4). As much casing as possible will be pulled from the ground then the well or borehole will be filled from the bottom to the ground surface with either bentonite slurry or pelletized or coarse grade crushed bentonite. An abandonment plan will be provided to the Navy prior to field work and a completed abandonment form [State Form 35680 (R5/9-04)] will be provided to the Navy for submittal to the Indiana Department of Natural Resources.

A new 2-inch polyvinyl chloride well to replace monitoring well 10C55P2 will be installed in alluvium to a depth of approximately 11 feet. Access to the site is steep and difficult, so a small track-mounted rig will likely be required. The new well will be labeled 10R62. Borehole development will be performed by an Indiana-licensed well driller in accordance with Indiana Code 25-39-4. The new well will be surveyed by an Indiana-licensed surveyor. The well completion shall include the following: outer steel casing, lockable lid, 4 square-foot concrete pad, protective bollards, and a well completion report with a boring log, installation diagram, and vertical and horizontal survey coordinates.

SAP WORKSHEET #14: FIELD PROJECT TASKS

(UFP-QAPP Manual Section 2.8.1)

Field Project Implementation (Field Project Instructions)

The following project tasks are summarized below:

- Field Tasks
- Analytical Laboratory Tasks
- Data Management and Review
- Project Reports

Field Tasks

Mobilization/Demobilization — Mobilization includes procurement of field equipment and supplies; a site walkover; mobilization of field staff, equipment, and supplies to the site; and site set-up. The NSA Crane PM will be notified of Resolution Consultants' mobilizations a minimum of one week before the start of field activities. If fieldwork will include intrusive activities, the NSA Crane PM will be notified at least 14 days in advance of site access to initiate the utility clearance process.

A field team orientation meeting will be conducted prior to starting the fieldwork to familiarize team personnel with the site-specific health and safety requirements, the objectives and scope of the field activities, and chain-of-command. This meeting will be attended by the field staff and conducted by the field team leader.

A site walkover will be conducted prior to field activities. The field team will identify related field support areas and requirements. Locations of the wells to be sampled are provided in Figure 10-2.

Demobilization includes removing field equipment and supplies from the site, returning rented equipment, managing investigation derived waste, performing general site cleanup, organizing and finalizing field paperwork, and entering field records/data into the database.

Inspection of Existing Monitoring Wells — Before each monitoring well is sampled; a brief inspection will be conducted:

- Inspect the protective casing and the condition of the cement seal surrounding the protective casing
- Note the presence of any standing water around the protective casing

- Inspect any dedicated sampling equipment
- Determine static water level
- Determine well total depth; check to determine if the well is obstructed
- Assess the presence/absence of immiscible layers
- Evaluate well security

Comparisons will be made between baseline conditions and sampling date conditions to determine whether significant changes have occurred that indicate well damage. When the well cap is opened prior to the static water level measurement, a reading of the ambient vapors within the well pipe will be taken using a photoionization detector to determine if VOCs are present within the well above background levels (as detailed in SOP-3-20). A record of all field observations will be maintained in a field logbook and recorded on a Monitoring Well Inspection Form (a blank form is included with SOP-3-24).

Site Wide Water Level Measurements — A coordinated round of water level measurements will be conducted as part of each groundwater sampling event before purging and sampling activities are conducted using SOP-3-14. Water level measurements will be completed within the shortest time possible, within 24 hours, and recorded to the nearest 0.01 foot (referenced to a top-of-casing mark, or if the mark is absent, to the north side of the top of the well casing). The measurement instrument will be decontaminated prior to conducting the measurement event and between each monitoring well. Groundwater measurements will be recorded on the Well Development and Groundwater Sampling Form (a blank form is included with SOP-3-24).

Well Abandonment — One monitoring well will be abandoned in accordance with state regulations and SOP-3-15.

Well Installation and Surveying — A new 2-inch polyvinyl chloride groundwater monitoring well will be installed to replace the abandoned monitoring well. The new well will be surveyed by a state licensed surveyor, so the well can be included in groundwater flow diagrams. Well installation and surveying will be performed in accordance with state regulations and using SOP-3-12 and SOP-3-07.

Well Development — The newly installed monitoring well will be developed prior to purging and collecting a groundwater sample. Well development will be performed according to state regulations and using SOP-3-13.

Groundwater Sampling — Water samples will be collected on a biennial basis as follows.

- Groundwater samples will be collected using SOP-3-14.
- Complete all applicable forms (Well Development and Groundwater Sampling form, sampling logs, Safe Work Assessment Permit) on a daily basis.
- Review health and safety plan with field sampling crews.
- Groundwater Level Measurements:
 - Water levels will be measured prior to the start of purging activities to obtain an initial (pre-sampling) water level. 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 measurements in each well.
- Collecting Groundwater Samples:
 - Groundwater samples will be collected using a bladder pump and dedicated Teflon or Teflon-lined tubing from existing wells according to the U.S. Environmental Protection Agency (U.S. EPA) micropurge (low flow/low stress) sampling protocol (tubing-in-screen method). Compressed nitrogen gas will be used to pressurize the bladder pump. Water quality measurements will be made concurrently with water level measurements. The pump will be connected to Teflon discharge tubing dedicated to the well.
 - Field measurements of pH, specific conductance, DO, ORP, temperature, and turbidity will be made every 3 to 5 minutes per SOP-3-24. Once parameters are stable, water samples will be obtained using the same pump and flow rate. If the water-quality parameters do not stabilize, 3 to 5 well volumes will be purged from the well (unless the well is pumped dry) and then the well will be sampled using low-flow techniques per SOP-3-14.
 - The sample naming scheme will be in accordance with the established convention for this site. See Worksheet #18 for wells to be sampled, designated sample identifications, and analyses.

- Monitoring well locations are shown on Figure 10-2.
- Worksheet #19 specifies the required bottle types, preservation, target analytes, analytical methods, and holding times for this investigation.

Surface Water Sampling — Surface water samples will be collected on a biennial basis as follows.

- Surface water samples will be collected using SOP-3-10. Surface sample locations are a mixture of accessible and remote areas. Depending on water depths, all surface water samples will be collected from the edge of the creek or stream in as deep a pocket of water as possible. Based on past LTM sampling, several of the surface water locations have been dry.
- Complete all applicable forms (field sampling form, Safe Work Assessment Permit) on a daily basis.
- Review health and safety plan with field sampling crew.
- Surface water will be collected using a dip or grab sample method. A sample container will be filled by submerging it just below the surface to avoid disturbing and/or stirring streambed sediment. The container's mouth should face upstream while the sample personnel are downstream of the container. Preservative should be added after sample collection. Alternately, a sampling device constructed of a nonreactive material, such as Teflon or stainless steel (with or without a pour spout and handle), can be used as a transfer device following the submerging technique.
- Field measurements of pH, specific conductance, DO, ORP, temperature, and turbidity should be measured and recorded from roughly the same area and same depth as the surface water sample location immediately after a sample has been collected. The field measurement readings will not affect when or if a surface water sample is collected.
- The sample naming scheme will be in accordance with the established convention for this site. See Worksheet #18 for locations, designated sample identifications, and analyses.
- Surface water sample locations are shown on Figure 10-2.
- Worksheet #19 specifies the required bottle types, preservation, target analytes, analytical methods, and holding times for this investigation.

Field Quality Control Tasks — Field QC samples will be collected as part of each sample round, including field duplicates and trip blanks. In addition, extra sample volume will be collected for the laboratory QC analysis of MS/MSD analysis. Equipment rinse blanks will be collected only when decontamination is required and will not be collected if only dedicated equipment is used. Worksheet #20 presents the field QC sample summary.

Decontamination — The decontamination procedures presented in SOP-3-06 will be followed. Non-disposable equipment that comes into contact with the sample medium will be decontaminated to prevent cross-contamination between sampling points. Water level indicators will be sprayed with de-ionized water and wiped with clean paper towels between use in each well.

Investigation Derived Waste — Investigation derived waste includes excess environmental media, decontamination fluid, used personal protective equipment, used disposable sampling equipment, and other materials. In general, wastes will be segregated by media (water, solids, personal protective equipment). Liquid wastes generated during the site activities will be disposed in accordance with SOP-3-05A-CRANE. Liquids will be temporarily stored in portable buckets before being transported to Building 3245 for disposal into a sanitary sewer drain. Nitrile gloves and plastic sheeting that have come in contact with sampling equipment and decontamination water are anticipated to have little to no contact with contaminated water; therefore, gloves and plastic sheeting will be double-bagged and disposed in a collection bin.

Analytical Laboratory Tasks

Chemical analysis of groundwater will be performed by a subcontracted laboratory, Empirical Laboratories, LLC. Empirical Laboratories is DoD ELAP-accredited and their certificate is provided in Appendix B. Analyses will be performed in accordance with the analytical methods specified in Worksheet #19. Empirical Laboratories will strive to meet the project action levels as shown in Worksheet #15 and will perform chemical analyses following laboratory-specific SOPs cited on Worksheet #23.

Data Management and Review

The principal data generated for this project will be from field data and laboratory analytical data. 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 field logbooks for this project will be used only for this Site, and will also be categorized and maintained in the project files after the completion of the field program. All project records will be maintained in a secure location.

Data Tracking — The Resolution Consultants Task Order Manager, or designee, is responsible for the overall tracking and control of data generated for the project. Data are tracked from generation to archiving in the project specific files. The Project Chemist, or designee, is responsible for tracking the samples collected and shipped to the contracted laboratory. Upon receipt of the data packages from the analytical laboratory, the Project Chemist will oversee the data validation effort, which includes verifying the data packages are complete and results for all samples have been delivered by the analytical laboratory.

Resolution Consultants shall submit all Administrative Record Files, Site Files, and Post Decision Files in accordance with the specifications defined in the NAVFAC *Environmental Restoration Recordkeeping Manual* (September 2009). Additionally, Resolution Consultants will update and manage the project related documents, data, maps, and associated data in the Naval Installation Restoration Information Solution (NIRIS) database. All documentation submittals for NIRIS will be coordinated with the Navy Remedial Project Manager.

Data Storage, Archiving, and Retrieval — After the data are validated, the data packages are entered into the Resolution Consultants file system and archived in secure files. The field records including field logbooks, sample logs, chain-of-custody records, and field calibration logs will be submitted by the Resolution Consultants Field Team Leader to be entered into the file system before archiving in secure project files. Project files are audited for accuracy and completeness. Project files will be kept in a secured, limited access area. At the completion of the Navy contract, files will be shipped to the Federal Records Center for storage where the files will remain until 50 years after the last decision document for the facility.

Data Security — Access to Resolution Consultants project files is restricted to designated personnel only. The Resolution Consultants Data Manager maintains the electronic data files and access to the data files is restricted to qualified personnel only. File and data backup procedures are routinely performed.

Electronic Data — Laboratory data, provided in electronic format, will be verified for accuracy prior to use and during the data validation process. After data are validated, the electronic data results will be uploaded into the Resolution Consultants database for use in data evaluation and subsequent report preparation. The project database will be on a password-protected secure network and access to changing data files will be restricted to qualified personnel. The Resolution Consultants Task Order Manager (or designee) is responsible for the overall tracking and control of data generated for

the project. All final electronic data and administrative records will be compiled and uploaded into the NIRIS database for final repository. Additionally, validated analytical data shall be uploaded within 60 days of collecting the last sample to the IDEM Office of Land Quality electronic database.

Data Review and Validation — After receipt of analytical laboratory results, Resolution Consultants will verify data completeness as specified on Worksheet #34. To ensure that the analytical results meet the project quality objectives, the laboratory data will undergo verification and validation as cited in Worksheets #34 through #36 and described below.

Prior to data validation, electronic laboratory data will be verified for accuracy against the hardcopy laboratory report and the electronic quality assurance project plan (eQAPP) will be established using the project-specific criteria defined in Worksheets #12, #19, and #28. The laboratory will be requested to resubmit electronic data found to be inaccurate.

During the data validation process, the Resolution Consultants Data Validation Assistant (DVA) tool will be used to review method accuracy and precision data from field and laboratory QC samples contained in the laboratory electronic data deliverable and to qualify that data according to the project-specific eQAPP. The DVA tool uses EarthSoft's EQuIS relational database to assemble a series of Excel worksheets into a DVA workbook for the validator that present:

- Data validation QC elements that need review, compared to control limits stored in the project-specific eQAPP
- Associated sample results for duplicated samples and blanks
- A place to make the necessary qualifications and result updates directly into an electronic format documentation of qualifications using coded reasons
- A list of all samples affected by the qualification

Laboratory calibration will be assessed against the criteria presented in the DoD Quality Systems Manual using the hardcopy laboratory report; the results of these findings will be added to the Excel DVA workbook. The DVA workbook is used to update the project database with the validator's changes, eliminating the manual data entry process and allowing for 100 percent of data to be reviewed prior to uploading to the project database.



For this LTM program the comparisons of upgradient and downgradient target analyte concentrations are not anticipated because the ultimate goal is to ensure target analyte concentrations eventually decrease to less than MCSs. All target analytes detected in groundwater and surface water are assumed to originate at SWMU 10. However, the upgradient conditions may be useful for establishing baseline geochemical conditions if consideration of natural degradation of target analytes becomes significant

Project Reports

The anticipated deliverables included under this task are a report detailing the findings of each biennial LTM sampling event. Resolution Consultants will prepare responses to comments from Navy and IDEM reviewers.

Every seventh year a Seven-Year Review Report will be prepared to evaluate the long-term reliability and effectiveness of the LTM program and to provide direction for further remedial action, if deemed necessary, or if sampling and LUCs are no longer required. Additionally, seven-year reviews will be conducted to evaluate whether or not the selected remedies remain protective of human health and the environment. The first seven-year review will be performed in 2015 within 6 months of the end of the seventh year of monitoring (2014).



SAP WORKSHEET #21: FIELD SOPS REFERENCE TABLE

(UFP-QAPP Manual Section 3.1.2)

SOP Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Location of SOP (if not included in the SAP)	Modified for Project Work? (Yes/No)	Comments
SOP-3-02	Logbooks, May 2012	Resolution Consultants	Appendix A	No	
SOP-3-03A	Sample Labeling and Chain of Custody, August 2012	Resolution Consultants	Appendix A	No	
SOP-3-04A	Sample Handling, Storage and Shipping Procedures of Low Level Environmental Samples, May 2012	Resolution Consultants	Appendix A	No	
SOP-3-05A-Crane	Investigative Derived Waste Management, February 2014	Resolution Consultants	Appendix A	Yes	
SOP-3-06	Equipment Decontamination, May 2012	Resolution Consultants	Appendix A	No	No organic solvents will be used in decontamination process.
SOP-3-07	Land Surveying, August 2012	Resolution Consultants	Appendix A	No	
SOP-3-10	Surface Water Sampling, August 2012	Resolution Consultants	Appendix A	No	
SOP-3-12	Monitoring Well Installation, May 2012	Resolution Consultants	Appendix A	No	
SOP-3-13	Monitoring Well Development, June 2012	Resolution Consultants	Appendix A	No	
SOP-3-14	Monitoring Well Sampling, May 2012	Resolution Consultants	Appendix A	No	
SOP-3-15	Monitoring Well Abandonment, June 2012	Resolution Consultants	Appendix A	No	
SOP-3-20	Operation and Calibration of a Photoionization Detector	Resolution Consultants	Appendix A	No	
SOP-3-24	Water Quality Parameter Testing for Groundwater Sampling, May 2012	Resolution Consultants	Appendix A	No	

Notes:

- SOP = Standard operating procedure
- SAP = Sampling and analysis plan



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)

Empirical Laboratories, LLC 621 Mainstream Drive Nashville, Tennessee 37228 615-345-1115, Sonya Gordon, sgordon@empirlabs.com				Analysis Group:		Explosives	
				Analytical Method:		SW-846 8330B	
				Laboratory SOP Reference:		SOP 327	
				Data Package Turnaround Time:		21 days	
				Container Type/Volume Required:		2-1 liter glass amber	
				Preservative:		Cool 0 to 6°C	
				Holding Time:		7 days until extraction/ 40 days extraction to analysis	
SWMU	Matrix	Well ID	Sample ID {Well ID-MMY}	X	Y	Frequency	
10	Groundwater	10-01	10-01-MMY	3048397.78	1327710.95	Biennial	1
10	Groundwater	10-02	10-02-MMY	3048428.58	1327653.03	Biennial	1
10	Groundwater	10-07	10-07-MMY	3044829.18	1327744.25	Biennial	1
10	Groundwater	10-08	10-08-MMY	3044800.71	1327754.20	Biennial	1
10	Groundwater	10-17	10-17-MMY	3045087.38	1327922.84	Biennial	1
10	Groundwater	10-18	10-18-MMY	3045027.83	1327941.19	Biennial	1
10	Groundwater	10-21	10-21-MMY	3044898.51	1327872.41	Biennial	1
10	Groundwater	10C55	10C55-MMY	3044979.14	1327823.92	Biennial	1
10	Groundwater	10C49P2	10C49P2-MMY	3045131.52	1327753.23	Biennial	1
10	Groundwater	10C48	10C48-MMY	3044798.84	1327915.73	Biennial	1
10	Groundwater	10C49	10C49-MMY	3045131.79	1327757.72	Biennial	1
10	Groundwater	10C56	10C56-MMY	3045260.53	1328213.85	Biennial	1
10	Groundwater	10C57	10C57-MMY	3045381.31	1328068.78	Biennial	1
10	Groundwater	10R62	10R62-MMY	TBD	TBD	Biennial	1
10	Surface Water	10SW09	SW09-MMY	3042893	1327351	Biennial	1
10	Surface Water	10SW11	SW11-MMY	3044108	1326730	Biennial	1
10	Surface Water	10SW12	SW12-MMY	3043682	1326110	Biennial	1
10	Surface Water	10SW13	SW13-MMY	3045293	1328142	Biennial	1
10	Surface Water	10SW14	SW14-MMY	3047034	1327133	Biennial	1
10	Surface Water	10SW15	SW15-MMY	3048319	1327683	Biennial	1
10	Surface Water	10SW16	SW16-MMY	3054540	1311818	Biennial	1
10	Field Duplicate	TBD	TBD	TBD	TBD	Biennial	2



Empirical Laboratories, LLC 621 Mainstream Drive Nashville, Tennessee 37228 615-345-1115, Sonya Gordon, sgordon@empirlabs.com				Analysis Group:		Explosives	
				Analytical Method:		SW-846 8330B	
				Laboratory SOP Reference:		SOP 327	
				Data Package Turnaround Time:		21 days	
				Container Type/Volume Required:		2-1 liter glass amber	
				Preservative:		Cool 0 to 6°C	
				Holding Time:		7 days until extraction/ 40 days extraction to analysis	
SWMU	Matrix	Well ID	Sample ID {Well ID-MMY}	X	Y	Frequency	
10	MS	TBD	TBD	TBD	TBD	Biennial	2
10	MS	TBD	TBD	TBD	TBD	Biennial	2
10	MSD	TBD	TBD	TBD	TBD	Biennial	2
10	MSD	TBD	TBD	TBD	TBD	Biennial	2
10	Equipment Blank	Not Applicable	EBMMDDYY	NA	NA	Biennial	1
Total Number of Samples to the Laboratory (minus MS/MSDs):							24

Notes:

Equipment rinse blanks will be collected if decontamination is required and will not apply if dedicated equipment is used.

- °C = Degrees Celsius
- ID = Identification
- EBMMDDYY = Equipment Blank, Month (MM), day (DD), year (YY), (e.g., EB030114 for 1 March 2014)
- mL = Milliliters
- MMYY = Month (MM), year (YY), (e.g., 0314 for March 2014)
- MS = Matrix spike
- MSD = Matrix spike duplicate
- NA = Not applicable
- SOP = Standard operating procedure
- SWMU = Solid Waste Management Unit
- TBD = To be determined; field duplicates and matrix spike/matrix spike duplicates will be determined in the field



SAP WORKSHEET #15: REFERENCE LIMITS AND EVALUATION TABLES

(UFP-QAPP Manual Section 2.8.1)

Matrix:		Groundwater and Surface Water						
Analytical Group:		Explosives (SW-846 8330B)						
Analyte	CAS No.	Project Action Level (µg/L)		Project Action Source ⁽¹⁾ (µg/L)	Project Quantitation Limit Goal (µg/L)	Laboratory Limit of Quantitation ⁽²⁾ (µg/L)	Laboratory Limit of Detection ⁽²⁾ (µg/L)	Laboratory Method Detection Limit ⁽²⁾ (µg/L)
		GW	SW					
1,3,5-Trinitrobenzene	99-35-4	1100	11	MCS	3.7	0.32	0.16	0.08
1,3-Dinitrobenzene	99-65-0	1	1	MCS	0.3	0.32	0.16	0.08
2,4,6-Trinitrotoluene	118-96-7	2	2	MCS	0.7	0.32	0.16	0.08
2,4-Dinitrotoluene	121-14-2	73	1.1	MCS	0.4	0.32	0.16	0.08
2,6-Dinitrotoluene	606-20-2	5	5	MCS	1.7	0.32	0.16	0.08
2-Amino-4,6-Dinitrotoluene	35572-78-2	7.3	11	MCS	2.4	0.32	0.16	0.08
2-Nitrotoluene	88-72-2	0.049	71	MCS	0.02	0.32	0.16	0.08
3-Nitrotoluene	99-08-1	120	42	MCS	14	0.32	0.16	0.08
4-Amino-2,6-Dinitrotoluene	19406-51-0	7.3	18	MCS	2.4	0.32	0.16	0.08
4-Nitrotoluene	99-99-0	0.66	46	MCS	0.2	0.32	0.16	0.08
HMX	2691-41-0	400	220	MCS	73.3	0.32	0.16	0.08
Nitrobenzene	98-95-3	3.4	17	MCS	1.1	0.32	0.16	0.08
RDX	121-82-4	2	2	MCS	0.7	0.32	0.16	0.08
Tetryl	479-45-8	360	360	MCS	120	0.32	0.16	0.08

Notes:

¹ Media cleanup standards for groundwater and surface water are project-specific goals taken from *Corrective Measures Implementation Plan/Quality Assurance Project Plan for SWMU 10 — Rockeye*, (SAIC 2010).

² Laboratory limit of quantitation, limit of detection, and method detection limits are provided by Empirical Laboratories, and may vary during the course of long-term monitoring.

shaded = Laboratory detection and quantitation limits are above the project action level. Therefore, the detection limit will be used to compare against the project action level.

µg/L = Micrograms per liter

CAS = Chemical Abstract Services
 GW = Groundwater
 HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
 MCS = Media cleanup standards
 RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine
 SW = Surface water
 Tetryl = Methyl-2,4,6-trinitrophenylnitramine



SAP WORKSHEET #23: ANALYTICAL SOP REFERENCES TABLE

(UFP-QAPP Manual Section 3.2.1)

Laboratory Name and Address: Empirical Laboratories, LLC, 621 Mainstream Drive, Suite 270, Nashville, Tennessee 37228 Laboratory Point of Contact/Project Manager: Sonya Gordon, sgordon@empirlabs.com, 615-345-1115						
Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to Quality Systems Manual	Modified for Project Work? (Yes/No)
SOP 327	<i>Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC) Method 8330, 8330A, 8330B and 8332 41677 Rev25 02/07/14</i>	Definitive	Groundwater and Surface Water Explosives (SW-846 8330B)	High performance liquid chromatograph	None	No

Note:

SOP = Standard operating procedure



SAP WORKSHEET #28: LABORATORY QC SAMPLES TABLE

(UFP-QAPP Manual Section 3.4)

Matrix:		Groundwater and Surface Water				
Analytical Group:		Explosives				
Analytical Method:		SW-846 8330B				
SOP Reference:		SOP 327				
QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicators	Measurement Performance Criteria
Method Blank	One per preparatory batch of 20 samples or less	No analytes detected > 1/2 LOQ 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 > LOQ. (see Box D-1 in QSM V4.2).	Correct problem; reanalyze any sample associated with a blank that fails criteria.	Analyst, Supervisor, QA Manager	Bias, Contamination	See Method/SOP QC Acceptance Limit Column
Surrogates	All field and QC samples	1-Chloro-3-nitrobenzene percent recovery 40%-145%	Reanalyze if sufficient sample is available. If reanalysis confirms failing recoveries, report and narrate.	Analyst, Supervisor, QA Manager	Accuracy, Bias	QC acceptance criteria specified in DoD QSM Version 4.2 See Method/SOP QC Acceptance Limit Column
LCS	One LCS per preparatory batch of 20 samples or less	QC acceptance criteria specified in DoD QSM Version 4.2. ⁽¹⁾	Correct problem. If the LCS recoveries are high but the sample results are <LOQ narrate. Otherwise, re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst, Supervisor, QA Manager	Accuracy, Bias	QC acceptance criteria specified in DoD QSM Version 4.2 See Method/SOP QC Acceptance Limit Column
Internal Standards	In all field samples and standards	Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard or daily CCV.	Inspect mass spectrometer or gas chromatograph for malfunctions. Reanalyze all samples with internal standard failures. If reanalysis confirms matrix interference, report sample and narrate.	Analyst, Supervisor, QA Manager	Accuracy, Bias	Retention time ± 30 seconds; EICP area within -50% to +100% of midpoint of ICAL



Matrix:		Groundwater and Surface Water				
Analytical Group:		Explosives				
Analytical Method:		SW-846 8330B				
SOP Reference:		SOP 327				
QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicators	Measurement Performance Criteria
MS/MSD	One per preparatory batch per matrix of 20 samples or less	For matrix evaluation, use LCS recovery criteria; RPD \leq 30%.	Contact the client to determine if additional measures are required.	Analyst, Supervisor, QA Manager	Accuracy, Bias, Precision	For matrix evaluation, use LCS recovery criteria; RPD \leq 30%.

Notes:

¹ Department of Defense Quality Systems Manual Version 4.2 may be updated to Version 5.0 after the laboratory has been audited and accredited for the updated version. Therefore, acceptance and measurement performance criteria will change to reflect the new version during the course of this project.

- CCV = Continuing calibration verification
- DoD QSM = Department of Defense Quality Systems Manual
- EICP = Extracted ion current profile
- ICAL = Initial calibration
- LCS = Laboratory control sample
- LOQ = Limit of quantitation
- MS/MSD = Matrix spike/matrix spike duplicate
- QA = Quality assurance
- QC = Quality control
- RPD = Relative percent difference
- SOP = Standard operating procedure



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)	Step I/IIa/IIb ⁽¹⁾	Internal/External ⁽²⁾
Verification Chain-of-custody forms Sample Login/Receipt	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. Verification of sample login/receipt and chain-of-custody forms will be documented on the laboratory sample receipt form.	Laboratory sample custodians and analysts	I	Internal
Verification Chain-of-custody forms	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. Verification of chain-of-custody forms will be documented in the DVA workbook.	Project Chemist or Data Validators, Resolution Consultants	I	External
Verification SAP sample tables	Verify that all proposed samples listed in the SAP tables have been collected. Sample completeness will be documented in the data validation report.	FTL or designee, Resolution Consultants	I	Internal
Verification Sample log sheets and field notes	Verify that information recorded in the log sheets and field notes are accurate and complete. Sample log sheet verification will be documented by dated signature on the last page or page immediately following the review material.	FTL or designee, Resolution Consultants	I	Internal
Verification Field QC samples	Check that field QC samples, described in Worksheet #12 and listed in Worksheet #20, were collected as required. QC sample completeness will be documented in the data validation report.	FTL or designee, Resolution Consultants	I	Internal
Verification Analytical data package	Verify all analytical data packages will be verified internally for completeness by the laboratory performing the work. The laboratory PM (or designee) will sign the case narrative for each data package. All laboratory data package reviews will be documented in the laboratory narratives.	Laboratory PM	I	Internal
Verification Analytical data package	Verify the data package for completeness. Missing information will be requested from the laboratory and validation (if performed) will be suspended until missing data are received. Data package completeness will be documented in the DVA workbook.	FTL, Project Chemist, or Data Validators, Resolution Consultants	I	External
Verification Electronic data deliverables	Verify the electronic data against the chain-of-custody and hard copy data package for accuracy and completeness before loading into project database. Electronic data deliverable verification will be documented in the DVA workbook.	Data Manager and/or Validator, Resolution Consultants	I	External
Validation 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. Chain-of-custody verification will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa	External



Data Review Input	Description	Responsible for Verification (name, organization)	Step I/ IIa/IIb ⁽¹⁾	Internal/ External ⁽²⁾
Validation 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. Holding time examination will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa	External
Validation 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. Representativeness will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation 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. Accuracy will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation 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 Worksheets #12 and 28. Precision will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation 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 action limit achievement will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation 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. Result qualification will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation 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. QC sample documentation will be documented in the DVA workbook and data validation report	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External
Validation Analytical data deviations	Determine the impact of any deviation from sampling or analytical methods, and laboratory SOP requirements and matrix interferences effect on the analytical results. Data deviations will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIb	External



Data Review Input	Description	Responsible for Verification (name, organization)	Step I/ IIa/IIb ⁽¹⁾	Internal/ External ⁽²⁾	
Validation Project quantitation limits for sensitivity	Ensure that the project detection limits were achieved. Project quantitation limit achievement will be documented in the DVA workbook and data validation report.	Project Chemist or Data Validators, Resolution Consultants	IIb	External	
Validation Explosives	Assess organic analytical data against MPC identified in Worksheets #12, #19, and #28. U.S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, (October 1999) will be used as a guidance on applying qualifiers when MPC identified in Worksheets #12, #19, and #28 are not met, including identifying when samples will be qualified estimated or rejected and when individual or all samples in a batch will be qualified. Validation will be limited to reviewing laboratory quality control summary information and raw data will not be reviewed.	Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External	
Validation Data qualifiers	Qualifiers that will be applied during the data validation process are summarized below and, as indicated, results will be considered usable unless qualified by an R-flag.				
	Data Qualifier	Qualifier Definition	Interpret Result As a Detection?	Result Usable?	Potential Result Bias
	no qualifier	Acceptable	Yes	Yes	None expected
	J	Estimated	Yes	Yes	High or Low
	U	Undetected	No	Yes	None expected
	UJ	Undetected and Estimated	No	Yes	High or Low
	UR	Undetected and Rejected	No	No	Unspecified
R	Rejected	No	No	Unspecified	
		Project Chemist or Data Validators, Resolution Consultants	IIa/IIb	External	

Notes:

- ¹ IIa Compliance with methods, procedures, and contracts [see Table 10, page 117, UFP-QAPP manual, V.1, March 2005.]
- ¹ IIb Comparison with measurement performance criteria in the SAP [see Table 11, page 118, UFP-QAPP manual, V.1, March 2005]
- ² Internal or external (independent) from the data generation activities
- DVA = Data Validation Assistant
- FTL = Field team leader
- LCS/LCSD = Laboratory control sample/laboratory control sample duplicate
- MS/MSD = Matrix spike/matrix spike duplicate

- MPC = Measurement performance criteria
- PM = Project manager
- QC = Quality control
- RPD = Relative percent difference
- SAP = Sampling and analysis plan
- SOP = Standard operating procedure
- UFP-QAPP = Uniform Federal Policy-Quality Assurance Project Plan
- U.S. EPA = U.S. Environmental Protection Agency

Appendix A
Standard Operating Procedures

Logbooks

Procedure 3-02

1.0 Purpose and Scope

- 1.1 This standard operating procedure (SOP) describes the activities and responsibilities pertaining to the identification, use, and control of logbooks and associated field data records.
- 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 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.

3.0 Terms and 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 Training and Qualifications

- 4.1 The **Contract Task Order (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** 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.
- 4.2 A knowledgeable individual such as the **Field Manager, CTO Manager, or Program Quality 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.
- 4.3 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.
- 4.4 The **Field Manager** is responsible for ensuring that all **field personnel** follow 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 (if required by the CTO Statement of Work).
- 4.5 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.

4.6 All **field personnel** are responsible for the implementation of this procedure.

5.0 Equipment and Supplies

5.1 Field logbooks shall be bound field notebooks with water-repellent pages.

5.2 Pens shall have indelible black ink.

6.0 Procedure

6.1 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.

6.2 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 of all samples collected in the logbook even if they are recorded elsewhere.

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

6.4 Typical information to be entered includes the following:

- Dates (month/day/year) and times (military) of all on-site activities and entries made in logbooks/forms;
- Site name and description;
- Site location by longitude and latitude, if known;
- Weather conditions, including temperature and relative humidity;
- 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 on-site personnel;
- Photograph references;
- Site sketches and diagrams made on site;
- Identification and description of sample morphology, collection locations, and sample numbers;
- 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;

- 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; and
- User signatures.

6.5 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.

6.6 At least at the end of each day, the person making the entry shall sign or initial each entry or group of entries.

6.7 Enter logbook page numbers on each page to facilitate identification of photocopies.

6.8 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.

6.9 At least weekly and preferably daily, the **preparer** shall photocopy and retain the pages completed during that session for backup. This will prevent loss of a large amount of information if the logbook is lost.

7.0 Quality Control and Assurance

7.1 Review per Section 4.2 shall be recorded.

8.0 Records, Data Analysis, Calculations

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

8.2 Deviations from this procedure shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

9.0 Attachments or References

9.1 Attachment 1 – Description of Logbook Entries

9.2 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.

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue

Attachment 1

Description of Logbook Entries

Logbook entries shall be consistent with Section A.1.4 *Field Documentation SOPs* of the UFP-QAPP Manual (DoD 2005) and contain the following information, as applicable, for each activity recorded. Some of these details may be entered on data forms, as described previously.

Name of Activity	For example, Asbestos Bulk Sampling, Charcoal Canister Sampling, Aquifer Testing.
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 Numbers	Indicate the unique numbers 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.
Chain of Custody and Distribution	Indicate chain-of-custody 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)	<p>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.</p> <p>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.</p>
Recorded by	Include the signature of the individual responsible for the entries contained in the logbook and referenced forms.
Checked by	Include the signature of the individual who performs the review of the completed entries.

Sample Labeling and Chain of Custody Procedures

Procedure 3-03A

1.0 Purpose and Scope

- 1.1 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.
- 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

Not applicable

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 Training and Qualifications

- 4.1 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 at the completion of each sampling event.
- 4.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.
- 4.3 The **Field Manager** is responsible for ensuring that all field equipment is decontaminated according to this procedure.
- 4.4 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.
- 4.5 All **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 Procedure

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 date. 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
GS	Soil gas	WB	Brackish Water

**Table 1
Navy Matrix Codes**

Matrix Code	Matrix Code Description	Matrix Code	Matrix Code Description
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

**Table 2
Navy Sample Type Codes**

Sample Type Code	Sample Type Code Description
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 References and Attachments

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.

Attachment 1: Chain-of-Custody Seal

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

Author	Reviewer	Revisions (Technical or Editorial)
Tina Cantwell QA Officer	Ben Brantley Project Manager	Rev 0 — Initial Issue

Attachment 1
Chain-of-Custody Seal

EXAMPLE CHAIN-OF-CUSTODY SEAL

[LABORATORY]	SAMPLE NO.	DATE	SEAL BROKEN BY
	SIGNATURE		DATE
	PRINT NAME AND TITLE (<i>Inspector, Analyst or Technician</i>)		

Attachment 2
Example Chain-of-Custody/Analytical Request Form

Sample Handling, Storage, and Shipping of Low Level Environmental Samples

Procedure 3-04A

1.0 Purpose and Scope

- 1.1 This Standard Operating Procedure (SOP) sets forth the methods for use by personnel engaged in handling, storing, and transporting low level environmental samples.
- 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 To avoid lifting injuries associated with heavy coolers, use the large muscles of the legs, not the back. Use dollies if possible.
- 2.2 When using tools for cutting purposes, cut away from yourself. The use of appropriate, task specific cutting tools is recommended.
- 2.3 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.

3.0 Terms and Definitions

DOT — Department of Transportation

4.0 Training and Qualifications

- 4.1 The **Contract Task Order (CTO) Manager** is responsible for verifying that these procedures are performed prior to the initiation of active subsurface exploration.
- 4.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.
- 4.3 The **Field Manager** is responsible for ensuring that sample handling, storage, and shipping are performed in accordance with this procedure.
- 4.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.0 Procedures

5.1 Handling and Packaging

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.
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.

5.2.2 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 all copies of chain of custodies and air bills with the project file. .

7.0 Attachments or 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.

Author	Reviewer	Revisions (Technical or Editorial)
Ben Brantley Program Manager	Tina Cantwell QA Officer	Rev 0 — Initial Issue

Standard Operating Procedure SOP-3-05A-CRANE
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:

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

The waste handling procedures will vary according to project-specific and facility requirements. Those specified in this Standard Operating Procedure (SOP) are unique to Naval Support Activity (NSA) Crane in Crane, Indiana. Additional procedures from Resolution Consultants, state, and/or federal regulations that are not addressed in this SOP and that are applicable may be added as an appendix to the project-specific Uniform Federal Policy-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 for Quality Assurance Project Plans (Department of Defense, 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 Manager and the Quality Assurance 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,

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 the NSA Crane Project Manager (PM) and, if applicable, the facility receiving the waste. Waste disposal facilities have specific requirements. Waste characterization shall be conducted to support both applicable regulations and facility requirements.

3.0 RESPONSIBILITY

The Contract Task Order Manager is responsible for overseeing and ensuring 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 will be used for handling IDW at NSA Crane.

4.1 Soil Waste

Excess solid material generated during soil and sediment sampling will be returned to the sample hole and tamped. If insufficient soil is available to fill a hole to ground surface, then bentonite pellets or chips will be mixed with the soil to backfill the hole and the material hydrated with potable water. Excess sediment sample material will be returned to the point of collection. The disposition of excess sediment will be carried out in such a manner as to not contribute to further environmental degradation or pose a threat to public health or safety. If gross contamination is encountered during soil or sediment sampling, the material will be containerized and securely staged pending arrangements for proper disposal. An inventory containing the source, volume, and description of grossly contaminated soil or sediment shall be documented in the field logbook.

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 documented in the field logbook.

If analytical data indicate that the waste meets the non-hazardous criteria characteristics and is below U.S. Environmental Protection Agency (U.S. EPA) Residential Regional Screening Levels, the soil will be spread at the area where it was generated, with approval of the NSA Crane PM. Soil will be seeded, covered with straw, and, if necessary, hay bales will be placed around the perimeter of the soil pile.

A sketch of sample locations shall be made in the field logbook. Upon receipt of the analytical data, a summary table of any detected contaminants shall be created with the appropriate screening/regulatory standards for documenting the final disposition of the soil IDW.

In the rare event soil waste is deemed hazardous or poses a residential risk based on detected contaminants, the disposal of any soil waste shall be coordinated directly with the NSA Crane PM. The NSA Crane PM or their designee will sign all waste disposal applications and waste manifests.

4.2 Waste Water

Waste water generated during groundwater monitoring well development, purging, and sampling will be collected in 5-gallon buckets, drums, and/or portable storage tanks. Liquid wastes generated from site activities including decontamination fluids from sampling equipment will be containerized in drums for analysis and disposal. Containers holding waste water awaiting analysis must be labeled, properly secured, and staged until analysis is complete and coordinated with the NSA Crane PM.

In the rare event waste water is deemed hazardous based on detected contaminants, the disposal of any waste water shall be coordinated directly with the NSA Crane PM. The NSA Crane PM or their designee will sign all waste disposal applications and waste manifests.

Typically, waste water generated during groundwater monitoring well sampling events is discharged to the NSA Crane sanitary sewer system at a drain inlet identified by the NSA Crane PM. Discharge dates and volumes shall be recorded in the field logbook and incorporated into the appropriate project-specific report.

4.3 Personal Protective Equipment and Incidental Trash

PPE and non-media solid waste (i.e., empty bags, supply containers, waste paper, trash) generated during the investigation shall be decontaminated (if contaminated), double bagged in plastic garbage bags, securely tied shut, and placed in a designated waste receptacle at NSA Crane.

4.4 Drum Handling

Soil or waste water destined for offsite disposal shall be containerized in U.S. Department of Transportation-approved drums. The drums shall be made of steel, have a 55-gallon capacity, and be completely painted. Soil drums shall have removable lids (i.e., United Nations Code 1A2 or 1H2), and liquid drums shall have closed-top lids. For short-term storage of non-hazardous IDW, reconditioned drums are acceptable for use. Verify the integrity of the foam or rubber sealing ring located on the underside of drum lids prior to sealing drums. 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 pending analysis.

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

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

The following labeling requirements shall be adhered to for all hazardous waste containers:

- Description of waste (i.e., purge water, soil cuttings) including waste code number
- Contact information including generator name, address, and telephone number

- U.S. EPA identification number (supplied by NSA Crane PM)
- Accumulation start date

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 including generator name, address, and telephone number
- Accumulation start date

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

Solid, liquid, or PPE wastes generated during investigation activities that are classified as hazardous shall not be accumulated on the site longer than 90 days. All waste deemed hazardous or drummed nonhazardous waste requiring offsite shipment will be staged temporarily at a location identified by the NSA Crane PM. Any waste destined for offsite disposal shall be coordinated with the NSA Crane PM. At a minimum, the following requirements for hazardous waste storage 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 must be used to contain spills.

- Spill containment equipment must be available.

- Fire extinguisher must be available.

- Adequate aisle space must be afforded for unobstructed movement of personnel.

Resolution Consultants will generate an inventory of all drums staged at the conclusion of field activities and their classification (hazardous versus nonhazardous) and the quantity will be provided to the NSA Crane PM. Any hazardous waste proposed for transport will be conducted by a state-certified hazardous waste hauler. Typically, the facility receiving waste can coordinate a hauler to transport the waste. Hazardous waste shall be disposed of in accordance with all Resource Conservation and Recovery Act, U.S. EPA, and State of Indiana requirements. All waste manifests or bills of lading will be signed by the NSA Crane PM or designee 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, Title 40, Part 261
- Code of Federal Regulations, Title 49, Parts 172, 173, 178, and 179

6.0 RECORDS

All containerized IDW shall be documented in the field logbook.

7.0 REFERENCES

Department of Defense, United States. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. Department of Defense: 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 2005. Online updates available at:
http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Equipment Decontamination

Procedure 3-06

1.0 Purpose and Scope

- 1.1 This standard operating procedure (SOP) describes methods of equipment decontamination, to be used for activities where samples for chemical analysis are collected or where equipment will need to be cleaned before leaving the site or before use in subsequent activities.
- 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

It is the responsibility of the **Site Safety Officer (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. Typically, for equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing cleaning solvents as described in this procedure or the Contract Task Order (CTO) Work Plan (WP) 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.

All **Field Personnel** responsible for equipment decontamination must adhere to the site-specific health and safety plan (HSP) and must wear the personal protective equipment (PPE) specified in the site-specific HSP. 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 on site. If safe alternatives are not achievable, discontinue site activities immediately.

In addition to the aforementioned precautions, the following sections describe safe work practices that will be employed.

2.1 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 HSP 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.

2.2 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.

3.0 Terms and Definitions

None.

4.0 Training and Qualifications

- 4.1 The **CTO Manager** is responsible for 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.
- 4.2 The **Program Quality Manager** is responsible for ensuring overall compliance with this procedure.
- 4.3 The **Field Manager** is responsible for ensuring that all field equipment is decontaminated according to this procedure.
- 4.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.0 Procedure

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, 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:

- Location where the decontamination procedures will be conducted
- Types of equipment requiring decontamination
- Frequency of equipment decontamination
- Cleaning technique and types of cleaning solutions appropriate to the contaminants of concern
- Method for containing the residual contaminants and wash water from the decontamination process
- Use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsections describe 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 contamination 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 rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and shall be properly disposed of 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 by sampling groundwater 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 can be 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 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; (4) rinse with deionized or distilled water; and (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.

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.

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 the CTO WP.

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 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 items, such as auger flights, which can be placed on metal stands or other similar equipment, on this equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Store clean equipment in a separate location to prevent recontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers as described below.

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 on site in secured containers, such as U.S. Department of Transportation-approved drums, until their disposition is determined by laboratory analytical results. Label containers in accordance with Procedure 3-05, *IDW Management*.

6.0 **Quality Control and Assurance**

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.

7.0 **Records, Data Analysis, Calculations**

Any project where sampling and analysis is performed shall be executed in accordance with an approved sampling and analysis plan. This procedure may be incorporated by reference or may be incorporated with modifications described in the plan.

Deviations from this procedure or the sampling and analysis plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Manager**.

8.0 **Attachments or References**

- 8.1 ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites*. ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.
- 8.2 NAVSEA T0300-AZ-PRO-010. *Navy Environmental Compliance Sampling and Field Testing Procedures Manual*. August 2009.
- 8.3 Procedure 3-05, *IDW Management*.

Author	Reviewer	Revisions (Technical or Editorial)
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue

Land Surveying

Procedure 3-07

1.0 Purpose and Scope

- 1.1 The purpose of this document is to define the standard operating procedure (SOP) for acquiring land surveying data to facilitate the location and mapping of geologic, hydrologic, geotechnical data, and analytical sampling points and to establish topographic control over project sites.
- 1.2 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).
- 1.3 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. 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 surface water sampling then those procedures may be added as an appendix to the project specific SAP.
- 1.4 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Program Quality Manager. Deviations to this SOP will be documented in the field records.
- 1.5 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 land surveying then those procedures may be added as an appendix to the project specific Sampling and Analysis Plan (SAP).

2.0 Safety

- 2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to conducting fieldwork. All **field sampling personnel** must review the project-specific health and safety plan (HASP) paying particular attention to the control measures planned for the specific field tasks. Conduct preliminary area monitoring to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor and liquid phase through the use of respirators and disposable clothing.
- 2.2 In addition, observe standard health and safety practices according to the project-specific HASP. Suggested minimum protection includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves, rubberized steel-toed boots, and an American National Standards Institute-standard hard hat. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations, and shall always be available on site.
- 2.3 Daily safety briefs will be conducted at the start of each working day before any work commences. These daily briefs will be facilitated by the **Site Safety Officer (SSO)** or designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the HASP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.
- 2.4 The health and safety considerations for the work associated with land surveying include:
 - Slip, trips and falls associated with work in the field;

- Biological hazards associated with work in the field; and,
- Potential hazards associated with contaminants of concern (COC) that may be located in the survey area,

3.0 Terms and Definitions

3.1 Boundary Survey

Boundary surveys are conducted by Certified Land Surveyors in order to delineate a legal property line for a site or section of a site.

3.2 Global Positioning System (GPS)

A system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

4.0 Interferences

- 4.1 Commercially available GPS units typically have a level of precision of (\pm) 3 to 5 meters. Field corrections can be made as described in Section 8.3 below.

5.0 Training and Qualifications

5.1 Qualifications and Training

- 5.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

- 5.2.1 The **Contract Task Order (CTO) Manager** is responsible for ensuring that land surveying activities comply with this procedure. The CTO Manager is responsible for ensuring that all field sampling personnel involved in land surveying 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 (FM)** is responsible for ensuring that all field personnel follow these procedures. In virtually all cases, subcontractors will conduct these procedures. The FM or designee is responsible for overseeing the activities of the subcontractor and ensuring that sampling points and topographic features are properly surveyed.

6.0 Equipment and Supplies

- 6.1 The following equipment list contains materials that may be needed in carrying out the procedures outlined in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.
- Personal protective equipment (PPE) and other safety equipment, as required by the HASP;
 - Commercially available GPS unit; and,
 - Field Logbook.

7.0 Calibration or Standardization

- 7.1 An authorized manufacturer's representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than six months prior to the start of the survey work.
- 7.2 Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (\pm) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (\pm) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (\pm) 0.01 feet.

8.0 Procedure

8.1 Theodolite/Electronic Distance Measurement (EDM)

Follow the procedures listed below during theodolite/EDM land surveying conducted under the NAVFAC CLEAN Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- Reference surveys to the local established coordinate systems and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- Reference surveyed points to Mean Sea Level (Lower Low Water Level).
- Jointly determine appropriate horizontal and vertical control points prior to the start of survey activities. If discrepancies in the survey (e.g., anomalous water level elevations) are observed, the surveyor may be required to verify the survey by comparison to a known survey mark. If necessary, a verification survey may be conducted by a qualified third party.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified by the project Work Plan or SAP.
- Begin and end all surveys at the designated horizontal and vertical control points to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and paint.
- Clearly mark the point on a monitoring well casing or well riser that is surveyed by filing grooves into the casing/riser on either side of the surveyed point, or by marking the riser with a permanent ink marker.

8.2 Global Positioning System (GPS) to Conduct Land Survey

Follow the procedures listed below during land surveying using GPS:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- Reference surveys to the local established coordinate systems and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.

- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified in the project Work Plan or SAP.
- Begin and end all surveys at the designated horizontal and vertical control points (as applicable) to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

8.3 **Global Positioning System (GPS) to Position Sample Locations or Locate Site Features**

Experienced field personnel may use a GPS system unit to position sample locations (e.g. grid positioned samples, soil boring locations) at a site. The decision to use field personnel or a licensed land surveyor will depend on the objectives of the survey (e.g. vertical elevation is not required) and the levels of precision required. Typically when a level of precision greater than (\pm) 3 to 5 meters is required, a licensed surveyor will be required. When a level of precision of (\pm) 3 to 5 meters is sufficient to meet project requirements (i.e. when laying sampling grids, identifying significant site features, or locating features identified in GIS figures) experienced field personnel may use commercially available, consumer-grade GPS units. Follow the procedures listed below to locate samples or site features using GPS:

- A commercially available GPS unit with Wide Angle Averaging System (WAAS), topographic map display, and waypoint storage capabilities should be used.
- If waypoints are to be imported into a GIS database, the same grid projection system should be used.
- If a permanent reference point near the site is available, it is recommended that a waypoint at this location be taken every day waypoints are stored.
- When laying out a sampling grid from a GIS map, upload the coordinates from GIS to the GPS unit, including coordinates for an easily identified, permanent, nearby feature (i.e. building corner, roadway intersection, or USGS benchmark).
- If during the initial site walk, the permanent feature identified does not overlay within (\pm) 5 meters as identified in the GPS unit, field corrections of the waypoints should be made.
- Field corrections can be made by adding/subtracting the difference in x,y coordinates between the field measurement of the permanent site feature and the anticipated x,y coordinates. This correction should then be applied to the x,y coordinates for each sampling location to be marked. Corrected x,y coordinates can then be uploaded into the GPS unit.
- Sampling points and site features can then be located in the field using the GPS units "Go To" function. When the distance to the sampling point or feature remains close to zero, the location can be marked.
- If no field corrections to the sampling location need to be made, or if sampling locations are to be surveyed by a licensed surveyor at a later date, no additional waypoints need to be taken. If significant changes to the sampling location are made, GPS coordinates at the corrected location shall be stored and labeled.

- It is recommended that GPS coordinates be uploaded to a storage device such as PC at the end of each day.
- Field logs shall indicate manufacturer and model number for GPS unit used, map datum and projection used, and any field corrections made. If the GPS unit cannot lock onto a WAAS system at the site, this should also be noted.

9.0 Quality Control and Assurance

None.

10.0 Data and Records Management

The surveyor shall record field notes daily using generally accepted practices. The data shall be neat, legible, in indelible ink, and easily reproducible. Copies of the surveyor's field notes and calculation forms generated during the work shall be obtained and placed in the project files.

Surveyor's field notes shall, at a minimum, clearly indicate:

- The date of the survey;
- General weather conditions;
- The name of the surveying firm;
- The names and job titles of personnel performing the survey work;
- Equipment used, including serial numbers; and,
- Field book designations, including page numbers.

A land surveyor registered in the state or territory in which the work was done shall sign, seal, and certify the drawings and calculations submitted by the surveyor.

Dated records of land surveying equipment calibration shall be provided by the surveyor and placed in the project files. Equipment serial numbers shall be provided in the calibration records.

11.0 Attachments or 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.

<i>Author</i>	<i>Reviewer</i>	<i>Revisions (Technical or Editorial)</i>
Robert Shoemaker Senior Scientist	Naomi Ouellette, Project Manager	Rev 0 – Initial Issue

Surface Water Sampling

Procedure 3-10

1.0 Purpose and Scope

- 1.1 The purpose of this document is to define the standard operating procedure (SOP) for use in sampling surface water. This SOP describes the equipment, field procedures, materials, and documentation procedures necessary to surface water samples from shallow and deep water using a variety of samplers. Specific information regarding coring locations can be found in the associated Sampling and Analysis Plan (SAP).
- 1.2 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).
- 1.3 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. 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 surface water sampling then those procedures may be added as an appendix to the project specific SAP.
- 1.4 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Program Quality Manager. Deviations to this SOP will be documented in the field records.

2.0 Safety

- 2.1 Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first surface water sampling location. All **field sampling personnel** responsible for sampling activities must review the project-specific health and safety plan (HASP) paying particular attention to the control measures planned for the sampling tasks. Conduct preliminary area monitoring to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor and liquid phase through the use of respirators and disposable clothing.
- 2.2 In addition, observe standard health and safety practices according to the project-specific HASP. Suggested minimum protection during well sampling activities includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves, rubberized steel-toed boots, and an American National Standards Institute-standard hard hat. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations, and shall always be available on site.
- 2.3 Daily safety briefs will be conducted at the start of each working day before any work commences. These daily briefs will be facilitated by the **Site Safety Officer (SSO)** or designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the HASP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.

- 2.4 The health and safety considerations for the work associated with surface water sampling include:
- Proper selection of personal protective equipment for work around water bodies (e.g., personal flotation devices [PFDs]), as specified in the project-specific HASP.
 - Appropriate health and safety protocols for working in a boat (if applicable), as specified in the project-specific HASP.
 - Proper lifting techniques when retrieving surface water samplers, large muscles of the legs should be used, not the back.
 - Stay clear of all moving equipment and avoid wearing loose fitting clothing.
 - To avoid slip/trip/fall hazards as a result of working on wet surfaces, wear work boots/work boot covers with textured soles.
 - To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended), and in cases of extreme cold, wear fitted insulated clothing

3.0 Terms and Definitions

None.

4.0 Interferences

None.

5.0 Training and Qualifications

5.1 Qualifications and Training

5.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

5.2 Responsibilities

- 5.2.1 The **Contract Task Order (CTO) Manager** is responsible for ensuring that surface water sampling activities comply with this procedure. The CTO Manager or designee shall review all surface water sampling forms on a minimum monthly basis. The CTO Manager is responsible for ensuring that all field sampling personnel involved in surface water 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 field sampling personnel follow these procedures.
- 5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure. Minimum qualifications for field sampling personnel require that one individual on the field team shall have a minimum of 6 months of experience with surface water sampling.
- 5.2.5 The **field sampler and/or task manager** is responsible for directly supervising the surface water sampling procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected during sampling. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the Program Quality Manager and then documented in the field logbook and associated report or equivalent document.

6.0 Equipment and Supplies

The following equipment list contains materials that may be needed in carrying out the procedures outlined in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- Work Plan
- Maps/Plot plan
- Tape measure
- Survey stakes, flags, or buoys
- Camera and film
- Stainless steel, plastic, or other appropriate composition (e.g., Teflon) bucket
- Laboratory supplied sampling containers
- Ziploc plastic bags for samples, and sample jars
- Logbook
- Labels
- Chain of Custody (COC) forms
- Site description forms
- Cooler(s)
- Ice
- Equipment/Apparatus
- Decontamination supplies/equipment
- Spade or shovel
- Spatula
- Scoop
- Trowel
- Task specific surface water sampling equipment

7.0 Calibration or Standardization

None.

8.0 Procedure

8.1 Selection of Sampling Techniques

Proper selection of sampling points and collection methodology are essential to meeting the objectives of a surface water sampling program. Sampling points should be selected for collection of surface water samples on the basis of characteristics of the body of surface water body to be monitored, the location of the body of surface water, and its hydrologic boundaries with respect to the site. Other considerations include the contaminants of concern, logistical considerations, such as access to the surface water body, the direction of flow, and determination of a background location.

Methods of collecting surface water samples vary from hand sampling procedures at a single point to sophisticated, multipoint sampling techniques. The number and type of samples to be collected depends on the characteristics of the body of water, the amount of suspended sediment that a moving body carries, the size of the discharge area at the site, and other factors. Multipoint sampling techniques apply to larger bodies of water; the samples are composited to provide a more representative sample.

Whenever possible, the sampling device, either disposable or constructed of a nonreactive material, should hold at least 500 milliliters to minimize the number of times the liquid must be disturbed, thus reducing agitation of any sediment layers. A 1-liter polypropylene or stainless steel beaker with a pour spout and handle works well. Any sampling device might contribute contaminants to a sample. The correct sampling device will not compromise the integrity of the sample and will give the desired analytical results.

8.1.1 **Shallow Water Body Surface Water Sample Collection**

A dip or grab sample is appropriate for a small body of water, or for collecting near-surface samples in a larger surface water body. The sampling method involves filling a sample container by submerging it either just below the surface, or by lowering the container to a desired depth by using a weighted holder. For shallow bodies of surface water, hold the sample container carefully just beneath the water surface to avoid disturbing the streambed and stirring the sediment. Position the container's mouth so that it faces upstream, while the sampling personnel are standing downstream. Any preservative added to the sample should be added after sample collection to avoid loss of preservative. Alternatively, a transfer device may be dipped into the water, and then the contents transferred to the appropriate container containing the preservative. For near-surface sample collection in a large surface water body, a pond sampler may be used if an extended reach is required to collect a representative sample. A pond sampler consists of a single use sample container attached to a telescoping, heavy-duty, aluminium pole via an adjustable clamp attached to the end. The collection technique for shallow surface water samples can be used for near-surface samples in a large surface water body.

8.1.2 **Deep Surface Water Sample Collection**

For deeper surface water bodies, either sample containers or transfer devices may be used to collect a sample. A weighted holder that allows either a sample transfer device or a sample container to be lowered, opened for filling, closed, and returned to the surface is suggested for sampling deeper surface water bodies. This is because concentrations of constituents near the surface of a deeper body of surface water might differ from the total concentration distributed throughout the water column cross section and thus a surface sample would not be representative of the water body. An open container that is lowered and raised to the surface at a uniform rate so that the bottle is just filled on reaching the surface is appropriate for deeper stagnant water bodies, however this method does not collect a truly representative sample in deeper flowing surface water bodies.

Kemmerer Samplers. Collect samples near the shore unless sampling from a boat is feasible and permitted. If a boat is used, the body of water should be cross-sectioned and samples should be collected at various depths across the water in accordance with the project specific SAP. The Kemmerer Sampler consists of a glass, plastic, or Teflon bottle, a weighted sinker, a bottle stopper, and a line that is used to open the bottle and to lower and raise the sampler during sampling. The general procedure for using the sampler is as follows (or refer to manufacturer's instructions):

1. Obtain the sampler and check the knot at the bottom of the sampler for tightness and size. The knot should be sufficiently large so that it will not pull through the central tube of the sampler.
2. Assemble the weighted bottle sampler for making the cast by pulling the trip head into the trip plate. This can be done by holding the top and bottom stoppers and giving a short, hard pull to the bottom stopper.
3. Measure and mark the desired depth on the sampling line. Tie the free end of the line to the railing of the vessel to prevent accidental dropping of the sampler.

4. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely.
5. Pull out the stopper with a sharp jerk of the sampler line or by lowering a messenger down the line to trip the stoppers.
6. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.
7. Raise the sampler and cap the bottle. Untie the line from the railing and carry the sampler to your sampling station.
8. Transfer water into appropriate sample containers. Preserve the sample, if necessary, following guidelines in the project-specific SAP. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.
9. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly.
10. Fill out the sample label and record all relevant information in the sample collection form, the field logbook, and/or the field laptop/tablet. In addition, the chain of custody form should be filled out as soon as possible. These procedures should be done in accordance with SOP 3-03 Recordkeeping, Sample Labeling, and Chain of Custody.
11. Immediately place the properly labeled sample bottle(s) in a cooler with ice.
12. Wipe the sample clean and decontaminate if necessary for the collection of additional samples. Decontaminate according to the procedures in SOP 3-06 Equipment Decontamination.
13. Always store the sampler in the open position (stoppers not in the tube).

Teflon Bailers. Teflon bailers can also be used to collect samples in deep bodies of water. When the use of Teflon bailers is deemed appropriate for sampling water from a specific depth, the bailers shall be equipped with a check valve that closes during sample retrieval.

1. Attach a line that is premeasured to the appropriate sampling depth to the dedicated Teflon bailer and lower to the desired depth.
2. Ensure that the check valve is engaged tugging on the line with a sharp jerk.
3. Raise the bailer and transfer the water to sample containers. Preserve the sample, if necessary, following guidelines in the project-specific SAP. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.
4. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly.
5. Fill out the sample label and record all relevant information in the sample collection form, the field logbook, and/or the field laptop/tablet. In addition, the chain of custody form should be filled out as soon as possible. These procedures should be done in accordance with SOP 3-03 Recordkeeping, Sample Labeling, and Chain of Custody.
6. Immediately place the properly labeled sample bottle(s) in a cooler with ice.
7. A new dedicated bailer and new line should be used for each sampling location.

Peristaltic Pump. Another method of extending the reach of sampling efforts is to use a small peristaltic pump. In this method, the sample is drawn through heavy-wall Teflon tubing and pumped directly into the sample container. This system allows the operator to reach into the liquid body, sample from depth, or sweep the width of narrow streams.

If medical-grade silicon tubing is used in the peristaltic pump, the system is suitable for sampling almost any analyte, including most organics. Some volatile stripping may occur; due to the relatively high flow rate of the pump. Therefore, avoid pumping methods for sampling volatile organics. Battery-operated peristaltic pumps are available and can be easily carried by hand or with a shoulder sling, as needed. It is necessary in most situations to change both the Teflon suction line and the silicon pump tubing between sampling locations to avoid cross contamination. This action requires maintaining a sufficiently large stock of material to avoid having to clean the tubing in the field.

Peristaltic pumps work especially well for sampling large bodies of water when a near-surface sample will not sufficiently characterize the body as a whole. When sampling a liquid stream that exhibits a considerable flow rate, it may be necessary to weight the bottom of the suction line.

Use the following procedures for collecting samples using peristaltic pumps:

1. Install clean, silicone tubing in the pump head, per the manufacturer's instructions. Pharmaceutical-grade silicone tubing (e.g., PharMed tubing) may be required for some projects depending on the analyses required. Refer to the project specific SAP for specific tubing requirements. Allow sufficient tubing on the discharge side to facilitate convenient dispensation of liquid into sample bottles but only enough on the suction end for attachment to the intake line. This practice will minimize sample contact with the silicone pump tubing. (Some types of thinner Teflon tubing may be used.)
2. Select the length of suction intake tubing necessary to reach the required sample depth and attach it to the tubing on the intake side of the pump. If necessary, a small weight composed of inert material (e.g., stainless steel) which will not react with chemicals of concern may be used to weight the intake tubing. Heavy-wall Teflon of a diameter equal to the required pump tubing will suit most applications. (A heavier wall will allow for a slightly greater lateral reach.)
3. A purge volume that is at a minimum equal to the tubing volume should be passed through the system prior to sample collection. Collect this purge volume in a bucket. Once the sample has been collected, the purged water volume can be returned to the water body.
4. Fill necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with smooth laminar flow and minimal entry turbulence. Cap each bottle as it is filled.
5. Preserve the sample, if necessary, following guidelines in the project-specific SAP. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.
6. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly.
7. Fill out the sample label and record all relevant information in the sample collection form, the field logbook, and/or the field laptop/tablet. In addition, the chain of custody form should be filled out as soon as possible. These procedures should be done in accordance with SOP 3-03 Recordkeeping, Sample Labeling, and Chain of Custody.
8. Immediately place the properly labeled sample bottle in a cooler with ice.
9. Allow the system to drain thoroughly, and then disassemble.

8.2 **Transfer Devices**

Samples from various locations and depths can be composited if project quality objectives indicate that it is appropriate; otherwise, collect separate samples. Identify approximate sampling points on a sketch of the water body. Use the following procedures for collecting samples using transfer devices:

1. Submerge a stainless steel dipper or other suitable device, causing minimal disturbance to the surface of the water and the sediment at the floor of the surface water body. Note the approximate depth and location of the sample source (e.g., 1 foot up from bottom or just below the surface).
2. Allow the device to fill slowly and continuously.
3. Retrieve the dipper or device from the surface water with minimal disturbance.
4. Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper or device edge.
5. Empty the dipper or device slowly, allowing the sample stream to flow gently down the side of the bottle with smooth laminar flow and minimal entry turbulence.
6. Continue delivery of the sample until the bottle is filled.
7. If necessary, preserve the sample according to guidelines in the project-specific SAP. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.

8. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly.
9. Fill out the sample label and record all relevant information in the sample collection form, the field logbook, and/or the field laptop/tablet. In addition, the chain of custody form should be filled out as soon as possible. These procedures should be done in accordance with SOP 3-03 Recordkeeping, Sample Labeling, and Chain of Custody.
10. Dismantle the sampler and decontaminate according to the procedures in SOP 3-06 Equipment Decontamination.

Multipoint sampling techniques that represent both dissolved and suspended constituents and both vertical and horizontal distributions are applicable to larger bodies of water. Subsequent to sample collection, multipoint sampling techniques may require a compositing and sub-sampling process to homogenize all the individual samples into the number of subsamples required to perform the analyses of interest. Homogenizing samples is discouraged for samples collected for volatile organic analysis, because aeration causes a loss of volatile compounds. If collection of composite samples is required, then include the procedure for compositing in the project-specific work plan.

The sampling devices selected must not compromise sample integrity. Collect samples with either disposable devices, or devices constructed of a nonreactive material, such as glass, stainless steel, or Teflon. The device must have adequate capacity to minimize the number of times the liquid must be disturbed, reducing agitation of any sediment layers. Further, the device must be able to transfer the water sample into the sample container without loss of volatile compounds. A single- or double-check valve or stainless steel bailer made of Teflon equipped with a bottom discharging device may be utilized.

All equipment used for sample collection must be decontaminated before and after use in accordance with Procedure 3-06 – Equipment Decontamination.

9.0 Quality Control and Assurance

- 9.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific SAP. The goal of the QA program should be to ensure precision, accuracy, representativeness, completeness, and comparability in the project sampling program.
- 9.2 Quality Control (QC) requirements for sample collection are dependent on project-specific sampling objectives. The project-specific SAP will provide requirements for sample preservation, holding times, container types, as well as various QC samples such as trip blanks, field blanks, equipment blanks, and field duplicates.

10.0 Data and Records Management

- 10.1 Field notes will be kept during sampling activities in accordance with SOP 3-03 – Recordkeeping, Sample Labeling, and Chain of Custody. During the completion of sampling activities, fill out the sample logbook and transmit forms to the CTO Manager for storage in project files.
- 10.2 Deviations to the procedures detailed in the SOP should be recorded in the field logbook.

11.0 Attachments or 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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<i>Author</i>	<i>Reviewer</i>	<i>Revisions (Technical or Editorial)</i>
Robert Shoemaker Senior Scientist	Naomi Ouellette, Project Manager	Rev 0 – Initial Issue

Monitoring Well Installation

Procedure 3-12

1.0 Purpose and Scope

- 1.1 This standard operating procedure (SOP) describes the methods to be used during the installation of groundwater monitoring wells. It describes the components of monitoring well design and installation and sets forth the rationale for use of various well installation techniques in specific situations.
- 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, 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 well installation commences, appropriate entities (e.g. DigSafe, local public works departments, company facilities) must be contacted to assure the anticipated well locations are marked for utilities, including electrical, telecommunications, water, sewer, and gas.
- 2.3 Physical Hazards Associated with Well Installation
- Stay clear of all moving equipment and avoid wearing loose fitting clothing.
 - When using an approved retractable-blade knife, always cut away from one self and make sure there are no other people in the cutting path or the retractable-blade knife.
 - To avoid slip/trip/fall conditions during drilling activities, keep the area clear of excess soil cuttings and groundwater. Use textured boots/boot cover bottoms in muddy areas.
 - To avoid heat/cold stress as a result of exposure to extreme temperatures and personal protective equipment (PPE), drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
 - To avoid hazards associated with subsurface utilities, ensure all sampling locations have been properly surveyed as described in SOP 3-01, Utility Clearance.
 - Be aware of restricted mobility caused by PPE.

3.0 Terms and Definitions

- 3.1 **Annulus:** The annulus is the down-hole space between the borehole wall and the well casing and screen.
- 3.2 **Bridge:** A bridge is an obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by the placement of filter pack materials during well completion. Bridging can also occur in the formation during well development.
- 3.3 **Filter Pack:** Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.
- 3.4 **Grout:** Grout is a fluid mixture of cement and water that can be forced through a tremie pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.
- 3.5 **Heaving (Running) Sands:** Loose sands in a confined water-bearing zone or aquifer which tend to rise up into the drill stem when the confining unit is breached by the drill bit. Heaving sands occur when the water in the aquifer has a pressure head great enough to cause upward flow into the drill stem with enough velocity to overcome the weight of the sand.
- 3.6 **Sieve Analysis:** Sieve analysis is the evaluation of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

4.0 Interferences

- 4.1 Heaving sands may be problematic in unconsolidated sands encountered below the water table.
- 4.2 Rotary drilling methods requiring bentonite-based drilling fluids should be used with caution to drill boreholes that will be used for monitoring well installation. The bentonite mud builds up on the borehole walls as a filter cake and permeates the adjacent formation, potentially reducing the permeability of the material adjacent to the well screen.
- 4.3 If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids should be obtained and analyzed for chemical constituents that may be of interest at the site. In addition, an attempt should be made to recover the quantity of fluid or water that was introduced, either by flushing the borehole prior to well installation and/or by overpumping the well during development.
- 4.4 Track-mounted drill rigs are suitable for travelling on many types of landscapes that truck-mounted units cannot access, but may have limitations on extremely uneven or soft terrain.
- 4.5 Care should be taken to prevent cross-contamination between well locations. All drilling equipment coming in contact with potentially contaminated soil and/or groundwater will be decontaminated by the drilling subcontractor prior to initial drilling activities and between drilling locations in accordance with SOP 3-06, Equipment Decontamination.

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 **Contract Task Order (CTO) Managers** are responsible for issuing sampling and analysis plans (SAPs) that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and possibly state regulatory agencies enforce regulations that may include well construction and installation requirements. The **CTO Manager** shall be familiar with current local and state regulations, and ensure that these regulations are followed. The **CTO Manager** is responsible for ensuring that all personnel involved in monitoring well installation 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 direct supervision of the installation of monitoring wells and ensuring that procedures and specifications are implemented in the field in accordance with the approved SAP and well installation permits. The qualifications for the **Field Manager** must be in accordance with local jurisdictions with authority over the operations conducted.
- 5.2.4 All field personnel are responsible for the implementation of this procedure.
- 5.2.5 The on-site hydrogeologist/engineer is expected to obtain a description of the lithologic samples obtained during the excavation and construction of a monitoring well. These data are often required to provide guidance regarding the installation of specific components of the monitoring well. Guidance for lithologic sample collection and sample description is contained within SOP 3-16, Soil and Rock Classification.

6.0 Equipment and Supplies

- 6.1 Materials provided by the drilling contractor may include:
- Drill rig, drill rods, hollow stem augers, etc.
 - Decontamination equipment (e.g., steam cleaner, high-pressure washer, brushes, etc.)
 - Decontamination pad materials
 - Well screen/riser pipe with flush-threaded couplings including riser and bottom caps
 - Clean, filter sand
 - Bentonite chips or pellets
 - Cement grout and tremie pipe
 - Portland cement for well pad completion
 - Steel protective riser covers and locking caps
 - Weighted calibrated tape
 - Split-spoon samplers
 - 55-gallon drums or containers for drill cuttings, decontamination fluids, etc.
- 6.2 In addition to those materials provided by the drilling contractor, equipment and materials required by the project geologist/engineer may include, but is not limited to, the following:
- Photoionization Detector (PID)
 - Spill kit, including at a minimum sorbent pads and shovel (if not provided by subcontractor)

- Plastic sheeting
- Teaspoon or spatula
- Resealable plastic bags
- Boring Log Records
- Decontamination materials (per SOP No. 3-06 - Equipment Decontamination)
- Weighted measuring tape for depth measurement
- Soil logging materials (e.g. USCS classification field card, millimeter rule, hand lens, etc.)
- Survey lathes or pin flags
- Digital camera
- PPE as required by the HASP
- Planning documents including the site-specific HASP and SAP
- Large indelible ink or paint pen
- Field logbook/field forms/site maps (water proof)

7.0 Procedure

7.1 General Procedures

- Specific drilling, sampling, and installation equipment and methodology will be dictated by the type of well to be installed (e.g., single case (Type II), double case (Type III), bedrock, etc.), geologic characteristics of the site, the type of contaminants being monitored, and local and state regulations.
- For access to locations when travelling over difficult terrain, an appropriate line should be chosen before mobilizing the drill rig or other support vehicles. If clearing of trees or ground cover is required, perform these activities in advance to avoid down time. Avoid wet or soft areas where possible or use ground mats and/or timbers to aid in supporting the rig as it travels. If drilling on soft material, place geomatting and ground mats under the rig tracks or stabilizers prior to drilling.
- A utility locate must be conducted to identify all underground utilities at the site prior to drilling (refer to SOP 3-01, Utility Clearance). Proper clearance procedures for aboveground/overhead utilities must also be followed as specified in the HASP.
- Although new well materials (well screen and riser pipe) generally arrive at the site boxed and sealed within plastic bags, it is sometimes necessary to decontaminate the materials prior to their use. Well materials should be inspected by the project geologist/engineer upon delivery to check for cleanliness. If the well materials appear dirty, or if local or regional regulatory guidance requires decontamination, then well material decontamination should be performed by the drilling subcontractor in accordance with SOP 3-06, Equipment Decontamination.
- The diameter of the borehole must be a minimum of 2 inches greater than the outside diameter of the well screen or riser pipe used to construct the well. This is necessary so that sufficient annular space is available to install filter packs, bentonite seals, and grout seals, and allow the passage of tremie pipe where grouting at depth is required. Bedrock wells may require reaming after coring in order to provide a large enough borehole diameter for well installation.
- When soil sampling is required (refer to the SAP), soil samples will be collected for visual logging by advancing split-spoon samplers through the augers. The soil will be visually logged by a field geologist and include lithologic characteristics (i.e., soil type, color, density, moisture content, etc.) using the the

methods described in SOP 3-16, Soil and Rock Classification. This information will be recorded on a boring/well log form, along with well construction details.

7.2 Drilling Techniques

Drilling of monitoring well boreholes may be accomplished by a variety of methods as described below. Preferred methods include those that temporarily case the borehole during drilling (i.e., hollow stem auger and sonic methods) using an override system. Other methods can be used where specific subsurface conditions or well design criteria dictate.

- Hollow stem auger (HSA) – Borings are advanced by rotating steel hollow stem augers with an attached cutting head. Soil cuttings are displaced by the cutting head and transported to the surface via continuous spiral flights attached to each auger stem. This method is widely used for unconsolidated soils that have a tendency to collapse within the boring. A bottom plug can be placed in the bottom auger to prevent soils from entering and clogging the auger, especially in the case of heaving sands. However, a bottom plug cannot be used when soil samples are to be collected through the augers. Soil plugs that accumulate in the bottom of the auger must be removed or knocked out prior to sampling or well installation.
- Solid stem auger – This type of drilling method is similar to HSA drilling using a solid stem or sealed hollow stem auger flights to advance the boring. Solid stem, continuous flight auger use is limited to semi-consolidated sediments or to cohesive or semi-cohesive unconsolidated sediments that don't have a tendency to collapse when disturbed.
- Sonic methods – Sonic drilling consists of advancing concentric hollow drill casings (inner and outer) using rotation in conjunction with axial vibration of the drill casing. Once the casings are advanced to the appropriate depth, the inner string is removed with a core of drill cuttings while the outer casing remains in place to keep the borehole open. Cuttings are removed from the inner casing relatively intact for logging or sampling purposes. This drilling method is used for a variety of soil types, from heaving sands to consolidated or indurated formations. Smearing of the formation along the borehole walls is minimal since moderate vibration and rotation techniques are used to advance the casings. Since the total borehole diameter in sonic drilling is only incrementally larger than the inner casing diameter, care should be taken during installation of the monitoring well to ensure the well is centered and adequate space is available for annular materials.
- Rotary methods (water or mud) – Rotary drilling methods consist of drill rods coupled to a drill bit that rotates and cuts through the soils to advance the borehole. Water or drilling fluid ("mud") is forced through the hollow drill rods and drill bit as the rods are rotated. The soil cuttings are forced up the borehole with the drilling fluids to the surface and the fluids recirculated. The drilling fluid provides a hydrostatic pressure that reduces or prevents the borehole from collapsing. Clean, potable water must be used for water-rotary drilling to prevent introducing trace contaminants. A sample of the potable water should be collected during the course of well installation for analysis of the same parameters defined for the groundwater samples. If mud-rotary is used to advance boreholes, potable water and bentonite drilling mud should only be used. No chemical additives shall be mixed in the drilling fluid to alter viscosity or lubricating properties. Adequate well development is essential for removal of drilling mud and fluids from the formation materials and ensure collection of representative groundwater samples.
- Rotary methods (Air) – Air rotary methods are similar to water rotary but use high air velocities in place of drilling fluids to rotate the drill bit and carry the soil cuttings up the borehole to the surface. Care must be taken to ensure that contaminants are not introduced into the air stream from compressor oils, etc. Most compressor systems are compatible with a coalescing filter system. Cuttings exiting the borehole under pressure must be controlled, especially when drilling in a zone of potential contamination. This can be accomplished by using an air diverter with hose or pipe to carry the cuttings to a waste container. Letting the cuttings blow uncontrolled from the borehole is not acceptable.

7.3 Well Construction and Installation

- If rotary drilling techniques are used, the borehole should be flushed or blown free of material prior to well installation. If hollow stem augers are used, the soil or bottom plug should be removed and the augers raised approximately six inches above the bottom of the borehole, while slowly rotating the augers to remove cuttings from the bottom of the boring. The depth of the borehole should be confirmed with a weighted, calibrated tape.
- The riser pipe and screen should be connected with flush-threaded joints and assembled wearing clean, disposable gloves. No solvent or anti-seize compound should be used on the connections. The full length of the slotted portion of the well screen and unslotted riser pipe should be measured and these measurements recorded on a well construction form (Attachment 1).
- If placed in an open borehole, the assembled well should be carefully lowered and centered in the borehole so that the well is true, straight, and vertical throughout. Centering can also be accomplished with the use of centralizers, if necessary. However, centralizers should be placed so that they do not inhibit the installation of filter sand, bentonite seal, and annular grout. Wells less than 50 deep generally do not require centralizers.
- If hollow stem augers are used, the well should be lowered through the augers and each auger flight removed incrementally as the filter sand, bentonite seal, and grout are tremmied or poured into the annular space of the well. The well should be temporarily capped before filter sand and other annular materials are installed.
- Clean, silica sand should be placed around the well screen to at least 1 foot above the top of the screen. The filter sand should be appropriately graded and compatible with the selected screen size and surrounding formation materials. In general, the filter pack should not extend more than 3 feet above the top of the screen to limit the thickness of the monitoring zone. As the filter pack is placed, a weighted tape should be lowered in the annular space to verify the depth to the top of the layer. This measurement will be recorded on the well construction form (Attachment 1). If necessary, to eliminate possible bridging or creation of voids, placement of the sand pack may require the use of a tremie pipe. Tremie pipe sandpack installations are generally suggested for deeper wells and for wells which are screened some distance beneath the water table.
- A minimum 2-foot thick layer of bentonite pellets or slurry seal will be installed immediately above the filter sand to prevent vertical flow within the boring from affecting the screened interval. Bentonite chips/pellets must be hydrated if placed above the water table prior to grouting. If bridging is of concern as in the case of deep wells, powdered bentonite may be mixed with water into a very thick slurry and a tremie pipe used to place the seal to the desired depth. Placement of the bentonite seal in the borehole will be recorded on the well construction form (Attachment 1).
- The remaining annular space around the well will be grouted from the top of the bentonite seal to the surface with a grout composed of neat cement, a bentonite cement mixture, or high solids sodium bentonite grout.
- Each well riser will be secured with an expandable, locking cap (vented if possible). Optionally, a hole can be drilled in the upper portion of the riser to allow venting of the well.
- The well will be completed within a concrete well pad consisting of a Portland cement/sand mixture. Well pads are generally 3 feet by 3 feet square but may be larger or smaller depending on site conditions and state-specific well construction standards. Round concrete well pads are also acceptable. A minimum of 1 inch of the finished pad should be below grade to prevent washing and undermining by soil erosion.
- If completed as a flush-mount well, the well riser will be cut off approximately 4 to 6 inches below ground surface and an expandable, locking cap placed on the well riser. The area around the riser is dug out and a steel well vault or manhole cover placed over the riser and set almost flush to the ground

to protect the well. The manhole cover should be water-tight and secured with bolts to prevent casual access. The well pad will then be constructed around the well vault and slightly mounded at the center and sloping away to prevent surface water from accumulating in the well vault.

- If completed as a stick-up well, the well riser is cut approximately 2.5 to 3 feet above the ground surface and an expandable, locking cap placed on the well riser. A steel guard pipe with hinged, locking cap is placed over the well riser as a protective casing. The bottom of the guard pipe will be set approximately 2 feet below ground surface and sealed by pouring concrete from the top of the annular grout around the pipe to grade. The concrete well pad should be completed at the same time. Weep holes will be drilled in the base of the guard pipe to facilitate draining of rainwater or purge water from inside the guard pipe.
- Bumper posts or bollards may be necessary for additional well protection, especially in high traffic areas. The bumper posts should be placed around the well pad in a configuration that provides maximum protection to the well and extend a minimum of 3 feet above the ground.

7.4 Double Cased Wells

Under certain site conditions, the use of a double-cased or telescoping (Type III) well may be necessary. Installation of double-cased wells may be required to prevent the interconnection of two separate aquifers, seal off a perched aquifer without creating a vertical hydraulic conduit, prevent cross-contamination during construction of wells in deeper aquifers hydro-stratigraphically below impacted aquifers, or case off highly impacted soils present above the aquifer to prevent potential "dragging down" of contaminants.

Similar to conventional wells, construction of double-cased wells can be accomplished using a variety of drilling methods. Well construction is initiated by "keying" a large diameter, outer casing into a stratigraphic zone of low permeability (clay layer or bedrock). The size of the outer casing should be a minimum of 2 inches greater than the outside diameter of the inner casing to allow installation of annular seal materials during well completion. A pilot borehole should be drilled through the overburden soil and/or contaminated zone into a clay confining layer or bedrock. The borehole for the outer casing should be of sufficient size to contain the outer casing with a minimum of 2 inches around the outside diameter to allow sufficient annular space for tremie or pressure grouting. The boring should extend a minimum of 2 feet into a clay layer and a minimum of 1 foot into bedrock, if possible, to ensure an adequate seal. The boring should never breach a confining layer or keyed zone under any circumstances.

Once the boring is completed, the outer casing can be set in the borehole and sealed with grout. The outer casing can be set two ways, with or without a bottom cap. If no bottom cap is applied, the casing is usually driven approximately 6 inches into the clay confining unit. A grout plug is generally placed in the bottom of the casing and once set, standing water in the casing is evacuated prior to drilling below the casing. As an alternative, a cap can be placed on the bottom of the casing and if set below the water table, the casing can be filled with clean, potable water to hold down the casing in the boring. Grouting should be conducted using tremie-grouting or pressure-grouting methods by pumping grout into the annular space between the outer casing and the borehole wall from the bottom of the casing to the ground surface. Grout around the casing should be allowed to cure at least 24 hours before attempting to drill through the bottom.

Once the grout is cured, a smaller diameter drill pipe/bit is used to bore through the grout plug or bottom cap to the desired well depth. The well is then constructed as described in Section 7.3 above.

7.5 Post Installation Procedures

- Wells should be permanently labelled or marked for identification. Well tags can be used to record the site name, well number, total depth, installation date, etc. At a minimum, the well number will be written in indelible marker or paint on both the outside of the protective casing and inside beneath the casing lid, as well as on the riser pipe.

- A measuring point will be marked on the top of the riser pipe for taking water level measurements. The measuring point can be notched using a knife or saw or can be marked with a waterproof marker or paint. The measuring point will also be the point which will be surveyed for vertical elevation data.
- Upon completion, the following measurements will be taken by the field geologist/engineer and recorded on the well construction diagram.
 - Depth to static water level
 - Depth of non-aqueous phase liquid (NAPL), if present
 - Total depth of well measured from top of casing (TOC)
 - Height of well casing above ground surface
 - Height of protective casing above ground surface
- All monitoring wells will be surveyed for horizontal and vertical control by a licensed surveyor.
- Investigation-derived waste (IDW) including drill cuttings, spent materials (e.g., PPE), and decontamination water should be properly managed in accordance with SOP 3-05, IDW Management.

8.0 Quality Control and Assurance

- 8.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the SAP. Certain quality control (QC) measures should be taken to ensure proper well installation and construction in accordance with this SOP, project specific SAP, and applicable well standards.
- 8.2 The borehole will be checked for total open depth, and extended by further drilling or shortened by backfilling, as required before installation of the well materials.
- 8.3 Water level and NAPL presence will be checked during well installation to ensure that the positions of well screen, filter sand, and seals relative to water level conform to project requirements
- 8.4 The depth to top of each layer of annular materials (i.e., filter sand, bentonite, grout) will be verified and adjusted as necessary for proper placement.

9.0 Records, Data Analysis, Calculations

All field information will be recorded in the field logbook and/or standardized field forms by field personnel. Field data recorded will include drilling contractor information, drilling methods, well material and construction information provided on the boring logs and well construction forms, observations or problems encountered during drilling, fluid level data, and any deviations from the procedures in this SOP and other project plans. Well Construction Forms (Attachment 1) will provide visual and descriptive information the monitoring well and are often the most critical form of documentation generated during the installation of a monitoring well. The field logbook is kept as a general log of activities and should not be used in place of the boring log.

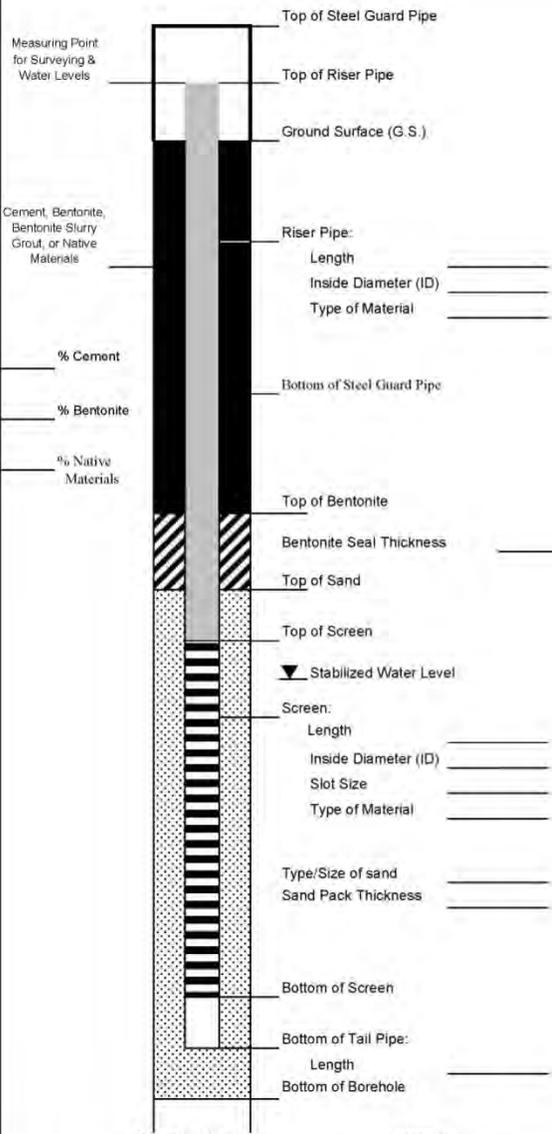
10.0 Attachments or References

- 10.1 Attachment 1 – Monitoring Well Construction Form

- 10.2 Environmental Protection Agency, United States (EPA). 1987. *A Compendium of Superfund Field Operations Methods*. Office of Solid Waste and Emergency Response. EPA/540/P-87/001.
- 10.3 EPA. 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.
- 10.4 EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.
- 10.5 EPA, 2008. SESD Operating Procedure SESDGUID-101-R0: *Design and Installation of Monitoring Wells*. USEPA, Science and Ecosystem Support Division (SESD), Athens, Georgia. Effective Date February 18, 2008.
- 10.6 U.S. Army Corps of Engineers. 2008. Manual No. EM 385-1-1. *Safety and Health Requirements*. 15 November 2008. http://140.194.76.129/publications/eng-manuals/em385-1-1/2008_English/toc.html.
- 10.7 SOP 3-01, *Utility Clearance*.
- 10.8 SOP 3-05, *IDW Management*
- 10.9 SOP 3-06, *Equipment Decontamination*.
- 10.10 SOP 3-16, *Soil and Rock Classification*.

<i>Author</i>	<i>Reviewer</i>	<i>Revisions (Technical or Editorial)</i>
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)

Attachment 1 Monitoring Well Construction Form

	Client: _____		WELL ID: _____
	Project Number: _____		
	Site Location: _____		
	Well Location: _____	Coords: _____	
	Method: _____		
MONITORING WELL CONSTRUCTION DETAIL			
		Depth from G.S. (feet)	Elevation(feet) Datum _____
	Top of Steel Guard Pipe	_____	_____
	Top of Riser Pipe	_____	_____
	Ground Surface (G.S.)	0.0	_____
	Riser Pipe:		
	Length _____		
	Inside Diameter (ID) _____		
	Type of Material _____		
	Bottom of Steel Guard Pipe	_____	_____
	Top of Bentonite	_____	_____
	Bentonite Seal Thickness _____		
	Top of Sand	_____	_____
	Top of Screen	_____	_____
	▼ Stabilized Water Level	_____	_____
	Screen:		
	Length _____		
Inside Diameter (ID) _____			
Slot Size _____			
Type of Material _____			
Type/Size of sand _____			
Sand Pack Thickness _____			
Bottom of Screen	_____	_____	
Bottom of Tail Pipe:			
Length _____			
Bottom of Borehole	_____	_____	
Borehole Diameter _____			
Approved: _____			
Describe Measuring Point: _____		Signature _____	Date _____

Monitoring Well Development

Procedure 3-13

1.0 Purpose and Scope

- 1.1 This standard operating procedure (SOP) describes the procedures used for developing newly installed monitoring wells and/or redeveloping existing wells.
- 1.2 The purpose of well development is to remove interferences from a well to provide better connection between the well and the formation, to improve pumping performance of the well, and to be able to collect more representative information from the well (e.g., samples, test results, etc.). Proper well development will:
- Remove drilling residuals (e.g., water, mud) from the borehole and surrounding formations;
 - Improve or restore hydraulic conductivity of the surrounding formations which may have been disturbed during the drilling process;
 - Remove residual fines from the well screen and sand pack (filter pack) materials, thus reducing turbidity of groundwater and permitting the collection of more representative groundwater samples.
- 1.3 There may be circumstances where well development is not desirable, for example, in the presence of non-aqueous phase liquids (NAPL) or other significant contamination if development could worsen the contaminant impact. If NAPL begins to intrude during development, the development process will be halted. This situation will be considered a cause for sample modification requiring approval by the CTO Manager and other stakeholders, as applicable.
- 1.4 The applicable well development procedures for a particular site may be subject to State or local regulatory requirements. In all cases, the project team should consult their local regulatory requirements and document the selected well development procedure in the project-specific Sampling and Analysis Plan (SAP). For project-specific information refer to the SAP, which takes precedence over these procedures.
- 1.5 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).
- 1.6 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, 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) SAP and/or direction from the Site Safety Officer (SSO).
- 2.2 Monitoring well development may involve chemical hazards associated with potential contaminants in the soil or aquifer being characterized and may involve physical hazards associated with use of well development equipment.

3.0 Terms and Definitions

None.

4.0 Interferences

- 4.1 Equipment/materials used for development may react with the groundwater during development. Appropriate development equipment has been selected for the anticipated condition of the groundwater.
- 4.2 Appropriate development methods such as using a surge-block to flush suspended fines in the groundwater in and out of the well screen can improve the yield of wells and improve their potential to be developed successfully. However, the effectiveness of development can be significantly reduced in wells that do not yield sufficient water to allow this flushing to take place.
- 4.3 For formations with a significant content of fine-grained materials (silts and clays), or wells with improperly sized screens, it may not be possible to reduce turbidity to commonly acceptable levels. Possible solutions may include collecting a sample even if excessively turbid, or installing a replacement well.
- 4.4 Development itself disturbs the surrounding formation and disrupts equilibrium conditions within the well. Groundwater samples will not be collected until a minimum of 24 hours after a well is developed to allow conditions to stabilize. For sites with fine-grained formations (silts and clays) and highly sorptive contamination, a longer time period between development and sampling should be considered.

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 well development activities comply with this procedure. The **CTO Manager** is responsible for ensuring that all personnel involved in well development 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 well development activities are conducted according to the either this procedure or the applicable procedure presented in the project-specific SAP.
- 5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure.
- 5.2.5 The field sampler and/or task manager is responsible for directly supervising the well development procedures to ensure that they are conducted according to this procedure and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

- 6.1 This equipment list was developed to aid in field organization and should be used in planning and preparation. Depending on the site-specific requirements and the development method selected, additional or alternative material and equipment may be necessary. In addition, for sites where groundwater is expected to be contaminated, the materials to be placed down the well and in contact with groundwater should be evaluated so that they are compatible with the chemical conditions expected in the well.
- 6.2 Equipment and materials used for well development may include, but is not limited to:

Well development equipment

- Surge block

- Disposable Teflon bailers, appropriate to the diameter of the well(s): 1-inch to 1.5-inch for 2-inch inside diameter (ID) monitoring wells.
- Watterra® footvalve
- Electric submersible pump
- 12-volt power source for electric pump
- High density polyethylene (HDPE) tubing appropriately sized for Watterra® footvalve and/or electric submersible pump
- Drums or containers for storage of purge water
- Nephelometer to measure turbidity
- Multi-parameter water quality meter(s) to measure temperature, pH, conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP)
- Instrument calibration solutions
- Water level meter
- Oil/water interface probe

General equipment

- Project-specific plans including the site-specific HASP and SAP
- Field notebook/field forms/site maps
- Indelible markers/pens
- 5-gallon buckets

Equipment decontamination supplies (refer to SOP 3-06, Equipment Decontamination)

- Health and safety supplies, including personal protective equipment (PPE)
- Appropriate hand tools
- Keys or combinations to access monitoring wells
- Distilled/deionized water supply
- Disposable bailer string (polypropylene)
- Plastic trash bags

7.0 Procedure

Development generally consists of removing water and entrained sediment from the well until the water is clear (to the extent feasible) and the turbidity is reduced, which indicates the well is in good hydraulic connection with the surrounding formation. In addition to simply removing water, development can be improved when flushing through the well screen and gravel pack takes place in both directions, that is, both into the well and into the formation. This action breaks down sediment bridges that can occur in the formation or sand pack, which reduce the connection between the well and the formation

7.1 General Preparation

- All down-well equipment should be decontaminated prior to use and between well locations in accordance with SOP 3-06, Equipment Decontamination
- Although equipment is decontaminated between well locations, if wells are known or suspected to be contaminated based on observations during well installation, it is recommended that well development be conducted in order from the least contaminated to the most contaminated well to minimize the chances of cross-contamination.
- Management of investigation-derived waste (IDW), including development purge water and miscellaneous expendable materials generated during the development process, will be conducted in accordance with SOP 3-05, IDW Management.

- Prior to accessing the well, the wellhead should be cleared of debris and/or standing water. Nothing from the ground surface should be allowed to enter the well.
- The depth to water and total well depth should be measured with a water level meter and recorded in the field logbook or on a Well Development Record (Attachment 1). This information will be used to calculate the volume of standing water (i.e., the well volume) within the well, and plan the specific details of the well development. If wells are suspected to contain NAPL, an oil/water interface probe should be used to measure liquid levels and depth to bottom of the well.
- Permanent monitoring wells will be developed no sooner than 24 hours after well installation is completed in order to allow well completion materials to set properly.

7.2 Monitoring Well Development Procedures

Generally, development will begin by gently surging the well with a surge block or bailer as described in Sections 7.2.1 and 7.2.2, respectively. Surging can become more vigorous as development progresses but initially the well must be gently surged to allow material blocking the screen to become suspended without damaging the well. Next, a bailer can be used to remove the sediment settled at the base of the well. A bailer, Watterra[®] pump, or electric submersible pump will then be used to purge the well, per Sections 7.2.2, 7.2.3, or 7.2.4, respectively. The well will be purged until the removed water becomes less turbid or per the requirements of the project-specific SAP, or State or local requirements. At this point the well will be surged again with a surge block or bailer. The well can be surged more vigorously at this point. After surging, the well will be purged again until the turbidity once again decreases. The surge/purge cycle should be completed at least three times during the development process. After the last surge, the well will be purged until the development completion criteria outlined in 7.3.2 or per the project-specific SAP are met.

7.2.1 Surge Block

The default method of well development is the use of a surge block in conjunction with pumping or bailing to remove sediment-laden water.

- The construction of the surge block must be appropriate for the diameter of the well. The surge block must be mounted on rods or other stiff materials to extend it to the appropriate depths and to allow for the surge block to be moved up and down in the well.
- Insert the surge block into the well and lower it slowly to the screened or open interval below the static water level. Start the surge action by slowly and gently moving the surge block up and down in the well. A slow initial surging, using plunger strokes of approximately 1 meter or 3 feet, will allow material which is blocking the screen to separate and become suspended.
- After 5 to 10 plunger strokes, remove water from the well using a separate bailer (Section 7.2.2) or pumping techniques (Sections 7.2.3 or 7.2.4). The returned water should be heavily laden with suspended fines. The water will be discharged to 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific SAP.
- In some cases, the bailer or Watterra[®] foot valve can act as a surge block, flushing water in and out of the well screen as groundwater is removed.
- Repeat the process of surging and pumping/bailing. As development continues, slowly increase the depth of surging to the bottom of the well screen. Surging within the riser portion of the well is neither necessary nor effective.

7.2.2 Bailer

- Tie a string or other cable securely to the bailer. Lower it to the screened or open interval of the monitoring well below the static water level.
- The bailer may be raised and lowered repeatedly within the screened interval to attempt to simulate the action of a surge block by pulling fines through the well screen, and pushing water out into the formation to break down bridging.

- With the bailer full of water, remove it from the well and discharge the water into 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific SAP.
- The Watterra® system (Section 7.2.3) or electric submersible pump (Section 7.2.4) may be used as a complementary development method to the bailer, especially when removal of additional water at a faster rate is beneficial.
- Continue alternately surging and bailing, monitoring the purge water periodically (Section 7.3.1) until development completion criteria are met (Section 7.3.2).

7.2.3 Watterra® system

- Attach high-density polyethylene (HDPE) tubing to the decontaminated Watterra® pump foot valve
- Lower the foot valve and tubing assembly near the bottom of the well.
- Lift and lower the tubing to allow water to enter the Watterra® foot valve and travel up the tubing and discharge the water into 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific SAP.
- The lifting and lowering action of the Watterra® system will cause some surging action to aid in breaking up fine material in the surrounding formation.
- A bailer (Section 7.2.2) may be used as a complementary development method to the Watterra® system, especially during the initial stages of development when a high volume of sediment may be required to be removed.
- An electric submersible pump (Section 7.2.4) may also be used as a complementary development method to the Watterra® system, especially when more volume of water is desired to be pumped or the turbidity criteria cannot be met due to the surging action of the Watterra® system.
- Continue alternately surging and pumping, monitoring the purge water periodically (Section 7.3.1) until well development completion criteria are met (Section 7.3.2).

7.2.4 Electric Submersible Pump

- Attach HDPE tubing to the decontaminated electric submersible pump.
- Lower the pump and tubing assembly near the bottom of the well, at least a few inches above the well total depth.
- Begin pumping, discharging the water into 5-gallon buckets or 55-gallon drums to be managed per the requirements presented in the project-specific SAP.
- Continue alternately surging and pumping, monitoring the purge water discharge periodically (Section 7.3.1) until well development completion criteria are met (Section 7.3.2).

7.3 Discharge Monitoring

7.3.1 Monitoring the Progress of Development

The progress of the development is evaluated through visual observation of the suspended sediment load and measurement of the turbidity and other parameters in the purged discharge water. As development progresses, the water should become clearer, measured turbidity should decrease, and specific capacity (pumping rate divided by drawdown) should stabilize. Water quality parameters, including DO, conductivity, ORP, pH, temperature, and turbidity may be measured and recorded periodically to determine the progress of development using the criteria outlined in Section 7.3.2 or per the project-specific SAP. Water quality parameters should be measured on each well volume removed.

7.3.2 Completion of Development

The well will be considered developed when the following criteria are met or per the criteria set forth in the project-specific SAP:

- A minimum of three times the standing water volume in a well (to include the well screen and casing plus saturated annulus, assuming 30 percent porosity) is removed.

- Groundwater parameters for three consecutive standing water volumes are within the following:
 - pH – within ± 0.2 units
 - Specific conductivity – within $\pm 3\%$
 - ORP – within ± 10 mV
 - Temperature – within ± 1 degree Celsius
 - Turbidity – at or below 10 nephelometric turbidity units (NTU) or within $\pm 10\%$ if above 10 NTU.
- The sediment thickness remaining within the well is less than 1 percent of the screen length or less than 30 millimeters (0.1 ft) for screens equal to or less than 10 feet long.

Dissolved oxygen (DO) readings may be recorded but DO readings will not be used as development completion criteria because DO may not stabilize.

If the well has slow groundwater recharge and is purged dry, the well will be considered developed when bailed or pumped dry three times in succession and the turbidity has decreased, or per the requirements set forth in the project-specific SAP. Water quality parameters may be recorded if feasible using the flow-through cell.

If any water is added to the well's borehole during development or drilling, three times the volume of water added will also be removed during well development, or per the requirements set forth in the project-specific SAP.

7.4 Development of Wells with Low Yield

Water is the primary mechanism to remove fines and flush water through the gravel pack for effective development. Therefore, development can be a challenge in wells that do not yield sufficient water to recharge when water is removed. However, often these wells are the most in need of development to improve their performance as they are typically installed in low permeability formations with a high content of fines. Development of these wells can improve their yield.

The surging portion of the development can be successfully performed in a well with standing water regardless of its yield. It is the subsequent removal of fine materials that is hindered when insufficient water is recharged to the well. When wells go dry or drawdown significantly during development, development can be performed intermittently, allowing sufficient water to recharge prior conducting the next stage of surging. These intermittent procedures can take place hours or even days apart, depending on project-specific time constraints.

7.5 Wells containing NAPL

Additional care should be taken when planning development of wells that contain NAPL. If the NAPL is flammable, there are health and safety as well as handling issues to consider. If NAPL in excess of a persistent sheen is noted, the recharge rate will be evaluated through hand bailing. In most cases, it is generally preferable to remove NAPL by bailing to the extent practical prior to performing development. Groundwater parameters, excluding turbidity, will not be collected during well development if NAPL or excessive sheen is noticed in the purged water during development to ensure the meter probes are not fouled or destroyed. Well development will be halted.

Development by surging or pumping the well dry can result in the spreading of NAPL vertically in the soil column around the well. These methods can be used, if information exists describing the vertical thickness of the NAPL smear zone around the well, and if the methods do not result in mounding or drawdown that exceeds this thickness. Alternate methods such as bailing may also be used, but any method should not allow the well to be pumped dry or result in significant drawdown that would spread the NAPL vertically.

7.6 Temporary Well Points

For certain projects, temporary well points (TWPs) may be installed to collect groundwater samples at a site. Since no sand pack, bentonite chips, or bentonite grout are generally used in the construction of the TWPs, development can proceed as soon as sufficient water has entered the well to static conditions. Due to the small diameter of these wells, generally ¾-inch to 1-inch ID, development will be performed using either a small diameter (0.5-inch) bailer and/or a peristaltic pump with dedicated tubing. The TWPs will have minimal water column and may purge dry during development. However, attempts will be made to remove fines from the well prior to sampling. Purging and sampling may occur as soon as approximately 80% of the static water has re-entered the TWP, or per the requirements set forth in the project-specific SAP.

8.0 Quality Control and Assurance

- 8.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific SAP.
- 8.2 Quality control (QC) requirements are dependent on project-specific sampling objectives. The project-specific SAP will provide requirements for equipment decontamination (frequency and materials) and IDW handling.

9.0 Records, Data Analysis, Calculations

- 9.1 All data and information (e.g., development method used) must be documented on field data sheets (Attachment 1) or within site logbooks with permanent ink. Data recorded may include the following:
- Well Location
 - Weather conditions
 - Date and Time
 - Purge Method
 - Reading/measurements obtained

10.0 Attachments or References

Attachment 1 – Well Development Record

SOP 3-05, *IDW Management*.

SOP 3-06, *Equipment Decontamination*.

<i>Author</i>	<i>Reviewer</i>	<i>Revisions (Technical or Editorial)</i>
Shawn Dolan Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (June 2012)

Attachment 1 Well Development Record



Well/Piezometer Development Record

Well ID:

Client: _____
 Project No: _____ Date: _____ Developer: _____
 Site Location: _____

Well/Piezometer Data

Well Piezometer Diameter _____ Material _____
 Measuring Point Description _____ Geology at Screen Interval _____
 (if known) _____
 Depth to Top of Screen (ft.) _____
 Depth to Bottom of Screen (ft.) _____ Time of Water Level Measurement _____
 Total Well Depth (ft.) _____ Calculate Purge Volume (gal.) _____
 Depth to Static Water Level (ft.) _____ Disposal Method _____
 Headspace _____
 Original Well Development Redevelopment Date of Original Development _____

DEVELOPMENT METHOD

PURGE METHOD

Time	Total Volume Purged (gal.)	Flow Rate (gpm)	Turbidity (NTU)	Color	pH	Temp	Other

ACCEPTANCE CRITERIA (from workplan)

Minimum Purge Volume Required _____ gallons
 Maximum Turbidity Allowed _____ NTUs
 Stabilization of parameters _____ %

Has required volume been removed
 Has required turbidity been reached
 Has parameters stabilized
 If no or N/A explain below:

Yes	No	N/A
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Signature _____ Date: _____

Monitoring Well Sampling

Procedure 3-14

1.0 Purpose and Scope

- 1.1 This standard operating procedure (SOP) describes the actions to be used during monitoring well sampling activities and establishes the method for sampling groundwater monitoring wells for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples that are representative of aquifer conditions with as little alteration to water chemistry as possible.
- 1.2 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).
- 1.3 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 Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. All field sampling personnel responsible for sampling activities must review the project-specific health and safety plan (HASP) paying particular attention to the control measures planned for the well sampling tasks. Conduct preliminary area monitoring of sampling wells to determine the potential hazard to field sampling personnel. If significant contamination is observed, minimize contact with potential contaminants in both the vapor phase and liquid matrix through the use of appropriate personal protective equipment (PPE).
- 2.2 Observe standard health and safety practices according to the project-specific HASP. Suggested minimum protection during well sampling activities includes inner disposable vinyl gloves, outer chemical-protective nitrile gloves and rubberized steel-toed boots. Half-face respirators and cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations. Refer to the project-specific HASP for the required PPE.
- 2.3 Physical Hazards associated with Well Sampling
 - To avoid lifting injuries associated with pump and bailers retrieval, use the large muscles of the legs, not the back.
 - Stay clear of all moving equipment, and avoid wearing loose fitting clothing.
 - When using tools for cutting purposes, cut away from yourself. The use of appropriate, task specific cutting tools is recommended.
 - To avoid slip/trip/fall conditions as a result of pump discharge, use textured boots/boot cover bottoms.
 - To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
 - Be aware of restricted mobility due to PPE.

3.0 Terms and Definitions

None.

4.0 Interferences

4.1 Potential interferences could result from cross-contamination between samples or sample locations. Minimization of the cross-contamination will occur through the following:

- The use of clean sampling tools at each location as necessary.
- Avoidance of material that is not representative of the media to be sampled.

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 **Contract Task Order (CTO) Manager** is responsible for ensuring that monitoring well sampling activities comply with this procedure. The **CTO Manager** is responsible for ensuring that all field sampling personnel involved in monitoring well 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 field sampling personnel follow these procedures.

5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure.

5.2.5 The field sampler and/or task manager is responsible for directly supervising the groundwater sampling procedures to ensure that they are conducted according to this procedure and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

6.1 Purging and Sampling Equipment

- Pump (Peristaltic, Portable Bladder, Submersible)
- Polyethylene or Teflon bladders (for portable bladder pumps)
- Bladder pump controller (for portable bladder pumps)
- Air compressor (for portable bladder pumps)
- Nitrogen cylinders (for portable bladder pumps)
- 12-volt power source
- Polyethylene inlet and discharge tubing (except for VOC analysis which requires Teflon tubing)
- Silicone tubing appropriate for peristaltic pump head
- Teflon bailer appropriately sized for well

- Disposable bailer string (polypropylene)
- Individual or multi-parameter water quality meter(s) with flow-through cell to measure temperature, pH, specific conductance, dissolved oxygen (DO), oxidation reduction potential (ORP), and/or turbidity
- Turbidity meter
- Water level meter
- Oil/water interface probe

6.2 General Equipment

- Sample kit (i.e., bottles, labels, preservatives, custody records and tape, cooler, ice)
- Sample Chain-of-Custody (COC) forms
- Sample Collection Records
- Sample packaging and shipping supplies
- Waterproof marker or paint
- Distilled/deionized water supply
- Water dispenser bottles
- Flow measurement cup or bucket
- 5-gallon buckets
- Instrument calibration solutions
- Stopwatch or watch
- Disposable Nitrile gloves
- Paper towels
- Trash bags
- Zipper-lock bags
- Equipment decontamination supplies
- Health and safety supplies (as required by the HASP)
- Approved plans such as: project-specific HASP and Sampling and Analysis Plan (SAP)
- Well keys or combinations
- Monitoring well location map(s)
- Field project logbook/pen

7.0 Calibration or Standardization

- 7.1 Field instruments will be calibrated daily according to the requirements of the SAP and manufacturer's specifications for each piece of equipment. Equipment will be checked daily with the calibration solutions at the end of use of the equipment. Calibration records shall be recorded in the field logbook or appropriate field form.
- 7.2 If readings are suspected to be inaccurate, the equipment shall be checked with the calibration solutions and/or re-calibrated.

8.0 Procedure

8.1 Preparation

8.1.1 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 history 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 an immiscible phase, historical water levels, and general hydrogeologic conditions.

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that might be encountered during sampling, such as excessive turbidity and low well yield. They may also indicate where dedicated pumps are placed in the water column. To help minimize the potential for cross-contamination, well purging and sampling and water level measurement collection shall proceed from the least contaminated to the most contaminated well as indicated by previous analytical results. 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.

8.1.2 Groundwater Analysis Selection

Establish the requisite field and laboratory analyses prior to water sampling. Decide on the types and numbers of quality assurance/quality control (QA/QC) samples to be collected (refer to the project-specific SAP), as well as the type and volume of sample preservatives, the type and number of sample containers, the number of coolers required, and the quantity of ice or other chilling materials. The field 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. Refer to the project-specific SAP for the project analytical requirements.

8.2 Groundwater Sampling Procedures

Groundwater sampling procedures at a site shall include:

- 1) An evaluation of the well security and condition prior to sampling;
- 2) Decontamination of equipment;
- 3) Measurement of well depth to groundwater;
- 4) Assessment of the presence or absence of an immiscible phase;
- 5) Assessment of purge parameter stabilization;
- 6) Purging of static water within the well and well bore; and
- 7) Obtaining a groundwater sample.

Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events. In all cases, consult the State and local regulations for the site, which may require more stringent time separation between well development and sampling.

8.2.1 Well Security and Condition

At each monitoring well location, observe the conditions of the well and surrounding area. The following information may be noted on a Groundwater Sample Collection Record (Attachment 1) or in the field logbook:

- Condition of the well's identification marker.
- Condition of the well lock and associated locking cap.
- Integrity of the well – well pad condition, protective outer casing, obstructions or kinks in the well casing, presence of water in the annular space, and the top of the interior casing.
- Condition of the general area surrounding the well.

8.2.2 Decontamination of Equipment

Where possible, dedicated supplies should be used at each well location to minimize the potential for cross-contamination and minimize the amount of investigation derived waste (IDW) fluids resulting from the decontamination process. If decontamination is necessary, establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with plastic sheeting and be located upwind of the well being sampled. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in SOP 3-06, Equipment Decontamination.

Decontaminate each piece of equipment prior to entering the well. Also, conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without on-site decontamination.

8.2.3 Measurement of Static Water Level Elevation

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. The best practice, if possible, is to measure all site wells (or wells within the monitoring well network) prior to sampling. If the well cap is not vented, remove the cap several minutes before measurement to allow water levels to equilibrate to atmospheric pressure.

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). If not already present, mark an easily identified reference point for water level measurements which will become the measuring point for all water level measurements. This location and elevation must be surveyed.

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 inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

At each location, measure water levels several times in quick succession to ensure that the well has equilibrated to atmospheric conditions prior to recording the measurement. As stated above, measure all site wells (or wells within the monitoring well network) prior to sampling whenever possible. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Prior to sampling, measure the water level in each well immediately prior to purging the well to ascertain that static conditions have been achieved prior to sampling.

8.2.4 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL before the well is purged for conventional sampling. These procedures may not be required for all wells. Consult the project-specific SAP to determine if assessing the presence of LNAPL and/or DNAPL is necessary.

- 1) Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a PID or an organic vapor analyzer, and record the measurements.
- 2) Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements.
- 3) 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.
- 4) In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water table contour maps until they are corrected for depression by the product.
- 5) If the well contains an immiscible phase, it may be desirable to sample this phase separately. Section 8.2.6 presents immiscible phase sampling procedures. 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 **Program Quality Manager** if this situation is encountered.

8.2.5 Purging Equipment and Use

General Requirements

The water present in a well prior to sampling may not be representative of in situ groundwater quality and shall be removed prior to sampling. Handle all groundwater removed from potentially contaminated wells in accordance with the IDW handling procedures in SOP 3-05, IDW Management. Purging shall be accomplished by methods as indicated in the project-specific SAP or by those required by State requirements. For the purposes of this SOP, purging methods will be described by removing groundwater from the well using low-flow techniques.

According to the U.S. Environmental Protection Agency (EPA) (EPA, 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/minute. EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated

corrosion or reaction products in the well. EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. In addition, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of increasing the turbidity of the sample due to mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The field sampler shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells should not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated based on the results of either the well development task or historical sampling events. In general, place the intake of the purge pump in the middle of the saturated screened interval within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified. If the well is purged dry, allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis during well purging and analyze them in the field preferably using in-line devices (i.e., flow through cell) for temperature, pH, specific conductivity, dissolved oxygen (DO), and oxidation-reduction (redox) potential. Turbidity should be measured separately (outside of the flow-through cell) with a nephelometer or similar device.

Readings should be taken every 2 to 5 minutes during the purging process. These parameters are measured to demonstrate that the natural character of the formation waters has been restored.

Purging shall be considered complete per the requirements set forth in the project-specific SAP, State requirements, or when three consecutive field parameter measurements of temperature, pH, specific conductivity, DO and ORP stabilize within approximately 10 percent and the turbidity is at or below 10 nephelometric turbidity units (NTU) or within $\pm 10\%$ if above 10 NTU. This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process into a groundwater sampling log. Attachment 1 shows an example of a groundwater sampling log and the information typically included in the form. Whatever form is used, all blanks need to be completed on the field log during field sampling.

Groundwater removed during purging shall be stored according to the project-specific SAP or per SOP 3-05, IDW Management.

Purging Equipment and Methods

Submersible Pump

A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling the groundwater for semivolatile and non-volatile constituents, but are generally not preferred for VOCs unless there are no other options (e.g., well over 200 feet deep). For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to overpumpage of the wells (<1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to limit the amount of

water that will flow back down the drop pipe into the well. Place the pump in the middle of the saturated screened interval within the well and maintain it in that position during purging.

Bladder Pump

A stainless steel bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Use of the bladder pump is most effective in low to moderate yield wells and are often the preferred method for low-flow sampling. When sampling for VOCs and/or SVOCs, Teflon bladders should be used. Polyethylene bladders may be used when sampling for inorganics.

Either compressed dry nitrogen or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use.

Centrifugal, Peristaltic, or Diaphragm Pump

A centrifugal, peristaltic, or diaphragm pump may be utilized to purge a well if the water level is within 20 feet of ground surface. New or dedicated tubing is inserted into the midpoint of the saturated screened interval of the well. Water should be purged at a rate that satisfies low-flow requirements (i.e., does not cause drawdown). Centrifugal, peristaltic, or diaphragm pump are generally discouraged for VOCs sampling; however, follow methods allowed per the project-specific SAP or State requirements.

Air Lift Pump

Airlift pumps are not appropriate for purging or sampling.

Bailer

Avoid using a bailer to purge a well because it can result in overdevelopment of the well and create excessive purge rates. If a bailer must be used, the bailer should either be dedicated or disposable. Teflon-coated cable mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well.

8.2.6 Monitoring Well Sampling Methodologies

Sampling Light, Non-Aqueous Phase Liquids (LNAPL)

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water interface depth as determined by measurement with the interface probe. Allow the bailer to fill with LNAPL and retrieve it.

When sampling LNAPLs, never drop bailers into a well and always remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. Teflon bailers should always be used when sampling LNAPL. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

Sampling Dense, Non-Aqueous Phase Liquids (DNAPL)

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

Groundwater Sampling Methodology

The well shall be sampled when groundwater within it is representative of aquifer conditions per the methods described in Section 8.2.5. Prior to sampling the flow-through cell shall be removed and the samples collected directly from the purge tubing. Flow rates shall not be adjusted once aquifer conditions are met. Additionally, a period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling in order to monitor drawdown when using low-flow techniques and gauge well volumes removed and recharged when using non-low-flow techniques.

Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers, minimizing exposure to sunlight, and immediately placing the sample on ice once collected.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride (PVC) bailers, Tygon® tubing, silicon rubber bladders, neoprene impellers, polyethylene, and Viton® are not acceptable when sampling for organics. If bailers are used, an inert cable/chain (e.g., fluorocarbon resin-coated wire or stainless steel wire or cable) shall be used to raise and lower the bailer. Dedicated equipment is highly recommended for all sampling programs.

Submersible Pumps

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. 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.

Bladder Pumps

A gas-operated stainless steel bladder pump with adjustable flow control and equipped with a Teflon bladder and 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. If only inorganics are being sampled, polyvinyl bladders and tubing may be used. 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.

When using a compressor, take several precautions. If the compressor is being powered by a gasoline generator, position the generator downwind of the well. Ground fault circuit interrupters (GFCIs) should always be used when using electric powered equipment. Do not connect the compression hose from the compressor to the pump controller until after the engine has been started.

When all precautions are completed and the compressor has been started, connect the compression hose to the pump controller. Slowly adjust the control knobs to discharge water in the shortest amount of time while maintaining a near constant flow. This does not mean that the compressor must be set 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 rate (purge rate) to yield 100 to 300 mL/minute. Avoid settings that produce pulsating streams of water instead of a steady stream if possible. Operate the pump at this low flow rate for several minutes to ensure that drawdown is not occurring. At no time shall the sample flow rate exceed the flow rate used while purging.

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

Peristaltic Pumps:

A peristaltic pump is a type of positive displacement pump that moves water via the process of peristalsis. The pump uses a flexible hose fitted inside a circular pump casing. A rotor with cams compresses the flexible tube as the rotor turns, which forces the water to be pumped to move through the tube. In peristaltic pumps, no moving parts of the pump are in contact with the water being pumped. Displacement is determined by tube size, so delivery rate can only be changed during operation by varying pump speed. Peristaltic pumps are simple and quite inexpensive for the flow rates they provide.

There are several methods available for transferring the sample into the laboratory containers. The selected method may vary based on State requirements and should be documented in the project-specific SAP. Samples typically can be collected directly from the discharge end of the Teflon tubing, after it has been disconnected from the flow through cell. For volatile analyses, the sampler should make sure that the pump is set such that a smooth laminar flow is achieved. In all cases, the project team should consult their local regulatory requirements and document the selected sample collection procedure in the project-specific SAP.

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, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, 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, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical, regulatory, or logistical reasons.

Dedicated or disposable bailers should always be used in order to eliminate the need for decontamination and to limit the potential of cross-contamination. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

8.2.7 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable and require preservation. The U.S. EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods (SW-846)* (EPA 1997), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 provides guidance on the types of sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory or State requirements prior to obtaining field samples. In many cases, the laboratory will supply the necessary sample bottles and required preservatives. In some cases, the field sampling personnel 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 container that has been prepared specifically for that analysis or set of compatible parameters as described in the project-specific SAP. 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 (TOX)

2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Nitrate and ammonia
10. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. The analytical laboratory performing the analysis shall provide these vials. Collect groundwater from the sampling device in 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. Sometimes it is not possible to collect a sample without air bubbles, particularly water that has high concentrations of dissolved gasses. In these cases, the field sampling personnel shall document the occurrence in the field logbook and/or sampling worksheet at the time the sample was collected. Likewise, the analytical laboratory shall note in the laboratory analysis reports any headspace in the sample container(s) at the time of receipt by the laboratory.

Special Handling Considerations

In general, samples for organic analyses should not be filtered. However, high turbidity samples for PCB analysis may require filtering. Consult the project-specific SAP for details on filtering requirements. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples should be handled in the same manner as VOC samples.

When collecting total and dissolved metals samples, the samples should be collected sequentially. The total metals sample is collected from the pump unfiltered. The dissolved metals sample is collected after filtering with a 0.45-micron membrane in-line filter. Allow at least 500 mL of effluent to flow through the filter prior to sampling to ensure that the filter is thoroughly wetted and seated in the filter capsule. If required by the project-specific SAP, include a filter blank for each lot of filters used and always record the lot number of the filters.

Field Sampling Preservation

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. Guidance for the preservation of environmental samples can be found in the U.S. EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other U.S. EPA documents (EPA 1992, 1996).

Field Sampling Log

A groundwater sampling log provided as Attachment 1 shall document the following:

- Identification of well

- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Types of sample containers used
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data
- Field observations on sampling event
- Name of sampler
- Weather conditions

9.0 Quality Control and Assurance

- 9.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific SAP. The goal of the QA program should be to ensure precision, accuracy, representativeness, completeness, and comparability in the project sampling program.
- 9.2 Quality control (QC) requirements for sample collection are dependent on project-specific sampling objectives. The project-specific SAP will provide requirements for sample preservation and holding times, container types, sample packaging and shipment, as well as requirements for the collection of various QC samples such as trip blanks, field blanks, equipment rinse blanks, and field duplicate samples.

10.0 Data and records management

- 10.1 Records will be maintained in accordance with SOP 3-03, Recordkeeping, Sample Labelling, and Chain-of-Custody. Various forms are required to ensure that adequate documentation is made of the sample collection activities. These forms may include:
- Sample Collection Records;
 - Field logbook;
 - Chain-of-custody forms; and
 - Shipping labels.

- 10.2 Sample collection records (Attachment 1) will provide descriptive information for the purging process and the samples collected at each monitoring well.
- 10.3 The field logbook is kept as a general log of activities and should not be used in place of the sample collection record.
- 10.4 Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes.
- 10.5 Shipping labels are required is sample coolers are to be transported to a laboratory by a third party (courier service).

11.0 Attachments or References

Attachment 1 – Groundwater Sampling Collection Record

ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites*. ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.

Environmental Protection Agency, United States (EPA). 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.

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

EPA. 1996. *Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA/540/S-95/504. Office of Solid Waste and Emergency Response. April.

EPA. 1997. *Test Methods for Evaluating Solid Waste, Physical/Chemical Method (SW-846)*. 3rd ed., Final Update IIIA. Office of Solid Waste. Online updates at: <http://www.epa.gov/epaoswer/hazwaste/test/new-meth.htm>.

NAVSEA T0300-AZ-PRO-010. *Navy Environmental Compliance Sampling and Field Testing Procedures Manual*. August 2009.

SOP 3-03, *Recordkeeping, Sample Labelling, and Chain-of-Custody*.

SOP 3-05, *IDW Management*.

SOP 3-06, *Equipment Decontamination*.

<i>Author</i>	<i>Reviewer</i>	<i>Revisions (Technical or Editorial)</i>
Mark Kromis Program Chemist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)

Attachment 1 Groundwater Sample Collection Record



Well ID: _____

Groundwater Sample Collection Record

Client: _____ Date: _____ Time: Start _____ am/pm
 Project No: _____ Finish _____ am/pm
 Site Location: _____
 Weather Conds: _____ Collector(s): _____

1. WATER LEVEL DATA: (measured from Top of Casing)

- a. Total Well Length _____ c. Length of Water Column _____ (a-b) Casing Diameter/Material _____
 b. Water Table Depth _____ d. Calculated Well Volume (see back) _____

2. WELL PURGEABLE DATA

- a. Purge Method: _____
 b. Acceptance Criteria defined (see SAP or Work Plan)
 - Minimum Required Purge Volume (@ _____ well volumes) _____
 - Maximum Allowable Turbidity _____ NTUs
 - Stabilization of parameters _____ %
 c. Field Testing Equipment used: Make Model Serial Number

Time (min)	Volume Removed (gal)	Temp. (°C)	pH s.u.	Spec. Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (m)	Color/Odor/etc.

- d. Acceptance criteria pass/fail Yes No N/A (continued on back)
 Has required volume been removed
 Has required turbidity been reached
 Have parameters stabilized
 If no or N/A - Explain below.

3. SAMPLE COLLECTION: Method: _____

Sample ID	Container Type	No. of Containers	Preservation	Analysis Req.	Time

Comments _____

Signature _____ Date _____

Monitoring Well Abandonment

Procedure 3-15

1.0 Purpose and Scope

- 1.1 This standard operating procedure (SOP) describes the methods used for the abandonment of groundwater monitoring wells and peizometers.
- 1.2 This procedure is the Program-approved professional guidance for work performed by Resolution Consultants under the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract (Contract Number N62470-11-D-8013).
- 1.3 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, 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 Physical hazards associated with well installation include:
 - To avoid lifting injuries associated with well abandonment practices, use the large muscles of the legs, not the back. The drilling contractor should use the drill rig wenching cables and appropriate heavy equipment to minimize manual lifting.
 - Stay clear of all moving equipment and avoid wearing loose fitting clothing.
 - When using an approved retractable-blade knife, cut away from one self.
 - To avoid slip/trip/fall conditions during site activities, keep the area clear of excess soil cuttings and formation groundwater and use textured boots/boot cover bottoms in muddy areas.
 - To avoid heat/cold stress because of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 - 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
 - Be aware of restricted mobility caused by PPE.

3.0 Terms and Definitions

- 3.1 **Annulus:** The annulus is the down-hole space between the borehole wall and the well casing and screen.
- 3.2 **Bridge:** A bridge is an obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by the placement of filter pack materials during well completion. Bridging can also occur in the formation during well development.
- 3.3 **Filter Pack:** Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

- 3.4 **Grout:** Grout is a fluid mixture of cement and water that can be forced through a tremie pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

4.0 Interferences

- 4.1 The total depth of the monitoring well will be measured and the measurement will be compared to the original well completion log prior to abandonment.
- 4.2 A map with the location of the well to be abandoned and the surrounding wells, if any, will be utilized in the field to confirm the location of the well to be abandoned.
- 4.3 Information from the well identification tags/markings will be noted and the information compared to both the well completion log and the total depth measurement obtained in the field to confirm the identity of the well being abandoned.

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 well abandonment activities comply with this procedure. The **CTO Manager** is responsible for ensuring that all personnel involved in well abandonment 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 well abandonment activities are conducted according to the either this procedure or the applicable procedure presented in the project-specific SAP.
- 5.2.4 **Field sampling personnel** are responsible for the implementation of this procedure.
- 5.2.5 The field sampler and/or task manager is responsible for directly supervising the well abandonment procedures to ensure that they are conducted according to this procedure and for recording all pertinent data collected during sampling.

6.0 Equipment and Supplies

- 6.1 Equipment and materials used during monitoring well and piezometer abandonment include the following:

- Drill rig or trailer-mounted mixer and grout pump
- Filter pack material
- Pure sodium bentonite with no additives
- Bentonite pellets/chips
- Bentonite grout
- Portland Type II cement
- Water from an approved source

- Weighted tape measure
- Flexible hose
- Tremie pipe (small-diameter, rigid polyvinyl chloride [PVC] pipe)
- Weatherproof bound field logbook with numbered pages
- Appropriate health and safety equipment

7.0 Procedure

7.1 General Procedures

The following procedure applies to the abandonment of wells aborted prior to completion and existing wells determined to be ineffective or otherwise in need of closure. Prior to abandoning any developed well, you may need to acquire a permit from the State or local governing body in which you are working. The permit application may require a detailed design of the well abandonment. In addition, prior to abandonment, all obstructions (e.g., pumps, lost equipment) must be removed from the well. Some States are strict in requiring the removal of all lost equipment prior to abandonment and will not allow the closure of a well with lost equipment in it. The State may require the removal of all objects to allow a proper seal during abandonment. Great lengths must be taken to reclaim lost items, such as the use of downhole video cameras to inspect and aid in the recovery of items. Prior to abandonment, confirm that the well selected for abandonment is properly located and identified to avoid abandoning the wrong well.

At locations where a well log is not available, the following procedure shall be implemented:

- The casing should be pulled, drilled out, or thoroughly pierced.
- With the use of a tremie pipe, grout should be placed from the bottom of the hole to within 3 feet of the ground surface.
- The material should be allowed to settle for 24 hours.
- The remainder of the hole should be filled with concrete.
- All historical sample data and abandonment procedures should be included in the records of work.

At locations where a well completion log is available, the following procedure shall be implemented:

- With the use of a tremie pipe, grout should be placed from the bottom of the hole to within 3 feet of the ground surface.
- The material should be allowed to settle for 24 hours.
- The remainder of the hole should be filled with concrete.
- All boring logs, historical sample data, completion records, and abandonment procedures should be included in the records of work.

Depending on the regulatory body under which you are working, the procedures listed above may differ. All work shall be performed by a licensed well driller in the State work is being performed. The licensed well driller is responsible for documenting the abandonment of the monitoring well with the appropriate State agency.

7.2 Replacement Wells

Replacement wells (if any) should normally be offset at least 15 feet from any abandoned well in an upgradient or crossgradient groundwater flow direction. Site-specific conditions may necessitate variation of this placement requiring the replacement well to be located either closer or further in proximity to the original well. To avoid potential issues related to grout migration into a well filter pack and/or screen section, replacement wells should be installed after the original/adjacent well is properly abandoned.

7.3 Grout

Bentonite grout is preferred for the abandonment of monitoring wells. Cement grout, if used for abandonment, should be composed of the following by weight:

- 20 parts cement (Portland cement, Type II or V)
- 0.4 to 1 part (maximum) (2 to 5 percent) bentonite
- 8 gallons (maximum) approved water per 94-pound bag of cement

Neither additives nor borehole cuttings should be mixed with the grout. Bentonite should be added after the required amount of cement has been mixed with the water. All grout material should be combined in an aboveground container and mechanically blended to produce a thick, lump-free mixture. The mixed grout should be recirculated through the grout pump prior to placement. The mixture can be combined and recirculated through a drill rig equipped for mud rotary drilling or through a mixer and grout pump mounted on a trailer.

Grout should be placed with the use of a commercially available grout pump and a rigid tremie pipe. Casing and grouting should be removed in stages, aquifer by aquifer, sealing the boring from the bottom to ground surface. This should be accomplished by placing a tremie pipe to the bottom and pumping grout through the pipe until undiluted grout reaches the bottom of the next higher section of casing or, for the topmost section, until grout flows from the boring at the ground surface.

After 24 hours, the abandoned drilling site should be checked for grout settlement. Any settlement depression should be filled with grout and rechecked 24 hours later. This process should be repeated until firm grout remains at the ground surface.

Be aware that when the drillers are finished, they will need a large supply of water to rinse out their equipment. This wash water must be containerized as IDW in accordance with SOP 3-05, *IDW Management*. Also, any materials (such as the removed protective casing, manhole covers, and concrete collars) shall be disposed of properly, or per the requirements of the project-specific SAP.

8.0 Quality Control and Assurance

8.1 Field personnel will follow specific quality assurance (QA) guidelines as outlined in the project-specific SAP.

8.2 Quality Control (QC) measures should be taken to ensure proper well abandonment in accordance with this SOP, project-specific SAP, and applicable well standards.

9.0 Records, Data Analysis, Calculations

9.1 All field information must be documented in the field logbook and/or on field data sheets with permanent ink. Data recorded may include the following:

- Date/time
- Well/piezometer location
- Personnel/subcontractor on site
- Abandonment method
- Depth of well/piezometer
- Materials used to seal each stratum
- Detailed description of procedure
- Date/time of return visit(s)
- Activities performed on return visit(s)
- Observations or problems encountered during abandonment

10.0 Attachments or References

Environmental Protection Agency, United States (EPA). 1987. *A Compendium of Superfund Field Operations Methods*. Office of Solid Waste and Emergency Response. EPA/540/P-87/001.

SOP 3-05, *IDW Management*.

<i>Author</i>	<i>Reviewer</i>	<i>Revisions (Technical or Editorial)</i>
Shawn Dolan Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (June 2012)

Operation and Calibration of a Photoionization Detector

Procedure 3-20

1.0 Purpose and Scope

1.1 Purpose and Applicability

- 1.1.1 This standard operating procedure (SOP) describes the procedures that will be followed by field staff for operation and calibration of a photoionization detector (PID). The PID is primarily used by AECOM personnel for safety and survey monitoring of ambient air, determining the presence of volatiles in soil and water, and detecting leakage of volatiles.
- 1.1.2 PIDs routinely used by field personnel include the Photovac Microtip, Thermoelectron 580EZ, and MiniRAE 2000. Personnel responsible for using the PID should first read and thoroughly familiarize themselves with the instrument instruction manual.

1.2 Principle of Operation

- 1.2.1 The PID is a non-specific vapor/gas detector. The unit generally consists of a hand-held probe that houses a PID, consisting of an ultraviolet (UV) lamp, two electrodes, and a small fan which pulls ambient air into the probe inlet tube. The probe is connected to a readout/control box that consists of electronic control circuits, a readout display, and the system battery. Units are available with UV lamps having an energy from 9.5 electron volts (eV) to 11.7 eV.
- 1.2.2 The PID analyzer measures the concentration of trace gas present in the atmosphere by photoionization. Photoionization occurs when an atom or molecule absorbs a photon of sufficient energy to release an electron and become a positive ion. This will occur when the ionization potential of the molecule (in electron volts (eV)) is less than the energy of the photon. The source of photons is an ultraviolet lamp in the probe unit. Lamps are available with energies ranging from 9.5 eV to 11.7 eV. All organic and inorganic vapor/gas compounds having ionization potentials lower than the energy output of the UV lamp are ionized and the resulting potentiometric change is seen as a positive reading on the unit. The reading is proportional to the concentration of organics and/or inorganics in the vapor.
- 1.2.3 Sample gases enter the probe through the inlet tube and enter the ion chamber where they are exposed to the photons emanating from the UV lamp. Ionization occurs for those molecules having ionization potentials near to or less than that of the lamp. A positive- biased polarizing electrode causes these positive ions to travel to a collector electrode in the chamber. Thus the ions create an electrical current which is amplified and displayed on the meter. This current is proportional to the concentration of trace gas present in the ion chamber and to the sensitivity of that gas to photoionization.
- 1.2.4 In service, the analyzer is first calibrated with a gas of known composition equal to, close to, or representative of that to be measured. Gases with ionization potentials near to or less than the energy of the lamp will be ionized. These gases will thus be detected and measured by the analyzer. Gases with ionization potentials greater than the energy of the lamp will not be detected. The ionization potentials of the major components of air, i.e., oxygen, nitrogen, and carbon dioxide, range from about 12.0 eV to 15.6 eV and are not ionized by any of the lamps available. Gases with ionization potentials near to or slightly higher than the lamp are partially ionized, with low sensitivity.

1.3 Specifications

- 1.3.1 Refer to the manufacturer's instructions for the technical specifications of the instrument being used. The operating concentration range is typically 0.1 to 2,000 ppm isobutylene equivalent.

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 Only PIDs stamped Division I Class I may be used in explosive atmospheres. Refer to the project HASP for instructions pertaining to instrument use in explosive atmospheres.

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 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 operation and calibration activities comply with this procedure. The CTO Manager is responsible for ensuring that all personnel involved in the operation and calibration 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 operation and calibration 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

- Calibration Gas: Compressed gas cylinder of isobutylene in air or similar stable gas mixture of known concentration. The selected gas should have an ionization potential similar to that of the vapors to be monitored, if known. The concentration should be at 50-75% of the range in which the instrument is to be calibrated;

- Regulator for calibration gas cylinder;
- Approximately 6 inches of Teflon® tubing;
- Tedlar bag (optional);
- Commercially-supplied zero grade air (optional);
- "Magic Marker" or "Sharpie" or other waterproof marker;
- Battery charger;
- Moisture traps;
- Spare lamps;
- Manufacturer's instructions; and
- Field data sheets or logbook/pen.

7.0 Procedure

7.1 Preliminary Steps

- 7.1.1 Preliminary steps (battery charging, check-out, calibration, maintenance) should be conducted in a controlled or non-hazardous environment.

7.2 Calibration

- 7.2.1 The PID must be calibrated in order to display concentrations in units equivalent to ppm. First a supply of zero air (ambient air or from a supplied source), containing no ionizable gases or vapors is used to set the zero point. A span gas, containing a known concentration of a photoionizable gas or vapor, is then used to set the sensitivity.
- 7.2.2 Calibrate the instrument according to the manufacturer's instructions. Record the instrument model and identification number, the initial and adjusted meter readings, the calibration gas composition and concentration, and the date and the time in the field records.
- 7.2.3 If the calibration cannot be achieved or if the span setting resulting from calibration is 0.0, then the lamp must be cleaned (Section 7.4).

7.3 Operation

- 7.3.1 Turn on the unit and allow it to warm up (minimum of 5 minutes). Check to see if the intake fan is functioning; if so, the probe will vibrate slightly and a distinct sound will be audible when holding the probe casing next to the ear. Also, verify on the readout display that the UV lamp is lit.
- 7.3.2 Calibrate the instrument as described in Section 7.2, following the manufacturer's instructions. Record the calibration information in the field records.
- 7.3.3 The instrument is now operational. Readings should be recorded in the field records.
- 7.3.4 When the PID is not being used or between monitoring intervals, the unit may be switched off to conserve battery power and UV lamp life; however, a "bump" test should be performed each time the unit is turned on and prior to taking additional measurements. To perform a bump test, connect the outlet tubing from a Tedlar bag containing a small amount of span gas to the inlet tubing on the unit and record the reading. If the reading is not within the tolerance specified in the project plan, the unit must be recalibrated.
- 7.3.5 At the end of each day, recheck the calibration. The check will follow the same procedures as the initial calibration (Section 7.2) except that no adjustment will be made to the instrument. Record the information in the field records.

- 7.3.6 Recharge the battery after each use (Section 7.4).
- 7.3.7 When transporting, ensure that the instrument is packed in its stored condition in order to prevent damage.

7.4 **Routine Maintenance**

- 7.4.1 Routine maintenance associated with the use of the PID includes charging the battery, cleaning the lamp window, replacing the detector UV lamp, replacing the inlet filter, and replacing the sample pump. Refer to the manufacturer's instructions for procedures and frequency.
- 7.4.2 All routine maintenance should be performed in a non-hazardous environment.

7.5 **Troubleshooting Tips**

- 7.5.1 One convenient method for periodically confirming instrument response is to hold the sensor probe next to the tip of a magic marker. A significant reading should readily be observed.
- 7.5.2 Air currents or drafts in the vicinity of the probe tip may cause fluctuations in readings.
- 7.5.3 A fogged or dirty lamp, due to operation in a humid or dusty environment, may cause erratic or fluctuating readings. The PID should never be operated without the moisture trap in place.
- 7.5.4 Moving the instrument from a cool or air-conditioned area to a warmer area may cause moisture to condense on the UV lamp and produce unstable readings.
- 7.5.5 A zero reading on the meter should not necessarily be interpreted as an absence of air contaminants. The detection capabilities of the PID are limited to those compounds that will be ionized by the particular probe used.
- 7.5.6 Many volatile compounds have a low odor threshold. A lack of meter response in the presence of odors does not necessarily indicate instrument failure.
- 7.5.7 When high vapor concentrations enter the ionization chamber in the PID the unit can become saturated or "flooded". Remove the unit to a fresh air environment to allow the vapors to be completely ionized and purged from the unit.

8.0 **Quality Control and Assurance**

- 8.1 The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Sampling and Analysis Plan (SAP), hereafter referred to as the project plan.
- 8.2 Calibration of the PID will be conducted at the frequency specified in the project plan. In the absence of project-specific guidance, calibration will be performed at the beginning of each day of sampling and will be checked at the end of the sampling day or whenever instrument operation is suspect. The PID will sample a calibration gas of known concentration. The instrument must agree with the calibration gas within $\pm 10\%$. If the instrument responds outside this tolerance, it must be recalibrated.
- 8.3 Checks of the instrument response (Section 7.5) should be conducted periodically and documented in the field records.

9.0 **Records, Data Analysis, Calculations**

Safety and survey monitoring with the PID will be documented in a bound field logbook, or on standardized forms, and retained in the project files. The following information is to be recorded:

- Project name and number;
- Instrument manufacturer, model, and identification number;

- Operator's signature;
- Date and time of operation;
- Calibration gas used;
- Calibration check at beginning and end of day (meter readings before adjustment);
- Span setting after calibration adjustment;
- Meter readings (monitoring data obtained);
- Instances of erratic or questionable meter readings and corrective actions taken; and
- Instrument checks and response verifications – e.g., battery check, magic marker response (Section 7.5) or similar test.

10.0 Attachments or References

United States Environmental Protection Agency. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM). USEPA, Region 4, SESD, Enforcement and Investigations Branch, Athens, GA. November 2001.

Author	Reviewer	Revisions (Technical or Editorial)
Robert Shoemaker Senior Scientist	Chris Barr Program Quality Manager	Rev 0 – Initial Issue (May 2012)

Standard Operating Procedure SOP-3-24
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.

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

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
						The colder the sample, the higher the DO reading.
Dissolved Oxygen	mg/L	0.0	14.6 (0°C) 10.1 (15°C) 8.3 (2°C)	0.0	5	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

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 ($\mu\text{S}/\text{cm}$) 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 $\mu\text{S}/\text{cm}$, 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.

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.

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 Factors

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.

$$K = \frac{(Km)(C)}{1 + 0.0191(T - 25)}$$

Where:

- K = Conductivity in $\mu\text{mhos/cm}$ at 25°C
- Km = Measured conductivity in $\mu\text{mhos/cm}$ 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:

$$K = \frac{(Km)}{1 + 0.0191(T - 25)}$$

5.7.2 Percentage Difference Calculation

For evaluating slope of readings from either a flow cell or a sample cup.

$$\%Difference = \frac{(Highest\ Value - Lowest\ Value)}{(Highest\ Value)} \times 100$$

5.7.3 Convert mm mercury (mmHG) to inches mercury (inHG)

$$mmHG = inHG \times 25.4$$

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.

$$TrueBP = (BP) - \frac{(2.5 \times [Local\ Altitude])}{100}$$

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 mmHG:

$$\text{mmHg} = 30.49 \text{ inHg} \times 25.4 = 774.4 \text{ mmHg}$$

Calculate True BP:

$$\text{TrueBP} = (774.4 \text{ mmHg}) - [2.5 * (544 / 100)] = 774.4 - 13.6 = 760.8 \text{ mmHg}$$

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

Attachment 1
Example Field Instrument Calibration Form

Field Instrument Calibration Form

Calibrated by: _____
Date: _____

Equipment (Make/Model/Serial#): _____
Equipment (Make/Model/Serial#): _____

pH (su) Standard: ± 0.2 standard units				DO (mg/L) Standard: ± 0.3 mg/L of theoretical*			
Initial Calibration		Initial Calibration Verification		IC (Temp:)		ICV (Temp:)	
Hach SL	Reading	Pine SL	Reading	Saturation (%)	Reading (%)	Theoretical (mg/L)	Reading (mg/L)
pH7				100			
pH4							
Continuing Calibration Verification				CCV (Temp:)			
Hach SL	Reading	Deviation	Acceptable Variance (Y/N)	Saturation (%)	Reading (%)	Deviation	Acceptable Variance (Y/N)
pH7				100			
pH4				Theoretical (mg/L)	Reading (mg/L)	Deviation	Acceptable Variance (Y/N)
ORP (mV) Standard: NA				Turbidity (ntu) Standard: ±10% of Standard			
IC (Zobell SL:)		ICV (Pine SL:)		Initial Calibration			
TCS (Std/Temp)	Reading	TCS (Std/Temp)	Reading	Standard	Reading		
CCV (Zobell SL:)				Continuing Calibration Verification			
TCS (Std/Temp)	Reading	Deviation	Acceptable Variance (Y/N)	Standard	Reading	Deviation	Acceptable Variance (Y/N)
Conductivity (ms ^c /cm) Standard: ± 5% of standard value				Comments:			
IC (YSI SL:)		ICV (Pine SL:)					
Standard	Reading	Standard	Reading				
CCV (YSI SL:)							
Standard	Reading	Deviation	Acceptable Variance (Y/N)				

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

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	<input type="checkbox"/> Bailer	<input type="checkbox"/> 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 <input type="checkbox"/>

SAMPLE DATA

<input type="checkbox"/> Bailer	<input type="checkbox"/> 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:

Monitoring Well Inspection Form

WELL ID: _____
 TIME: _____

INSPECTOR NAME: _____
 DATE: _____

Inspection Item	Types of Problems	Status		Observation
		S	U	
Well Tag	Is it in-place, legible			
Well Security	Condition of protective case, cap, lock			
Well Pad	Concrete or gravel & condition			
Well Seal	Condition			
Area Immediately around well pad	Record any evidence of/or standing water in area of well			
Dedicated Sampling Equipment	Condition			
PVC Riser	Condition of riser & survey reference point			

Note: S=Satisfactory, U=Unsatisfactory

Signature(s): _____

Appendix B
Laboratory Accreditation Certificate



**LABORATORY
ACCREDITATION
BUREAU**



Certificate of Accreditation

ISO/IEC 17025:2005

Certificate Number L2226

Empirical Laboratories, LLC

621 Mainstream Drive, Suite 270
Nashville TN 37228

has met the requirements set forth in L-A-B's policies and procedures, all requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the U.S. Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP).*

The accredited lab has demonstrated technical competence to a defined "Scope of Accreditation" and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

Accreditation valid through: November 30, 2015



**R. Douglas Leonard, Jr., President, COO
Laboratory Accreditation Bureau
Presented the 30th of January 2013**

*See the laboratory's Scope of Accreditation for details of accredited parameters

**Laboratory Accreditation Bureau is found to be in compliance with ISO/IEC 17011:2004 and recognized by ILAC (International Laboratory Accreditation Cooperation) and NACLA (National Cooperation for Laboratory Accreditation).

Scope of Accreditation For Empirical Laboratories, LLC

621 Mainstream Drive, Suite 270
Nashville, TN 37228
Marcia K. McGinnity
877-345-1113

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.2) based on the National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003), accreditation is granted to Empirical Laboratories, LLC to perform the following tests:

Accreditation granted through: **November 30, 2015**

Testing - Environmental

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260B/C; EPA 624	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/C; EPA 624	1,1,1-Trichloroethane (1,1,1-TCA)
GC/MS	EPA 8260B/C; EPA 624	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/C; EPA 624	1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)
GC/MS	EPA 8260B/C; EPA 624	1,1,2-Trichloroethane
GC/MS	EPA 8260B/C; EPA 624	1,1-Dichloroethane (1,1-DCA)
GC/MS	EPA 8260B/C; EPA 624	1,1-Dichloroethene (1,1-DCE)
GC/MS	EPA 8260B/C; EPA 624	1,1-Dichloropropene
GC/MS	EPA 8260B/C; EPA 624	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B/C; EPA 624	1,2,3-Trichloropropane
GC/MS	EPA 8260B/C; EPA 624	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/C; EPA 624	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/C; EPA 624	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 8260B/C; EPA 624	1,2-Dibromoethane (EDB)
GC/MS	EPA 8260B/C; EPA 624	1,2-Dichlorobenzene

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260B/C; EPA 624	1,2-Dichloroethane (EDC)
GC/MS	EPA 8260B/C; EPA 624	1,2-Dichloropropane
GC/MS	EPA 8260B/C; EPA 624	1,3,5- Trichlorobenzene
GC/MS	EPA 8260B/C; EPA 624	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B/C; EPA 624	1,3-Dichlorobenzene
GC/MS	EPA 8260B/C; EPA 624	1,3-Dichloropropane
GC/MS	EPA 8260B/C; EPA 624	1,4-Dichlorobenzene
GC/MS	EPA 8260B/C; EPA 624	1,4-Dioxane
GC/MS	EPA 8260B/C; EPA 624	1-Chlorohexane
GC/MS	EPA 8260B/C; EPA 624	2,2-Dichloropropane
GC/MS	EPA 8260B/C; EPA 624	2-Butanone (Methyl ethyl ketone; MEK)
GC/MS	EPA 8260B/C; EPA 624	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B/C; EPA 624	2-Chlorotoluene
GC/MS	EPA 8260B/C; EPA 624	2-Hexanone (Methyl butyl ketone; MBK)
GC/MS	EPA 8260B/C; EPA 624	4-Chlorotoluene
GC/MS	EPA 8260B/C; EPA 624	4-Methyl-2-pentanone (Methyl isobutyl ketone; MBK)
GC/MS	EPA 8260B/C; EPA 624	Acetone
GC/MS	EPA 8260B/C; EPA 624	Acetonitrile
GC/MS	EPA 8260B/C; EPA 624	Acrolein
GC/MS	EPA 8260B/C; EPA 624	Acrylonitrile
GC/MS	EPA 8260B/C; EPA 624	Allyl chloride
GC/MS	EPA 8260B/C; EPA 624	Benzene
GC/MS	EPA 8260B/C; EPA 624	Bromobenzene
GC/MS	EPA 8260B/C; EPA 624	Bromochloromethane
GC/MS	EPA 8260B/C; EPA 624	Bromodichloromethane
GC/MS	EPA 8260B/C; EPA 624	Bromoform
GC/MS	EPA 8260B/C; EPA 624	Bromomethane
GC/MS	EPA 8260B/C; EPA 624	Carbon Disulfide
GC/MS	EPA 8260B/C; EPA 624	Carbon Tetrachloride
GC/MS	EPA 8260B/C; EPA 624	Chlorobenzene

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260B/C; EPA 624	Chloroethane
GC/MS	EPA 8260B/C; EPA 624	Chloroform
GC/MS	EPA 8260B/C; EPA 624	Chloromethane
GC/MS	EPA 8260B/C; EPA 624	Chloroprene
GC/MS	EPA 8260B/C; EPA 624	cis-1,2-Dichloroethene (cis-1,2-DCE)
GC/MS	EPA 8260B/C; EPA 624	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/C; EPA 624	cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C; EPA 624	Cyclohexane
GC/MS	EPA 8260B/C; EPA 624	Dibromochloromethane
GC/MS	EPA 8260B/C; EPA 624	Dibromomethane
GC/MS	EPA 8260B/C; EPA 624	Dichlorodifluoromethane (CFC-12)
GC/MS	EPA 8260B/C; EPA 624	Diethyl ether
GC/MS	EPA 8260B/C; EPA 624	Di-isopropyl ether
GC/MS	EPA 8260B/C; EPA 624	Ethyl tert-butyl ether (ETBE)
GC/MS	EPA 8260B/C; EPA 624	Ethyl methacrylate
GC/MS	EPA 8260B/C; EPA 624	Ethylbenzene
GC/MS	EPA 8260B/C; EPA 624	Hexachlorobutadiene
GC/MS	EPA 8260B/C; EPA 624	Hexane
GC/MS	EPA 8260B/C; EPA 624	Iodomethane
GC/MS	EPA 8260B/C; EPA 624	Isobutyl alcohol
GC/MS	EPA 8260B/C; EPA 624	Isopropylbenzene (Cumene)
GC/MS	EPA 8260B/C; EPA 624	m,p-Xylenes
GC/MS	EPA 8260B/C; EPA 624	Methacrylonitrile
GC/MS	EPA 8260B/C; EPA 624	Methyl Acetate
GC/MS	EPA 8260B/C; EPA 624	Methyl methacrylate
GC/MS	EPA 8260B/C; EPA 624	Methyl tert-Butyl Ether (MTBE)
GC/MS	EPA 8260B/C; EPA 624	Methylcyclohexane
GC/MS	EPA 8260B/C; EPA 624	Methylene Chloride, or Dichloromethane
GC/MS	EPA 8260B/C; EPA 624	Naphthalene
GC/MS	EPA 8260B/C; EPA 624	n-Butylbenzene

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260B/C; EPA 624	n-Propylbenzene
GC/MS	EPA 8260B/C; EPA 624	o-Xylene
GC/MS	EPA 8260B/C; EPA 624	p-Isopropyltoluene
GC/MS	EPA 8260B/C; EPA 624	Propionitrile
GC/MS	EPA 8260B/C; EPA 624	sec-Butylbenzene
GC/MS	EPA 8260B/C; EPA 624	Styrene
GC/MS	EPA 8260B/C; EPA 624	tert-Amyl alcohol
GC/MS	EPA 8260B/C; EPA 624	tert-Butyl alcohol
GC/MS	EPA 8260B/C; EPA 624	tert-Amyl methyl ether
GC/MS	EPA 8260B/C; EPA 624	tert-Butylbenzene
GC/MS	EPA 8260B/C; EPA 624	Tetrachloroethene (PCE; PERC)
GC/MS	EPA 8260B/C; EPA 624	Tetrahydrofuran
GC/MS	EPA 8260B/C; EPA 624	Toluene
GC/MS	EPA 8260B/C; EPA 624	trans-1,2-Dichloroethene (trans-1,2-DCE)
GC/MS	EPA 8260B/C; EPA 624	trans-1,3-Dichloropropene
GC/MS	EPA 8260B/C; EPA 624	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C; EPA 624	Trichloroethene (TCE)
GC/MS	EPA 8260B/C; EPA 624	Trichlorofluoromethane (CFC-11)
GC/MS	EPA 8260B/C; EPA 624	Vinyl acetate
GC/MS	EPA 8260B/C; EPA 624	Vinyl Chloride (VC)
GC/MS	EPA 8260B/C; EPA 624	Xylenes (Total)
GC/MS	EPA 8270C/D; EPA 625	1,1'-Biphenyl
GC/MS	EPA 8270C/D; EPA 625	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C/D; EPA 625	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C/D; EPA 625	1,2-Dichlorobenzene
GC/MS	EPA 8270C/D; EPA 625	1,2-Diphenylhydrazine
GC/MS	EPA 8270C/D; EPA 625	1,3-Dichlorobenzene
GC/MS	EPA 8270C/D; EPA 625	1,4-Dichlorobenzene
GC/MS	EPA 8270C/D; EPA 625	1,4-Dioxane
GC/MS	EPA 8270C/D; EPA 625	1-Methylnaphthalene

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270C/D; EPA 625	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C/D; EPA 625	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/D; EPA 625	2,4,6-Trichlorophenol (TCP)
GC/MS	EPA 8270C/D; EPA 625	2,4-Dichlorophenol (DCP)
GC/MS	EPA 8270C/D; EPA 625	2,4-Dimethylphenol
GC/MS	EPA 8270C/D; EPA 625	2,4-Dinitrophenol
GC/MS	EPA 8270C/D; EPA 625	2,4-Dinitrotoluene (DNT)
GC/MS	EPA 8270C/D; EPA 625	2,6-Dichlorophenol
GC/MS	EPA 8270C/D; EPA 625	2,6-Dinitrotoluene
GC/MS	EPA 8270C/D; EPA 625	2-Chloronaphthalene
GC/MS	EPA 8270C/D; EPA 625	2-Chlorophenol
GC/MS	EPA 8270C/D; EPA 625	2-Methylnaphthalene
GC/MS	EPA 8270C/D; EPA 625	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270C/D; EPA 625	2-Nitroaniline
GC/MS	EPA 8270C/D; EPA 625	2-Nitrophenol (ONP)
GC/MS	EPA 8270C/D; EPA 625	3,3'-Dichlorobenzidine (DCB)
GC/MS	EPA 8270C/D; EPA 625	3-Methylphenol/4-Methylphenol
GC/MS	EPA 8270C/D; EPA 625	3-Nitroaniline
GC/MS	EPA 8270C/D; EPA 625	4,6-Dinitro-2-methylphenol (DNOC)
GC/MS	EPA 8270C/D; EPA 625	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C/D; EPA 625	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/D; EPA 625	4-Chloroaniline
GC/MS	EPA 8270C/D; EPA 625	4-Chlorophenyl phenyl ether
GC/MS	EPA 8270C/D; EPA 625	4-Methylphenol (p-Cresol)
GC/MS	EPA 8270C/D; EPA 625	4-Nitroaniline (PNA)
GC/MS	EPA 8270C/D; EPA 625	4-Nitrophenol (PNP)
GC/MS	EPA 8270C/D; EPA 625	Acenaphthene
GC/MS	EPA 8270C/D; EPA 625	Acenaphthylene
GC/MS	EPA 8270C/D; EPA 625	Acetophenone
GC/MS	EPA 8270C/D; EPA 625	Aniline

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270C/D; EPA 625	Anthracene
GC/MS	EPA 8270C/D; EPA 625	Atrazine
GC/MS	EPA 8270C/D; EPA 625	Benzaldehyde
GC/MS	EPA 8270C/D; EPA 625	Benzidine
GC/MS	EPA 8270C/D; EPA 625	Benzo(a)anthracene
GC/MS	EPA 8270C/D; EPA 625	Benzo(a)pyrene
GC/MS	EPA 8270C/D; EPA 625	Benzo(b)fluoranthene
GC/MS	EPA 8270C/D; EPA 625	Benzo(g,h,i)perylene
GC/MS	EPA 8270C/D; EPA 625	Benzo(k)fluoranthene
GC/MS	EPA 8270C/D; EPA 625	Benzoic Acid
GC/MS	EPA 8270C/D; EPA 625	Benzyl Alcohol
GC/MS	EPA 8270C/D; EPA 625	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270C/D; EPA 625	bis(2-Chloroethyl)ether (BCEE)
GC/MS	EPA 8270C/D; EPA 625	bis(2-chloroisopropyl)ether, or 2,2'-oxybis(1-Chloropropane)
GC/MS	EPA 8270C/D; EPA 625	bis(2-Ethylhexyl)phthalate (BEHP)
GC/MS	EPA 8270C/D; EPA 625	Butyl benzyl phthalate (BBP)
GC/MS	EPA 8270C/D; EPA 625	Caprolactam
GC/MS	EPA 8270C/D; EPA 625	Carbazole
GC/MS	EPA 8270C/D; EPA 625	Chrysene
GC/MS	EPA 8270C/D; EPA 625	Dibenz(a,h)anthracene
GC/MS	EPA 8270C/D; EPA 625	Dibenzofuran (DBF)
GC/MS	EPA 8270C/D; EPA 625	Diethyl phthalate (DEP)
GC/MS	EPA 8270C/D; EPA 625	Dimethyl phthalate (DMP)
GC/MS	EPA 8270C/D; EPA 625	Di-n-butyl phthalate (DBP)
GC/MS	EPA 8270C/D; EPA 625	Di-n-octyl phthalate (DNOP)
GC/MS	EPA 8270C/D; EPA 625	Fluoranthene
GC/MS	EPA 8270C/D; EPA 625	Fluorene
GC/MS	EPA 8270C/D; EPA 625	Hexachlorobenzene (HCB)
GC/MS	EPA 8270C/D; EPA 625	Hexachlorobutadiene (HCBd)
GC/MS	EPA 8270C/D; EPA 625	Hexachlorocyclopentadiene (HCCPD)

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270C/D; EPA 625	Hexachloroethane (HCE)
GC/MS	EPA 8270C/D; EPA 625	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270C/D; EPA 625	Isophorone
GC/MS	EPA 8270C/D; EPA 625	Naphthalene
GC/MS	EPA 8270C/D; EPA 625	Nitrobenzene
GC/MS	EPA 8270C/D; EPA 625	N-Nitrosodimethylamine
GC/MS	EPA 8270C/D; EPA 625	N-Nitroso-di-n-propylamine (NDPA)
GC/MS	EPA 8270C/D; EPA 625	N-nitrosodiphenylamine (NDPHA)
GC/MS	EPA 8270C/D; EPA 625	Pentachlorophenol
GC/MS	EPA 8270C/D; EPA 625	Phenanthrene
GC/MS	EPA 8270C/D; EPA 625	Phenol
GC/MS	EPA 8270C/D; EPA 625	Pyrene
GC/MS	EPA 8270C/D; EPA 625	Pyridine
GC/ECD	EPA 8081A/B	4,4'-DDD
GC/ECD	EPA 8081A/B	4,4'-DDE
GC/ECD	EPA 8081A/B	4,4'-DDT
GC/ECD	EPA 8081A/B	Aldrin
GC/ECD	EPA 8081A/B	alpha-BHC (alpha-HCH)
GC/ECD	EPA 8081A/B	alpha-Chlordane
GC/ECD	EPA 8081A/B	beta-BHC (beta-HCH)
GC/ECD	EPA 8081A/B	delta-BHC (delta-HCH)
GC/ECD	EPA 8081A/B	Dieldrin
GC/ECD	EPA 8081A/B	Endosulfan I
GC/ECD	EPA 8081A/B	Endosulfan II
GC/ECD	EPA 8081A/B	Endosulfan sulfate
GC/ECD	EPA 8081A/B	Endrin
GC/ECD	EPA 8081A/B	Endrin aldehyde
GC/ECD	EPA 8081A/B	Endrin ketone
GC/ECD	EPA 8081A/B	gamma-BHC (Lindane; gamma-HCH)
GC/ECD	EPA 8081A/B	gamma-Chlordane

Non-Potable Water		
Technology	Method	Analyte
GC/ECD	EPA 8081A/B	Heptachlor
GC/ECD	EPA 8081A/B	Heptachlor epoxide
GC/ECD	EPA 8081A/B	Methoxychlor
GC/ECD	EPA 8081A/B	Chlordane (n.o.s.)
GC/ECD	EPA 8081A/B	Toxaphene
GC/ECD	EPA 8082A	Aroclor-1016
GC/ECD	EPA 8082A	Aroclor-1221
GC/ECD	EPA 8082A	Aroclor-1232
GC/ECD	EPA 8082A	Aroclor-1242
GC/ECD	EPA 8082A	Aroclor-1248
GC/ECD	EPA 8082A	Aroclor-1254
GC/ECD	EPA 8082A	Aroclor-1260
GC/ECD	EPA 8082A	Aroclor-1262
GC/ECD	EPA 8082A	Aroclor-1268
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4,5-TP (Silvex)
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichlorprop
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP (Mecoprop)
HPLC/UV	EPA 8330A/B	1,3,5-Trinitrobenzene
HPLC/UV	EPA 8330A/B	1,3-Dinitrobenzene
HPLC/UV	EPA 8330A/B	2,4,6-Trinitrophenylmethylnitramine (Tetryl)
HPLC/UV	EPA 8330A/B	2,4,6-Trinitrotoluene (TNT)
HPLC/UV	EPA 8330A/B	2,6-Dinitrotoluene (DNT)
HPLC/UV	EPA 8330A/B	2,6-Dinitrotoluene

Non-Potable Water		
Technology	Method	Analyte
HPLC/UV	EPA 8330A/B	2-Amino-4,6-dinitrotoluene
HPLC/UV	EPA 8330A/B	2-Nitrotoluene (ONT)
HPLC/UV	EPA 8330A/B	3,5-Dinitroaniline
HPLC/UV	EPA 8330A/B	3-Nitrotoluene
HPLC/UV	EPA 8330A/B	4-Amino-2,6-dinitrotoluene
HPLC/UV	EPA 8330A/B	4-Nitrotoluene (PNT)
HPLC/UV	EPA 8330A/B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC/UV	EPA 8330A/B	Nitrobenzene
HPLC/UV	EPA 8330A/B	Nitroglycerin
HPLC/UV	EPA 8330A/B	Nitroguanidine
HPLC/UV	EPA 8330A/B	Octahydro-1,3,5,6-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC/UV	EPA 8330A/B	3,5-Dinitroaniline
HPLC/UV	EPA 8330A/B	PETN
GC/FID	FL PRO	Petroleum Range Organics
GC/FID	EPA 8015B/C	TPH DRO
GC/FID	EPA 8015B/C	TPH ORO
GC/FID	EPA 8015B/C	TPH GRO
GC/FID	RSK-175	Methane
GC/FID	RSK-175	Ethane
GC/FID	RSK-175	Ethene
GC/ECD	EPA 8011	1,2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1,2-Dibromo-3-chloropropane (DBCP)
HPLC/MS	EPA 6850	Perchlorate
ICP	EPA 6010B/C; EPA 200.7	Aluminum
ICP	EPA 6010B/C; EPA 200.7	Antimony
ICP	EPA 6010B/C; EPA 200.7	Arsenic
ICP	EPA 6010B/C; EPA 200.7	Barium
ICP	EPA 6010B/C; EPA 200.7	Beryllium

Non-Potable Water		
Technology	Method	Analyte
ICP	EPA 6010B/C; EPA 200.7	Boron
ICP	EPA 6010B/C; EPA 200.7	Cadmium
ICP	EPA 6010B/C; EPA 200.7	Calcium
ICP	EPA 6010B/C; EPA 200.7	Chromium, total
ICP	EPA 6010B/C; EPA 200.7	Cobalt
ICP	EPA 6010B/C; EPA 200.7	Copper
ICP	EPA 6010B/C; EPA 200.7	Iron
ICP	EPA 6010B/C; EPA 200.7	Lead
ICP	EPA 6010B/C; EPA 200.7	Magnesium
ICP	EPA 6010B/C; EPA 200.7	Manganese
CVAA	EPA 7470A; EPA 245.1	Mercury
ICP	EPA 6010B/C; EPA 200.7	Molybdenum
ICP	EPA 6010B/C; EPA 200.7	Nickel
ICP	EPA 6010B/C; EPA 200.7	Potassium
ICP	EPA 6010B/C; EPA 200.7	Selenium
ICP	EPA 6010B/C; EPA 200.7	Silver
ICP	EPA 6010B/C; EPA 200.7	Sodium
ICP	EPA 6010B/C; EPA 200.7	Strontium
ICP	EPA 6010B/C; EPA 200.7	Thallium
ICP	EPA 6010B/C; EPA 200.7	Tin
ICP	EPA 6010B/C; EPA 200.7	Titanium

Non-Potable Water		
Technology	Method	Analyte
ICP	EPA 6010B/C; EPA 200.7	Vanadium
ICP	EPA 6010B/C; EPA 200.7	Zinc
ICP	SM 2340 B-2011; EPA 200.7; EPA 6010C	Hardness
IC	EPA 300.0	Bromide
IC	EPA 300.0	Chloride
IC	EPA 300.0	Fluoride
IC	EPA 300.0	Nitrate
IC	EPA 300.0	Nitrite
IC	EPA 300.0	Sulfate
IC	EPA 9056A	Bromide
IC	EPA 9056A	Chloride
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Nitrate
IC	EPA 9056A	Nitrite
IC	EPA 9056A	Sulfate
Titration	SM 2320 B-2011	Alkalinity
Colorimetric	SM 4500 NH3 G-2011	Ammonia
Probe	SM 5210 B-2011	BOD
Probe	SM 5210 B-2011	CBOD
Colorimetric	EPA 410.4	COD
Colorimetric	EPA 9012A/B SM 4500 CN G-2011	Cyanide
UV/Vis	EPA 7196A SM 3500 Cr B-2011	Hexavalent Chromium
Physical	EPA 1010A	Ignitability / Flashpoint
Colorimetric	EPA 353.2	Nitrate/Nitrite
Colorimetric	EPA 353.2 MOD	Nitrocellulose
Colorimetric	SM 4500 NO2 B-2011	Nitrite as N
Gravimetric	EPA 1664A	Oil and Grease
Physical	EPA 9095B	Paint Filter

Non-Potable Water		
Technology	Method	Analyte
Probe	EPA 9040B/C SM 4500 H+ B-2011	pH(Corrosivity)
Titration	Chap.7, Sect. 7.3.4 Mod.	Reactive Sulfide
Titration	SM 4500 S2 F-2011	Sulfide
UV/Vis	SM 4500 P B5-2011	Total Phosphorus (as P)
UV/Vis	SM 4500 P E-2011	Ortho-Phosphate (as P)
TOC	EPA 9060A; SM 5310 C-2011	Total Organic Carbon
Gravimetric	SM 2540 C-2011	TDS
Gravimetric	SM 2540 D-2011	TSS
Preparation	Method	Type
Preparation	EPA 1311	TCLP
Preparation	EPA 3005A	Metals digestion
Preparation	EPA 3010A	Metals digestion
Preparation	EPA 3510C	Organics Liquid Extraction
Preparation	EPA 5030A/B	Purge and Trap Water

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8260B/C	1,1,1-Trichloroethane (1,1,1-TCA)
GC/MS	EPA 8260B/C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)
GC/MS	EPA 8260B/C	1,1,2-Trichloroethane
GC/MS	EPA 8260B/C	1,1-Dichloroethane (1,1-DCA)
GC/MS	EPA 8260B/C	1,1-Dichloroethene (1,1-DCE)
GC/MS	EPA 8260B/C	1,1-Dichloropropene
GC/MS	EPA 8260B/C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B/C	1,2,3-Trichloropropane
GC/MS	EPA 8260B/C	1,2,4-Trichlorobenzene

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8260B/C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/C	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 8260B/C	1,2-Dibromoethane (EDB)
GC/MS	EPA 8260B/C	1,2-Dichlorobenzene
GC/MS	EPA 8260B/C	1,2-Dichloroethane (EDC)
GC/MS	EPA 8260B/C	1,2-Dichloropropane
GC/MS	EPA 8260B/C	1,3,5-Trichlorobenzene
GC/MS	EPA 8260B/C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B/C	1,3-Dichlorobenzene
GC/MS	EPA 8260B/C	1,3-Dichloropropane
GC/MS	EPA 8260B/C	1,4-Dichlorobenzene
GC/MS	EPA 8260B/C	1,4-Dioxane
GC/MS	EPA 8260B/C	1-Chlorohexane
GC/MS	EPA 8260B/C	2,2-Dichloropropane
GC/MS	EPA 8260B/C	2-Butanone (Methyl ethyl ketone; MEK)
GC/MS	EPA 8260B/C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B/C	2-Chlorotoluene
GC/MS	EPA 8260B/C	2-Hexanone (Methyl butyl ketone; MBK)
GC/MS	EPA 8260B/C	4-Chlorotoluene
GC/MS	EPA 8260B/C	4-Methyl-2-pentanone (Methyl isobutyl ketone; MIBK)
GC/MS	EPA 8260B/C	Acetone
GC/MS	EPA 8260B/C	Acetonitrile
GC/MS	EPA 8260B/C	Acrolein
GC/MS	EPA 8260B/C	Acrylonitrile
GC/MS	EPA 8260B/C	Allyl chloride
GC/MS	EPA 8260B/C	Benzene
GC/MS	EPA 8260B/C	Bromobenzene
GC/MS	EPA 8260B/C	Bromochloromethane
GC/MS	EPA 8260B/C	Bromodichloromethane
GC/MS	EPA 8260B/C	Bromoform

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8260B/C	Bromomethane
GC/MS	EPA 8260B/C	Carbon Disulfide
GC/MS	EPA 8260B/C	Carbon Tetrachloride
GC/MS	EPA 8260B/C	Chlorobenzene
GC/MS	EPA 8260B/C	Chloroethane
GC/MS	EPA 8260B/C	Chloroform
GC/MS	EPA 8260B/C	Chloromethane
GC/MS	EPA 8260B/C	Chloroprene
GC/MS	EPA 8260B/C	cis-1,2-Dichloroethene (cis-1,2-DCE)
GC/MS	EPA 8260B/C	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/C	cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	Cyclohexane
GC/MS	EPA 8260B/C	Dibromochloromethane
GC/MS	EPA 8260B/C	Dibromomethane
GC/MS	EPA 8260B/C	Dichlorodifluoromethane (CFC-12)
GC/MS	EPA 8260B/C	Diethyl ether
GC/MS	EPA 8260B/C	Di-isopropyl ether
GC/MS	EPA 8260B/C	Ethyl methacrylate
GC/MS	EPA 8260B/C	Ethyl tert-butyl ether (ETBE)
GC/MS	EPA 8260B/C	Ethylbenzene
GC/MS	EPA 8260B/C	Hexachlorobutadiene
GC/MS	EPA 8260B/C	Hexane
GC/MS	EPA 8260B/C	Iodomethane
GC/MS	EPA 8260B/C	Isobutyl alcohol
GC/MS	EPA 8260B/C	Isopropylbenzene (Cumene)
GC/MS	EPA 8260B/C	m,p-Xylenes
GC/MS	EPA 8260B/C	Methacrylonitrile
GC/MS	EPA 8260B/C	Methyl Acetate
GC/MS	EPA 8260B/C	Methyl methacrylate
GC/MS	EPA 8260B/C	Methyl Tert-Butyl Ether (MTBE)

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8260B/C	Methylcyclohexane
GC/MS	EPA 8260B/C	Methylene Chloride, or Dichloromethane
GC/MS	EPA 8260B/C	Naphthalene
GC/MS	EPA 8260B/C	n-Butylbenzene
GC/MS	EPA 8260B/C	n-Propylbenzene
GC/MS	EPA 8260B/C	o-Xylene
GC/MS	EPA 8260B/C	p-Isopropyltoluene
GC/MS	EPA 8260B/C	Propionitrile
GC/MS	EPA 8260B/C	sec-Butylbenzene
GC/MS	EPA 8260B/C	Styrene
GC/MS	EPA 8260B/C	tert-Amyl alcohol
GC/MS	EPA 8260B/C	Tert-Amyl ethyl ether
GC/MS	EPA 8260B/C	tert-Amyl methyl ether
GC/MS	EPA 8260B/C	tert-Butyl alcohol
GC/MS	EPA 8260B/C	tert-Butylbenzene
GC/MS	EPA 8260B/C	Tetrachloroethene (PCE; PERC)
GC/MS	EPA 8260B/C	Tetrahydrofuran
GC/MS	EPA 8260B/C	Toluene
GC/MS	EPA 8260B/C	trans-1,2-Dichloroethene (trans-1,2-DCE)
GC/MS	EPA 8260B/C	trans-1,3-Dichloropropene
GC/MS	EPA 8260B/C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	Trichloroethene (TCE)
GC/MS	EPA 8260B/C	Trichlorofluoromethane (CFC-11)
GC/MS	EPA 8260B/C	Vinyl acetate
GC/MS	EPA 8260B/C	Vinyl Chloride (VC)
GC/MS	EPA 8260B/C	Xylenes (Total)
GC/MS	EPA 8270C/D	1,1'-Biphenyl
GC/MS	EPA 8270C/D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C/D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C/D	1,2-Dichlorobenzene

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	1,2-Diphenylhydrazine
GC/MS	EPA 8270C/D	1,3-Dichlorobenzene
GC/MS	EPA 8270C/D	1,4-Dichlorobenzene
GC/MS	EPA 8270C/D	1,4-Dioxane
GC/MS	EPA 8270C/D	1-Methylnaphthalene
GC/MS	EPA 8270C/D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C/D	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/D	2,4,6-Trichlorophenol (TCP)
GC/MS	EPA 8270C/D	2,4-Dichlorophenol (DCP)
GC/MS	EPA 8270C/D	2,4-Dimethylphenol
GC/MS	EPA 8270C/D	2,4-Dinitrophenol
GC/MS	EPA 8270C/D	2,4-Dinitrotoluene (DNT)
GC/MS	EPA 8270C/D	2,6-Dichlorophenol
GC/MS	EPA 8270C/D	2,6-Dinitrotoluene
GC/MS	EPA 8270C/D	2-Chloronaphthalene
GC/MS	EPA 8270C/D	2-Chlorophenol
GC/MS	EPA 8270C/D	2-Methylnaphthalene
GC/MS	EPA 8270C/D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270C/D	2-Nitroaniline
GC/MS	EPA 8270C/D	2-Nitrophenol (ONP)
GC/MS	EPA 8270C/D	3,3'-Dichlorobenzidine (DCB)
GC/MS	EPA 8270C/D	3-Methylphenol/4-Methylphenol
GC/MS	EPA 8270C/D	3-Nitroaniline
GC/MS	EPA 8270C/D	4,6-Dinitro-2-methylphenol (DNOC)
GC/MS	EPA 8270C/D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C/D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/D	4-Chloroaniline
GC/MS	EPA 8270C/D	4-Chlorophenyl phenyl ether
GC/MS	EPA 8270C/D	4-Methylphenol (p-Cresol)
GC/MS	EPA 8270C/D	4-Nitroaniline (PNA)

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	4-Nitrophenol (PNP)
GC/MS	EPA 8270C/D	Acenaphthene
GC/MS	EPA 8270C/D	Acenaphthylene
GC/MS	EPA 8270C/D	Acetophenone
GC/MS	EPA 8270C/D	Aniline
GC/MS	EPA 8270C/D	Anthracene
GC/MS	EPA 8270C/D	Atrazine
GC/MS	EPA 8270C/D	Benzaldehyde
GC/MS	EPA 8270C/D	Benzidine
GC/MS	EPA 8270C/D	Benzo(a)anthracene
GC/MS	EPA 8270C/D	Benzo(a)pyrene
GC/MS	EPA 8270C/D	Benzo(b)fluoranthene
GC/MS	EPA 8270C/D	Benzo(g,h,i)perylene
GC/MS	EPA 8270C/D	Benzo(k)fluoranthene
GC/MS	EPA 8270C/D	Benzoic Acid
GC/MS	EPA 8270C/D	Benyl alcohol
GC/MS	EPA 8270C/D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270C/D	bis(2-Chloroethyl)ether (BCEE)
GC/MS	EPA 8270C/D	bis(2-chloroisopropyl)ether, or 2,2'-oxybis (1-Chloropropane)
GC/MS	EPA 8270C/D	bis(2-Ethylhexyl)phthalate (BEHP)
GC/MS	EPA 8270C/D	Butyl benzyl phthalate (BBP)
GC/MS	EPA 8270C/D	Caprolactam
GC/MS	EPA 8270C/D	Carbazole
GC/MS	EPA 8270C/D	Chrysene
GC/MS	EPA 8270C/D	Dibenz(a,h)anthracene
GC/MS	EPA 8270C/D	Dibenzofuran (DBF)
GC/MS	EPA 8270C/D	Diethyl phthalate (DEP)
GC/MS	EPA 8270C/D	Dimethyl phthalate (DMP)
GC/MS	EPA 8270C/D	Di-n-butyl phthalate (DBP)

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	EPA 8270C/D	Di-n-octyl phthalate (DNOP)
GC/MS	EPA 8270C/D	Fluoranthene
GC/MS	EPA 8270C/D	Fluorene
GC/MS	EPA 8270C/D	Hexachlorobenzene (HCB)
GC/MS	EPA 8270C/D	Hexachlorobutadiene (HCBd)
GC/MS	EPA 8270C/D	Hexachlorocyclopentadiene (HCCPD)
GC/MS	EPA 8270C/D	Hexachloroethane (HCE)
GC/MS	EPA 8270C/D	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270C/D	Isophorone
GC/MS	EPA 8270C/D	Naphthalene
GC/MS	EPA 8270C/D	Nitrobenzene
GC/MS	EPA 8270C/D	N-Nitrosodimethylamine
GC/MS	EPA 8270C/D	N-Nitroso-di-n-propylamine (NDPA)
GC/MS	EPA 8270C/D	N-nitrosodiphenylamine (NDPHA)
GC/MS	EPA 8270C/D	Pentachlorophenol
GC/MS	EPA 8270C/D	Phenanthrene
GC/MS	EPA 8270C/D	Phenol
GC/MS	EPA 8270C/D	Pyrene
GC/MS	EPA 8270C/D	Pyridine
GC/ECD	EPA 8081A/B	4,4'-DDD
GC/ECD	EPA 8081A/B	4,4'-DDE
GC/ECD	EPA 8081A/B	4,4'-DDT
GC/ECD	EPA 8081A/B	Aldrin
GC/ECD	EPA 8081A/B	alpha-BHC (alpha-HCH)
GC/ECD	EPA 8081A/B	alpha-Chlordane
GC/ECD	EPA 8081A/B	beta-BHC (beta-HCH)
GC/ECD	EPA 8081A/B	delta-BHC (delta-HCH)
GC/ECD	EPA 8081A/B	Chlordane (n.o.s.)
GC/ECD	EPA 8081A/B	Dieldrin
GC/ECD	EPA 8081A/B	Endosulfan I

Solid and Chemical Materials		
Technology	Method	Analyte
GC/ECD	EPA 8081A/B	Endosulfan II
GC/ECD	EPA 8081A/B	Endosulfan sulfate
GC/ECD	EPA 8081A/B	Endrin
GC/ECD	EPA 8081A/B	Endrin aldehyde
GC/ECD	EPA 8081A/B	Endrin ketone
GC/ECD	EPA 8081A/B	gamma-BHC (Lindane; gamma-HCH)
GC/ECD	EPA 8081A/B	gamma-Chlordane
GC/ECD	EPA 8081A/B	Heptachlor
GC/ECD	EPA 8081A/B	Heptachlor epoxide
GC/ECD	EPA 8081A/B	Methoxychlor
GC/ECD	EPA 8081A/B	Toxaphene
GC/ECD	EPA 8082A	Aroclor-1016
GC/ECD	EPA 8082A	Aroclor-1221
GC/ECD	EPA 8082A	Aroclor-1232
GC/ECD	EPA 8082A	Aroclor-1242
GC/ECD	EPA 8082A	Aroclor-1248
GC/ECD	EPA 8082A	Aroclor-1254
GC/ECD	EPA 8082A	Aroclor-1260
GC/ECD	EPA 8082A	Aroclor-1262
GC/ECD	EPA 8082A	Aroclor-1268
HPLC/UV	EPA 8330A	1,3,5-Trinitrobenzene
HPLC/UV	EPA 8330A	1,3-Dinitrobenzene
HPLC/UV	EPA 8330A	2,4,6-Trinitrophenylmethylnitramine (Tetryl)
HPLC/UV	EPA 8330A	2,4,6-Trinitrotoluene (TNT)
HPLC/UV	EPA 8330A	2,4-Dinitrotoluene (DNT)
HPLC/UV	EPA 8330A	2,6-Dinitrotoluene
HPLC/UV	EPA 8330A	2-Amino-4,6-dinitrotoluene
HPLC/UV	EPA 8330A	2-Nitrotoluene (ONT)
HPLC/UV	EPA 8330A	3-Nitrotoluene
HPLC/UV	EPA 8330A	3,5-Dinitroaniline

Solid and Chemical Materials		
Technology	Method	Analyte
HPLC/UV	EPA 8330A	4-Amino-2,6-dinitrotoluene
HPLC/UV	EPA 8330A	4-Nitrotoluene (PNT)
HPLC/UV	EPA 8330A	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC/UV	EPA 8330A	Nitroglycerin
HPLC/UV	EPA 8330A	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC/UV	EPA 8330A	Nitrobenzene
HPLC/UV	EPA 8330A	Nitroguanidine
HPLC/UV	EPA 8330A	PETN
HPLC/UV	EPA 8330B	1,3,5-Trinitrobenzene
HPLC/UV	EPA 8330B	1,3-Dinitrobenzene
HPLC/UV	EPA 8330B	2,4,6-Trinitrophenylmethylnitramine (Tetryl)
HPLC/UV	EPA 8330B	2,4,6-Trinitrotoluene (TNT)
HPLC/UV	EPA 8330B	2,4-Dinitrotoluene (DNT)
HPLC/UV	EPA 8330B	2,6-Dinitrotoluene
HPLC/UV	EPA 8330B	2-Amino-4,6-dinitrotoluene
HPLC/UV	EPA 8330B	2-Nitrotoluene (ONT)
HPLC/UV	EPA 8330B	3-Nitrotoluene
HPLC/UV	EPA 8330B	3,5-Dinitroaniline
HPLC/UV	EPA 8330B	4-Amino-2,6-dinitrotoluene
HPLC/UV	EPA 8330B	4-Nitrotoluene (PNT)
HPLC/UV	EPA 8330B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC/UV	EPA 8330B	Nitroglycerin
HPLC/UV	EPA 8330B	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC/UV	EPA 8330B	Nitrobenzene
HPLC/UV	EPA 8330B	Nitroguanidine
HPLC/UV	EPA 8330B	PETN
GC/FID	FL PRO	Petroleum Range Organics
GC/FID	EPA 8015B/C	TPH DRO
GC/FID	EPA 8015B/C	TPH ORO

Solid and Chemical Materials		
Technology	Method	Analyte
GC/FID	EPA 8015B/C	TPH GRO
HPLC/MS	EPA 6850	Perchlorate
ICP	EPA 6010B/C	Aluminum
ICP	EPA 6010B/C	Antimony
ICP	EPA 6010B/C	Arsenic
ICP	EPA 6010B/C	Barium
ICP	EPA 6010B/C	Beryllium
ICP	EPA 6010B/C	Boron
ICP	EPA 6010B/C	Cadmium
ICP	EPA 6010B/C	Calcium
ICP	EPA 6010B/C	Chromium, total
ICP	EPA 6010B/C	Cobalt
ICP	EPA 6010B/C	Copper
ICP	EPA 6010B/C	Iron
ICP	EPA 6010B/C	Lead
ICP	EPA 6010B/C	Magnesium
ICP	EPA 6010B/C	Manganese
ICP	EPA 6010B/C	Molybdenum
ICP	EPA 6010B/C	Nickel
ICP	EPA 6010B/C	Potassium
ICP	EPA 6010B/C	Selenium
ICP	EPA 6010B/C	Silver
ICP	EPA 6010B/C	Sodium
ICP	EPA 6010B/C	Strontium
ICP	EPA 6010B/C	Tin
ICP	EPA 6010B/C	Titanium
ICP	EPA 6010B/C	Thallium
ICP	EPA 6010B/C	Vanadium
ICP	EPA 6010B/C	Zinc
CVAA	EPA 7471A/B	Mercury

Solid and Chemical Materials		
Technology	Method	Analyte
IC	EPA 9056A	Bromide
IC	EPA 9056A	Chloride
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Nitrate
IC	EPA 9056A	Nitrite
IC	EPA 9056A	Sulfate
Colorimetric	EPA 9012A/B	Cyanide
UV/Vis	EPA 7196A	Hexavalent Chromium
Physical	EPA 1010A	Ignitability/Flashpoint
Colorimetric	EPA 353.2 MOD	Nitrocellulose
Probe	EPA 9045C/D	pH (Corrosivity)
Titration	Chap.7, Sect. 7.3.4 Mod.	Reactive Sulfide
Titration	EPA 9034	Sulfide
TOC	Lloyd Kahn	Total Organic Carbon
Preparation	Method	Type
Preparation	EPA 1311	TCLP
Preparation	EPA 1312	SPLP
Preparation	NJ Modified 3060A	Hexavalent Chromium
Preparation	EPA 3050B	Metals Digestion
Preparation	EPA 3546	Organics Microwave Extraction
Preparation	EPA 3550B/C	Organics Sonication
Preparation	SM 2540 B-1997	Percent Solids (Percent Moisture)
Preparation	EPA 5035 /A	Purge and Trap Solid

Notes:

- 1) This laboratory offers commercial testing service.

Approved by:


 R. Douglas Leonard
 Chief Technical Officer

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