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Naval Facilities Engineering Command

Final

Sampling and Analysis Plan
Site Inspection for Perfluorinated Compounds in Groundwater
Outlying Landing Field Coupeville

NAS Whidbey Island
Coupeville, Washington

January 2017

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SAP Worksheet #1—Title and Approval Page

Final

Sampling and Analysis Plan
Site Inspection for Perfluorinated Compounds in Groundwater

Outlying Landing Field Coupeville
NAS Whidbey Island
Coupeville, Washington

Contract Task Order 08

January 2017

Prepared for:

Department of the Navy
Naval Facilities Engineering Command
Northwest

Under the:

NAVFAC CLEAN 9000 Program
Contract N62470-16-D-9000

Prepared by:

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Approval Signatures:

[redacted]

Digitally signed by [redacted]

[redacted]

Date: 2016.11.16 14:27:48 -05'00'

[redacted] Date

NAVFAC Atlantic– Chemist/Quality Assurance Officer

Other Approval Signatures:

[redacted] Date

NAVFAC Atlantic– Technical Representative

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Executive Summary

This Sampling and Analysis Plan (SAP) outlines the sampling activities in support of a Site Inspection (SI) for perfluorinated compounds (PFCs) in groundwater at Outlying Landing Field (OLF) Coupeville, Naval Air Station (NAS) Whidbey Island, in Coupeville, Washington.

CH2M HILL, Inc. (CH2M) prepared this document under the United States Department of the Navy (Navy), Naval Facilities Engineering Command (NAVFAC), Comprehensive Long-term Environmental Action—Navy (CLEAN) 9000 Contract N62470-16-D-9000, Contract Task Order 08, in accordance with the Navy's Uniform Federal Policy (UFP) +SAP policy guidance to help ensure that environmental data collected are scientifically sound, of known and documented quality, and suitable for intended uses.

OLF Coupeville was commissioned for use by the Navy in 1943 and has provided support for day and night Field Carrier Landing Practice (FCLP) operations by the Navy for aircraft based out of NAS Whidbey Island. The initial rationale for an SI at OLF Coupeville SI was that at similar Navy sites, aqueous film-forming foam containing PFCs was used, and PFCs were detected in groundwater. There are no reports of the use of aqueous film-forming foam-containing PFCs at OLF Coupeville. However, in October 2016, PFCs were detected in one of two on base drinking water supply wells. OLF Coupeville likely sits on a groundwater mound, resulting in groundwater flow radially away from the OLF (Island County, 2005).

No groundwater investigations have been conducted at OLF Coupeville. The objectives of this SI are as follows:

- Refine understanding of groundwater flow at the OLF
- Confirm the presence of PFCs in groundwater and characterize their nature (if present)

Monitoring wells will be installed throughout the OLF. A groundwater level survey will be conducted to gain an understanding of local groundwater flow, and groundwater samples will be collected from these monitoring wells to confirm the presence of PFCs and, if present, to characterize the nature of PFCs in groundwater. If PFCs are present in groundwater, then these data will be used as confirmation of a release of PFCs, and off base drinking water samples will be collected within 1 mile downgradient of any areas where PFCs were detected in groundwater. Samples from off base drinking water wells will be analyzed to determine whether PFCs are present in drinking water above the project action levels. If PFCs are present above the project action levels in the drinking water samples, an alternate drinking water source will be provided. Sampling of drinking water will be conducted under a separate SAP.

This SAP consists of 37 worksheets specific to the scope of work for the investigation of PFCs at OLF Coupeville. All tables are embedded within the worksheets. All figures are included at the end of the document. Field standard operation procedures are included in **Appendix A**. Laboratory Department of Defense Environmental Laboratory Accreditation Program Accreditation letters are included in **Appendix B**. Laboratory standard operation procedures are included in **Appendix C**.

The laboratory information cited in this SAP is specific to Vista Analytical in El Dorado Hills, California. If additional laboratory services are requested requiring modification to the existing SAP, revised SAP worksheets will be submitted to the Navy for approval.

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SAP Worksheets

Appendices

Tables

Figures

Acronyms and Abbreviations

°C	degree(s) Celsius
µg/L	microgram(s) per liter
AFFF	aqueous film-forming foam
bgs	below ground surface
CA	corrective action
CAS	Chemical Abstract Services
CCV	continuing calibration verification
CH2M	Ch2M HILL, Inc.
CLEAN	Comprehensive Long-term Environmental Action—Navy
DL	detection limit
DO	dissolved oxygen
DoD	Department of Defense
DQI	data quality indicator
DV	data validation
EDD	electronic data deliverable
EDS	Environmental Data Services, Inc.
ELAP	Environmental Laboratory Accreditation Program
FCLP	Field Carrier Landing Practice
FD	field duplicate
FTL	Field Team Leader
H&S	health and safety
HDPE	high density polyethylene
HQ	hazard quotient
HSM	Health and Safety Manager
HSP	Health and Safety Plan
ICAL	initial calibration
ID	identification
IDW	investigation-dDerived waste
IS	internal standard
LC	liquid chromatograph
LCL	lower criteria limit
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MDL	method detection limit
mL	milliliter(s)
MPC	measurement performance criteria
MS	matrix spike
MS	mass spectrometer
MSD	matrix spike duplicate
N/A	not applicable

NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
OLF	Outlying Field
ORP	oxidation-reduction potential
PAL	project action limit
PC	Project Chemist
PFBS	perfluorobutane sulfonate
PFC	perfluoronated compound
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PID	photoionization detector
PM	Project Manager
POC	point of contact
PQL	project quantitation limit
PVC	polyvinyl chloride
QA	quality assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
QM	Quality Manager
QSM	Quality Systems Manual
RL	reporting limit
RPD	relative percent difference
RPM	Remedial Project Manager
RSD	relative standard deviation
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SBO	safe behavior observation
SI	Site Investigation
SOP	standard operating procedure
SSC	Site Safety Coordinator
STC	Senior Technical Consultant
TAL	target analyte list
TBD	to be determined
TCL	target compound list
TM	Task Manager
UCL	upper confidence limit
UFP	Uniform Federal Policy
USEPA	United States Environmental Protection Agency
WQP	water quality parameter

SAP Worksheet #2—SAP Identifying Information

(UFP-QAPP Manual Section 2.2.4)

Site Name:	Outlying Landing Field (OLF) Coupeville, Naval Air Station (NAS) Whidbey Island
Contractor Name:	CH2M HILL, Inc. (CH2M)
Contract Number:	N62470-16-D-9000
Contract Title:	Comprehensive Long-term Environmental Action—Navy (CLEAN) 9000 Program
Work Assignment Number (optional):	Contract Task Order 08

1. This Sampling and Analysis Plan (SAP) was prepared in accordance with the requirements of the following:
   - *Guidance for Quality Assurance Project Plans (QAPPs)* (USEPA, 1998)
   - *Quality Assurance (QA)/G-5, Quality Assurance Management Staff (QAMS)* (USEPA, 2002)
   - *Uniform Federal Policy (UFP) – QAPP* (USEPA, 2005)
   - *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006).
2. Identify regulatory program:
   - Comprehensive Environmental Response, Compensation, and Liability Act of 1980
3. This document is a project-specific SAP.
4. List dates of scoping sessions that were held:

Scoping Session	Date
Project Scoping Session with NAVFAC Atlantic and NAS Whidbey Island Remedial Project Manager (RPM)	October 13, 2016

5. List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation.

Title	Date
None	

6. List organizational partners (stakeholders) and connection with lead organization:
   - OLF Coupeville, NAS Whidbey Island – Base stakeholder
   - Naval Facilities Engineering Command (NAVFAC) Atlantic – Technical Representative
7. Lead organization:
   - United States Department of the Navy (Navy) – NAVFAC Atlantic
8. If any required SAP elements or required information are not applicable (N/A) to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion as follows:
   - A crosswalk table is excluded because all required information is provided in this SAP.

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SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number	Email Address or Mailing Address
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		
[redacted]	[redacted]	[redacted]		
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

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SAP Worksheet #4—Project Personnel Sign-Off Sheet

Name	**Organization/Title/Role**	**Telephone Number**	**Signature/Email receipt**	**SAP Section Reviewed**	**Date SAP Read**
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]			

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SAP Worksheet #5—Project Organizational Chart

[redacted]

- - - - - - - - - - Lines of Communication
———————— Lines of Authority
DV = data validation
EDS = Environmental Data Services, Inc.
IDW = investigation-derived waste
QAO = Quality Assurance Officer
TBD = to be determined

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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number and/or Email	Procedure
Communication with Navy (lead agency)	Technical Representative	[redacted]	[redacted]	Primary point of contact (POC) for Navy; can delegate communication to other internal or external POCs.
Communication with Base	Base RPM	[redacted]	[redacted]	Primary POC for facility; can delegate communication to other internal or external POCs. CH2M PM will notify the Technical Representative and RPM by email or telephone call within 24 hours for field changes affecting the scope or implementation of the design. OLF Coupeville will have 14 days for work plan review.
Communication regarding overall project status and implementation and primary POC with RPMs and project team	CH2M PM	[redacted]	[redacted]	Oversees project and will be informed of project status by the Deputy PM and TM. If field changes occur, PM will work with the RPM to communicate in-field changes to the team by email within 24 hours. All data results will be communicated to the project team following data receipt and review.
Quality issues, and technical communications for project implementation, and data interpretation	CH2M QM and STC	[redacted]	[redacted]	Contact the QM regarding quality issues during project implementation. The QM will report to the PM, the Technical Representative, and the RPM. Contact STC regarding questions/issues encountered in the field, input on data interpretation, as needed. STC will have 24 hours to respond to technical field questions as necessary. Additionally, STC will review the data as necessary prior to Base and Navy discussions and reporting review.
Health and safety (H&S)	CH2M HSM	[redacted]	[redacted]	Responsible for generation of the Health and Safety Plan (HSP) and approval of the activity hazard analyses prior to the start of fieldwork. The PM will contact the HSM as needed regarding questions/issues encountered in the field.
H&S	CH2M SSC	TBD	TBD	Responsible for the adherence of team members to the site safety requirements described in the HSP. Will report H&S incidents and near losses to the PM as soon as possible.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure, Pathway, and so forth.
Stop Work Order	CH2M PM	[redacted] [redacted]	[redacted] [redacted]	Any field member can immediately stop work if an unsafe condition that is immediately threatening to human health is observed. The field staff, FTL, or SSC should notify the Technical Representative, the RPM, and the CH2M PM immediately. Ultimately, the FTL and PM can stop work for a period of time. NAVFAC Atlantic and Northwest can stop work at any time.
	CH2M FTL	TBD	TBD	
	Field Team Members	TBD	TBD	
Work plan changes in field	FTL	TBD	TBD	Documentation of deviations from the work plan will be made in the field logbook, and the PM will be notified immediately. Deviations will be made only with approval from the PM.
Field changes/field progress reports	FTL	TBD	TBD	Documentation of field activities and work plan deviations (made with the approval of STC and/or QAO) in field logbooks; provide daily progress reports to PM.
Reporting laboratory data quality issues	TBD	TBD	TBD	All QA/quality control (QC) issues with project field samples will be reported within 2 days to the PC by the laboratory.
Field and analytical corrective actions (CAs)	Program Chemist	[redacted]	[redacted]	Any CAs for field and analytical issues will be determined by the FTL and/or the PC and reported to the PM within 4 hours.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure, Pathway, and so forth.
Data tracking from field collection to database upload Release of analytical data	PC	[redacted]	[redacted]	Tracks data from sample collection through database upload daily. No analytical data can be released until validation of the data is completed and has been approved by the PC. The PC will review analytical results within 24 hours of receipt for release to the project team. The PC will inform the Navy CLEAN Program chemist who will notify the Navy QAO of any laboratory issues that would prevent the project from meeting project quality objectives or would cause significant delay in project schedule.
Reporting data quality issues	DV	[redacted]	[redacted]	The data validator reviews and qualifies analytical data as necessary. The data along with a validation narrative are returned to the PC within 7 calendar days.
Field CAs	FTL, PM, and Deputy PM	TBD [redacted] [redacted]	TBD [redacted] [redacted]	Field and analytical issues requiring CA will be determined by the FTL and/or PM on an as-needed basis. The PM will ensure SAP requirements are met by field staff for the duration of the project. The FTL will notify the PM via phone of any need for CA within 4 hours. The PM may notify the Technical Representative and RPM of any field issues that would negatively affect schedule or the ability to meet project data quality objectives.

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SAP Worksheet #7—Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities
[redacted]	Technical Representative	NAVFAC Atlantic	Oversees project.
[redacted]	RPM	Base RPM	Oversees project, provides base-specific information, and coordinates with Base Environmental Manager.
[redacted]	PM	CH2M	Oversees and manages project activities.
[redacted]	Deputy PM	CH2M	Oversees and manages project activities.
[redacted]	STC/QM	CH2M	Provides senior technical support for project approach and execution. Provides QA oversight.
[redacted]	HSM	CH2M	Prepares HSP and manages H&S for all field activities.
[redacted]	Navy Program Chemist	CH2M	Provides SAP project delivery support, reviews and approves SAPs, and performs final data evaluation and QA oversight.
[redacted]	SAP Reviewer	CH2M	Reviews and approves changes or revisions to the SAP.
[redacted]	PC	CH2M	Data management: Performs data evaluation and QA oversight, is the POC with laboratory and validator for analytical issues.
[redacted]	Data Validator	EDS	Validate laboratory data from an analytical standpoint prior to data use.
TBD	FTL	CH2M	Coordinates all field activities and sampling.
TBD	Field Staff	CH2M	Conducts field activities.
[redacted]	Laboratory PM	Vista Analytical	Manages samples tracking and maintains good communication with PC.
[redacted]	Laboratory QAO	Vista Analytical	Responsible for audits, CA, and checks of QA performance within the laboratory.

SAP Worksheet #8—Special Personnel Training Requirements Table

No specialized training beyond standard H&S training is required for this project.

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SAP Worksheet #9—Project Scoping Session Participants Sheet

Project Name: Site Inspection for Perfluoronated Compounds (PFCs) in Groundwater **Projected Date(s) of Sampling:** November-December 2016 **PM:** [redacted]			**Site Name**: OLF Coupeville **Site Location:** Coupeville, Washington	
Date of Session: October 13, 2016 **Scoping Session Purpose:** To obtain consensus on investigation approach and schedule.				
Name	**Title/Project Role**	**Affiliation**	**Phone #**	**E-mail Address**
[redacted]	Technical Representative	NAVFAC Atlantic	[redacted]	[redacted]
[redacted]	Technical Representative	NAVFAC Atlantic	[redacted]	[redacted]
[redacted]	RPM	NAS Whidbey Island	[redacted]	[redacted]
[redacted]	PM	CH2M	[redacted]	[redacted]
[redacted]	Deputy PM	CH2M	[redacted]	[redacted]
[redacted]	SAP Lead Author	CH2M	[redacted]	[redacted]
[redacted]	Hydrogeologist	CH2M	[redacted]	[redacted]
[redacted]	TM	CH2M	[redacted]	[redacted]

Comments

The purpose of the scoping session was to obtain consensus on the path forward for the Site Inspection (SI) for PFCs in groundwater at OLF Coupeville. The initial rationale for an SI at OLF Coupeville was that at similar Navy sites, aqueous film-forming foam (AFFF)-containing PFCs was used, and PFCs were detected in groundwater. There are no records of the use of AFFF-containing PFCs at OLF Coupeville. Recent sampling of on-base wells yielded a detection of perfluorooctanoic acid (PFOA) in one well, but the result was below the health advisory level. The team agreed that this detection was confirmation of a release, and that because this detection was in a sample collected from approximately 180 feet below ground surface (bgs), higher concentrations of PFCs might be present in shallower groundwater. Additionally, the primary off base drinking water source is groundwater. The current limited information regarding groundwater flow indicates that the potential release of PFCs may have impacted the drinking water. Up to 20 monitoring wells will be installed at various depths throughout the OLF. Wells will be gauged to determine groundwater elevations and these data will be used to refine groundwater flow. Groundwater samples will then be collected and analyzed for PFCs to confirm the presence and characterize the nature of PFCs in groundwater.

Field work is expected to begin in late November 2016.

Action Items

Begin preparation of SAP.

Consensus Decisions

The Project Field Team agrees to the approach for the SI for PFCs in groundwater at OLF Coupeville.

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SAP Worksheet #10—Conceptual Site Model

OLF Coupeville is located on Whidbey Island near Coupeville, Washington (**Figure 1). Figure 2** presents the site layout. **Table 10-1** presents a summary of the site description and background.

Table 10-1. Site Description and Background
NAS Whidbey Island, Oak Harbor, Washington

Site Name		OLF Coupeville
Site Location		OLF Coupeville is a military airfield associated with NAS Whidbey Island, located 2 miles southeast of Coupeville, Washington, in Island County (**Figure 1**).
Site History		OLF Coupeville was commissioned for use by the Navy in 1943 and provides support for day and night Field Carrier Landing Practice (FCLP) operations by the Navy for aircraft based out of NAS Whidbey Island. Such operations allow aviators and crew to fly in patterns as well as practice touch-and-go, simulating carrier landings and take offs. During these practice runs, jet aircraft approach the runway and touch down, immediately taking off again and looping around the field to prepare for another landing and takeoff. OLF Coupeville is seen by the Navy as an ideal airfield for this type of carrier training because of its remote location and low ambient lighting, which allows pilots and crew to have the optimum experience for replication of landing aboard an aircraft carrier. There is no available documentation that AFFF was used at the site. However, similar sites at other bases have documented AFFF use. In addition, recent sampling of on base wells yielded a detection of PFOA in one well; the result was below the health advisory.
Current Use		Outlying Landing Field for day and night FCLP
Site Conditions	**Physical Characteristics**	OLF Coupeville is located on a broad plateau of Smith Prairie in southern Whidbey Island at an elevation of approximately 195 feet above mean sea level. The paved runway is approximately 5,400 feet long and is bordered by grass maintained by mowing operations extending to the public roads (Navy, 1994). A runway safety area extends approximately 3,300 feet south of the runway footprint and is bordered by trees and residential parcels (**Figure 2**).
	Geology and Hydrogeology	The shallowest deposits represent glaciomarine drift, consisting of sands and gravel extending to approximately 50 feet bgs. These materials are generally unsaturated, although evidence of localized perched groundwater exists to the southwest of the OLF, with static water levels reported at 15 feet bgs. The shallow sands and gravel are generally underlain by recessional outwash (Partridge Gravel) consisting primarily of sand and gravel extending to roughly 180 feet bgs. The sands and gravel are underlain by Vashon till, consisting of a dark gray, laterally continuous, sand, silt, and clay unit present in the majority of well borings completed within a mile of the OLF. The till likely acts as an aquitard and ranges in depth from 150 to 180 feet bgs. Localized saturated conditions exist above the till, and static water levels in wells have been reported between 140 and 160 feet bgs; however, few nearby water supply wells are completed to depths of less than 180 feet bgs. A highly-transmissive sand and gravel bed (advance outwash; 5 to 10 feet thick) underlies the till and is the primary supply aquifer for the area (180 to 220 feet bgs). Static water levels in wells screened in this sand and gravel indicate confined conditions, with hydrostatic heads rising 30 to 40 feet above the base of the till aquitard. The sand and gravel bed is underlain by fine-grained undifferentiated Pleistocene deposits (Sapik et.al, 1988). The Island County Water Resource Management Plan suggests that OLF is located on a hydrogeologic mound, and groundwater flow is likely to be radial away from OLF Coupeville (Island County, 2005). The impact of off base water supply wells (pumping conditions) on localized groundwater flow is unknown.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 10-1. Site Description and Background
NAS Whidbey Island, Oak Harbor, Washington

Source Area	PFOA was detected in groundwater sample collected from water supply well located at OLF Building 2807. Additional suspected source areas include the runway and storage buildings located east of the runway.
COPCs	PFCs: PFOA, perfluorooctane sulfonate (PFOS), and perfluorobutane sulfonate (PFBS)
Nature and Extent	Unknown
Migration Pathways	• Direct release of PFCs to surface and/or subsurface soil • Leaching of PFCs currently and/or historically present from soil to groundwater • Transport via advection with groundwater flow • The well construction records for the water supply wells at OLF Coupeville show that the steel well casings were not grouted deeper than 18 feet bgs, potentially leaving an open annulus from 18 feet bgs to the bottom of the borehole at 180 feet bgs. The absence of a grout seal could allow shallow, potentially contaminated groundwater, to migrate downward and reach the deeper aquifer used locally for water supply purposes.
Potential Receptors/ Exposure Routes	Current users of drinking water (ingestion)

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements

Problem Statement

PFOA has been detected at levels below the health advisory in an on-base water supply well, and drinking water supply wells have been identified within 1 mile of the base.

The objectives of this SI are to:

- Refine understanding of groundwater flow at the OLF.
- Confirm the presence of PFCs in groundwater and characterize their nature (if present).

What are the environmental questions that are being answered?

1. ***What is the direction of groundwater flow?***

   New monitoring wells will be installed throughout the OLF at various depths (**Figure 3**). Groundwater level data will be collected and used to identify localized flow within the perched groundwater and/or the deeper aquifers to refine groundwater flow and identify downgradient areas. Additional monitoring wells may be installed to further refine groundwater flow.

2. ***Can the presence of PFCs in groundwater be confirmed, and what is the nature of PFCs in groundwater?***

   Groundwater samples collected from the new monitoring wells (**Figure 3**) and will be analyzed for PFCs (PFOA, PFOS, and PFBS). The sampling rationale and counts are outlined in **Worksheets #17** and **#18**.

   Groundwater samples will be analyzed via United States Environmental Protection Agency (USEPA) Method 537 (Modified) for PFOA, PFOS, and PFBS; if PFCs are present, drinking water samples will be collected from off-base drinking water wells within 1 mile downgradient (under a separate SAP). Analytical data will be compared to the USEPA lifetime health advisory (**Worksheet #15**) for informational purposes only; the comparison results will not be used for decision-making

   If PFCs are not detected, then no drinking water samples will be collected.

   Additional monitoring wells may be installed if the additional groundwater data are needed, as determined by the Team.

What are the Project Action Limits (PALs)?

- USEPA lifetime Health Advisory for PFOA and PFOS: 0.07 microgram per liter (μg/L). f both chemicals are detected, then 0.07 μg/L is the Health Advisory for the cumulative concentration of the two chemicals.
- USEPA Regional Screening Level for PFBS: 380 μg/L (based on a hazard quotient [HQ] = 1.0).

For what purpose will the data be used?

The data will be used to:

- Refine understanding of groundwater flow at the OLF.
- Confirm the presence of PFCs in groundwater and characterize their nature (if present).

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

What types of data are needed?

The data to be collected during this investigation will include the following:

- Laboratory analytical results for groundwater samples
- Soil boring logs describing site lithology
- Water quality parameters (WQPs), including pH, conductivity, oxidation-reduction potential (ORP), dissolved oxygen (DO), temperature, and turbidity
- Groundwater level measurements
- Topographic survey information

Where, when, and how should the data be collected/generated?

- All sampling locations are shown on **Figure 3.** These locations are based on the rationale presented in **Worksheet #17** and in accordance with the project schedule outlined in **Worksheet #16**.
- The data will be collected following the standard operating procedures (SOPs) presented in **Worksheet #21**.

SAP Worksheet #12-1—Measurement Performance Criteria Table – Field QC Samples

Matrix: Groundwater
Analytical Group: PFCs
Concentration Level: Low

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)
Field Duplicate	PFCs (PFOA, PFOS, and PFBS)	One per 10 samples	Precision	Relative percent difference (RPD) < 30%
Equipment Rinsate Blank		One per day of sampling for decontaminated equipment One per lot for disposable equipment	Bias/Contamination	No analytes detected > ½ limit of quantitation (LOQ) or > 1/10 sample concentration, whichever is greater
Field Reagent Blank		One per site	Bias/Contamination	No analytes detected > ½ LOQ or > 1/10 sample concentration, whichever is greater
Cooler Temperature Indicator		One per cooler	Accuracy/Representativeness	≤ 10°C for up to 48 hours after sampling, upon sample receipt, then stored at laboratory at ≤ 6 degrees Celsius (°C), but not frozen

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SAP Worksheet #13—Secondary Data Criteria and Limitations Table

Secondary Data	**Data Source (originating organization, report title and date)**	**Data Generator(s) (originating organization, data types, data generation/collection dates)**	**How Data Will Be Used**	**Limitations on Data Use**
Unregulated Contaminant Monitoring Rule 3 Results	ALS Environmental. 2016. *Analytical Report for Service Request No. K161172.*	Analytical results for PFCs in onsite drinking water wells	Confirm release of PFCs to groundwater	None

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SAP Worksheet #14—Summary of Project Tasks

Pre-sampling Tasks

- Subcontractor procurement
  - Analytical laboratories
  - Utility locator
  - Driller
  - Surveyor
  - IDW transportation and disposal contractor
- Fieldwork scheduling

Mobilization for the field effort includes procurement of necessary field equipment and initial transport to the site. Equipment and supplies will be brought to the site when the CH2M field team mobilizes for field activities. Prior to beginning any phase of work, CH2M and its subcontractors will have field meetings to discuss the work items and worker responsibilities, and to familiarize workers with the HSP.

All monitoring wells will be installed in accordance with Washington well construction standards by a Washington-licensed driller.

Utility Clearance

Utilities will be cleared before beginning intrusive activities. CH2M will coordinate utility clearance. In addition, a third-party utility clearance subcontractor will be procured by CH2M to clearly mark the proposed monitoring well locations. Any proposed monitoring well locations within 5 feet of utility locations will be relocated to avoid impact to utilities. If a monitoring well location needs to be relocated, the field team will use its best judgment in relocating the well and will notify the CH2M PM of its new location.

Monitoring Well Installation

Monitoring wells will be installed using sonic drilling techniques in accordance with the *Installation of Monitoring Wells by Sonic Drilling* SOP in **Appendix A**. Because of the presence of shallow perched zones of groundwater, it will be necessary to utilize isolation casings to limit potential cross-contamination during well construction.

Continuous soil cores will be collected for lithologic classification, and screened for volatile organic compounds using a photoionization detector (PID). Soil cores will be closely examined for signs of saturation and the presence of fine-grained beds that could indicate presence of perched groundwater conditions.

Each monitoring well will be constructed of 2-inch inside-diameter Schedule 40 polyvinyl chloride (PVC) riser connected to a 10-foot, 2-inch inside-diameter factory slotted, PVC screen with a bottom cap. A silica sand filter pack will be placed around the annular space of the well screen from the bottom of the boring and extend to a minimum height of 2 feet above the top of the well screen. A bentonite seal, at least 2 feet thick, will be placed above the top of the sand pack. After the bentonite has been hydrated, a cement–bentonite grout will be placed in the remaining annular space.

All monitoring wells will be completed with flush-mount completions that include a manhole cover or equivalent. A locking watertight cap will be placed on the PVC pipe and the wells will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the well identification.

Worksheet #14—Summary of Project Tasks (Continued)

Well Development

Following installation, each monitoring well will be developed by the drilling subcontractor using a combination of surging and pumping throughout the well screen. During monitoring well development, the CH2M field crew will measure WQPs, including pH, temperature, conductivity, and turbidity with a water quality meter. Development will continue until the water is relatively clear and free of sediment or until 1 hour of development has passed, whichever occurs first.

Development information, including turbidity, pH, specific conductivity, temperature, and gallons of water removed will be recorded in the field logbook. In addition, the water quality meter will be calibrated daily (at a minimum) and the calibration documented in the field notebook.

Surveying

The newly installed monitoring wells will be horizontally and vertically located by a Washington-licensed surveyor. The surveyor will provide coordinates of all horizontal points X, Y, to the nearest 0.5 foot and vertical point Z to the nearest 0.01 foot (0.1 foot for unpaved ground surface elevations).

Sampling Tasks

Applicable field logbook and forms should be filled out completely each day.

- Groundwater Level Measurements
  - Before sitewide groundwater sampling, and at least 24 hours after well installation and development has been completed, the depth to groundwater, to the nearest 0.01 foot, will be measured from all monitoring wells. Measurements will be made from the top of the PVC riser, which will be marked with an indelible marker. If during removal of the locking well cap, the well demonstrates signs of being under pressure (escaping air sounds or cap being pushed off by pressure), then the depth to water in that monitoring well will be measured repeatedly over a period of several minutes to determine whether the water level is still changing. If over several minutes the water level continues to change, the water level in that well will not be measured for a period of 1 hour to allow the water level to equilibrate. Depth to water and time measured will be recorded in the field logbook.
- Collection of groundwater samples
  - Groundwater samples will be collected in accordance with **Worksheet #18** and with the SOPs listed in **Worksheet #21** and provided in **Appendix A**

    For groundwater samples collected under low flow/low stress conditions, the pump intake will be placed at the middle of the well screen interval. Depth to water readings and WQPs (specific conductance, pH, turbidity, temperature, DO, and ORP) will be measured and recorded (approximately every 5 minutes) prior to sampling using a water quality meter, calibrated daily (at a minimum). If excessive drawdown is created at the minimum acceptable flow rate for low flow/low stress sampling conditions, the pump intake must be raised to within a few feet of the top of the water column and a minimum of three well volumes must be purged. Sampling will begin when three well volumes have been purged or when minimal water level drawdown requirements are met and WQPs have stabilized for three consecutive readings, as follows:

    - Temperature is constant
    - pH within 0.1 pH units

Worksheet #14—Summary of Project Tasks (Continued)

    - Conductivity within 10 percent
    - Turbidity measurements are less than 10 nephelometric turbidity units or agree within 10 percent
  - During sample collection, the bottles will be filled in such a manner so as to minimize aeration of the samples.
  - Depth to water, WQPs, and total well depth measurements will be recorded on Groundwater Sampling Data Sheets.

Decontamination

- All drilling equipment used during monitoring well installation, and re-usable sampling equipment (i.e., Grundfos centrifuge pump) will be decontaminated immediately after each use in accordance with applicable SOPs referenced in **Worksheet #21**. Sensitive instrumentation such as equipment used to collect WQPs will be decontaminated in accordance with the equipment manufacturers' guidelines.

IDW Handling

- Refer to SOP-007 (IDW Handling) in **Appendix A** for specific implementation guidelines and details.
- Wastes generated during investigation of contaminated sites are classified as IDW and will be managed to protect human health and the environment, as well as to meet legal requirements. IDW will be managed in accordance with applicable SOPs referenced in **Worksheet #21**.

Analyses and Testing Tasks

- The subcontracted analytical laboratory will process and prepare samples for analyses, and will analyze all samples for branched and linear PFCs (PFOA, PFOS, and PFBS) in accordance with **Worksheets #18** and **#19**.

QC Tasks

- Implement SOPs for field and laboratory activities being performed.
- QC samples are described on **Worksheet #20**.

Secondary Data

- None.

DV, Review, and Management Tasks

- See **Worksheets #34 through #36** for discussion of data management procedures.

Documentation and Reporting

- A summary of field activities as well as a data evaluation will be documented in a technical memorandum and submitted to the Base and Navy RPMs for review and approval.

Assessment/Audit Tasks

- **Worksheets #31** and **#32**.

Worksheet #14—Summary of Project Tasks (Continued)

Demobilization

Full demobilization will occur when the project is completed and appropriate QA/QC checks have been performed. Personnel no longer needed during the course of field operations may be demobilized prior to the final project completion date. The following will occur prior to demobilization:

- Chain-of-custody records will be reviewed to verify that all samples were collected as planned and submitted for appropriate analyses.
- Restoration of the site to an appropriate level (e.g., repair of deep ruts) will be verified by the CH2M FTL.
- All equipment will be inspected, packaged, and shipped to the appropriate location.

SAP Worksheet #15-1—Reference Limits and Evaluation Table[a]

Matrix: Groundwater

Analytical Group: PFCs

Analyte	Chemical Abstract Services (CAS) Number	PAL[a] (µg/L)	PAL Reference	PQL Goal[b] (µg/L)	Laboratory-specific Limits (µg/L)			LCS and MS/MSD Recovery Limits and RPD (percent)[c]		
					LOQs	LODs	DLs	LCL	UCL	RPD
Perfluorooctanesulfonic Acid (PFOS)	1763-23-1	0.07	USEPA Lifetime Health Advisory[a]	0.035	0.008	0.004	0.000424	70	130	30
Perfluorooctanoic Acid (PFOA)	335-67-1	0.07	USEPA Lifetime Health Advisory[a]	0.035	0.008	0.004	0.00131	70	130	30
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	380	RSLs Tapwater HQ = 1 (May 2016b)	190	0.008	0.004	0.000927	60	130	30

Notes:

[a] PALs are provided to ensure that the laboratory can detect PFCs at that level. Data will be compared to the PALs for informational purposes only.

The PFOS and PFOA USEPA Lifetime Health Advisories are from the USEPA Office of Water.

[b] The Project Quantitation Limit (PQL) Goal is half of the PAL.

[c] Accuracy and precision limits are in house laboratory limits.

DL = detection limit
LCL = lower criteria limit
LCS = laborary control sample
LOD = limit of detection
LOQ= limit of quantitation
MS = matrix spike
MSD = matrix spike duplicate
RSL = regional screening level
UCL = upper confidence limit
µg/L = microgram per liter

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SAP Worksheet #16—Project Schedule/Timeline Table

Activities	**Organization**	**Dates (MM/DD/YY)**		**Deliverable**
		Anticipated Date(s) of Initiation	**Anticipated Date of Completion**	
Draft SAP preparation	CH2M	October 2016	October 2016	Draft SAP
Navy SAP review	Navy, OLF Coupeville	November 2016	November 2016	comments
Final SAP	CH2M	November 2016	November 2016	Final SAP
Pre-sampling, subcontracting	CH2M	October 2016	November 2016	
Monitoring Well Installation	CH2M, Subcontractor	November 2016	February 2017	
Groundwater Sampling	CH2M	February 2017	February 2017	
Analytical Data	Subcontractor	7-day turnaround time		Analytical data
Data management	CH2M	February 2017	May 2017	
Reporting	CH2M	March 2017	September 2017	Draft and Final Technical Memorandum

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SAP Worksheet #17—Sampling Design and Rationale

The objectives of this SI are to:

- Refine understanding of groundwater flow at the OLF
- Confirm the presence of PFCs in groundwater and characterize their nature (if present).

Table 17-1 presents the sampling strategy and rationale.

Table 17-1. Sampling Strategy and Rationale
OLF Coupeville, Coupeville, Washington

Matrix	Depth of Samples[a]	Analysis and Method	Number of Samples	Sampling Strategy	Rationale
Groundwater	40 to 50 feet bgs (expected depth of perched groundwater zone, if present)	PFCs (PFOA, PFOS, and PFBS) USEPA Method 537 (Modified)	Up to two	Monitoring wells, may be installed with a 10-foot screen within the perched groundwater zone (if present). The locations of these wells will ultimately be field-determined. If perched groundwater is encountered during installation of other wells, additional wells may be installed at this depth at the location where it was encountered.	Groundwater samples may be collected from the perched groundwater zone if encountered; this is the shallowest depth of groundwater expected.
	140 to 150 feet bgs (expected depth of deep perched groundwater zone, if present)	PFCs (PFOA, PFOS, and PFBS) USEPA Method 537 (Modified)	Up to six	Monitoring wells may be installed with a 10-foot screen within the deep perched groundwater zone (if present). The locations of these wells will be field determined. If deep perched groundwater is encountered during installation of other wells, additional wells may be installed at this depth at the location where it was encountered.	Groundwater samples may be collected from the deep perched groundwater zone, if encountered.
	180 to 220 feet bgs	PFCs (PFOA, PFOS, and PFBS) USEPA Method 537 (Modified)	12	Six potential source area wells will be installed with a 10-foot screen near the runway and storage buildings: WI-CV-MW01, WI-CV-MW02, WI-CV-MW03, WI-CV-MW04, WI-CV-MW05, and WI-CV-MW06. An additional six wells will be installed with a 10-foot screen downgradient of the potential source areas: WI-CV-MW07, WI-CV-MW08, WI-CV-MW09, WI-CV-MW10, WI-CV-MW11, and WI-CV-MW12 Well locations are shown on **Figure 3**.	Groundwater samples will be collected (from this depth because it is the primary drinking water supply aquifer. Well locations were selected to be in proximity of the potential source areas and also to be downgradient of potential source areas.

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SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table

Sampling Location	Sample ID	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
WI-CV-MW01	WI-CV-MW01-MMYY	Groundwater	Middle of well screen	PFCs	1	Worksheet #21
WI-CV-MW02	WI-CV-MW02-MMYY				3 (MS/MSD)	
	WI-CV-MW02-MMYY-MS					
	WI-CV-MW02-MMYY-SD					
WI-CV-MW03	WI-CV-MW03-MMYY				1	
WI-CV-MW04	WI-CV-MW04-MMYY				1	
WI-CV-MW05	WI-CV-MW05-MMYY				2 (FD)	
	WI-CV-MW05P-MMYY					
WI-CV-MW06	WI-CV-MW06-MMYY				1	
WI-CV-MW07	WI-CV-MW07-MMYY				1	
WI-CV-MW08	WI-CV-MW08-MMYY				1	
WI-CV-MW09	WI-CV-MW09-MMYY				2 (FD)	
	WI-CV-MW09P-MMYY					
WI-CV-MW10	WI-CV-MW10-MMYY				1	
WI-CV-MW11	WI-CV-MW11-MMYY				1	
WI-CV-MW12	WI-CV-MW12-MMYY				1	
WI-CV-MWXX*	WI-CV-MWXX-MMYY				1	

Notes:

* Installation of monitoring wells in the perched groundwater will be field-determined (**Worksheet #17**).

FD = field duplicate

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SAP Worksheet #19—Analytical SOP Requirements Table

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Containers	Sample Volume	Preservation Requirements	Maximum Holding Time[a] (preparation/analysis)
Groundwater	PFCs	USEPA Method 537 Modified /SOP49	One 125-mL HDPE	125 mL	≤ 10°C for up to 48 hours after sampling, upon sample receipt, then stored at laboratory ≤ 6°C, but not frozen	14 days/28 days

Notes:

[a] Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

HDPE = high-density polyethylene

mL = milliliter

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SAP Worksheet #20—Field Quality Control Sample Summary Table

Samples will be collected as detailed in **Worksheets #17** and **#18** of this SAP. Field QA/QC samples will be collected as detailed in **Worksheet #12**.

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SAP Worksheet #21—Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
SOP-001	Chain-of-Custody, rev. 04/2015	CH2M	Chain-of-custody form	No	
SOP-002	Field Measurement of pH, Specific Conductance, Turbidity, DO, ORP, and Temperature Using a WQP Meter with Flow-through Cell, rev. 04/2015	CH2M	Water Quality Meter with Flow-through Cell	No	
SOP-003	Preparing Field Log Books, rev. 04/2015	CH2M	Logbook and Indelible Pen	No	
SOP-004	Utility Location, General, rev. 04/2015	CH2M		No	
SOP-005	Equipment Blank and Field Blank Preparation, rev. 04/2015	CH2M	Laboratory provided Blank Liquid and Sample Bottles	No	
SOP-006	Decontamination of Personnel and Equipment, rev. 06/2015	CH2M	For Cleansing Reusable Samplers	No	
SOP-007	Disposal of Waste Fluids and Solids, rev. 03/2016	CH2M	United States Department of Transportation 55-gallon Drums or Tank	No	
SOP-008	Low-Flow Groundwater Sampling from Monitoring Wells, rev. 4/2015	CH2M	Pump, Poly Tubing	No	
SOP-009	Installation of Deep Monitoring Wells, rev. 04/2015	CH2M	Drill Rig	No	
SOP-010	Installation of Monitoring Wells, rev. 04/2015	CH2M	Drill Rig	No	
SOP-011	Installation of Shallow Monitoring Wells, rev. 04/2015	CH2M	Drill Rig	No	
SOP-012	Field Sampling Protocols to Avoid Cross-Contamination during Water Sampling for PFCs	Navy		No	
SOP-013	Water-Level Measurements	CH2M	Water Level Meter	No	
SOP-014	Packaging and Shipping Procedures for Low-Concentration Samples, rev. 04/2015	CH2M	Laboratory-supplied Coolers	No	
SOP-015	Field Operation of the Geopump Peristaltic Pump by Geotech, rev. 03/2015	Geotech	Geotech Peristaltic Pump	No	
SOP-016	MultiRae Photoionization Detector (PID), rev. 04/2015	CH2M	PID	No	
SOP-017	Decontamination of Drilling Rigs and Equipment	CH2M	Drill Rig	No	
SOP-018	Installation of Monitoring Wells by Sonic Drilling, rev. 04/2015	CH2M	Sonic Drill Rig	No	

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SAP Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Activity[a]	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference[b]	Comments
Water Quality Meter	Calibrate probes using Auto-Calibration Standard Solution	Daily, As Needed	Parameter specific per model/ instruction manual	Manufacturer technical support for calibration errors	FTL	SOP-002	Appendix A
PID	Calibrate using ambient air and isobutylene 100 parts per million calibration gas	Daily and as Needed	Parameter specific per model/ instruction manual	Manufacturer technical support for calibration errors	FTL	SOP-019	Appendix A

[a] Activities may include: calibration, verification, testing, and maintenance.

[b] Specify the appropriate reference letter or number from the Project Sampling SOP References table (**Worksheet #21**).

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SAP Worksheet #23—Analytical SOP References Table

Lab SOP Number	Title, Revision Date, and/or Number	Date Reviewed if not Revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to QSM	Modified for Project Work (Y/N)
49	*Preparation and Analysis for the Determination of Per and Poly-Fluorinated Compounds; Rev. 8; 7/27/16*		Definitive	Groundwater/PFCs	LC/MS/MS	Vista Analytical	Y[c]	N
12	*Sample Receiving and Sample Control Procedures; rev. 11; 6/15/16*		N/A	Groundwater/PFCs	N/A	Vista Analytical	N	N
14	*Bottle Order Preparation; rev. 4; 9/03/14*		N/A	Groundwater/PFCs	N/A	Vista Analytical	N	N

Notes:

[a] Non-analytical SOPs do not require an annual review cycle. This worksheet was prepared in October 2016.

[b] Vista Analytical’s Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) accreditation through A2LA is granted through September 30, 2017.

[c] Vista Analytical Laboratory performs isotope dilution of PFCs in addition to the more traditional matrix spike samples specified in DoD Quality Systems Manual (QSM) v. 5.0. This has an overall positive effect on data quality because in essence each sample is a matrix spike with associated spike recoveries.

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SAP Worksheet #24—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference
LC/MS/MS	Tune Check	Prior to initial calibration (ICAL) and after any mass calibration or maintenance is performed.	Tuning standard must contain analytes of interest or appropriate substitute. Mass assignments of tuning standard within 0.5 atomic mass unit (amu) of true value.	Retune instrument. If the tuning will not meet acceptance criteria, an instrument mass calibration must be performed and the tuning redone. Sample analysis shall not proceed without acceptable tuning.	Analyst / Supervisor	SOP 49, Rev. 7
	Minimum five-point initial calibration for target analytes, lowest concentration standard at or below limit of detection.	Initial calibration prior to sample analysis	Coefficient of determination ≥ 0.96 for all analytes and an RSD of ≤ 35% for all Internal Standards. Each calibration point for each analyte must calculate to be within 75-125% recovery, except the lowest calibration point which must calculate to within 70-130% recovery.	Evaluate standards, chromatography, and mass spectrometer response. If problem found with above, correct as appropriate, then repeat initial calibration. No samples can be analyzed until initial calibration has passed.		
	Second-source calibration verification	Once per initial calibration, following initial calibration.	All reported analytes and labelled compounds within ± 25 percent of true value.	Correct problem and verify second source standard. Rerun initial calibration verification. If that fails, correct problem and repeat ICAL. No samples may be analyzed until calibration has been verified.		
	Daily calibration verification	Analysis of mid-level standard after every 10 field samples. All samples must be bracketed by the analysis of a standard.	All reported analytes and labelled compounds (internal standards) within ± 25 percent of true value.	Recalibrate, and reanalyze all affected samples since the last acceptable continuing calibration verification (CCV). OR Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take CA(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Data flagging is only appropriate in cases where the samples cannot be reanalyzed.		

Notes:

LC = liquid chromatograph

MS/MS is the combination of two mass analyzers in one mass spectrometer instrument.

DoD QSM v.5.0 is the basis for specifications on this table. Exceptions to the QSM include the utilization of isotopic dilution with LC/MS/MS.

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SAP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference
LC/MS/MS	Clean sample and gas cones. Change the column. Clean the T-Wave.	Modified USEPA 537	Check the sample and gas cones.	T-Wave cleaning is performed when the instrument response deteriorates. Other instrument maintenance is done as needed to keep the instrument performing at peak performance.	ICAL within acceptance criteria on **Worksheet #24** and internal standards (IS) recovery within acceptance criteria on **Worksheet #28**	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Analyst/ Supervisor	SOP 49

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SAP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Project Field Team, FTL/CH2M. Field SOPs are in Appendix A of this SAP.
Sample Packaging (Personnel/Organization): Project Field Team, FTL/CH2M. Field SOPs are in Appendix A of this SAP.
Coordination of Shipment (Personnel/Organization): FTL/CH2M.
Type of Shipment/Carrier: FedEx Priority Overnight
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Receipt Personnel/Vista Analytical
Sample Custody and Storage (Personnel/Organization): Sample Receipt Personnel/Vista Analytical
Sample Preparation (Personnel/Organization): Extractions Personnel/Vista Analytical
Sample Determinative Analysis (Personnel/Organization): Analysts/Vista Analytical
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 45 days
Sample Extract/Digestate Storage (No. of days from extraction/digestion): 90 days
Biological Sample Storage (No. of days from sample collection): N/A
SAMPLE DISPOSAL
Personnel/Organization): Sample Disposal – Environmental Health and Safety Officer/Vista Analytical
Number of Days from Analysis: 45 days

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SAP Worksheet #27—Sample Custody Requirements Table

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory):

Samples will be collected by field team members under the supervision of the FTL. As samples are collected, they will be placed into containers and labeled. Labels will be taped to the jar to ensure they do not separate. Samples will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples cooler than 10°C (but not frozen) until they are received by the laboratory.

The chain-of-custody record will be placed into the cooler in a resealable zip-top plastic bag. Coolers will be taped up and shipped to the laboratories via FedEx overnight, with the airbill number indicated on the chain of custody (to relinquish custody). Upon delivery, the laboratory will log each cooler and report the status of the samples to CH2M.

See **Worksheet #21** for SOPs containing sample custody guidance.

The CH2M field team will ship all environmental samples directly to the laboratory performing the analysis. This will require shipment to Vista Analytical in El Dorado Hills, California.

Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal):

Laboratory custody procedures can be found in the laboratory SOPs, which will be provided upon request.

Sample Identification (ID) Procedures:

Sample labels will include, at a minimum, client name, site, sample ID, date/time collected, analysis group or method, preservation, and sampler's initials. The field logbook will identify the sample ID with the location and time collected and the parameters requested. The laboratory will assign each field sample a laboratory sample ID based on information in the chain of custody. The laboratory will send sample log-in forms to the CH2M PC to check that sample IDs and parameters are correct.

Chain-of-Custody Procedures:

Chain-of-custody records will include, at minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information. Sample information will include sample ID. Date/time collected, number and type of containers, preservative information, analysis method, and comments. The chain-of-custody record will link location of the sample from the field logbook to the laboratory receipt of the sample. The laboratory will use the sample information to populate the Laboratory Information Management Systems database for each sample.

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SAP Worksheet #28-1—Laboratory QC Samples Table

Matrix: Groundwater
Analytical Group: PFCs
Analytical Method/SOP Reference: USEPA Method 537

QC Sample	Frequency/Number	Method/ SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per prep batch of 20 or fewer samples of similar matrix; or one per day, whichever comes first	No target analytes ≥ ½ LOQ and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Verify instrument clean (evaluate calibration blank and samples prior to method blank), then reanalyze. Evaluate to determine if systematic issue within laboratory, correct, then re-prepare and reanalyze the method blank and all samples processed with the contaminated blank in accordance with DoD QSM requirements. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed.	Analyst/ Supervisor	Bias/Contamination	Same as Method/SOP QC Acceptance Limits
Internal Standards	Addition of isotopically labeled analytes to every sample, batch QC sample, standard, instrument blank, and method blank	13C-PFOA 50 - 150 percent 13C-PFOS 50 - 150 percent	For failed QC samples, correct problem and rerun all associated failed field samples. If reanalysis cannot be performed, the data must be qualified and explained in the case narrative. If recoveries are acceptable for QC samples, but not field samples, the field samples may be considered to suffer from a matrix effect. Failing internal standards should be thoroughly documented in the case narrative.		Accuracy/Bias	
LCS	One per prep batch of 20 or fewer samples of similar matrix; or one per day, whichever comes first	See **Worksheet #15**	Correct problem. Re-prep and reanalyze the LCS and all samples in the associated preparatory batch, if sufficient sample material is available. If reanalysis cannot be performed, the data must be qualified and explained in the case narrative. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.		Accuracy/Bias	
MS/MSD	One per prep batch of 20 or fewer samples of similar matrix; or one per day, whichever comes first	See **Worksheet #15**	Evaluate the data, and re-prepare/ reanalyze the native sample and MS/MSD pair if laboratory error is indicated. Examine the project-specific requirements. Contact the client as to additional measures to be taken. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference, i.e., matrix effect or analytical error. For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met.		Accuracy/Bias	

Notes:

The specifications in this table meet the requirements of DoD QSM 5.0. Exceptions to the QSM include the utilization of isotopic dilution with LC/MS/MS.

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SAP Worksheet #29—Project Documents and Records Table

Document	Where Maintained
• Field Notebooks • Chain-of-Custody Records • Air Bills • Custody Seals • CA Forms • Electronic Data Deliverables (EDDs) • ID of QC Samples • Meteorological Data from Field • Sampling instrument calibration logs • Sampling locations and sampling plan • Sampling notes and drilling logs • WQPs • Sample Receipt, Chain of Custody, and Tracking Records • Standard Traceability Logs • Equipment Calibration Logs • Sample Preparation Logs • Run Logs • Equipment Maintenance, Testing, and Inspection Logs • CA Forms • Reported Field Sample Results • Reported Result for Standards, QC Checks, and QC Samples • Instrument printouts (raw data) for Field Samples, Standards, QC Checks, and QC Samples • Data Package Completeness Checklists • Sample disposal records • Extraction/Clean-up Records • Raw Data (archived per Navy CLEAN contract) • DV Reports • CA Forms • Laboratory QA Plan • Method Detection Limit (MDL) Study Information	• Field data deliverables such as logbooks entries, chains of custody, airbills, EDDs, and so forth, will be kept on CH2M's network server. • Field parameter data will be loaded with the analytical data into the Navy database • Analytical laboratory hardcopy deliverables and DV reports will be saved on the network server and archived per the Navy CLEAN contract. • Electronic data from the laboratory will be loaded into Navy database • Following project completion, hardcopy deliverables such as logbooks, chain of custodies, and so forth will be archived at Iron Mountain: Iron Mountain Headquarters 745 Atlantic Avenue Boston, Massachusetts 02111 (800) 899-IRON • Following project completion, hardcopy deliverables including chain of custodies and raw data will be archived at the Washington National Records Center: Washington National Records Center 4205 Suitland Road Suitland, Maryland 20746-8001 (301) 778-1550

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SAP Worksheet #30—Analytical Services Table

Matrix	Analytical Group	Sample Locations/ID Number	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization	Backup Laboratory/ Organization
Groundwater	PFCs	Refer to **Worksheets #18** and **#20**	PFC by Modified EPA 537 LC/MS/MS, SOP 49, rev8	7 calendar days	Vista Analytical Laboratory Attn: Sample Receiving 1104 Windfield Way El Dorado Hills, California 95762 [redacted]	Test America

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SAP Worksheet #31—Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (title and organizational affiliation)	Person(s) Responsible for Responding to Assessment Findings (title and organizational affiliation)	Person(s) Responsible for Identifying and Implementing CA (title and organizational affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (title and organizational affiliation)
Field Performance Audit	One during first quarter sampling event	Internal	CH2M	PM/CH2M	FTL/CH2M	PM/CH2M	PM/CH2M
Safe Work Observation	One during each quarterly sampling event	Internal	CH2M	SSC/CH2M	Field Team Member observed/CH2M	HSM/CH2M	SSC/CH2M
Field Document Review	Daily during each quarterly sampling event	Internal	CH2M	PM or TM/CH2M	FTL/CH2M	PM/CH2M	PM/CH2M

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SAP Worksheet #32—Assessment Findings and Corrective Action Responses

Assessment Type	**Nature of Deficiencies Documentation**	**Individual(s) Notified of Findings (name, title, organization)**	**Timeframe of Notification**	**Nature of CA Response Documentation**	**Individual(s) Receiving CA Response (name, title, organization)**	**Timeframe for Response**
Field Performance Audit	Checklist and Written Audit Report	FTL/CH2M	Within 1 day of audit	Verbal and Memorandum	FTL/CH2M	Within 1 day of receipt of CA Form
Safe Behavior Observation (SBO)	SBO Form	HSM/CH2M	Within 1 week of SBO	Memorandum	Field Team Member/CH2M	Immediately
Field Document Review	Markup copy of field documentation	FTL/CH2M	Within 1 day of review	Verbal and Memorandum	FTL/CH2M	Within 1 day of receipt of markup

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SAP Worksheet #32-1—Laboratory Corrective Action Form

Person initiating CA: ______________________________ Date: ______________

Description of problem and when identified:

____
____
____
____
____

Cause of problem, if known or suspected:

____
____
____
____
____

Sequence of CA: (including date implemented, action planned and personnel/data affected)

____
____
____
____
____

CA implemented by: ______________________________ Date: ______________
CA initially approved by: ______________________________ Date: ______________
Follow-up date: ______________________________
Final CA approved by: ______________________________ Date: ______________

Information copies to:

____
____
____
____

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SAP Worksheet #32-2—Field Performance Audit Checklist

Project Responsibilities

Project No.: ____________________ Date: ____________________

Project Location: ____________________ Signature: ____________________

Team Members

Yes No 1) Is the approved work plan being followed?

Comments ____________________

____

Yes No 2) Was a briefing held for project participants?

Comments ____________________

____

Yes No 3) Were additional instructions given to project participants?

Comments ____________________

____

Sample Collection

Yes No 1) Is there a written list of sampling locations and descriptions?

Comments ____________________

____

Yes No 2) Are samples collected as stated in the Master SOPs?

Comments ____________________

____

Yes No 3) Are samples collected in the type of containers specified in the work plan?

Comments ____________________

____

Yes No 4) Are samples preserved as specified in the work plan?

Comments ____________________

____

Yes No 5) Are the number, frequency, and type of samples collected as specified in the work plan?

Comments ____________________

____

Worksheet #32-2—Field Performance Audit Checklist (continued)

Yes No 6) Are QA checks performed as specified in the work plan??

Comments ______________________________

____

Yes No 7) Are photographs taken and documented?

Comments ______________________________

____

Document Control

Yes No 1) Have any accountable documents been lost?

Comments ______________________________

____

Yes No 2) Have any accountable documents been voided?

Comments ______________________________

____

Yes No 3) Have any accountable documents been disposed of?

Comments ______________________________

____

Yes No 4) Are the samples identified with sample tags?

Comments ______________________________

____

Yes No 5) Are blank and duplicate samples properly identified?

Comments ______________________________

____

Yes No 6) Are samples listed on a chain-of-custody record?

Comments ______________________________

____

Yes No 7) Is chain of custody documented and maintained?

Comments ______________________________

____

SAP Worksheet #32-3—Safe Behavior Observation Form

☐ Federal or ☐ Commercial Sector (check one)		☐ Construction or ☐ Consulting (check one)	
Project Number:		Client/Program:	
Project Name:		Observer:	Date:
Position/Title of worker observed:		Background Information/ comments:	
Task/Observation Observed:			

- Identify and reinforce safe work practices/behaviors
- Identify and improve on at-risk practices/acts
- Identify and improve on practices, conditions, controls, and compliance that eliminate or reduce hazards
- Proactive PM support facilitates eliminating/reducing hazards (do you have what you need?)
- Positive, corrective, cooperative, collaborative feedback/recommendations

Actions & Behaviors	Safe	At-Risk	Observations/Comments
Current and accurate Pre-Task Planning/Briefing (for example, Project Safety Plan, safety training and consulting, activity hazard analyses, Pre-task Safety Plan, tailgate briefing, as needed)			**Positive Observations/Safe Work Practices:**
Properly trained/qualified/ experienced			
Tools/equipment available and adequate			
Proper use of tools			**Questionable Activity/Unsafe Condition Observed:**
Barricades/work zone control			
Housekeeping			
Communication			
Work Approach/Habits			
Attitude			
Focus/attentiveness			**Observer's CAs/Comments:**
Pace			
Uncomfortable/unsafe position			
Inconvenient/unsafe location			
Position/Line of fire			
Apparel (hair, loose clothing, jewelry)			
Repetitive motion			**Observed Worker's CAs/Comments:**
Other			

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SAP Worksheet #33—QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, and so forth)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
Field Audit Report	One during sampling event	Submitted with final report	PM/CH2M	Included in project files.

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SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description[3]	Responsible for Verification or Validation	Step I/IIa/IIb[1]	Internal/ External[2]
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	FTL/CH2M	Step I	Internal
Chain-of-Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody record will be initialed by the reviewer, a copy of the chains-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chains-of-custody will also be reviewed for adherence to the SAP by the PC.	FTL/CH2M PC/CH2M	Step I	Internal & External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the PC in the form of laboratory logins.	PC/CH2M	Step I	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the PC. Documentation will be incorporated into the case narrative which becomes part of the final hardcopy data package.	PC/CH2M	Step I	External
EDDs	EDDs will be compared against hardcopy laboratory results (10 percent check).	PC/CH2M	Step I	External
Case Narrative	Case narratives will be reviewed by the data validator during the DV process. This is verification that they were generated and applicable to the data packages.	Data Validator	Step I	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Laboratory QAO	Step I	Internal
Laboratory Data	The data will be verified for completeness by the PC. In order to ensure completeness, EDDs will be compared to the SAP. This is a verification that all samples were included in the laboratory data and that correct analyte lists were reported.	PC/CH2M	Step I	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If CAs are required, a copy of the documented CA taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and CA forms will be reviewed internally to ensure that all appropriate CAs have been taken and that CA reports are attached. If CAs have not been taken, the project manager will be notified to ensure action is taken.	PM/CH2M PC/CH2M	Step I	Internal
CA Reports	CA reports will be reviewed by the PC or PM and placed into the project file for archival at project closeout.	PM/CH2M PC/CH2M	Step I	External
Laboratory Methods	Ensure the laboratory analyzed samples using the correct methods.	PC/CH2M	Step IIa	External
Target Compound List (TCL) and Target Analyte List (TAL)	Ensure the laboratory reported all analytes from each analysis group as per **Worksheet #15**.	PC/CH2M	Step IIa	External
Reporting Limits (RLs)	Ensure the laboratory met the project-designated quantitation limits (QLs) as per **Worksheet #15**. If QLs were not met, the reason will be determined and documented.	PC/CH2M	Step IIb	External
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	Laboratory QAO	Step IIa	Internal
Sample Chronology	Holding times from collection to extraction or analysis and from extraction to analysis will be considered during the DV process.	Data Validator	Step IIa and IIb	External
Raw Data	10 percent review of raw data to confirm laboratory calculations. For a recalculated result, the data validator attempts to re-create the reported numerical value. The laboratory is asked for clarification if a discrepancy is identified which cannot reasonably be attributed to rounding. In general, this is outside 5 percent difference.	Data Validator	Step IIa	External

SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table (continued)

Data Review Input	Description[1]	Responsible for Verification or Validation	Step I/IIa/IIb[2]	Internal/ External[3]
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records.	FTL/CH2M	Step IIb	Internal
Documentation of Method QC Results	Establish that all required QC samples were run and met limits.	Data Validator	Step IIa	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run and met limits.	PC/CH2M	Step IIa	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP Certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	PC/CH2M	Step I	External
Analytical data for PFCS analyzed for in groundwater	Analytical methods and laboratory SOPs as presented in this SAP will be used to evaluate compliance against QA/QC criteria. Should adherence to QA/QC criteria yield deficiencies, data may be qualified. The data qualifiers used are those presented in *National Functional Guidelines for Superfund Organic Data Review* (USEPA, 2016a). National Functional Guidelines may be used for DV, and the specific qualifiers listed therein may be applied to data should non-conformances against the QA/QC criteria as presented in this SAP be identified.	Data Validator	Step IIa and IIb	External

Notes:

[1] Should CH2M find discrepancies during the verification or validation procedures above, an email documenting the issue will be circulated to the internal project team, and a Corrections to File Memo will be prepared identifying the issues and the corrective action needed. This memo will be sent to the laboratory, or applicable party, and maintained in the project file.

[2] Verification (Step I) is a completeness check that is performed before the data review process continues in order to determine whether the required information (complete data package) is available for further review. Validation (Step IIa) is a review that the data generated is in compliance with analytical methods, procedures, and contracts. Validation (Step IIb) is a comparison of generated data against measurement performance criteria in the SAP (both sampling and analytical).

[3] Internal or external is in relation to the data generator.

SAP Worksheet #37—Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:

- Non-detected site contaminants will be evaluated to ensure that project required QLs in **Worksheet #15** were achieved. If PQLs were achieved and the verification and validation steps yielded acceptable data, then the data are considered usable.
- During verification and validation steps, data may be qualified as estimated with the following qualifiers: J or UJ. The qualifiers represent minor QC deficiencies, which will not affect the usability of the data. When major QC deficiencies are encountered, data will be qualified with an R and in most cases is not considered usable for project decisions.
  - J = Analyte present. Reported value may or may not be accurate or precise.
  - J+ = Analyte present. Reported value is estimated and may be biased high.
  - J- = Analyte present. Reported value is estimated and may be biased low.
  - UJ = Analyte not detected. Associated non-detect value may be inaccurate or imprecise.
  - R = Rejected result. Result not reliable.
- The following additional qualifiers may be given by the validator:
  - N = Tentative ID. Consider Present. Special methods may be needed to confirm its presence or absence in future sampling efforts.
  - NJ = Qualitative ID questionable due to poor resolution. Presumptively present at approximate quantity.
  - U = Not Detected.
- Analytical data will be checked to ensure the values and any qualifiers are appropriately transferred to the electronic database. The checks include comparison of hardcopy data and qualifiers to the EDD. Once the data have been uploaded into the electronic database, another check will be performed to ensure all results were loaded accurately.
- Field and laboratory precision will be compared as RPD between the two results.
- Deviations from the SAP will be reviewed to assess whether CA is warranted and to assess impacts to achievement of project objectives.

Describe the evaluative procedures used to assess overall measurement error associated with the project.

- To assess whether a sufficient quantity of acceptable data is available for decision making, the data will be compared to the 95 percent completeness goal and reconciled with MPC following validation and review of DQI.
- If significant biases are detected with laboratory QA/QC samples, they will be evaluated to assess impact on decision making. Low biases will be described in greater detail as they represent a possible inability to detect compounds that may be present at the site.
- If significant deviations are noted between laboratory and field precision, the cause will be further evaluated to assess impact on decision making.

SAP Worksheet #37—Usability Assessment (continued)

Describe the documentation that will be generated during the usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

The following will be prepared by CH2M and presented to and submitted to the Navy and OLF Coupeville for review and decisions on the path forward for the site:

- Data tables will be produced to reflect detected and non-detected site analytes. Data qualifiers will be reflected in the tables and discussed in the data quality evaluation, and will be provided in a technical memorandum.

Identify the personnel responsible for performing the usability assessment.

The CH2M team, including the PM and PC, will review the data and present to the Navy and OLF Coupeville for review and approval of usability.

References

ALS Environmental. 2016. *Analytical Report for Service Request No. K161172, Naval Air Station Outlying Field Coupeville, Coupeville, Washington.* October.

Board of Island County Commissioners (Island County). 2005. *Island County Water Resource Management Plan, 2415 Watershed Planning*. June 20.

CH2M HILL, Inc. (CH2M). 2016. *Technical Memorandum – Results of Desktop Evaluation to Verify Off-Base Drinking Water Sources.* September.

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U.S. Environmental Protection Agency (USEPA). 1998. *Guidance for Quality Assurance Project Plans.*

USEPA. 2002. *USEPA QA/G-5, Quality Assurance Management Staff.* EPA/240/R-02/009. December.

USEPA. 2005. *Uniform Federal Policy for Quality Assurance Project Plans: Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs - Part 1: UFP-QAPP Manual.* Intergovernmental Data Quality Task Force. EPA-505-B-04-900A. Final Version 1. March.

USEPA. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process.* EPA QA/G-4. EPA/240/B-06/001. February.

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USEPA. 2016b. *Regional Screening Level (RSL) Resident Tapwater Table*. May.

United States Navy (Navy). 1994. *Final Remedial Investigation Report for Operable Unit 3, Naval Air Station Whidbey Island. Prepared for Engineering Field Activity Northwest, Naval Facilities Engineering Command by URS Consultants Under Contract No. N62474-89-D-9295, CTO 0074*. January.

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Figures

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Legend

● City

━ Secondary Road

─ Local Connecting Road

─ Important Local Road

⬚ Base Boundary

N

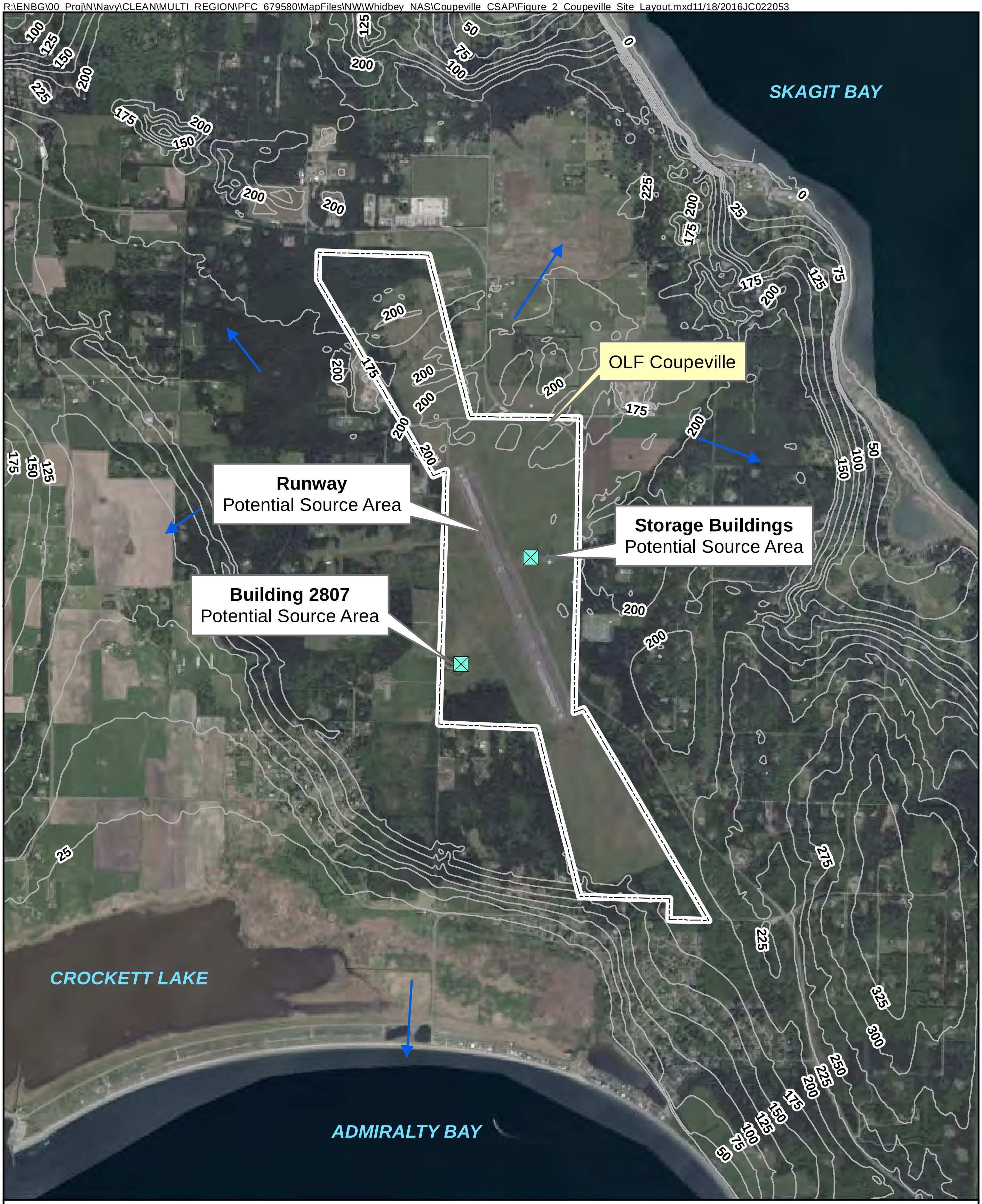
0 1 2 Miles

1 inch = 2 miles

Figure 1
Base Location Map
OLF Coupeville
Coupeville, Washington

For Official Use Only

R:\ENBG\00_Proj\N\Navy\CLEAN\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\Coupeville_CSAP\Figure_2_Coupeville_Site_Layout.mxd11/18/2016JC022053



Legend

- ☒ OLF Coupeville Supply Well
- → Estimated Groundwater Flow Direction
- — Elevation Contour (25 ft Interval)
- ⬚ Base Boundary

N

0 0.25 0.5 Mile

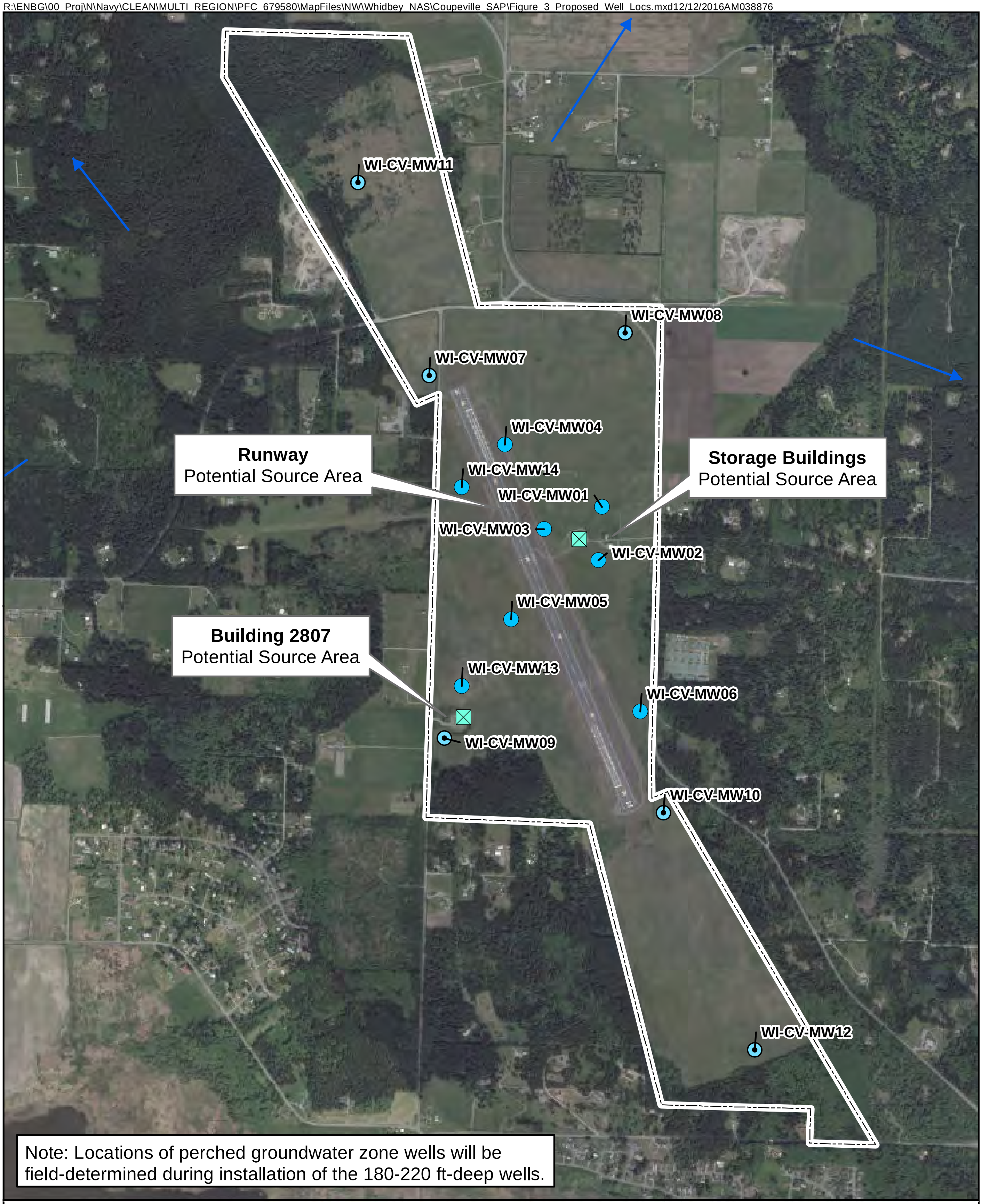
1 inch = 0.5 mile

Imagery Source: Esri

Figure 2
Layout Map
OLF Coupeville
Coupeville, WA

For Official Use Only

R:\ENBG\00_Proj\N\Navy\CLEAN\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\Coupeville_SAP\Figure_3_Proposed_Well_Locs.mxd12/12/2016AM038876



Runway
Potential Source Area

Storage Buildings
Potential Source Area

Building 2807
Potential Source Area

Note: Locations of perched groundwater zone wells will be field-determined during installation of the 180-220 ft-deep wells.

Legend
- ☒ Water Supply Well
- ● Potential Source Area Well
- ⊙ Downgradient Well
- → Estimated Groundwater Flow Direction
- ⬚ Base Boundary

N

0 0.15 0.3 Mile

1 inch = 0.3 mile

Imagery Source: Esri

Figure 3
Proposed Well Locations
OLF Coupeville
Coupeville, Washington

For Official Use Only

Appendix A
Field Standard Operating Procedures – CH2M

STANDARD OPERATING PROCEDURE

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

A. Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When *in situ* measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

B. Sample Label

Samples, other than for *in situ* measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project - CTO Number.

- Station Location - The unique sample number identifying this sample.

- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 08/21/12).

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site). The field team should always follow the sample ID system prepared by the project EIS and reviewed by the Project Manager.

C. Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

D. Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include ***only*** the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample locations in photographs, an easily read sign with the appropriate sample location number should be included.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.)

E. Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. **A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler**. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under “Relinquished by” entry.
- Have the person receiving the sample sign the “Received by” entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).
- If a carrier is used, enter the airbill number under “Remarks,” in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

A. Sample Label
B. Chain of Custody Form
C. Custody Seal

VII References

USEPA. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Attachment A
Example Sample Label

QAL

Quality Analytical Laboratories, Inc.
2567 Fairlane Drive
Montgomery, Alabama 36116
PH. (334)271-2440

Client ____________________

Sample No. ____________________

Location ____________________

Analysis ____________________

Preservative HCL

Date __________ By __________

CEIMIC
CORPORATION
10 Dean Knauss Drive, Narragansett, R.I. 02882 • (401) 782-8900

SITE NAME	**DATE**
ANALYSIS	**TIME**
	PRESERVATIVE

SAMPLE TYPE

☐ **Grab** ☐ **Composite** ☐ **Other** ________

COLLECTED BY:

Attachment B

Example Chain-of-Custody Record

CH2M H

APPLIED S ENCES LABORATORY

CHAIN OF CUSTODY ORD AND AGREEMENT TO PERFORM SERVICES

CH2M Hill Project # ☐☐☐☐☐☐☐☐.☐☐.☐☐

Purchase Order #

Project Name

Company Name CH2M HILL Office

Project Manager & Phone #
Mr. [ ]
Ms. [ ]
Dr. [ ]

Report Copy to:

Requested Completion Date:

Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

Sample Disposal: Dispose ☐ Return ☐

LAB TEST CODES

ANALYSES REQUESTED

SHADED AREA– FOR LAB USE ONLY

Lab 1 #
Lab 2 #
Quote #
Kit Request #
Project #
No. of Samples
Page of
Login
LIMS Ver

Sampling Date	Sampling Time	Type COMP	Type GRAB	Matrix WATER	Matrix SOIL	Matrix AIR	CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS	ANALYSES REQUESTED										REMARKS	LAB 1 ID	LAB 2 ID

Sampled By & Title (Please sign and print name) Date/Time

Received By (Please sign and print name) Date/Time

Received By (Please sign and print name) Date/Time

Received By (Please sign and print name) Date/Time

Work Authorized By (Please sign and print name)

Relinquished By (Please sign and print name) Date/Time

Relinquished By (Please sign and print name) Date/Time

Relinquished By (Please sign and print name) Date/Time

QC Level: 1 2 3 Other: ____

COC Rec	ICE
Ana Req	TEMP
Cust Seal	Ph

Shipped Via
UPS BUS Fed-Ex Hand Other ____

Shipping #

Remarks

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: Original - LAB, Yellow - LAB, Pink - Client

REV 3/94 FORM 340

Attachment C
Example Custody Seal

CH2M HILL

CUSTODY SEAL

Date

Signature

STANDARD OPERATING PROCEDURE

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Water Quality Meter with Flow-Through Cell

---

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using a water quality meter for field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of aqueous samples. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Water Quality Monitoring System with flow-though cell (Horiba, YSI, In-Situ, Ion Science, etc)
- Auto-Calibration Standard Solution (provided by rental company)
- Distilled water in squirt bottle

III. Procedures and Guidelines

A. General Parameters and Specifications:

Note: the general parameters listed below may not be available for every type of meter used. Please refer to the specific meter's manual to determine meter's range of measurement and accuracy.

Parameter	Range of measurement	Accuracy
pH	0 to 14 pH units	+/- 0.1 pH units
Specific conductance	0 to 9.99 S/m	+/- 3 % full scale
Turbidity	0 to 800 NTU	+/- 5 % full scale
Dissolved oxygen	0 to 19.99 mg/l	+/- 0.2 mg/l
Temperature	0 to 55 ^{o}C	+/- 1.0 ^{o}C
ORP	-999 to +999 mV	+/- 15 mV
Salinity	0 to 4 %	+/- 0.3 %

B. Calibration:

Prior to each day's use, clean the probe and flow-through cell using deionized water and calibrate using the Standard Solution. Refer to the specific instrumentation manual for the proper calibration methods.

C. Sample Measurement:

The water quality probes are inserted into a flow-through cell, and the purged groundwater is directed through the cell by connecting the pump discharge tubing to the bottom port on the flow through cell, allowing measurements to be collected before the water contacts the atmosphere. The flow-through cell should be positioned out of direct sunlight to reduce solar heating, and wrapped in aluminum foil to minimize heat loss or gain.

As water passes through the flow-through the flow cell, press MEAS to obtain readings or the readings are displayed on the meter for each parameter (dependent on the type of meter used). Record the water quality parameter data in a field notebook.

Once the parameters have stabilized (see *Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III* or *Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region IV* depending on project site location), remove the tubing from the bottom port of the flow-through cell.

Never collect a groundwater sample for laboratory analysis from the flow-through cell. Rinse the flow-through cell between wells to remove any sediment buildup within the cell.

IV. Key Checks and Preventive Maintenance

- Calibrate meter
- Clean probe with deionized water when done
- Refer to operations manual for recommended maintenance and troubleshooting
- Check batteries, and have a replacement set on hand
- Due to the importance of obtaining these parameters, the field team should have a spare unit readily available in case of an equipment malfunction.

STANDARD OPERATING PROCEDURE

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Horiba or YSI Water Quality Parameter Meter with Flow-through Cell

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using a water quality parameter meter (e.g., Horiba® or YSI) for field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of aqueous samples. The YSI instrument does not measure turbidity. A separate turbidity meter (i.e., Hanna Turbidity Meter) will need to be used in conjunction with the YSI meter. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Water Quality Parameter Meter such as a Horiba® Water Quality Monitoring System or YSI with flow-though cell
- Auto-Calibration Standard Solution (provided by rental company)
- Distilled water in squirt bottle

III. Procedures and Guidelines

A. Parameters and Specifications:

Parameter	**Range of measurement**	**Accuracy**
pH	0 to 14 pH units	+/- 0.1 pH units
Specific conductance	0 to 9.99 S/m	+/- 3 % full scale
Turbidity	0 to 800 NTU	+/- 5 % full scale
Dissolved oxygen	0 to 19.99 mg/l	+/- 0.2 mg/l
Temperature	0 to 55 ^{o}C	+/- 1.0 ^{o}C
ORP	-999 to +999 mV	+/- 15 mV
Salinity	0 to 4 %	+/- 0.3 %

B. Calibration:

Prior to each day's use, clean the probe and flow-through cell using deionized water and calibrate using the Standard Solution.

Horiba Calibration procedure:

1. Fill a calibration beaker with standard solution to the recommended fill line.
2. Insert the probe into the beaker. All the parameter sensors will now be immersed in the standard solution except the D.O. sensor; the D.O. calibration is done using atmospheric air.
3. Turn power on and allow some time for the machine to warm-up prior to starting the calibration. When the initial readings appear to stabilize the instrument is ready to calibrate.
4. Press CAL key to put the unit in the calibration mode.
5. Press the ENT key to start automatic calibration. Wait a moment, and the upper cursor will gradually move across the four auto-calibration parameters one by one: pH, COND, TURB, and DO. When the calibration is complete, the readout will briefly show END. The instrument is now calibrated.
6. If the unit is calibrated properly the instrument readings, while immersed in the standard solution, will match the standard solution values provided on the solution container. The typical standard solution values are: pH = 4.0 +/- 3%, conductivity 4.49 mS/cm +/- 3%, and turbidity = 0 NTU +/- 3%.
7. Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

YSI Calibration procedure:

1. Press the **On/off** key to display the run screen
2. Press the **Escape** key to display the main menu screen
3. Use the arrow keys to highlight the **Calibrate**
4. Press the **Enter** key. The Calibrate screen is displayed
5. Choose the parameter to calibrate

A. *Conductivity Calibration:*

This procedure calibrates specific conductance (recommended), conductivity and salinity. Calibrating any one option automatically calibrates the other two.

1) Use the arrow keys to highlight the **Conductivity** selection
2) Press **Enter.** The Conductivity Calibration Selection Screen is displayed.
3) Use the arrow keys to highlight the Specific Conductance selection.
4) Press **Enter.** The Conductivity Calibration Entry Screen is displayed.
5) Place the correct amount of conductivity standard (see Instrument Manual) into a clean, dry or pre-rinsed transport/calibration cup.
6) Carefully immerse the sensor end of the probe module into the solution.
7) Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.

   NOTE: The sensor must be completely immersed past its vent hole. Using the recommended volumes from the Instrument Manual Calibration Volumes should ensure that the vent hole is covered.

8) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not over tighten as this could cause damage to the threaded portions.

9) Use the keypad to enter the calibration value of the standard you are using.

   NOTE: Be sure to enter the value in **mS/cm at 25°C**.

10) Press **Enter**. The Conductivity Calibration Screen is displayed.
11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
12) Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
13) Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen
14) Press **Escape** to return to the calibrate menu.
15) Rinse the probe module and sensors in tap or purified water and dry.

B. *Dissolved Oxygen Calibration:*

This procedure calibrates dissolved oxygen. Calibrating any one option (% or mg/L) automatically calibrates the other.

1) Go to the calibrate screen as described in Section

   NOTE: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.

2) Use the arrow keys to highlight the **Dissolved Oxygen** selection.
3) Press **Enter**. The dissolved oxygen calibration screen is displayed.
4) DO calibration in mg/L is carried out in a water sample which has a known concentration of dissolved oxygen (usually determined by a Winkler titration).
5) Use the arrow keys to highlight the **DO mg/L** selection.
6) Press **Enter**. The DO mg/L Entry Screen is displayed.
7) Place the probe module in water with a known DO concentration.

   NOTE: Be sure to completely immerse all the sensors.

8) Use the keypad to enter the known DO concentration of the water.
9) Press **Enter**. The Dissolved Oxygen mg/L Calibration Screen is displayed.
10) Stir the water with a stir bar, or by rapidly moving the probe module, to provide fresh sample to the DO sensor.
11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
12) Observe the DO mg/L reading, when the reading is stable (shows no significant change for approximately 30 seconds), press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
13) Press **Enter**. This returns you to the DO calibration screen.
14) Press **Escape** to return to the calibrate menu.
15) Rinse the probe module and sensors in tap or purified water and dry.

C. *pH Calibration:*

1) Go to the calibrate screen.
2) Use the arrow keys to highlight the **pH** selection.
3) Press **Enter**. The pH calibration screen is displayed.

- ➢ Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a one point calibration. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select only one pH buffer.
- ➢ Select the **2-point** option to calibrate the pH sensor using only two calibration standards. Use this option if the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is sufficient. A three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.
- ➢ Select the **3-point** option to calibrate the pH sensor using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer.

4) Use the arrow keys to highlight the **2-point** selection.
5) Press **Enter**. The pH Entry Screen is displayed.
6) Place the correct amount of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.

    NOTE: For maximum accuracy, the pH buffers you choose should be within the same pH range as the water you are preparing to sample.

    NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.
7) Carefully immerse the sensor end of the probe module into the solution.
8) Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.

    NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the sensor is covered.
9) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

    NOTE: Do not over tighten as this could cause damage to the threaded portions.
10) Use the keypad to enter the calibration value of the buffer you are using **at the current temperature**.

    NOTE: pH vs. temperature values are printed on the labels of all YSI pH buffers.
11) Press **Enter**. The pH calibration screen is displayed.
12) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
13) Observe the reading under pH, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
14) Press **Enter**. This returns you to the Specified pH Calibration Screen.

15) Rinse the probe module, transport/calibration cup and sensors in tap or purified water and dry.
16) Repeat steps 6 through 13 above using a second pH buffer.
17) Press **Enter**. This returns you to the pH Calibration Screen.
18) Press **Escape** to return to the calibrate menu.
19) Rinse the probe module and sensors in tap or purified water and dry.

D. ORP Calibration:

1) Go to the calibrate screen.
2) Use the arrow keys to highlight the **ORP** selection.
3) Press **Enter**. The ORP calibration screen is displayed.
4) Place the correct amount of a known ORP solution into a clean, dry or pre-rinsed transport/calibration cup.

   NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the ORP sensor with a small amount of solution that can be discarded. Be certain that you avoid cross-contamination with other solutions.
5) Carefully immerse the sensor end of the probe module into the solution.
6) Gently rotate and/or move the probe module up and down to remove any bubbles from the ORP sensor.

   NOTE: The sensor must be completely immersed.
7) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.
8) Use the keypad to enter the correct value of the calibration solution you are using at the current temperature.
9) Press **Enter**. The ORP calibration screen is displayed.
10) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
11) Observe the reading under ORP, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
12) Press **Enter**. This returns you to the Calibrate Screen.
13) Rinse the probe module and sensors in tap or purified water and dry.

   Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

C. Sample Measurement:

Horiba measurement procedure:

As water passes through the flow-through the flow cell, press MEAS to obtain reading; record data in a field notebook.

YSI measurement procedure:

As water passes through the flow-through the flow cell, the readings are displayed for each parameter. Record the water quality parameter data in a field notebook. In addition, the data is recorded in the YSI and can be downloaded to a computer following completion of the sampling event.

IV. Key Checks and Preventive Maintenance

- Calibrate meter
- Clean probe with deionized water when done
- Refer to operations manual for recommended maintenance and troubleshooting
- Check batteries, and have a replacement set on hand
- Due to the importance of obtaining these parameters, the field team should have a spare unit readily available in case of an equipment malfunction.

V. References

YSI 556 Multi Probe System Operator Manual

YSI **Environmental**

Pure Data for a Healthy Planet.™

YSI 556 MPS
Multi Probe System

Operations Manual

Contents

1. Safety

1.1 General Safety Information

Read all safety information in this manual carefully before using the YSI 556 Multi-Probe System (MPS). Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review *Appendix D Health and Safety*.

⚠ **WARNING**

Warnings are used in this manual when misuse of the instrument could result in death or serious injury to a person.

⚠ **CAUTION**

Cautions are used in this manual when misuse of the instrument could result in mild or serious injury to a person and/or damage to equipment.

⚠ **IMPORTANT SAFETY INSTRUCTIONS!**

⚠ **SAVE THESE INSTRUCTIONS!**

⚠ In essence, the most important safety rule for use of the YSI 556 MPS is to utilize the instrument ONLY for purposes documented in this manual. This is particularly true of the YSI 6117 rechargeable battery pack that contains nickel metal hydride (NiMH) batteries. The user should be certain to read all of the safety precautions outlined below before using the instrument.

⚠ YSI 6117 Rechargeable Battery Pack Safety Information

⚠ **Restrictions on Usage**

1. Never dispose of the battery pack in a fire.
2. Do not attempt to disassemble the YSI 6117 battery pack.
3. Do not tamper with any of the electronic components or the batteries within the battery pack. Tampering with either the electronic circuitry or the batteries will result in the voiding of the warranty and the compromising of the system performance, but, more importantly, can cause safety

hazards which result from overcharging such as overheating, venting of gas, and loss of corrosive electrolyte.

4. Do not charge the battery pack outside the 0–40°C temperature range.
5. Do not use or store the battery at high temperature, such as in strong direct sunlight, in cars during hot weather, or directly in front of heaters.
6. Do not expose the battery pack to water or allow the terminals to become damp.
7. Avoid striking or dropping the battery pack. If the pack appears to have sustained damage from these actions or malfunctions after an impact or drop, the user should not attempt to repair the unit. Instead, contact YSI Customer Service. Refer to *Appendix E Customer Service*.
8. If the battery pack is removed from the YSI 556 MPS, do not store it in pockets or packaging where metallic objects such as keys can short between the positive and negative terminals.

⚠ Precautions for Users with Small Children

Keep the battery pack out of reach of babies and small children.

⚠ Danger Notifications – Misuse creates a STRONG possibility of death or serious injury.

FAILURE TO CAREFULLY OBSERVE THE FOLLOWING PROCEDURES AND PRECAUTIONS CAN RESULT IN LEAKAGE OF BATTERY FLUID, HEAT GENERATION, BURSTING, AND SERIOUS PERSONAL INJURY.

1. Never dispose of the battery pack in a fire or heat it.
2. Never allow the positive and negative terminals of the battery pack to become shorted or connected with electrically conductive materials. When the battery pack has been removed from the YSI 556 MPS, store it in a heavy plastic bag to prevent accidental shorting of the terminals.

3. Never disassemble the battery pack and do not tamper with any of the electronic components or the batteries within the battery pack. The battery pack is equipped with a variety of safety features. Accidental deactivation of any of these safety features can cause a serious hazard to the user.
4. The NiMH batteries in the battery pack contain a strong alkaline solution (electrolyte). The alkaline solution is extremely corrosive and will cause damage to skin or other tissues. If any fluid from the battery pack comes in contact with a user’s eyes, immediately flush with clean water and consult a physician immediately. The alkaline solution can damage eyes and lead to permanent loss of eyesight.

⚠ Warning Notifications – Misuse creates a possibility of death or serious injury

1. Do not allow the battery pack to contact freshwater, seawater, or other oxidizing reagents that might cause rust and result in heat generation. If a battery becomes rusted, the gas release vent may no longer operate and this failure can result in bursting.
2. If electrolyte from the battery pack contacts the skin or clothing, thoroughly wash the area immediately with clean water. The battery fluid can irritate the skin.

⚠ Caution Notifications – Misuse creates a possibility of mild or serious injury or damage to the equipment.

1. Do not strike or drop the battery pack. If any impact damage to the battery pack is suspected, contact YSI Customer Service. Refer to *Appendix E Customer Service*.
2. Store the battery pack out of reach of babies and small children.
3. Store the battery pack between the temperatures of -20 and 30°C.
4. Before using the battery pack, be sure to read the operation manual and all precautions carefully. Then store this information carefully to use as a reference when the need arises.

⚠ YSI 616 Cigarette Lighter Charger Safety Information

1. This section contains important safety and operating instructions for the YSI 556 MPS cigarette lighter battery charger (YSI 616; RadioShack Number 270-1533E). BE SURE TO SAVE THESE INSTRUCTIONS.
2. Before using the YSI 616 cigarette lighter charger, read all instructions and cautionary markings on battery charger, battery pack, and YSI 556 MPS.
3. Charge the YSI 6117 battery pack with the YSI 616 cigarette lighter charger ONLY when the YSI 6117 is installed in the YSI 556 MPS.
4. Do not expose charger to rain, moisture, or snow.
5. Use of an attachment not recommended or sold by the battery charger manufacturer may result in a risk of fire, electric shock, or injury to persons.
6. To reduce risk of damage to cigarette lighter and cord, pull by cigarette lighter rather than cord when disconnecting charger.
7. Make sure that the cord is located so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.
8. Do not operate charger with damaged cord or cigarette lighter connector – replace it immediately.
9. Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; contact YSI Customer Service. Refer to *Appendix E Customer Service*.
10. Do not disassemble charger other than to change the fuse as instructed. Replace the part or send it to YSI Product Service if repair is required (refer to *Appendix E Customer Service*). Incorrect reassembly may result in a risk of electric shock or fire.
11. To reduce risk of electric shock, unplug charger before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

⚠ YSI 556 MPS Water Leakage Safety Information

The YSI 556 MPS has been tested and shown to comply with IP67 criterion, i.e. submersion in 1 meter of water for 30 minutes with no leakage into either the battery compartment or the main case. However, if the instrument is submersed for periods of time in excess of 30 minutes, leakage may occur with subsequent damage to the batteries, the rechargeable battery pack circuitry, and/or the electronics in the main case.

If leakage into the battery compartment is observed when using alkaline C cells, remove batteries, dispose of batteries properly, and dry the battery compartment completely, ideally using compressed air. If corrosion is present on the battery terminals, contact YSI Customer Service for instructions. Refer to *Appendix E Customer Service*.

If leakage into the battery compartment is observed when using the YSI 6117 rechargeable battery pack, remove the battery assembly and set aside to dry. Return the battery pack to YSI Product Service for evaluation of possible damage. Finally dry the battery compartment completely, ideally using compressed air. If corrosion is present on the battery terminals, contact YSI Customer Service for instructions. Refer to *Appendix E Customer Service*.

⚠ **CAUTION:** If water has contacted the rechargeable battery pack, do not attempt to reuse it until it has been evaluated by YSI Product Service (refer to *Appendix E Customer Service*). Failure to follow this precaution can result in serious injury to the user.

If it is suspected that leakage into the main cavity of the case has occurred, remove the batteries immediately and return the instrument to YSI Product Service for damage assessment. Refer to *Appendix E Customer Service*.

⚠ **CAUTION:** Under no circumstances should the user attempt to open the main case.

2. General Information

2.1 Description

The rugged and reliable YSI 556 MPS (Multi-Probe System) combines the versatility of an easy-to-use, easy-to-read handheld unit with all the functionality of a multi-parameter system. Featuring a waterproof, impact-resistant case, the YSI 556 MPS simultaneously measures dissolved oxygen, conductivity, temperature, and optional pH and ORP. A simple cellular phone style keypad and large display make the instrument easy to use. The YSI 556 MPS is compatible with YSI EcoWatch^{TM} for Windows^{TM} software.

The YSI 556 MPS assists the user in conforming to Good Laboratory Practice (GLP) standards which help ensure that quality control/quality assurance methods are followed. Battery life is displayed with a fuel gauge, and the user can choose standard alkaline batteries or an optional rechargeable battery pack.

The 1.5 MB memory can store more than 49,000 data sets. Other options include a flow cell and barometer. The internal barometer can be user-calibrated and displayed along with other data, used in dissolved oxygen calibrations, and logged to memory for tracking changes in barometric pressure.

Features

- Waterproof - meets IP67 specifications
- Field-replaceable DO electrode module; pH and pH/ORP sensors
- Compatible with Ecowatch^{TM} for Windows^{TM} data analysis software
- Assists with Good Laboratory Practice Standards (GLP)
- Choice of DO membrane material for different applications
- Easy-to-use, screw-on cap DO membranes
- User-upgradable software from YSI website
- Three-year warranty on the instrument; one-year on the probe modules
- Available with 4,10, and 20 m cable lengths
- Stores over 49,000 data sets, time and date stamped

- Auto temperature compensating display contrast
- Optional barometer
- Optional rechargeable battery pack or standard alkaline batteries

2.2 Unpacking the Instrument

1. Remove the instrument from the shipping box. Note that the probe module and sensors are shipped in a separate box and will be unpacked later in Section *3.2 Unpacking the Probe Module*.

   NOTE: Do not discard any parts or supplies.

2. Use the packing list to ensure all items are present.

3. Visually inspect all components for damage.

   NOTE: If any parts are missing or damaged, contact your YSI Service Center immediately. Refer to *Appendix E Customer Service* or www.ysi.com.

2.3 Features of the YSI 556 Multi-Probe System

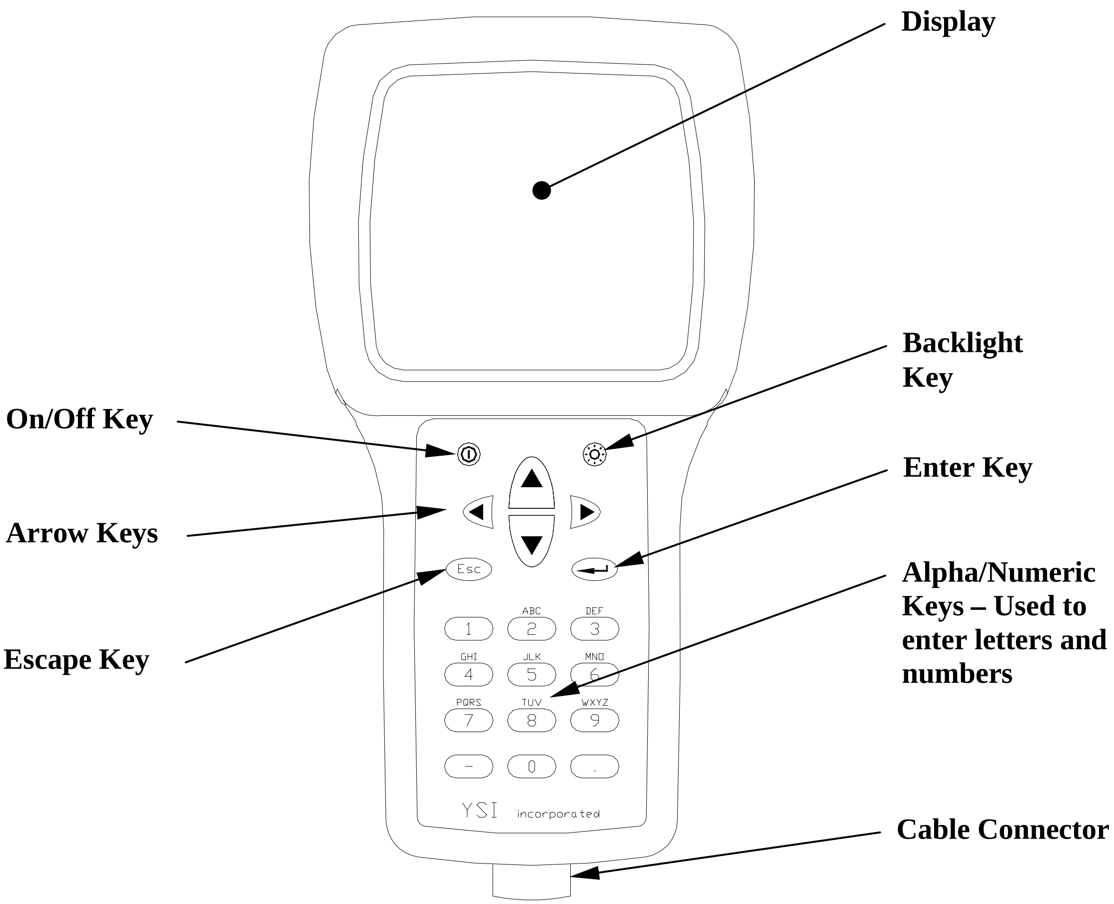


Figure 2.1 Front View of YSI 556 MPS

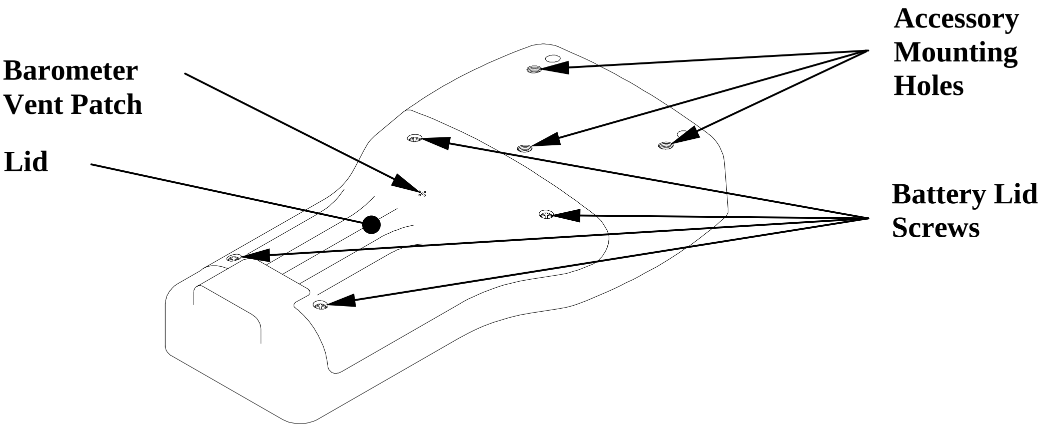


Figure 2.2 Back View of YSI 556 MPS

2.4 Batteries

2.4.1 Battery Life

Standard Alkaline Batteries

With the standard battery configuration of 4 alkaline C cells, the YSI 556 MPS will operate continuously for approximately 180 hours. Assuming a standard usage pattern when sampling of 3 hours of "on time" in a typical day, the alkaline cells will last approximately 60 days.

Optional Rechargeable Battery Pack

When fully charged, the optional rechargeable battery pack will provide approximately 50 hours of battery life.

2.4.2 Inserting 4 C Batteries

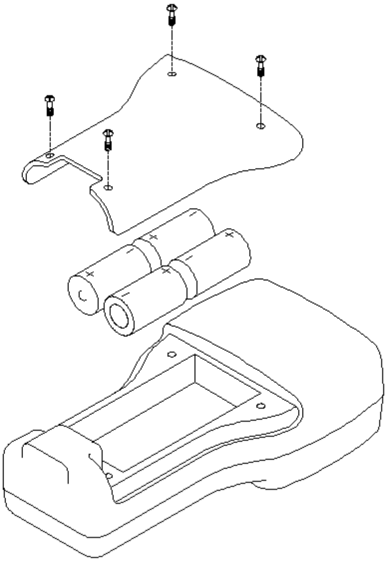


Figure 2.3 Inserting C Cells

⚠ **CAUTION: Install batteries properly to avoid damage to the instrument.**

1. Loosen the four screws in the battery lid on the back of the instrument using any screwdriver.

2. Remove the battery lid.

3. Insert four C batteries between the clips following the polarity (+ and -) labels on the bottom of the battery compartment.

4. Check gasket for proper placement on the battery lid.

5. Replace the battery lid and tighten the 4 screws securely and evenly.

   NOTE: Do not over-tighten the screws.

2.4.3 Inserting Optional Rechargeable Battery Pack

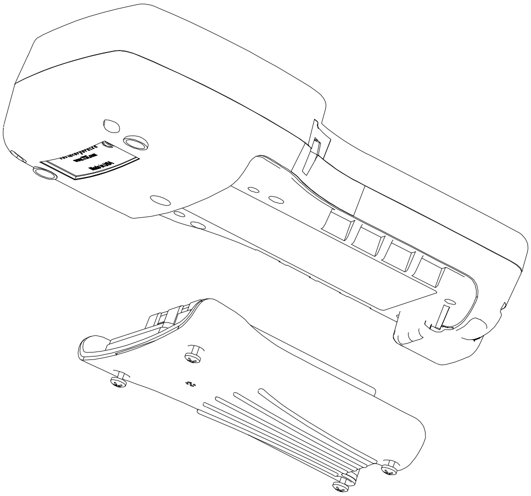


Figure 2.4 Inserting Battery Pack

⚠ **CAUTION: Read all cautions and warnings that come with the battery pack *before* using the battery pack.**

1. Loosen the four screws in the battery lid on the back of the instrument using any screwdriver.

2. Remove the C battery lid and store for future use. Remove C batteries, if installed.

3. Check for proper placement of gasket on the rechargeable battery pack and lid.

4. Install the rechargeable battery pack and lid and tighten the 4 screws securely and evenly.

   NOTE: Do not over tighten the screws.

2.4.4 Charging the Optional Rechargeable Battery Pack

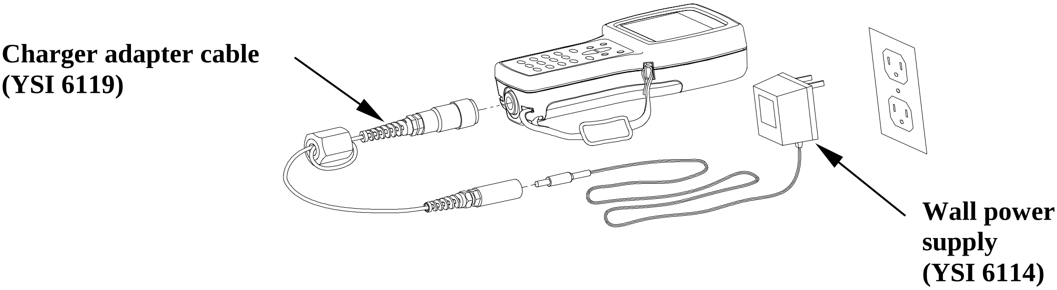


Figure 2.5 Charging the Battery Pack

⚠ **CAUTION: Do not use or store the battery pack at extreme temperatures such as in strong direct sunlight, in cars during hot weather or close to heaters.**

1. Install the rechargeable battery pack into the instrument as described in Section *2.4.3 Inserting Optional Rechargeable Battery Pack*.

2. Attach the charger adapter cable (YSI 6119) to the instrument.

   NOTE: Wall power supplies for use in countries outside the US and Canada can be found in *Appendix B Instrument Accessories*.

3. Insert the barrel connector of the wall power supply into the barrel of the adapter cable.

⚠ **CAUTION: Do not charge the battery pack continuously for more than 48 hours.**

⚠ **CAUTION: Do not drop or expose to water.**

⚠ **CAUTION: Do not charge the battery pack at temperatures below 0°C or above 40°C.**

4. Plug the wall power supply into an AC power outlet for approximately 2 hours to obtain an 80% to 90% charge and for 6 hours to get a full charge.

   NOTE: The battery pack can be recharged whether the instrument is on or off.

2.4.5 Storing the Battery Pack

Remove the battery pack from the instrument when the instrument will not be used for extended periods of time to prevent over discharge of the battery pack.

Store the battery pack in a heavy plastic bag to prevent accidental shorting of the terminals. Store between –20 and 30°C.

2.4.6 Optional Cigarette Lighter Charger

⚠ **CAUTION: Read all warnings and cautions that come with the charger before using the charger.**

⚠ **CAUTION: Only use cigarette lighter charger when *rechargeable* battery pack is inserted into instrument.**

⚠ **CAUTION: Do not mishandle cigarette lighter charger. Do not expose to moisture.**

1. Plug the barrel connector of the cigarette lighter charger into the mating end of the YSI 6119 Charger Adapter Cable.

2. Attach the MS-19 end of the YSI 6119 Charger Adapter Cable to the instrument.

3. Make one of the following modifications to the other end of the charger:

   Slide the adapter ring off the plug to use the device with an American or Japanese vehicle.

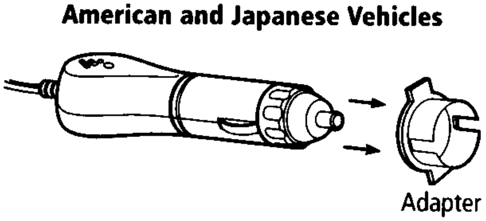


Figure 2.6 Charger Plug Adapter Use

Leave the adapter ring on the plug and position it so that the slots on the adapter ring line up with the plug's spring clips to use the device on a European vehicle.

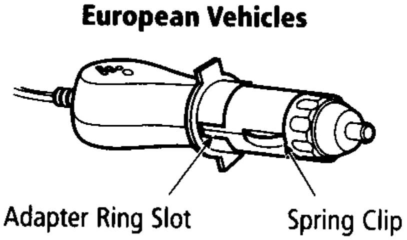


Figure 2.7 European Charger Plug Adapter Use

NOTE: If the charger stops working properly, refer to Section *13 Troubleshooting.*

2.5 Power On

Press and release the on/off button in the upper left corner of the instrument keypad to turn the instrument on or off. See Figure 2.1 Front View of YSI 556 MPS.

2.6 Setting Display Contrast

The display contrast automatically compensates for temperature changes. However, under extreme temperature conditions you may wish to optimize the display by manual adjustment as follows:

1. Press and *hold down* the backlight key in the upper right corner of the keypad and press the “up” arrow to increase (darken) the contrast.

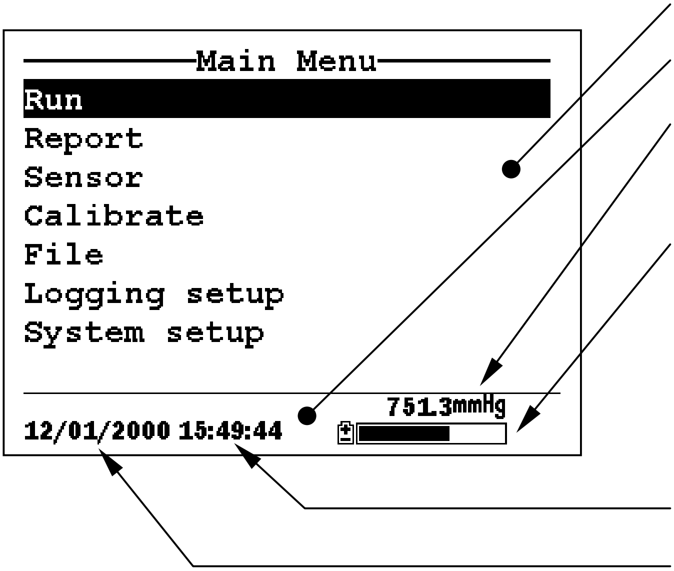
2. Press and *hold down* the backlight key in the upper right corner of the keypad and press the “down” arrow to decrease (lighten) the contrast.

2.7 Backlight

Press and *release* the backlight key in the upper right corner of the keypad to turn the backlight on or off. See Figure 2.1 Front View of YSI 556 MPS.

NOTE: The backlight turns off automatically after two minutes of non-use.

2.8 General Screen Features



Main Display

Status Bar

Barometer Reading (optional)– Updated in real time, not corrected to sea level

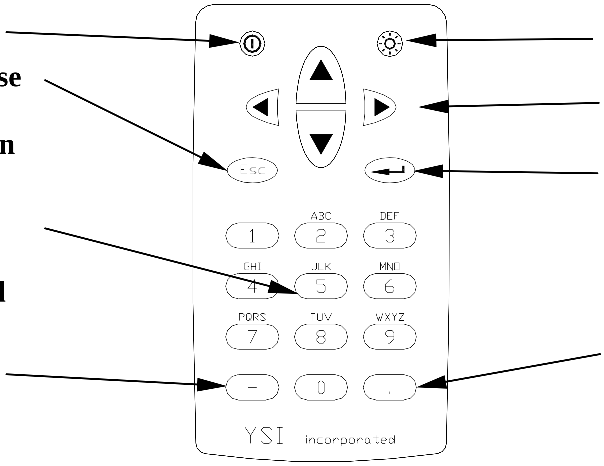
Battery Charge – NiMH label indicates use of optional rechargeable battery pack, pulsing indicates that battery is charging, flashing indicates batteries almost exhausted

Current Time

Current Date

Figure 2.8 Main Menu Screen

2.9 Keypad Use



On/Off Key

Escape Key – Use to return to previous position in menu

Alpha/Numeric Keys – Used to enter letters and numbers

Minus/Hyphen (-) Key

Backlight/Contrast

Arrows Keys

Enter Key

Period/Decimal Point Key

Figure 2.9 Keypad Features

KEY	LETTER/ NUMBER
1	1
2	ABC2abc3
3	DEF3def3
4	GHI4ghi4
5	JKL5jkl5
6	MNO6mno6
7	PQRS7pqrs7
8	TUV8tuv8
9	WXYZ9wxyz9
0	0

Figure 2.10 Keypad Letters & Numbers

1. See Figure 2.10 Keypad Letters & Numbers and press the appropriate key repeatedly until letter or number desired appears in display.

   NOTE: Press the key repeatedly in rapid succession to get to the desired letter or number. If you pause for more than a second, the cursor automatically scrolls to the right to prepare for the next input.

EXAMPLE 1: Press the **6** key *once* and *release* to display an uppercase “M.”

EXAMPLE 2: Press the **6** key *four times* and *release* to display the number “6.”

EXAMPLE 3: Press the **6** key *five times* and *stop* to display a lowercase “m.”

2. Press the left arrow key to go back and reenter a number or letter that needs to be changed.

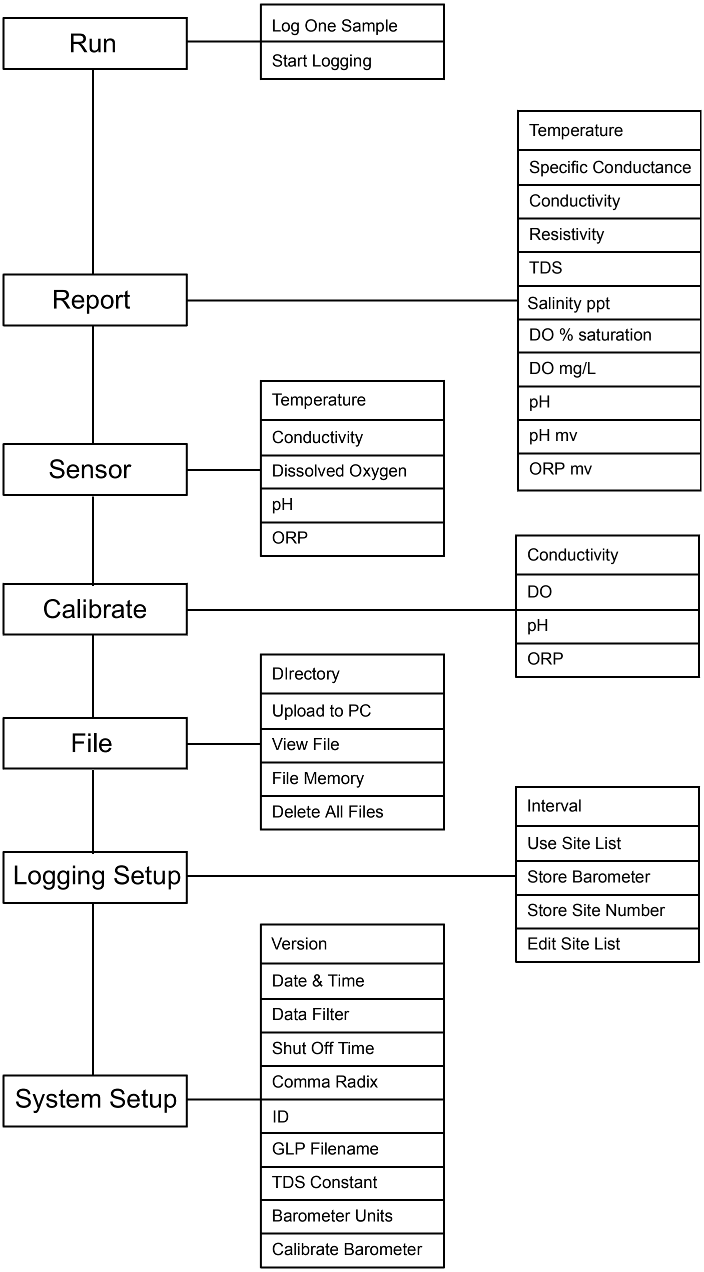
3. Press the **Enter** key when your entry is complete.

NOTE: The instrument software permits only numeric entries in many instances, such as when setting the clock or entering calibration parameters.

2.10 Instrument Reset

The YSI 556 MPS is characterized by sophisticated software that should provided trouble-free operation. However as with all high-capability software packages, it is always possible that the user will encounter circumstances in which the instrument does not respond to keypad entry. If this occurs, the instrument function can easily be restored by removing and then reapplying battery power. Simply remove either your C-cells or rechargeable battery pack from the battery compartment, wait 30 seconds and then replace the batteries. See Section *2.4 Batteries* for battery removal/reinstallation instructions.

2.11 Menu Flowchart



3. Probe Module

3.1 Introduction

The YSI 5563 Probe module is used for measuring dissolved oxygen, temperature, conductivity, and optional pH and ORP. The probe module is rugged, with the sensors enclosed in a heavy duty probe sensor guard with attached sinking weight. A 4, 10 or 20 meter cable is directly connected to the probe module body making it waterproof. An MS-19 connector at the end of the cable makes the YSI 5563 fully compatible with the YSI 556 Multi-Probe System.

3.2 Unpacking the Probe Module

1. Remove the YSI 5563 Probe module from the shipping boxes.

   NOTE: Do not discard any parts or supplies.

2. Use the packing list to ensure all items are present.

3. Visually inspect all components for damage.

   NOTE: If any parts are missing or damaged, contact your YSI Service Center immediately. Refer to *Appendix E Customer Service* or www.ysi.com.

3.3 Features of the YSI 5563 Probe Module

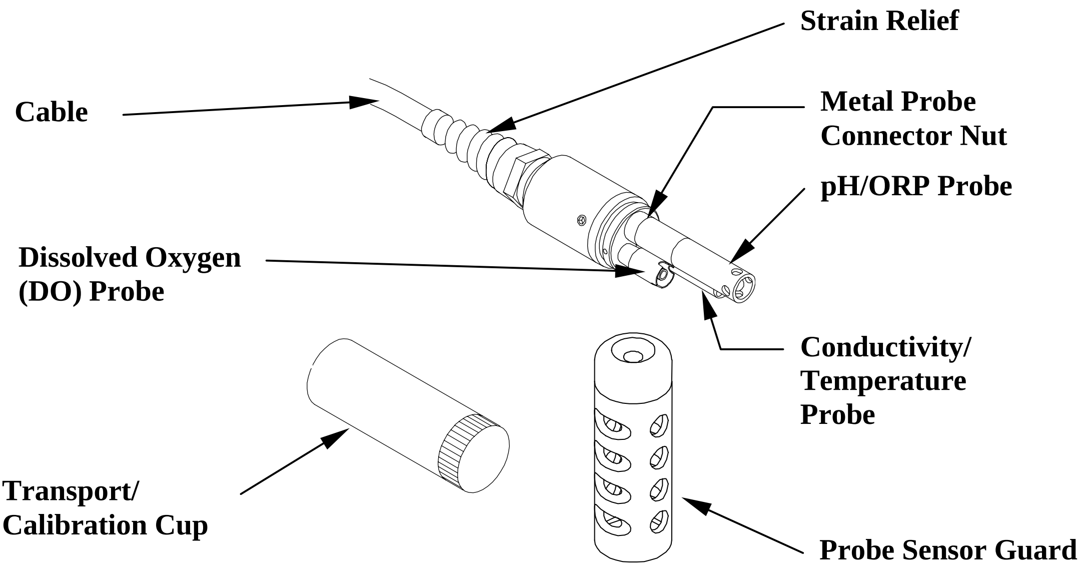


Figure 3.1 Probe Module

3.4 Preparing the Probe Module

To prepare the probe module for calibration and operation, you need to install the sensors into the connectors on the probe module bulkhead. In addition to sensor installation, you need to install a new DO membrane cap.

3.4.1 Sensor Installation

Whenever you install, remove or replace a sensor, it is extremely important that the entire probe module and all sensors be thoroughly dried prior to the removal of a sensor or a sensor port plug. This will prevent water from entering the port. Once you remove a sensor or plug, examine the connector inside the probe module sensor port. If any moisture is present, use compressed air to completely dry the connector. If the connector is corroded, return the probe module to your dealer or directly to YSI Customer Service. Refer to *Appendix E Customer Service*.

Conductivity/Temperature and pH, pH/ORP Sensor Installation

1. Unscrew and remove the probe sensor guard.

2. Using the sensor installation tool supplied in the YSI 5511 maintenance kit, unscrew and remove the sensor port plugs.

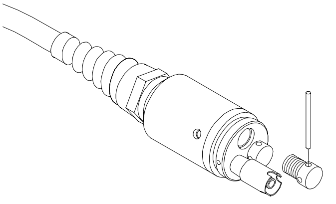


Figure 3.2 Port Plug Removal

3. Locate the port with the connector that corresponds to the sensor that is to be installed.

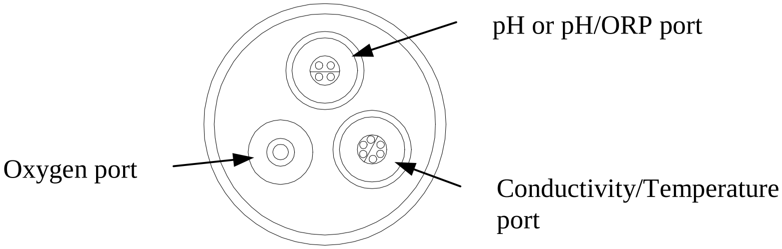


Figure 3.3 Sensor Port Identification

4. Apply a thin coat of o-ring lubricant (supplied in the YSI 5511 maintenance kit) to the o-rings on the connector side of the sensor (see Figure 3.4 O-Ring Lubrication).

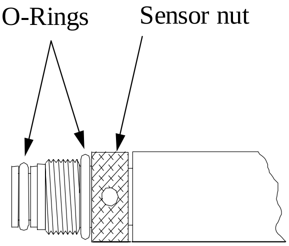


Figure 3.4 O-Ring Lubrication

⚠ **CAUTION:** Make sure that there are NO contaminants between the O-ring and the sensor. Contaminants that are present under the O-ring may cause the O-ring to leak.

5. Be sure the probe module sensor port is free of moisture and then insert the sensor into the correct port. Gently rotate the sensor until the two connectors align.

6. With connectors aligned, screw down the sensor nut using the sensor installation tool.

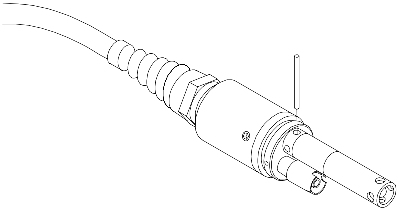


Figure 3.5 Sensor Installation

⚠ **CAUTION:** Do not cross thread the sensor nut. Tighten the nut until it is flush with the face of the probe module bulkhead. Do not over tighten.

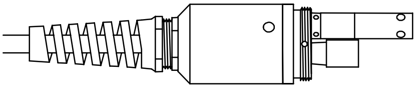


Figure 3.6 Bulkhead Seating

7. Repeat steps 3-6 for any other sensors.

8. Replace the probe sensor guard.

Dissolved Oxygen Sensor Installation

The YSI 5563 comes with the DO sensor already installed. Refer to Section *11.1.2 DO Sensor Replacement* for instructions on installing the YSI 558 Replaceable DO Module Kit.

3.4.2 Membrane Cap Selection

The YSI 5563 is shipped with a YSI 5909 kit that contains membrane caps made with 2 mil polyethylene (PE), a material which should be ideal for most field applications of the 556. However, YSI also offers membrane caps made with two other materials (1 mil polyethylene and 1 mil Teflon) which some users may also prefer. All membranes available for the 556/5563 system provide comparable accuracy if used properly. The difference between the two thicknesses of PE is found in the trade-off of flow dependence and response time as described below. Teflon is offered because some users may prefer to continue using the traditional membrane material used by YSI. To avoid confusion, the membrane caps are color coded as described below and can be ordered in kits as noted:

1 mil Teflon – Black Caps (Kit = YSI 5906)
1 mil Polyethylene (PE) – Yellow Caps (Kit = YSI 5908)
2 mil Polyethylene (PE) – Blue Caps (Kit = YSI 5909)

The 1 mil Teflon caps will offer traditional, reliable performance for most dissolved oxygen applications. The 1 mil PE caps will provide a significantly faster dissolved oxygen response (as long as your 556 Data Filter is set correctly as described below in Sections 10.2 and 10.3.1)) while also giving readings which are significantly less flow dependent than the 1 mil Teflon caps. Finally, 2 mil PE caps will show a large reduction in flow dependence over 1 mil Teflon while not significantly increasing the response time. Generally, one of the PE caps is likely to provide better performance for your application.

IMPORTANT: No matter which type of membrane cap you select, you will also have to confirm your selection in the 556 software from the Sensor menu as described in Section *4 Sensors*.

3.4.3 Membrane Cap Installation

NOTE: The YSI 5563 DO sensor (already installed in the probe module) was shipped dry. A shipping membrane was installed to protect the electrode. **A new membrane cap must be installed before the first use**.

1. Unscrew and remove the probe sensor guard.

2. Unscrew, remove, and discard the old membrane cap.

3. Thoroughly rinse the sensor tip with distilled water.

4. Prepare the electrolyte according to the directions on the electrolyte solution bottle.

5. Hold the new membrane cap and fill it at least 1/2 full with the electrolyte solution.

6. Screw the membrane cap onto the sensor moderately tight. A small amount of electrolyte should overflow.

⚠ **CAUTION:** Do not touch the membrane surface.

7. Screw the probe sensor guard on moderately tight.

3.5 Transport/Calibration Cup

The YSI 5563 Probe module has been supplied with a convenient transport/calibration cup. This cup is an ideal container for calibration of the different sensors, minimizing the amount of solution needed. Refer to Section *6 Calibrate*.

3.5.1 Transport/Calibration Cup Installation

1. Remove probe sensor guard, if already installed.

2. Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body.

3. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

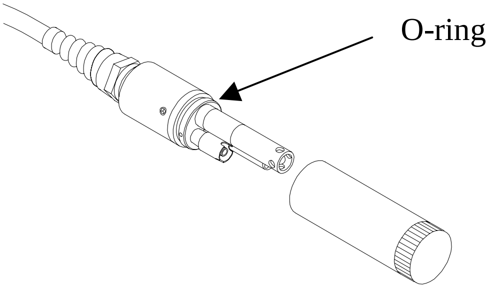


Figure 3.7 Transport/Calibration Cup Installation

3.6 Instrument/Cable Connection

Attach the cable to the instrument as follows:

1. Line up the pins and guides on the cable with the holes and indentations on the cable connector at the bottom of the YSI 556 instrument. See Figure 2.1 Front View of YSI 556 MPS.

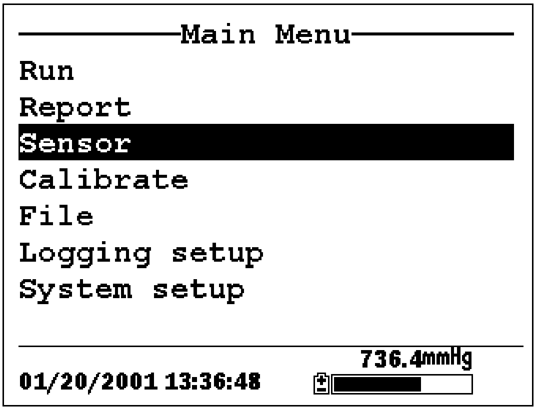
2. Holding the cable firmly against the cable connector, turn the locking mechanism clockwise until it snaps into place.

Remove the cable from the instrument by turning the cable connector counterclockwise until the cable disengages from the instrument.

The Sensors Enabled screen allows the user to enable or disable each of the sensors and select which membrane material will be used for the dissolved oxygen sensor. Disabled sensors will not be displayed on the screen in real time or logged to files.

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.



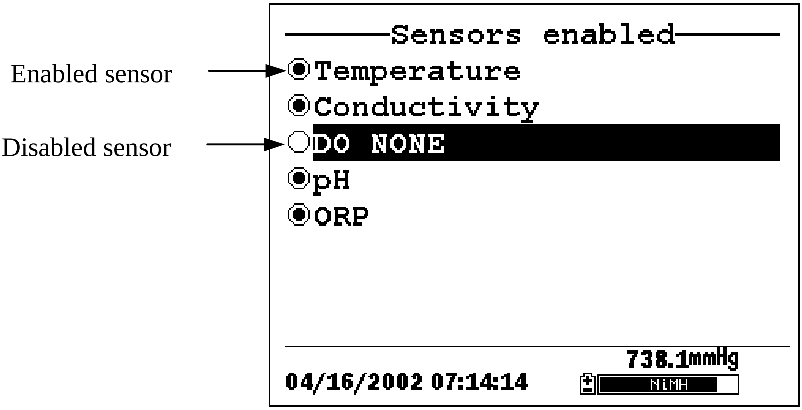
Main Menu
Run
Report
Sensor
Calibrate
File
Logging setup
System setup

736.4mmHg
01/20/2001 13:36:48

Figure 4.1 Main Menu Screen

3. Use the arrow keys to highlight the **Sensor** selection.

4. Press the **Enter** key to display the sensors enabled screen.



Enabled sensor
Disabled sensor

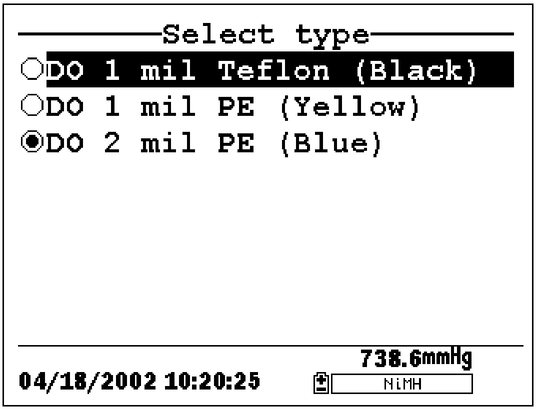
Sensors enabled
● Temperature
● Conductivity
○ DO NONE
● pH
● ORP

738.1mmHg
04/16/2002 07:14:14
NiMH

Figure 4.2 Sensors Enabled Screen Before DO Membrane Selection

A black dot to the left of a sensor indicates that sensor is enabled. Sensors with an empty circle are disabled.

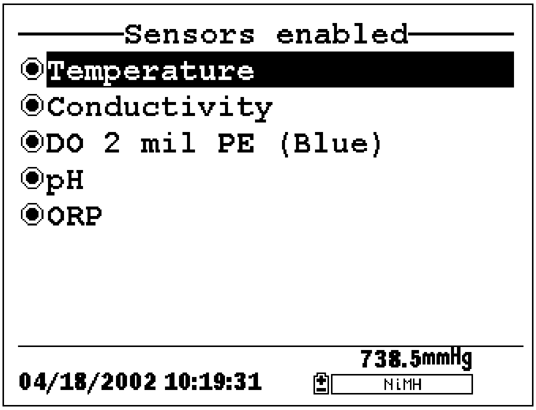
Highlight the “DO None” entry as shown above and press **Enter** to display the membrane choice screen. Consult Section *3.4.2 Membrane Cap Selection* for information on the advantages of each type of membrane material. Blue membrane caps using 2 mil polyethylene (PE) were shipped with your YSI 5563 and are likely to be the best choice for most 556 field applications.



```
Select type
○DO 1 mil Teflon (Black)
○DO 1 mil PE (Yellow)
●DO 2 mil PE (Blue)

                        738.6mmHg
04/18/2002 10:20:25     NiMH
```

Figure 4.3 Membrane Selection Screen

Highlight the desired membrane choice – in this case, 2 mil PE -- and press Enter to activate your selection with a dot to the left of the screen. Then press **Escape** to return to the Sensor menu that now shows your DO membrane selection.



```
Sensors enabled
●Temperature
●Conductivity
●DO 2 mil PE (Blue)
●pH
●ORP

                        738.5mmHg
04/18/2002 10:19:31     NiMH
```

Figure 4.4 Sensors Enabled Screen After DO Membrane Selection

NOTE: The Temperature sensor cannot be disabled. Most other sensors require temperature compensation for accurate readings. In addition, the conductivity sensor must be activated in order to obtain accurate dissolved oxygen mg/L readings.

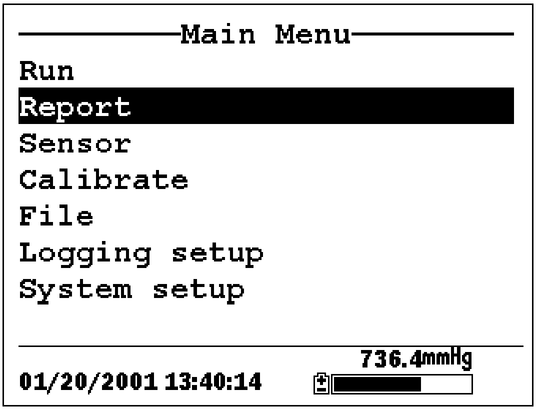
5. Use the arrow keys to highlight the sensor you want to change, then press the **Enter** key to enable or disable it.
6. Repeat step 5 for each sensor you want to change.
7. Press the **Escape** key to return to the main menu screen.

5. Report

The Report Setup screen allows the user to select which sample parameters and units the YSI 556 MPS will display on the screen. It does NOT determine which parameters are logged to memory. Refer to Section *4 Sensors*.

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.



Main Menu

Run

Report

Sensor

Calibrate

File

Logging setup

System setup

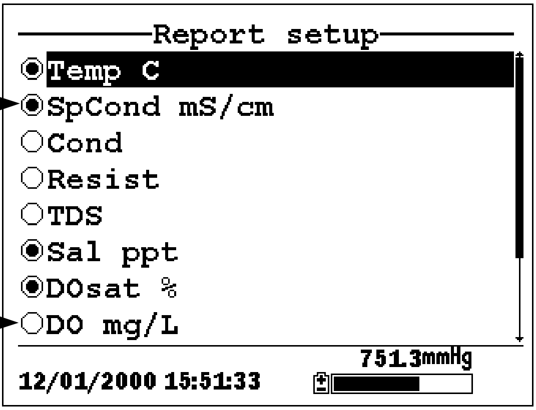
736.4mmHg

01/20/2001 13:40:14

Figure 5.1 Main Menu

3. Use the arrow keys to highlight the **Report** selection.

4. Press the **Enter** key to display the report setup screen.



Report setup

● Temp C

● SpCond mS/cm

○ Cond

○ Resist

○ TDS

● Sal ppt

● DOsat %

○ DO mg/L

751.3mmHg

12/01/2000 15:51:33

Selected for display

NOT selected for display

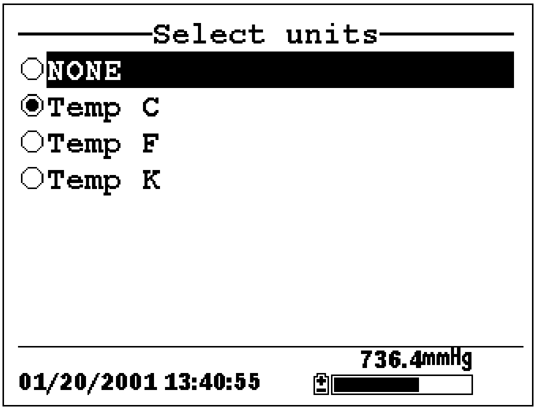
Figure 5.2 Report Setup Screen

NOTE: A black dot to the left of a parameter indicates that parameter is selected for display. Parameters with an empty circle will not be displayed.

NOTE: You may have to scroll down past the bottom of the screen to see all the parameters.

5. Use the arrow keys to highlight the parameter you want to change, then press the **Enter** key. If you can't find the parameter you want, even after scrolling down past the bottom of the screen, the sensor used for that parameter is disabled. Refer to Section *4 Sensors*.

6. If you selected Temperature, Specific Conductivity, Conductivity, Resistance or Total Dissolved Solids, the Units screen will appear.



Select units

○NONE

●Temp C

○Temp F

○Temp K

736.4mmHg

01/20/2001 13:40:55

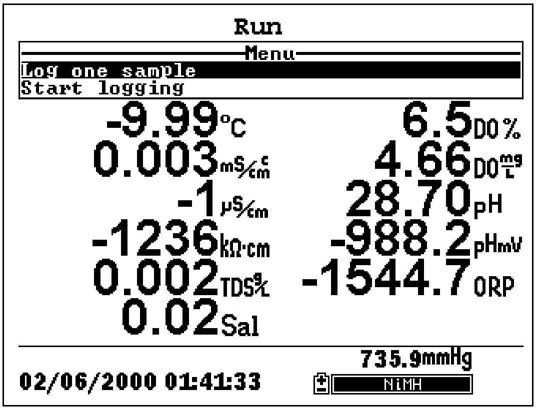
Figure 5.3 Units Screen

7. Use the arrow keys to select the units desired, then press the **Enter** key to return to the report setup screen.

If you selected Salinity, Dissolved Oxygen %, Dissolved Oxygen mg/L, pH, pH mv or ORP mv, the selection dot will simply toggle on or off.

8. Repeat steps 5 and 6 for each parameter you want to change.

NOTE: All parameters may be enabled at the same time.



```
   -9.99°C            6.5DO %
  0.003mS/cm c       4.66DO mg/L
      -1µS/cm       28.70pH
  -1236kΩ·cm       -988.2pHmV
  0.002TDS g/L    -1544.7ORP
   0.02Sal
                      735.9mmHg
02/06/2000 01:41:33       NiMH
```

Figure 5.4 All Parameters Displayed

9. Press the **Escape** key to return to the Main menu screen.

6. Calibrate

All of the sensors, except temperature, require periodic calibration to assure high performance. You will find specific calibration procedures for all sensors that require calibration in the following sections. If a sensor listed is not installed in your probe module, skip that section and proceed to the next sensor until the calibration is complete.

⚠ **CAUTION:** Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review *Appendix D Health and Safety*. Some calibration standard solutions may require special handling.

6.1 Getting Ready to Calibrate

6.1.1 Containers Needed to Calibrate the Probe Module

The transport/calibration cup that comes with your probe module serves as a calibration chamber for all calibrations and minimizes the volume of calibration reagents required.

Instead of the transport/calibration cup, you may use laboratory glassware to perform calibrations. If you do not use the transport/calibration cup that is designed for the probe module, you are cautioned to do the following:

- ✓ Perform all calibrations with the Probe Sensor Guard installed. This protects the sensors from possible physical damage.
- ✓ Use a ring stand and clamp to secure the probe module body to prevent the module from falling over. Most laboratory glassware has convex bottoms.
- ✓ Ensure that all sensors are immersed in calibration solutions. Many of the calibrations factor in readings from other sensors (e.g., temperature sensor). The top vent hole of the conductivity sensor must also be immersed during some calibrations.

6.1.2 Calibration Tips

1. If you use the Transport/Calibration Cup for dissolved oxygen (DO) calibration, make certain to loosen the seal to allow pressure equilibration before calibration. The DO calibration is a water-saturated air calibration.
2. The key to successful calibration is to ensure that the sensors are completely submersed when calibration values are entered. Use recommended volumes when performing calibrations.
3. For maximum accuracy, use a small amount of previously used calibration solution to pre-rinse the probe module. You may wish to save old calibration standards for this purpose.
4. Fill a bucket with ambient temperature water to rinse the probe module between calibration solutions.
5. Have several clean, absorbent paper towels or cotton cloths available to dry the probe module between rinses and calibration solutions. Shake the excess rinse water off of the probe module, especially when the probe sensor guard is installed. Dry off the outside of the probe module and probe sensor guard. Making sure that the probe module is dry reduces carry-over contamination of calibrator solutions and increases the accuracy of the calibration.
6. If you are using laboratory glassware for calibration, you do not need to remove the probe sensor guard to rinse and dry the sensors between calibration solutions. The inaccuracy resulting from simply rinsing the sensor compartment and drying the outside of the guard is minimal.
7. If you are using laboratory glassware, remove the stainless steel weight from the bottom of the probe sensor guard by turning the weight counterclockwise. When the weight is removed, the calibration solutions have access to the sensors without displacing a lot of fluid. This also reduces the amount of liquid that is carried between calibrations.
8. Make certain that port plugs are installed in all ports where sensors are not installed. It is extremely important to keep these electrical connectors dry.

6.1.3 Recommended Volumes

Follow these instructions to use the transport/calibration cup for calibration procedures.

- ✓ Ensure that an o-ring is installed in the o-ring groove of the transport/calibration cup bottom cap, and that the bottom cap is securely tightened.

  NOTE: Do not over-tighten as this could cause damage to the threaded portions.
- ✓ Remove the probe sensor guard, if it is installed.
- ✓ Remove the o-ring, if installed, from the probe module and inspect the installed o-ring on the probe module for obvious defects and, if necessary, replace it with the extra o-ring supplied.
- ✓ Some calibrations can be accomplished with the probe module upright or upside down. A separate clamp and stand, such as a ring stand, is required to support the probe module in the inverted position.
- ✓ To calibrate, follow the procedures in the next section, Calibration Procedures. The approximate volumes of the reagents are specified below for both the upright and upside down orientations.
- ✓ When using the Transport/Calibration Cup for dissolved oxygen % saturation calibration, make certain that the vessel is vented to the atmosphere by loosening the bottom cap or cup assembly and that approximately 1/8” of water is present in the cup.

Sensor to Calibrate	Upright	Upside Down
Conductivity	55ml	55ml
pH/ORP	30ml	60ml

Table 6.1 Calibration Volumes

6.2 Calibration Procedures

6.2.1 Accessing the Calibrate Screen

1. Press the **On/off** key to display the run screen.
2. Press the **Escape** key to display the main menu screen.
3. Use the arrow keys to highlight the **Calibrate** selection.

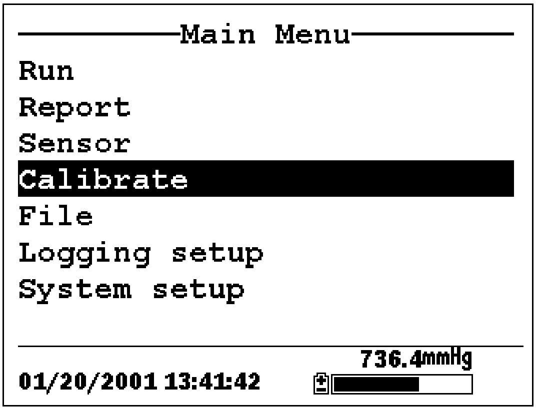


Figure 6.1 Main Menu

4. Press the **Enter** key. The Calibrate screen is displayed.

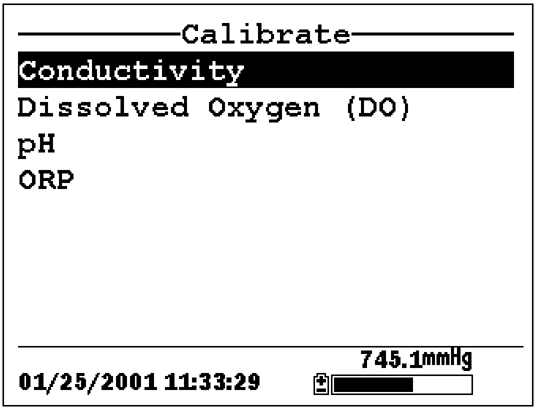


Figure 6.2 Calibrate Screen

6.2.2 Conductivity Calibration

This procedure calibrates specific conductance (recommended), conductivity and salinity. Calibrating any one option automatically calibrates the other two.

1. Go to the calibrate screen as described in Section 6.2.1 Accessing the Calibrate Screen.

2. Use the arrow keys to highlight the **Conductivity** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter.** The Conductivity Calibration Selection Screen is displayed.

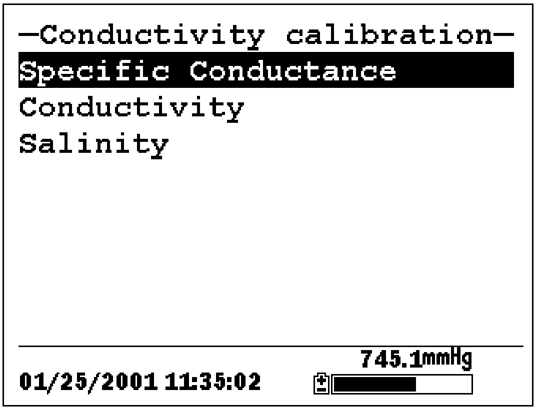
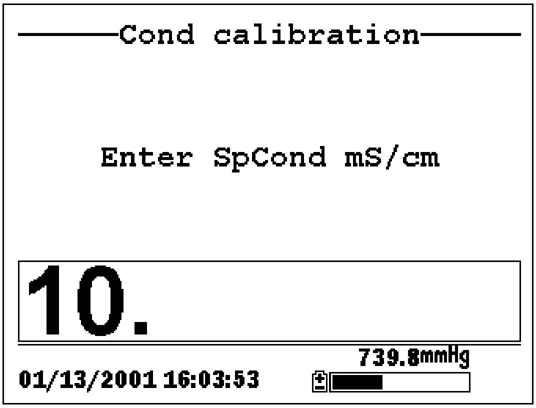


Figure 6.3 Conductivity Calibration Selection Screen

4. Use the arrow keys to highlight the Specific Conductance selection.

5. Press **Enter.** The Conductivity Calibration Entry Screen is displayed.



Cond calibration

Enter SpCond mS/cm

10.

Figure 6.4 Conductivity Calibration Entry Screen

6. Place the correct amount of conductivity standard (see Table 6.1 Calibration Volumes) into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: For maximum accuracy, the conductivity standard you choose should be within the same conductivity range as the samples you are preparing to measure. However, we do not recommend using standards less than 1 mS/cm. For example:

- ✓ For fresh water use a 1 mS/cm conductivity standard.
- ✓ For brackish water use a 10 mS/cm conductivity standard.
- ✓ For seawater use a 50 mS/cm conductivity standard.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the conductivity sensor with a small amount of standard that can be discarded. Be certain that you avoid cross-contamination of solutions. Make certain that there are no salt deposits around the oxygen and pH/ORP sensors, particularly if you are employing standards of low conductivity.

7. Carefully immerse the sensor end of the probe module into the solution.

8. Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.

   NOTE: The sensor must be completely immersed past its vent hole. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the vent hole is covered.

9. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

10. Use the keypad to enter the calibration value of the standard you are using.

    NOTE: Be sure to enter the value in **mS/cm at 25°C**.

11. Press **Enter**. The Conductivity Calibration Screen is displayed.

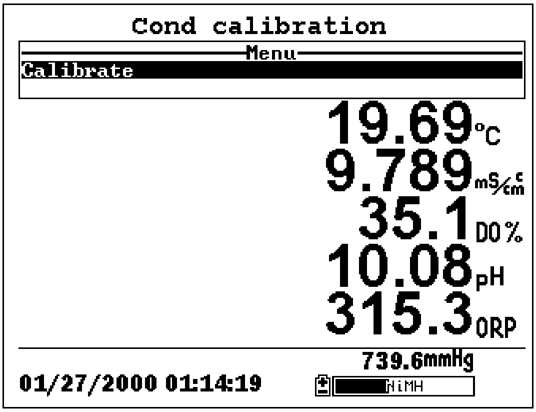


Figure 6.5 Conductivity Calibration Screen

12. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors

will appear on the screen and will change with time as they stabilize.

13. Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

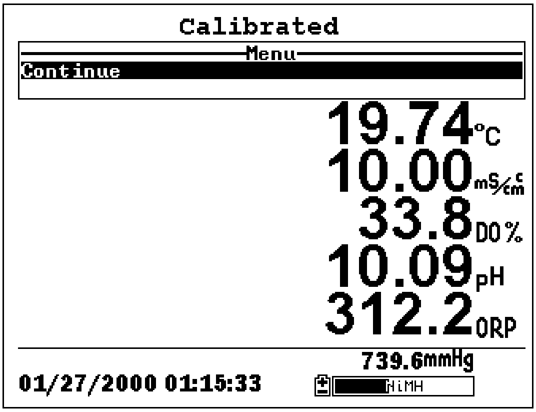


Figure 6.6 Calibrated

14. Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen, See Figure 6.3 Conductivity Calibration Selection Screen.

15. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

16. Rinse the probe module and sensors in tap or purified water and dry.

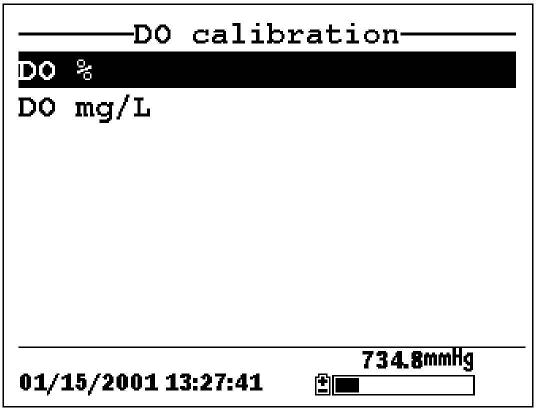
6.2.3 Dissolved Oxygen Calibration

This procedure calibrates dissolved oxygen. Calibrating any one option (% or mg/L) automatically calibrates the other.

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen*.

NOTE: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.

2. Use the arrow keys to highlight the **Dissolved Oxygen** selection. See Figure 6.2 Calibrate Screen.
3. Press **Enter**. The dissolved oxygen calibration screen is displayed.



DO calibration

DO %

DO mg/L

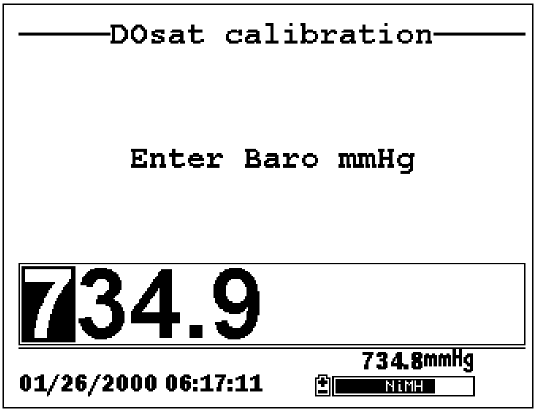
734.8mmHg

01/15/2001 13:27:41

Figure 6.7 DO Calibration Screen

DO Calibration in % Saturation

1. Use the arrow keys to highlight the DO% selection.
2. Press **Enter**. The DO Barometric Pressure Entry Screen is displayed.



DOsat calibration

Enter Baro mmHg

734.9

734.8mmHg

01/26/2000 06:17:11

Figure 6.8 DO Barometric Pressure Entry Screen

3. Place approximately 3 mm (1/8 inch) of water in the bottom of the transport/calibration cup.

4. Place the probe module into the transport/calibration cup.

   NOTE: Make sure that the DO and temperature sensors are **not** immersed in the water.

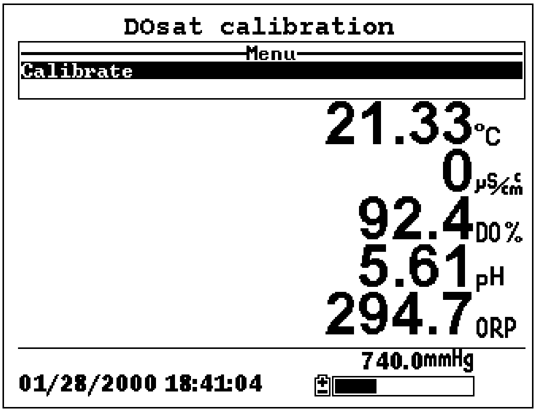
5. Engage only 1 or 2 threads of the transport/calibration cup to ensure the DO sensor is vented to the atmosphere.

6. Use the keypad to enter the current local barometric pressure.

   NOTE: If the unit has the optional barometer, no entry is required.

   NOTE: Barometer readings that appear in meteorological reports are generally corrected to sea level and must be uncorrected before use (refer to Section *10.10 Calibrate Barometer, Step 2*).

7. Press **Enter**. The DO% saturation calibration screen is displayed.



```
21.33°C
0µS/cm c
92.4DO%
5.61pH
294.7ORP
740.0mmHg
01/28/2000 18:41:04
```

Figure 6.9 DO Sat Calibration Screen

8. Allow approximately ten minutes for the air in the transport/calibration cup to become water saturated and for

the temperature to equilibrate before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

9. Observe the reading under DO %. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue. See Figure 6.6 Calibrated.

10. Press **Enter**. This returns you to the DO calibration screen, See Figure 6.7 DO Calibration Screen.

11. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

12. Rinse the probe module and sensors in tap or purified water and dry.

DO Calibration in mg/L

DO calibration in mg/L is carried out in a water sample which has a known concentration of dissolved oxygen (usually determined by a Winkler titration).

1. Go to the DO calibrate screen as described in Section *6.2.3 Dissolved Oxygen Calibration*, steps 1 through 3.

2. Use the arrow keys to highlight the **DO mg/L** selection.

3. Press **Enter**. The DO mg/L Entry Screen is displayed.

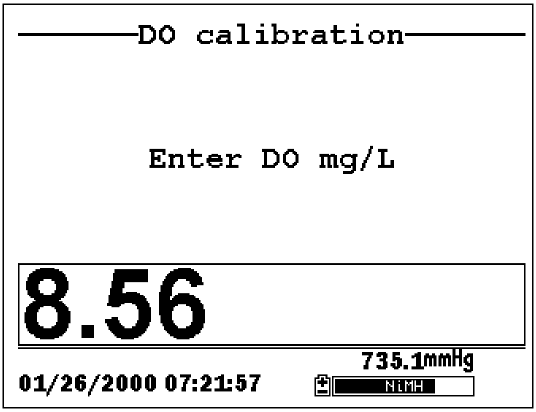


Figure 6.10 DO mg/L Entry Screen

4. Place the probe module in water with a known DO concentration.

   NOTE: Be sure to completely immerse all the sensors.

5. Use the keypad to enter the known DO concentration of the water.

6. Press **Enter**. The Dissolved Oxygen mg/L Calibration Screen is displayed.

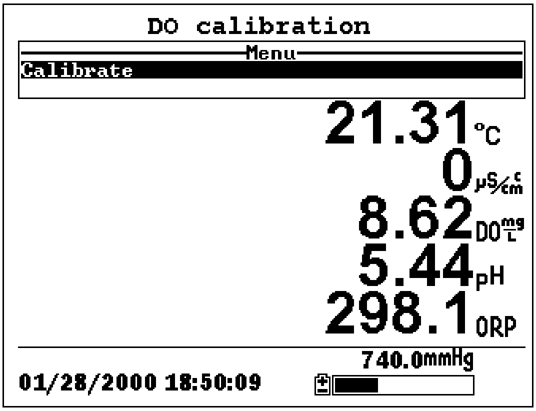


Figure 6.11 DO mg/L Calibration Screen

7. Stir the water with a stir bar, or by rapidly moving the probe module, to provide fresh sample to the DO sensor.

8. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

9. Observe the DO mg/L reading, when the reading is stable (shows no significant change for approximately 30 seconds), press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

10. Press **Enter**. This returns you to the DO calibration screen. See Figure 6.7 DO Calibration Screen.

11. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

12. Rinse the probe module and sensors in tap or purified water and dry.

6.2.4 pH Calibration

1. Go to the calibrate screen as described in *Section 6.2.1 Accessing the Calibrate Screen*.

2. Use the arrow keys to highlight the **pH** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter**. The pH calibration screen is displayed.

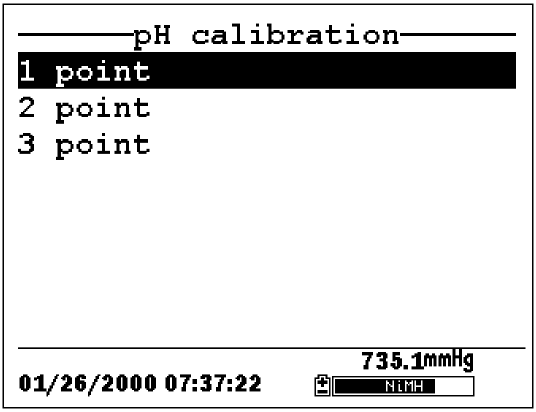
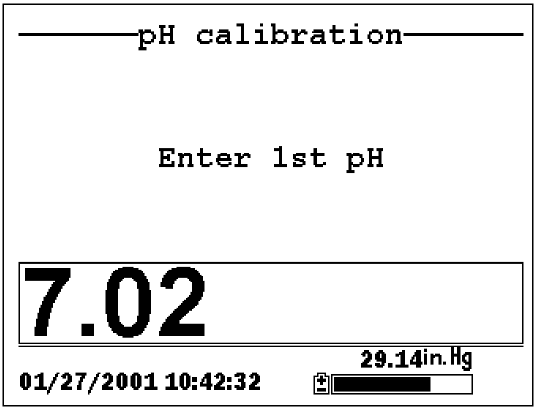


Figure 6.12 pH Calibration Screen

- Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a one point calibration. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select only one pH buffer.
- Select the **2-point** option to calibrate the pH sensor using only two calibration standards. Use this option if the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is sufficient. A three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.
- Select the **3-point** option to calibrate the pH sensor using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer.

4. Use the arrow keys to highlight the **2-point** selection.

5. Press **Enter**. The pH Entry Screen is displayed.



pH calibration

Enter 1st pH

7.02

29.14in.Hg

01/27/2001 10:42:32

Figure 6.13 pH Entry Screen

6. Place the correct amount (see Table 6.1 Calibration Volumes) of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: For maximum accuracy, the pH buffers you choose should be within the same pH range as the water you are preparing to sample.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.

7. Carefully immerse the sensor end of the probe module into the solution.

8. Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.

NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the sensor is covered.

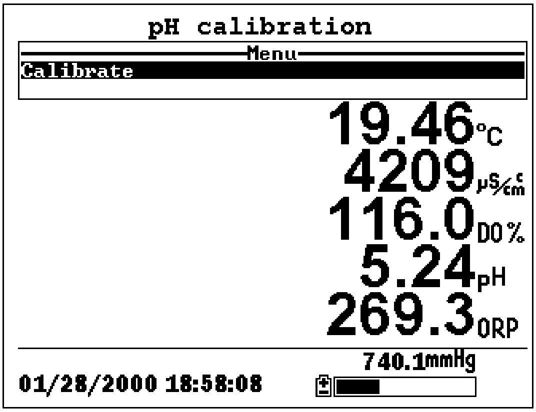
9. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

NOTE: Do not overtighten as this could cause damage to the threaded portions.

10. Use the keypad to enter the calibration value of the buffer you are using **at the current temperature**.

NOTE: pH vs. temperature values are printed on the labels of all YSI pH buffers.

11. Press **Enter**. The pH calibration screen is displayed.



```
19.46°C
4209μS/cm
116.0DO%
5.24pH
269.3ORP
740.1mmHg
01/28/2000 18:58:08
```

Figure 6.14 pH Calibration Screen

12. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

13. Observe the reading under pH, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

14. Press **Enter**. This returns you to the Specified pH Calibration Screen, See Figure 6.13 pH Entry Screen.

15. Rinse the probe module, transport/calibration cup and sensors in tap or purified water and dry.

16. Repeat steps 6 through 13 above using a second pH buffer.

17. Press **Enter**. This returns you to the pH Calibration Screen, See Figure 6.12 pH Calibration Screen.

18. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

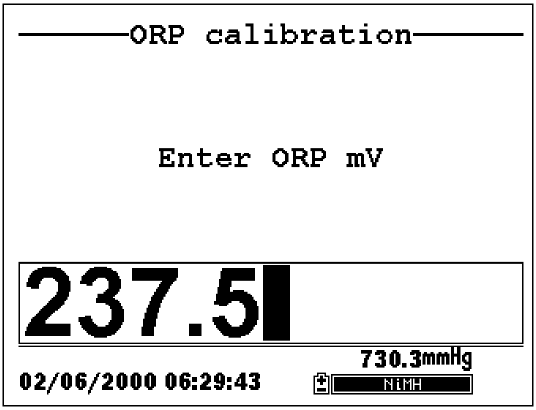
19. Rinse the probe module and sensors in tap or purified water and dry.

6.2.5 ORP Calibration

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen*.

2. Use the arrow keys to highlight the **ORP** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter**. The ORP calibration screen is displayed.


ORP calibration

Enter ORP mV

237.5

730.3mmHg
02/06/2000 06:29:43

Figure 6.15 Specified ORP Calibration Screen

4. Place the correct amount (see Table 6.1 Calibration Volumes) of a known ORP solution (we recommend Zobell solution) into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the ORP sensor with a small amount of solution that can be discarded. Be certain that you avoid cross-contamination with other solutions.

5. Carefully immerse the sensor end of the probe module into the solution.

6. Gently rotate and/or move the probe module up and down to remove any bubbles from the ORP sensor.

   NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes should ensure that the sensor is covered.

7. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

8. Use the keypad to enter the correct value of the calibration solution you are using at the current temperature. Refer to Table 6.2 Zobel Solution Values.

Temperature °C	Zobell Solution Value, mV
-5	270.0
0	263.5
5	257.0
10	250.5
15	244.0
20	237.5
25	231.0
30	224.5
35	218.0
40	211.5
45	205.0
50	198.5

Table 6.2 Zobel Solution Values

9. Press **Enter**. The ORP calibration screen is displayed.

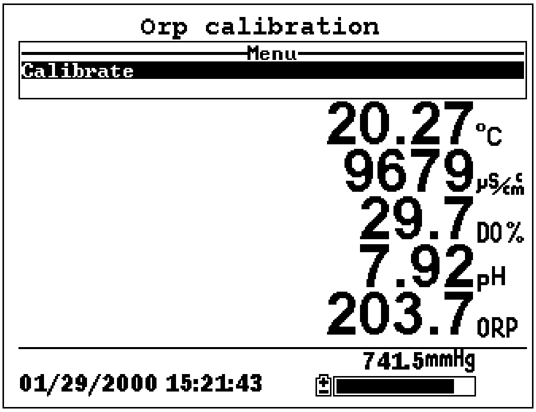


Figure 6.16 ORP Calibration Screen

10. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

    NOTE: Verify that the temperature reading matches the value you used in Table 6.2 Zobel Solution Values.

11. Observe the reading under ORP, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

12. Press **Enter**. This returns you to the Calibrate Screen. See Figure 6.2 Calibrate Screen.

13. Rinse the probe module and sensors in tap or purified water and dry.

6.3 Return to Factory Settings

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen*.

2. Use the arrow keys to highlight the **Conductivity** selection. See Figure 6.2 Calibrate Screen.

   NOTE: We will use the Conductivity sensor as an example; however, this process will work for any sensor.

3. Press **Enter.** The Conductivity Calibration Selection Screen is displayed. See Figure 6.3 Conductivity Calibration Selection Screen.

4. Use the arrow keys to highlight the **Specific Conductance** selection.

5. Press **Enter.** The Conductivity Calibration Entry Screen is displayed. See Figure 6.4 Conductivity Calibration Entry Screen.

6. Press and hold the **Enter** key down and press the **Escape** key.

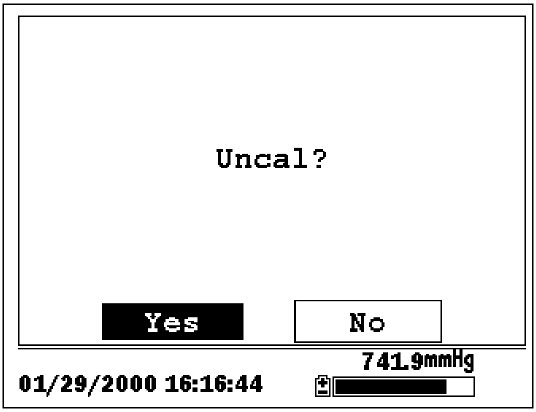

Uncal?

Figure 6.17 ORP Calibration Screen

7. Use the arrow keys to highlight the **YES** selection.

CAUTION: This returns a sensor to the factory settings. For example, in selecting to return specific conductance to the factory setting, salinity and conductivity will automatically return to their factory settings.

8. Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen, See Figure 6.3 Conductivity Calibration Selection Screen.

9. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

7. Run

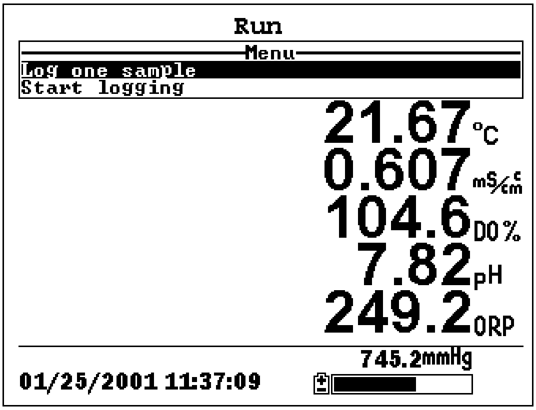
The Run screen displays data from the sensors in real-time and allows the user to log sample data to memory for later analysis. Refer to Section *9 Logging* for details on logging sample data.

7.1 Real-Time Data

NOTE: Before measuring samples you must prepare the probe module (refer to Section *3.4 Preparing the Probe Module*), attach the probe module to the instrument (refer to Section *3.6 Instrument/Cable Connection*) and calibrate the sensors (refer to Section *6 Calibrate*).

1. Press the **On/off** key.

OR select Run from the main menu to display the run screen.



21.67 °C
0.607 mS/cm^c
104.6 DO %
7.82 pH
249.2 ORP
745.2mmHg
01/25/2001 11:37:09

Figure 7.1 Run Screen

2. Make sure the probe sensor guard is installed.

3. Place the probe module in the sample. Be sure to completely immerse all the sensors.

4. Rapidly move the probe module through the sample to provide fresh sample to the DO sensor.

5. Watch the readings on the display until they are stable.

6. Refer to Section *9 Logging* for instructions on logging sample data.

8. File

The File menu allows the user to view, upload or delete sample data and calibration record files stored in the YSI 556 MPS.

8.1 Accessing the File Screen

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.

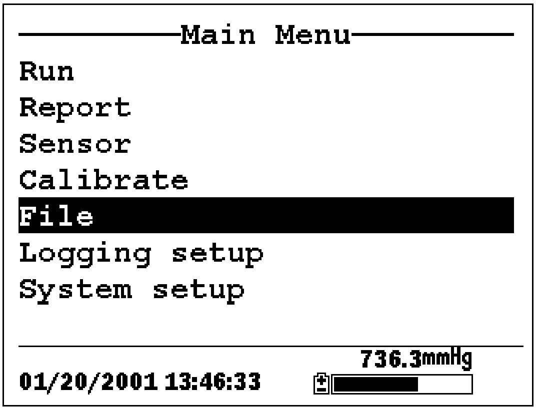
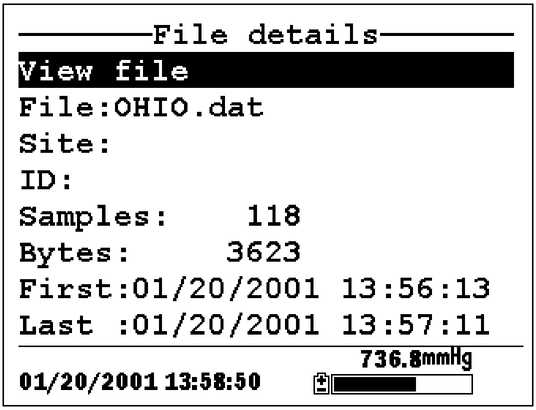


Figure 8.1 Main Menu Screen

3. Use the arrow keys to highlight the **File** selection.

4. Press the **Enter** key. The file screen is displayed.

Figure 8.2 File Screen



File details

View file

File:OHIO.dat

Site:

ID:

Samples: 118

Bytes: 3623

First:01/20/2001 13:56:13

Last :01/20/2001 13:57:11

736.8mmHg

01/20/2001 13:58:50

Figure 8.4 File Details Screen

6. Press the **Enter** key to view the file data. Refer to Section *8.3 View File* for details.

7. Press the **Escape** key repeatedly to return to the main menu screen.

8.3 View File

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*. See Figure 8.2 File Screen.

2. Use the arrow keys to highlight the **View file** selection.

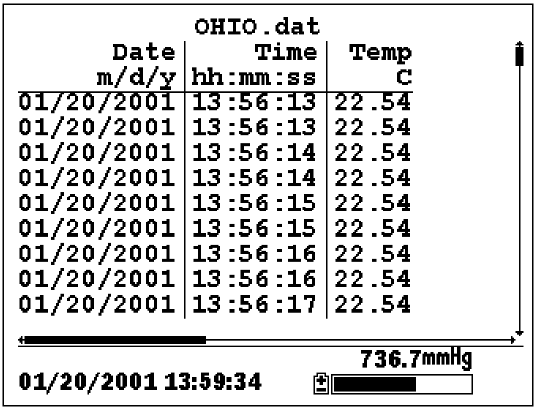
3. Press the **Enter** key. A list of files is displayed. See Figure 8.3 File List Screen.

4. Use the arrow keys to highlight an individual file.

   NOTE: You may have to scroll down to see all the files.

5. Press the **Enter** key. The file data is displayed with the file name at the top of the display.

   NOTE: If no file name was specified, the data is stored under the default name NONAME1.dat.



```
                OHIO.dat
      Date |     Time |  Temp
     m/d/y |hh:mm:ss |     C
01/20/2001 |13:56:13 |22.54
01/20/2001 |13:56:13 |22.54
01/20/2001 |13:56:14 |22.54
01/20/2001 |13:56:14 |22.54
01/20/2001 |13:56:15 |22.54
01/20/2001 |13:56:15 |22.54
01/20/2001 |13:56:16 |22.54
01/20/2001 |13:56:16 |22.54
01/20/2001 |13:56:17 |22.54
                         736.7mmHg
01/20/2001 13:59:34
```

Figure 8.5 File Data Screen

6. Use the arrow keys to scroll horizontally and/or vertically to view all the data.

7. Press the **Escape** key repeatedly to return to the main menu screen.

8.4 Upload to PC

EcoWatch™ for Windows™ must be used as the PC software interface to the YSI 556 MPS. Refer to *Appendix G EcoWatch* for more information. EcoWatch for Windows is available at no cost via a download from the YSI Web Site (www.ysi.com) or by contacting YSI Customer Support. Refer to *Appendix E Customer Service.*

8.4.1 Upload Setup

1. Disconnect the YSI 5563 Probe Module from the YSI 556 MPS instrument.

2. Connect the YSI 556 MPS to a serial (Comm) port of your computer via the 655173 PC Interface cable as shown in the following diagram:

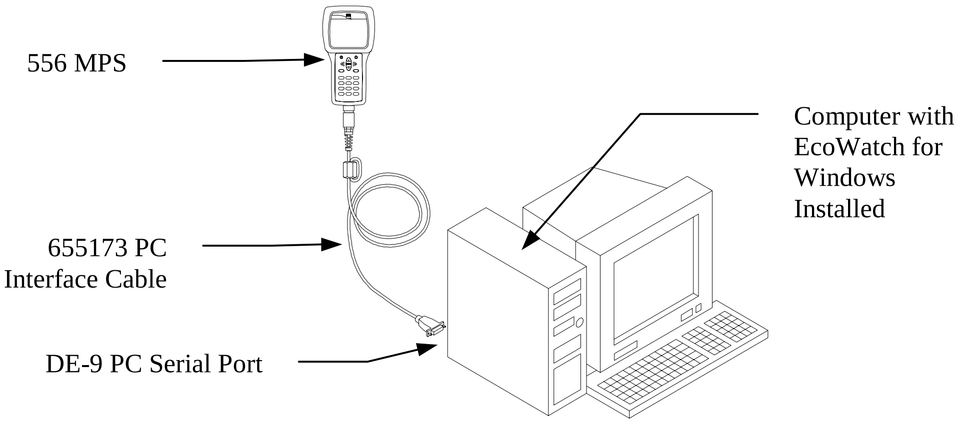


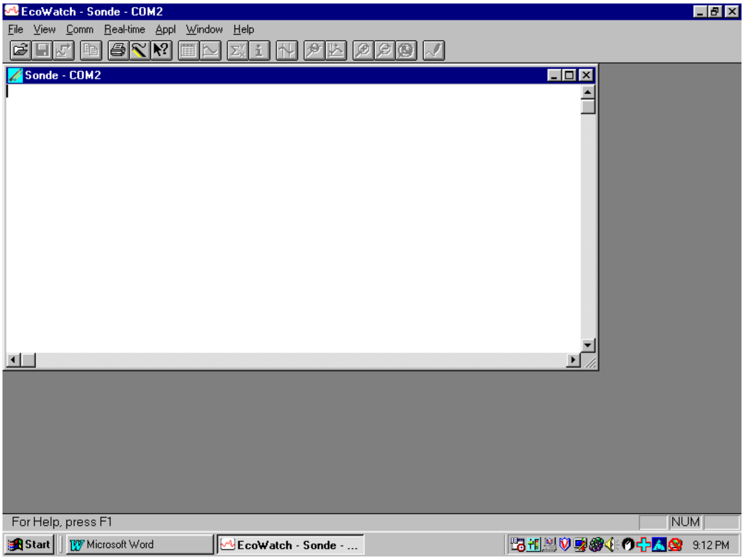
Figure 8.6 Computer/Instrument Interface

3. Open EcoWatch for Windows on your computer.

   NOTE: See *Appendix G EcoWatch* for installation instructions.

4. Click on the sonde/probe icon in the upper toolbar.

5. Set the Comm port number to match the port the YSI 556 MPS is connected to. After this setup procedure, the following screen will be present on your PC monitor:



8.4.2 Uploading a .DAT File

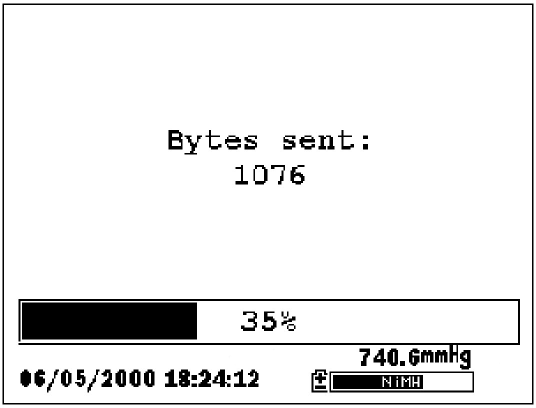
1. Setup the instrument as described in Section *8.4.1 Upload Setup*.

2. Go to the YSI 556 MPS file screen as described in Section *8.1 Accessing the File Screen.*

3. Use the arrow keys to highlight the **Upload to PC** selection. See Figure 8.2 File Screen.

4. Press the **Enter** key. The file list screen is displayed. See Figure 8.3 File List Screen.

5. Use the arrow keys to highlight the DAT file that you wish to transfer and press **Enter**, both the YSI 556 MPS and PC displays show the progress of the file transfer.



Bytes sent:
1076

35%

740.6mmHg

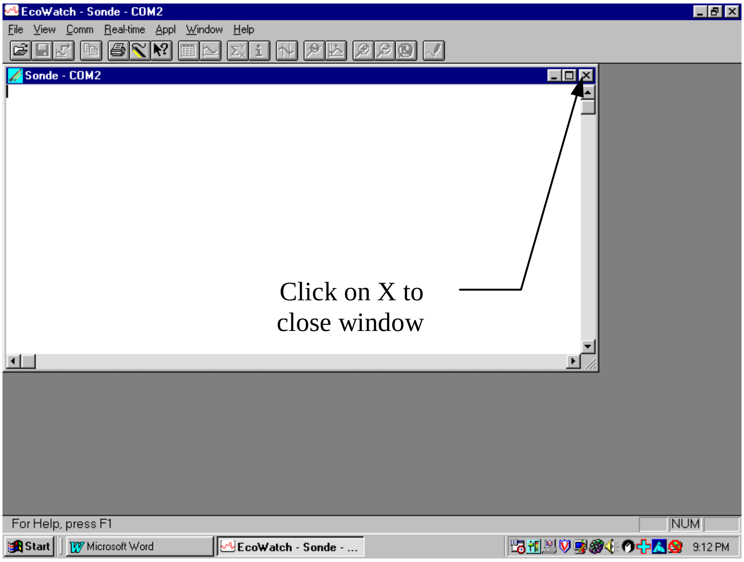
06/05/2000 18:24:12

NiMH

Figure 8.7 File Transfer Progress Screen

NOTE: After transfer, the file will be located in the C:\ECOWWIN\DATA folder of your PC, designated with a .DAT extension.

6. After the file transfer is complete, close the terminal window (small window on the PC) by clicking on the "X" at its upper right corner.



Click on X to
close window

7. Press the **Escape** key on the YSI 556 MPS repeatedly to return to the main menu screen.

8.4.3 Uploading a Calibration Record (.glp) File

For more information on the calibration record, Refer to *Appendix H Calibration Record Information*.

1. Setup up the instrument as described in Section *8.4.1 Upload Setup*.

2. Go to the YSI 556 MPS file screen as described in Section *8.1 Accessing the File Screen.*

3. Use the arrow keys to highlight the **Upload to PC** selection. See Figure 8.2 File Screen.

4. Press the **Enter** key. The file list screen is displayed. See Figure 8.3 File List Screen.

5. Use the arrow keys to highlight the calibration record file that you wish to transfer and press **Enter.**

6. You will then be given a choice of uploading the file in three formats; **Binary, Comma & “” Delimited, and ASCII Text**.

   NOTE: The binary format is reserved for future YSI software packages.

7. Choose an option and press **Enter,** both the YSI 556 and PC displays show the progress of the file transfer.

   NOTE: After transfer, the file will be located in the C:\ECOWWIN\DATA folder of your PC, designated with the appropriate file extension.

   NOTE: To view the Calibration Record data after upload, simply open the .txt file in a general text editor such as Wordpad or Notepad.

8. After the file transfer is complete, close the terminal window (small window on the PC) by clicking on the “X” at its upper right corner.

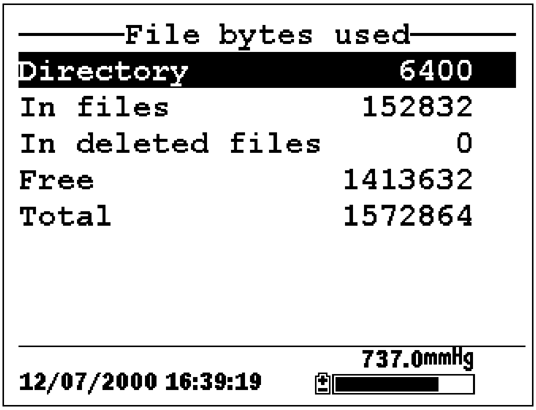
9. Press the **Escape** key repeatedly to return to the main menu screen.

8.5 File Memory

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*.

2. Use the arrow keys to highlight the **File memory** selection. See Figure 8.2 File Screen.

3. Press the **Enter** key. The file bytes used screen is displayed.



```
------File bytes used------
Directory               6400
In files              152832
In deleted files           0
Free                 1413632
Total                1572864

                   737.0mmHg
12/07/2000 16:39:19
```

Figure 8.8 File Bytes Used Screen

4. The amount of free memory is listed in line 4 of the file bytes used screen.

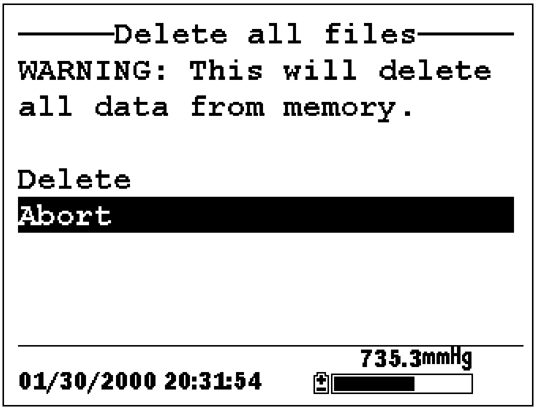
   NOTE: If the amount of free memory is low, it may be time to delete all files (after first uploading all data to a PC). Refer to Section *8.6 Delete All Files*.

5. Press the **Escape** key repeatedly to return to the main menu screen.

8.6 Delete All Files

NOTE: It is not possible to delete individual files in order to free up memory. The only way to free up memory is to delete ALL files present. Take care to transfer all files to your computer (refer to Section *8.4 Upload to PC*) *before* deleting them.

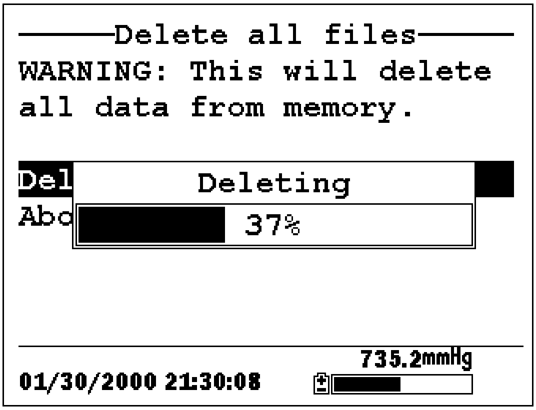
1. Go to the file screen as described in Section *8.1 Accessing the File Screen*.
2. Use the arrow keys to highlight the **Delete all files** selection. See Figure 8.2 File Screen.
3. Press the **Enter** key. The Delete all Files screen is displayed.



WARNING: This will delete all data from memory.

Figure 8.9 Delete All Files Screen

4. Use the arrow keys to highlight the **Delete** selection.
5. Press the **Enter** key.



Delete all files

WARNING: This will delete all data from memory.

Figure 8.10 Deleting

The progress of file deletion is displayed in bar graph format.

NOTE: Deleting all files in the directory will not change any information in the site list.

6. Press the **Escape** key repeatedly to return to the main menu screen.

9. Logging

9.1 Accessing the Logging Setup Screen

1. Press the **On/off** key to display the run screen.
2. Press the **Escape** key to display the main menu screen.

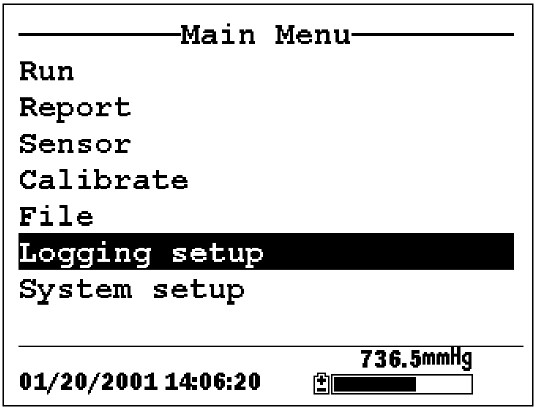
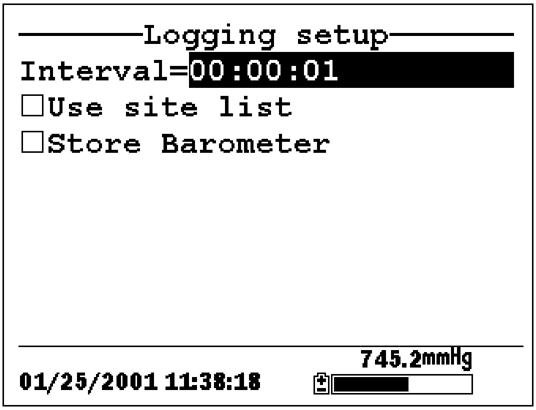


Figure 9.1 Main Menu

3. Use the arrow keys to highlight the **Logging setup** selection.
4. Press the **Enter** key. The logging setup screen is displayed.


Logging setup

Interval=00:00:01

☐Use site list

☐Store Barometer

Figure 9.2 Logging Setup Screen

9.2 Setting Logging Interval

Follow steps below to set the interval for logging a data stream.

NOTE: If you do not specify an interval, the instrument will use a default interval setting of 1 second.

NOTE: It is not necessary to set a logging interval when logging a single sample.

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the keypad to enter an interval between 1 second and 15 minutes. Refer to Section *2.9 Keypad Use*.

   NOTE: The interval field has hour, minute and second entry fields. Any entry over 15 minutes will change automatically to a 15-minute setting.

3. Press the **Enter** key. The data stream interval is set.

4. Press the **Escape** key repeatedly to return to the main menu screen.

9.3 Storing Barometer Readings

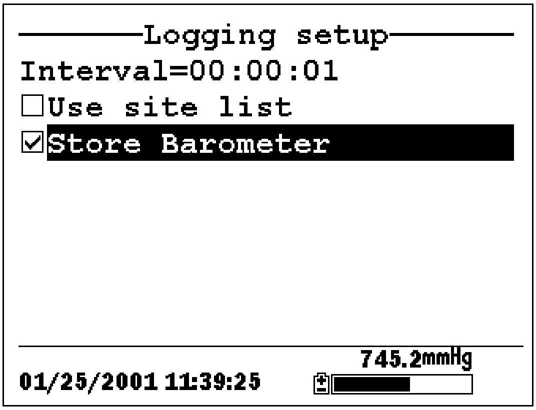
NOTE: The **Store barometer** option is only available on instruments that are equipped with the optional barometer.

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the arrow keys to highlight the **Store barometer** selection. See Figure 9.2 Logging Setup Screen.

3. Press the **Enter** key until a check mark is entered in the box next to the store barometer selection if you want to log barometric readings.

   OR press the **Enter** key until the box next to the barometer selection is empty if you do not want to log barometric readings.



Logging setup
Interval=00:00:01
☐Use site list
☑Store Barometer
745.2mmHg
01/25/2001 11:39:25

Figure 9.3 Store Barometer

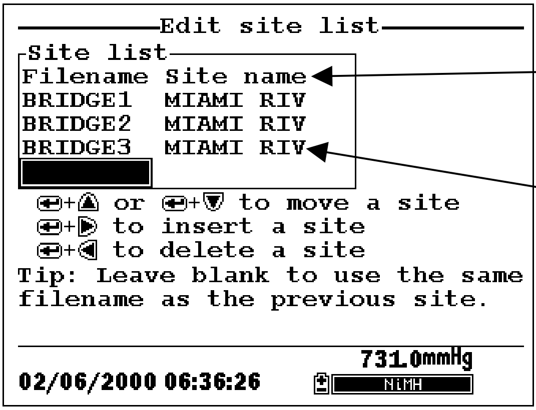
4. Press the **Escape** key repeatedly to return to the main menu screen.

9.4 Creating a Site List

The site list option allows you to define file and site descriptions in the office or laboratory before moving to field logging studies. This is usually more convenient than entering the information at the site and is particularly valuable if you are visiting certain sites on a regular basis. The following section describes how to set up site lists which contain entries designated “Site Descriptions” that will be instantly available to the user in the field to facilitate the logging of data with pre-established naming of files and sites. There are two kinds of **Site Descriptions** available for use in Site lists:

- **Site Descriptions** associated with applications where data from a <u>single site</u> is always logged to a <u>single file</u>. This type is referred to as a “Single-Site Description” and is characterized by two parameters – a file name and a site name. Files logged to YSI 556 MPS memory under a **Single-Site Description** will be characterized primarily by the file name, but will also have the Site name attached, so that it is viewable in either the YSI 556 MPS **File directory** or in EcoWatch for Windows after upload to a PC

- **Site Descriptions** associated with applications where data from <u>multiple sites</u> are logged to a <u>single file</u>. This type is referred to as a “Multi-site Description” and is characterized by three parameters – a file name, a site name, and a site number. Files logged to YSI 556 MPS memory under a **Multi-site Description** are characterized by a file name, but not a site name, since multiple sites are involved. However, each data point has a Site Number attached to it so that the user can easily determine the sampling site when viewing the data from the YSI 556 MPS **File** menu or processing the data in EcoWatch for Windows after upload to a PC.

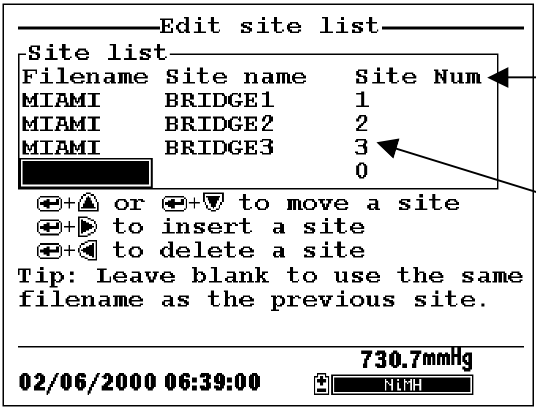


```
-----------Edit site list-----------
Site list
Filename Site name
BRIDGE1  MIAMI RIV
BRIDGE2  MIAMI RIV
BRIDGE3  MIAMI RIV

 ⏎+▲ or ⏎+▼ to move a site
 ⏎+▶ to insert a site
 ⏎+◀ to delete a site
Tip: Leave blank to use the same
filename as the previous site.

                          731.0mmHg
02/06/2000 06:36:26        NiMH
```

Site List

Single-Site Descriptions with Different File Names

Figure 9.4 Single-Site Descriptions



```
-----------Edit site list-----------
Site list
Filename Site name    Site Num
MIAMI    BRIDGE1      1
MIAMI    BRIDGE2      2
MIAMI    BRIDGE3      3
                      0
 ⏎+▲ or ⏎+▼ to move a site
 ⏎+▶ to insert a site
 ⏎+◀ to delete a site
Tip: Leave blank to use the same
filename as the previous site.

                          730.7mmHg
02/06/2000 06:39:00        NiMH
```

Site List

Multi-Site Descriptions with the Same File Name

Figure 9.5 Multiple-Site Descriptions

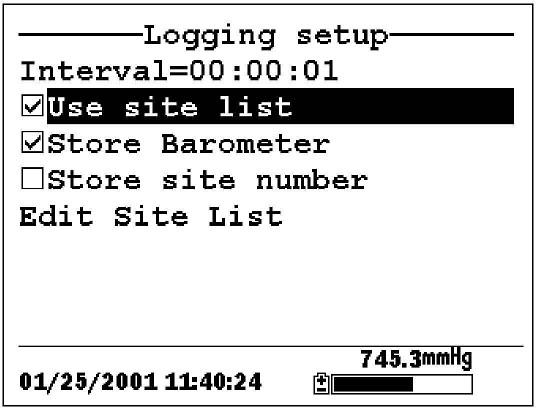
NOTE: Site lists containing Single Site Descriptions are usually input with the designation **Store Site Number** INACTIVE in the YSI 556 MPS **Logging setup** menu. Thus, no site numbers appear in the first **Site list** example. Conversely, **Site lists** containing **Multi-Site Descriptions** MUST be input with the **Store Site Number** selection ACTIVE as shown in the second example.

To create a site list:

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the arrow keys to highlight the **Use site list** selection.

3. Press the **Enter** key. A check mark is entered in the box next to the use site list selection *and* two new entries appear on the logging setup screen. See Figure 9.6 Logging Setup Screen.



Logging setup

Interval=00:00:01

☑Use site list

☑Store Barometer

☐Store site number

Edit Site List

745.3mmHg

01/25/2001 11:40:24

Figure 9.6 Logging Setup Screen

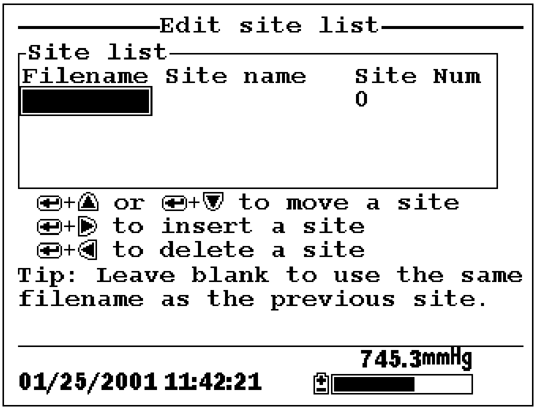
4. Use the arrow keys to highlight the **Store site number** selection.

5. If you are creating Multi-Site Descriptions (which require that the site **number** be stored in your data files), press the **Enter** key until a check mark appears in the box next to the store site number selection.

OR Press the **Enter** key until the box next to the store site number selection is empty, to create Single-Site Descriptions. The site **name** will be stored in the header of your data files.

6. Use the arrow keys to highlight the **Edit site list** selection.

7. Press the **Enter** key. The edit site list screen is displayed. See Figure 9.7 Edit Site List Screen. The **Filename** field is ready for input.



```
Edit site list
Site list
Filename Site name    Site Num
                      0

 ⏎+▲ or ⏎+▼ to move a site
 ⏎+▶ to insert a site
 ⏎+◀ to delete a site
Tip: Leave blank to use the same
filename as the previous site.

                      745.3mmHg
01/25/2001 11:42:21
```

Figure 9.7 Edit Site List Screen

8. Use the keypad to enter a filename up to 8 characters in length. Refer to Section *2.9 Keypad Use*.

9. Press the **Enter** key. The cursor moves to the right for the entry of a **Site name**.

10. Use the keypad to enter a site name up to 11 characters in length. Refer to Section *2.9 Keypad Use*.

    NOTE: If the store site number selection is *not* checked, skip to Step 13.

11. Press the **Enter** key. The cursor moves to the site number entry position.

12. Use the keypad to enter a site number up to 7 characters in length. Refer to Section *2.9 Keypad Use*.

13. Press **Enter**. The cursor moves to the next filename entry position.

14. Repeat Steps 8 to 13 until all filenames and sites have been entered.

15. Press **Escape** repeatedly to return to the main menu screen.

9.5 Editing a Site List

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the arrow keys to highlight the **Edit Site List** selection. See Figure 9.6 Logging Setup Screen.

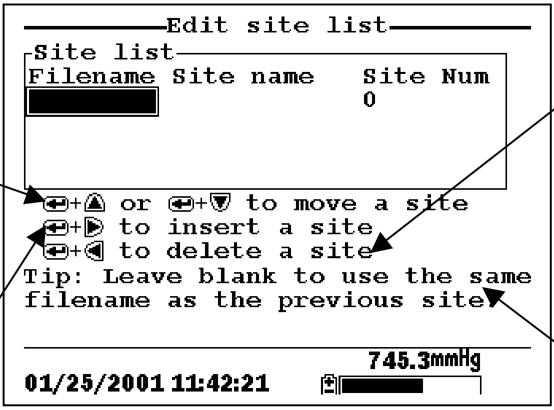
3. Press the **Enter** key. The edit site list screen is displayed.

4. Edit the site list using the keystrokes described below.

   NOTE: Editing the site list will not have any effect on files stored in the instrument memory.

<u>To MOVE a site:</u> **Use the arrow keys to highlight a site. Press the Up or Down arrow key while holding down the Enter key.**

<u>To INSERT a site above another site:</u> **Use the arrow keys to highlight the site. Press the** Right **arrow key while holding down the** Enter **key. Use keypad to input letters. Refer to Section *2.9 Keypad Use*.**



```
———————Edit site list———————
Site list
Filename Site name    Site Num
                      0

↵+▲ or ↵+▼ to move a site
↵+▶ to insert a site
↵+◀ to delete a site
Tip: Leave blank to use the same
filename as the previous site.
                     745.3mmHg
01/25/2001 11:42:21
```

Figure 9.8 Keystrokes for Editing Site List

<u>To DELETE a site:</u> **Use the arrow keys to highlight a site. Press the Left arrow key while holding down the Enter key.**

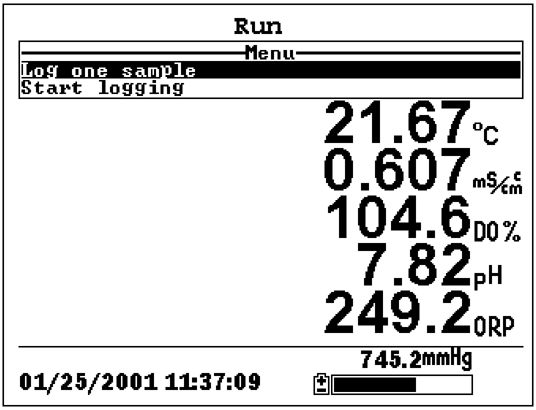
<u>To use the same file name as the previous site:</u> **Leave the filename blank.**

9.6 Logging Data Without a Site List

1. Follow Steps 1 through 5 in Section 7.1 Real-Time Data.

2. Use the arrow keys to highlight the **Log one sample** selection on the run screen if only a single sample is being logged.

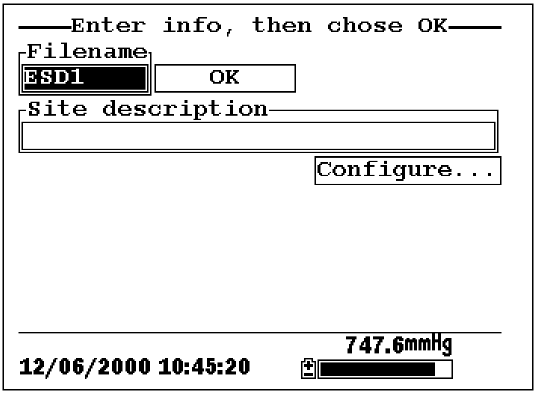
   OR Use the arrow keys to highlight the **Start logging** selection on the run screen if a data stream is being logged.



21.67 °C
0.607 mS/cm c
104.6 DO %
7.82 pH
249.2 ORP
745.2 mmHg
01/25/2001 11:37:09

Figure 9.9 Run Screen

3. Press the **Enter** key. The Enter information screen is displayed.



Filename
ESD1

Site description

747.6 mmHg
12/06/2000 10:45:20

Figure 9.10 Enter Information Screen

NOTE: The last filename used will be displayed.

4. Use the keypad to enter a file name. Refer to Section *2.9 Keypad Use*.

   NOTE: The instrument will assign a default file name of NONAME if no file name is specified.

5. Press the **Enter** key to input the file name.

6. Use the arrow keys to highlight the **Site description** field in the enter information screen.

   NOTE: Entering a Site Description is optional. You may leave the Site Description blank and skip to Step 9.

7. Use the keypad to enter a site description name. Refer to Section *2.9 Keypad Use*.

8. Press the **Enter** key to input the site description.

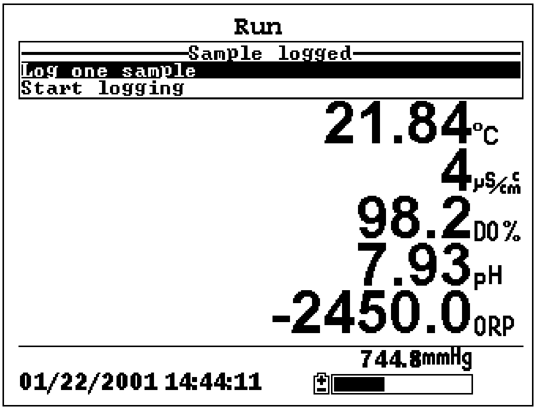
   NOTE: If you want to change the logging setup, such as sampling interval or storing the barometer reading, use the arrow keys to highlight the **Configure** field, press the **Enter** key, then refer to Section *9.2 Setting Logging Interval* or *9.3 Storing Barometer Readings* for details.

9. Use the arrow keys to highlight the **OK** field in the center of the information screen.

10. Press the **Enter** key to start logging.

    NOTE: If the parameter mismatch screen is displayed, refer to Section *9.8 Adding Data to Existing Files*.

11. If a single point is being logged, the header on the run screen changes momentarily from **Menu** to **Sample logged** to confirm that the point was successfully logged. Skip to Step 13.



Run

Sample logged

Log one sample

Start logging

21.84 °C

4 µS/cm c

98.2 DO %

7.93 pH

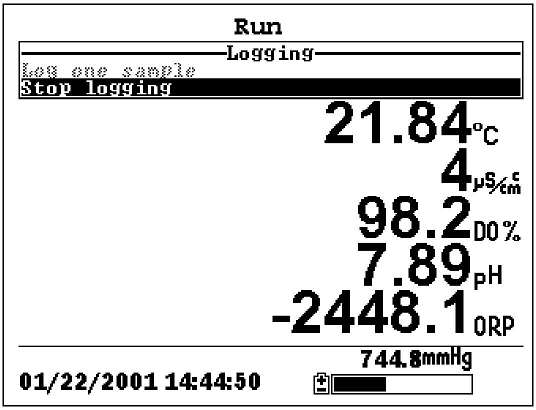
-2450.0 ORP

744.8 mmHg

01/22/2001 14:44:11

Figure 9.11 Sample Logged Screen

If a continuous stream of points is being logged, the start logging entry in the run screen changes from **Start logging** to **Stop logging**.



Run

Logging

Log one sample

Stop logging

21.84 °C

4 µS/cm c

98.2 DO %

7.89 pH

-2448.1 ORP

744.8 mmHg

01/22/2001 14:44:50

Figure 9.12 Logging Screen

12. At the end of the logging interval, press **Enter** to stop logging.

13. Refer to Section *8.3 View File* to view the data on the instrument display.

9.7 Logging Data With a Site List

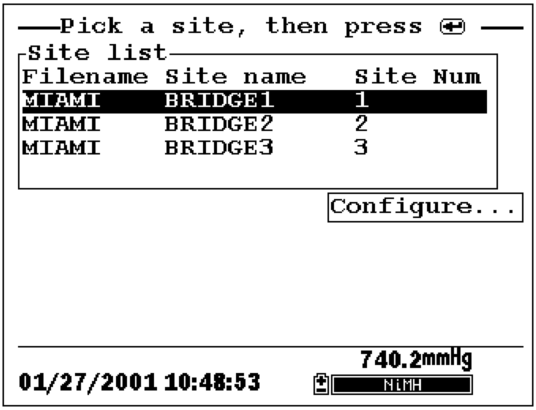
1. If you have not already created a site list, refer to Section *9.4 Creating a Site List*.

2. Follow Steps 1 through 5 in Section 7.1 Real-Time Data.

3. Use the arrow keys to highlight the **Log one sample** selection on the run screen if only a single sample is being logged.

   OR Use the arrow keys to highlight the **Start logging** selection on the run screen if a data stream is being logged. See Figure 9.9 Run Screen.

4. Press the **Enter** key. The Pick a site screen is displayed.



```
——Pick a site, then press ↵ ——
Site list
Filename Site name   Site Num
MIAMI    BRIDGE1     1
MIAMI    BRIDGE2     2
MIAMI    BRIDGE3     3
                    Configure...
                            740.2mmHg
01/27/2001 10:48:53          NiMH
```

Figure 9.13 Pick a Site Screen

5. Use the arrow keys to highlight the **site** of your choice.

   NOTE: If the site of your choice is grayed out in the site list, refer to Section *9.8 Adding Data to Existing Files*.

   NOTE: Refer to Section *9.5 Editing a Site List* if you want to edit the site list.

6. Press the **Enter** key to start logging.

NOTE: If the parameter mismatch screen is displayed, refer to Section *9.8 Adding Data to Existing Files*.

7. If a single point is being logged, the header on the run screen changes momentarily from **Menu** to **Sample logged** to confirm that the point was successfully logged. See Figure 9.11 Sample Logged Screen. Skip to Step 9.

   If a continuous stream of points is being logged, the start logging entry in the run screen changes from **Start logging** to **Stop logging**. See Figure 9.12 Logging Screen.

8. At the end of the logging interval, press **Enter** to stop logging.

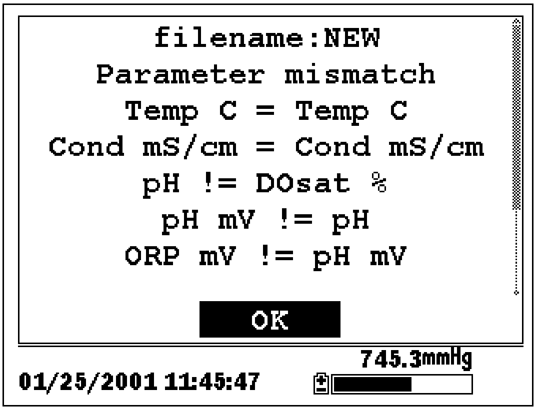
9. Refer to Section *8.3 View File* to view the data on the instrument display.

9.8 Adding Data to Existing Files

In order to add new data to an existing file, the current logging and sensor setup must be *exactly* the same as when the file was created. The following settings must be the same:

- **Sensors enabled** (refer to Section *4 Sensors*)
- **Store Barometer** (refer to Section *9.3 Storing Barometer Readings*)
- **Store Site Number** (refer to Section *9.4 Creating a Site List*)

If the current logging setup is not exactly the same as when the file was created, a parameter mismatch screen is displayed.



filename:NEW
Parameter mismatch
Temp C = Temp C
Cond mS/cm = Cond mS/cm
pH != DOsat %
pH mV != pH
ORP mV != pH mV

Figure 9.14 Parameter Mismatch Screen

NOTE: The right column shows parameters used when the file was created. The left column shows current parameters.

1. Press the **Down Arrow** key to scroll down and find the mismatch(es).

2. Use the following chart to resolve the mismatch(es).

Mismatch	**Action**	**Reference**
Sensor(s) missing from left column	Enable the missing sensor(s)	Section *4 Sensors*
Extra sensor(s) listed in left column	Disable the extra sensor(s)	Section *4 Sensors*
Barometer missing from left column, but present in right column	Enable the Store Barometer setting	Section *9.3 Storing Barometer Readings*
Barometer present in left column, but missing from right column	Disable the Store Barometer setting	Section *9.3 Storing Barometer Readings*
Store Site Number missing from left column, but present in right column	Enable the Store Site Number setting	Section *9.4 Creating a Site List*
Store Site Number present in left column, but missing from right column	Disable the Store Site Number setting	Section *9.4 Creating a Site List*

3. Return to Section *9.6 Logging Data Without a Site List* or *9.7 Logging Data With a Site List*.

10. System Setup

The YSI 556 MPS has a number of features that are user-selectable or can be configured to meet the user's preferences. Most of these choices are found in the **System setup** menu.

10.1 Accessing the System Setup Screen

1. Press the **On/off** key to display the run screen. See Figure 2.1 Front View of YSI 556 MPS.

2. Press the **Escape** key to display the main menu screen.

3. Use the arrow keys to highlight the **System setup** selection.

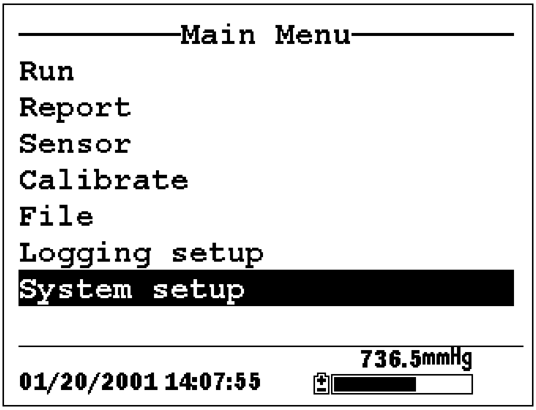
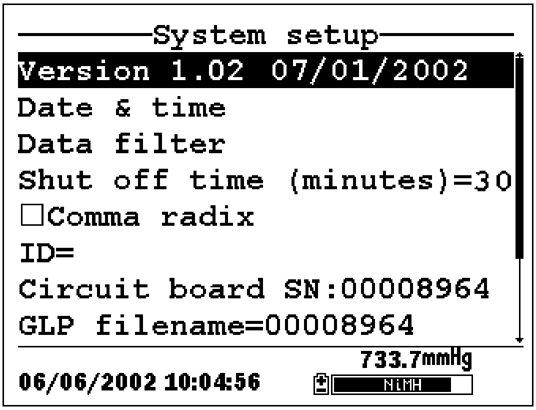


Figure 10.1 Main Menu

4. Press the **Enter** key. The system setup screen is displayed.



```
System setup
Version 1.02 07/01/2002
Date & time
Data filter
Shut off time (minutes)=30
☐Comma radix
ID=
Circuit board SN:00008964
GLP filename=00008964
733.7mmHg
06/06/2002 10:04:56
```

Figure 10.2 System Setup Screen

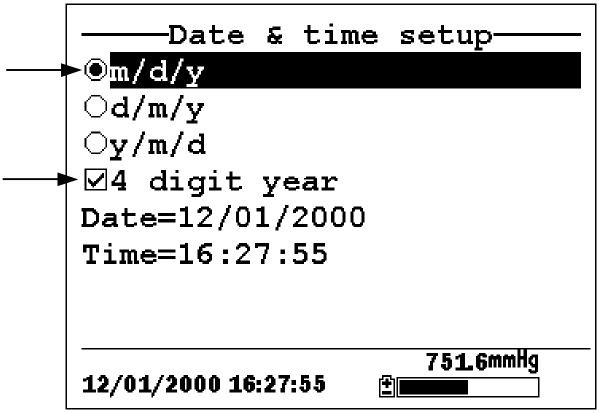
NOTE: The first line of the **System setup** menu shows the current software version of your YSI 556 MPS. As software enhancements are introduced, you will be able to upgrade your YSI 556 MPS from the YSI Web site. Refer to Section *11.2 Upgrading YSI 556 MPS* Software for details.

10.2 Date and Time Setup

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Date & time** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Press **Enter**. The date and time setup screen is displayed.



Currently selected date format

4-digit year selected

Date & time setup

● m/d/y

○ d/m/y

○ y/m/d

☑ 4 digit year

Date=12/01/2000

Time=16:27:55

751.6mmHg

12/01/2000 16:27:55

Figure 10.3 Date Setup Screen

NOTE: A black dot to the left of a date format indicates that format is selected.

4. Use the arrow keys to highlight your desired date format.

5. Press **Enter**.

6. Use the arrow keys to highlight the 4-digit year selection.

7. Press **Enter**. A check mark appears in the check box next to the 4-digit year selection.

   NOTE: If unchecked, a 2-digit year is used.

8. Use the arrow keys to highlight the **Date** selection.

9. Press **Enter**. A cursor appears over the first number in the date.

10. Enter the proper number from the keypad for the highlighted date digit. The cursor moves automatically to the next date digit. Refer to Section *2.9 Keypad Use* for more keypad information.

11. Repeat Step 10 until all date digits are correct.

12. Press **Enter** to input the specified date.

13. Use the arrow keys to highlight the **Time** selection.

14. Press **Enter**. A cursor appears over the first number in the time selection.

15. Enter the proper number from the keypad for the highlighted time digit. The cursor moves automatically to the next time digit.

    NOTE: Use military format when entering time. For example, 2:00 PM is entered as 14:00.

16. Repeat Step 15 until all time digits are correct.

17. Press **Enter** to input the correct time.

18. Press the **Escape** key repeatedly to return to the Main menu screen.

10.3 Data Filter

The Data Filter is a software filter that eliminates sensor noise and provides more stable readings.

NOTE: YSI recommends using the default values for the data filter for most field applications.

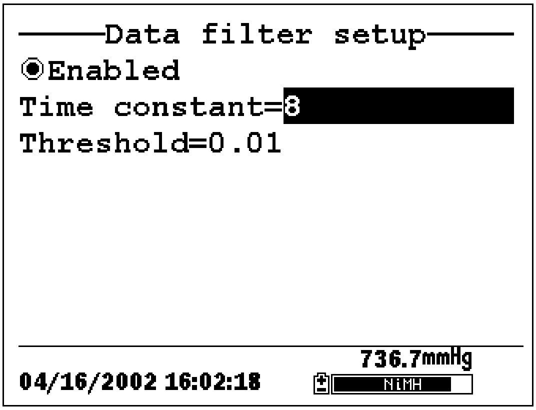
However, users who are primarily interested in a fast response from their dissolved oxygen sensor should consider a change of the default time constant setting of 8 seconds to one of 2 seconds. This change can be made according to the instructions in Section *10.3.1 Changing the Data Filter Settings* below. The disadvantage of lowering the time constant is that field pH readings may appear somewhat noisy if the cable is in motion.

10.3.1 Changing the Data Filter Settings

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Data filter** selection. See Figure 10.1 Main Menu.

3. Press the **Enter** key. The Data filter setup screen is displayed.



Data filter setup

● Enabled

Time constant=8

Threshold=0.01

04/16/2002 16:02:18

736.7mmHg

Figure 10.4 Data Filter Screen

4. With Enabled highlighted, press the **Enter** key to Enable or Disable the data filter. A black dot to the left of the selection indicates the data filter is enabled.

5. Use the arrow keys to highlight the **Time constant** field.

   NOTE: This value is the time constant in seconds for the software data filter. Increasing the time constant will result in greater filtering of the data, but will also slow down the apparent response of the sensors.

6. Use the keypad to enter a value. The default value is 8 and this value is ideal for most 556 field applications. As described in Section *10.3 Data Filter* above, users who wish to decrease the response time of the DO readings at the expense of some noise for the pH readings determined concurrently, should change the Time Constant to a value of 2.

7. Press the **Enter** key to enter the time constant.

8. Use the arrow keys to highlight the **Threshold** field.

   NOTE: This value determines when the software data filter will engage/disengage, speeding the response to large changes in a reading. When the difference between two consecutive readings is larger than the threshold, then the reading is displayed unfiltered. When the difference between two consecutive readings drops below the threshold, readings will be filtered again.

9. Use the keypad to enter a value. The default value is 0.01.

10. Press the **Enter** key to enter the threshold.

11. Press the **Escape** key repeatedly to return to the Main menu screen.

10.4 Shutoff Time

The YSI 556 MPS shuts off automatically after 30 minutes of inactivity. The shut off time may be changed as described below.

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Shutoff time** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Use the keypad to enter a value from 0 to 60 minutes. The default value is 30.

   NOTE: To disable the automatic shutoff feature, enter a zero (0).

4. Press the **Enter** key to enter the correct shutoff time.

5. Press the **Escape** key repeatedly to return to the main menu screen.

10.5 Comma Radix

The user can toggle between a period (default) and comma for the radix mark by selecting this item and pressing the **Enter** key as follows:

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.
2. Use the arrow keys to highlight the **Comma radix** selection on the system setup screen. See Figure 10.2 System Setup Screen.
3. Press the **Enter** key. A check mark appears in the check box next to the comma radix selection indicating that the radix mark is a comma.

10.6 ID

This selection allows you to enter an identification name/number for your YSI 556 MPS. This ID name/number is logged in the header of each file.

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.
2. Use the arrow keys to highlight the **ID** selection. See Figure 10.1 Main Menu.
3. Use the keypad to enter an alphanumeric ID up to 15 characters in length. Refer to Section *2.9 Keypad Use*.
4. Press the **Enter** key to enter the ID.
5. Press the **Escape** key repeatedly to return to the main menu screen.

10.7 GLP Filename

This selection allows you to enter a different filename for the YSI 556 MPS Calibration Record file.

NOTE: The default filename is the “556 PC board Serial Number.glp.”

6. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

7. Use the arrow keys to highlight the **GLP Filename** selection. See Figure 10.1 Main Menu.

8. Use the keypad to enter a filename up to 8 characters in length. Refer to Section *2.9 Keypad Use*.

9. Press the **Enter** key to enter the new filename.

Press the **Escape** key repeatedly to return to the main menu screen.

10.8 TDS Constant

This selection allows you to set the constant used to calculate Total Dissolved Solids (TDS). TDS in g/L is calculated by multiplying this constant times the specific conductance in mS/cm.

10.8.1 Changing the TDS Constant

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **TDS Constant** selection. See Figure 10.1 Main Menu.

3. Use the keypad to enter a value. Refer to Section *2.9 Keypad Use*. The default value is 0.65.

4. Press the **Enter** key to enter the correct TDS constant.

5. Press the **Escape** key repeatedly to return to the main menu screen.

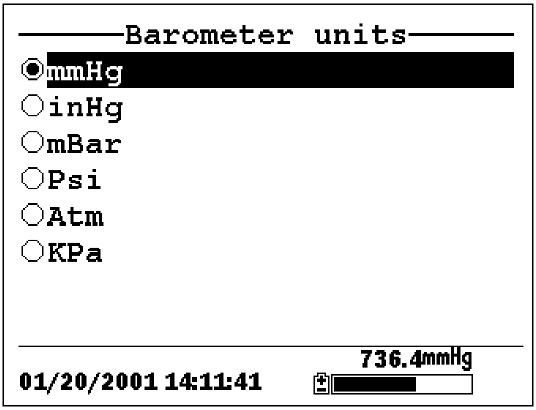
10.9 Barometer Units

The following information is only for instruments with the barometer option.

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Barometer units** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Press the **Enter** key. The Barometer units screen will appear.



Barometer units

● mmHg

○ inHg

○ mBar

○ Psi

○ Atm

○ KPa

736.4mmHg

01/20/2001 14:11:41

Figure 10.5 Barometer Units Screen

A black dot indicates the currently selected units.

4. Use the arrow keys to highlight your desired barometric unit.

5. Press the **Enter** key to select your choice. A black dot will appear in the circle next to your selected units.

6. Press the **Escape** key repeatedly to return to the main menu screen.

10.10 Calibrate Barometer

The optional barometer has been factory calibrated to provide accurate readings. However, some sensor drift may occur over time, requiring occasional calibration by the user, as follows:

1. Determine your local barometric pressure from an independent laboratory barometer or from your local weather service.

2. If the barometric pressure (BP) reading is from your local weather station, reverse the equation that corrects it to sea level.

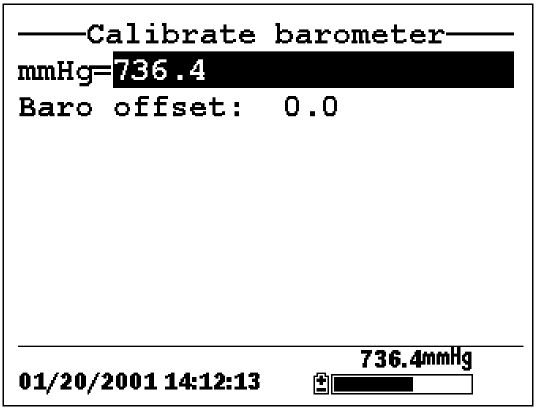
   NOTE: For this equation to be accurate, the barometric pressure units must be in mm Hg.

   True BP = (Corrected BP) – [2.5 * (Local Altitude/100)]

3. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

4. Use the arrow keys to highlight the **Calibrate barometer** selection on the system setup screen. See Figure 10.2 System Setup Screen.

5. Press the **Enter** key. The Calibrate Barometer screen is displayed.



```
————Calibrate barometer————
mmHg=736.4
Baro offset:  0.0

                    736.4mmHg
01/20/2001 14:12:13
```

6. Use the keypad to input the known barometric pressure value as determined in Step 2.

7. Press the **Enter** key. The new barometer reading is displayed as well as the approximate offset from the factory reading.

   NOTE: To return the sensor to the factory setting, subtract the offset amount from the current setting and repeat Steps 5 to 7.

8. Press the **Escape** key repeatedly to return to the main menu screen.

11. Maintenance

11.1 Sensor Care and Maintenance

Once the sensors have been properly installed, remember that periodic cleaning and DO membrane changes are required.

11.1.1 DO Sensor

For best results, we recommend that the KCl solution and the membrane cap be changed at least once every 30 days.

1. It is important to recognize that oxygen dissolved in the sample is consumed during sensor operation. It is therefore essential that the sample be continuously stirred at the sensor tip. If stagnation occurs, your readings will be artificially low. Stirring may be accomplished by mechanically moving the sample around the sensor tip, or by rapidly moving the sensor through the sample. The rate of stirring should be at least 1 foot per second.

2. Membrane life depends on usage. Membranes will last a long time if installed properly and treated with care. Erratic readings are a result of loose, wrinkled, damaged, or fouled membranes, or from large (more than 1/8" diameter) bubbles in the electrolyte reservoir. If erratic readings or evidence of membrane damage occurs, you should replace the membrane and the electrolyte solution. The average replacement interval is two to four weeks.

3. If the membrane is coated with oxygen consuming (e.g. bacteria) or oxygen producing organisms (e.g. algae), erroneous readings may occur.

4. Chlorine, sulfur dioxide, nitric oxide, and nitrous oxide can affect readings by behaving like oxygen at the sensor. If you suspect erroneous readings, it may be necessary to determine if these gases are the cause.

5. Avoid any environment that contains substances that may attack the probe module and sensor materials. Some of these substances are concentrated acids, caustics, and strong

solvents. The sensor materials that come in contact with the sample include FEP Teflon, acrylic plastic, EPR rubber, stainless steel, epoxy, polyetherimide and the PVC cable covering.

6. It is possible for the silver anode, which is the entire silver body of the sensor, to become contaminated. This will prevent successful calibration. To restore the anode, refer to Section *11.1.1 DO Sensor, Silver Anode Cleaning.*

7. For correct sensor operation, the gold cathode must always be bright. If it is tarnished (which can result from contact with certain gases), or plated with silver (which can result from extended use with a loose or wrinkled membrane), the gold surface must be restored. To restore the cathode, refer to Section *11.1.1 DO Sensor, Gold Cathode Cleaning.*

8. To keep the electrolyte from drying out, store the sensor in the transport/calibration cup with at least 1/8″ of water.

Silver Anode Cleaning

After extended use, a thick layer of AgCl builds up on the silver anode reducing the sensitivity of the sensor. The anode must be cleaned to remove this layer and restore proper performance. The cleaning can be chemical or mechanical:

Chemical Cleaning: Remove the membrane cap and soak the entire anode section in a 14% ammonium hydroxide solution for 2 to 3 minutes, followed by a thorough rinsing with distilled or deionized water. The anode should then be thoroughly wiped with a wet paper towel to remove the residual layer from the anode.

Mechanical Cleaning: Sand off the dark layer from the silver anode with 400 grit wet/dry sandpaper. Wrap the sandpaper around the anode and twist the sensor. Rinse the anode with clean water after sanding, followed by wiping thoroughly with a wet paper towel.

NOTE: After cleaning, a new membrane cap must be installed. Refer to Section *3.4.3 Membrane Cap Installation***.**

Turn the instrument on and allow the system to stabilize for at least 30 minutes. If, after several hours, you are still unable to calibrate, contact your dealer or YSI Customer Service. Refer to *Appendix E Customer Service*.

Gold Cathode Cleaning

For correct sensor operation, the gold cathode must be textured properly. It can become tarnished or plated with silver after extended use. The gold cathode can be cleaned by using the adhesive backed sanding disc and tool provided in the YSI 5238 Probe Reconditioning Kit.

Using the sanding paper provided in the YSI 5238 Probe Reconditioning Kit, wet sand the gold with a twisting motion about 3 times or until all silver deposits are removed and the gold appears to have a matte finish. Rinse the cathode with clean water after sanding, followed by wiping thoroughly with a wet paper towel. If the cathode remains tarnished, contact your dealer or YSI Customer Service. Refer to *Appendix E Customer Service*.

NOTE: After cleaning, a new membrane cap must be installed. Refer to Section *3.4.3 Membrane Cap Installation***.**

11.1.2 DO Sensor Replacement

1. Remove the probe sensor guard.

⚠ **CAUTION:** Thoroughly dry the sensor so that no water enters the probe module sensor port when the sensor is removed.

2. Insert the long end of the hex key wrench into the small hole in the side of the probe module bulkhead. Turn the wrench counterclockwise and remove the screw. (You do not have to remove the screw all the way to release the sensor.)

3. Pull the old DO sensor module straight out of the probe module body.

   NOTE: The DO sensor is not threaded, it is keyed, so it cannot be removed by twisting.

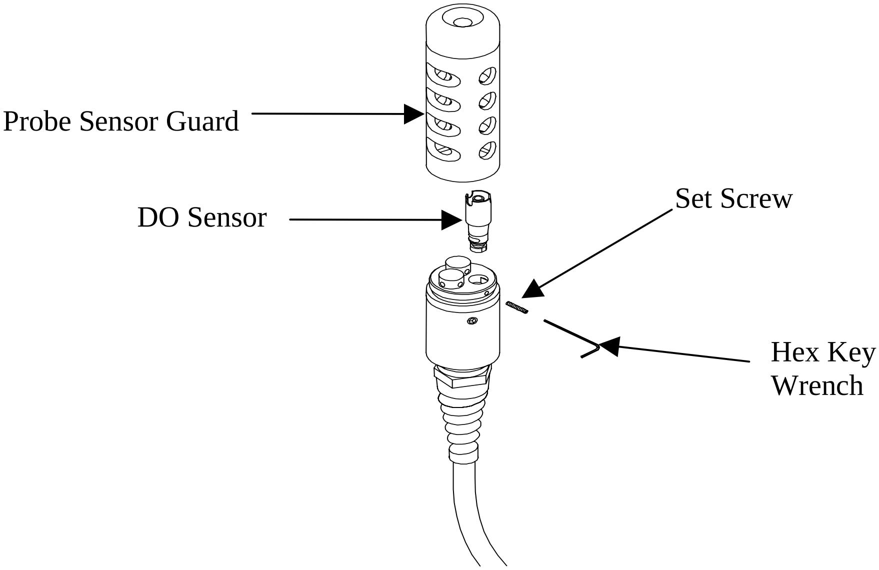


Figure 11.1 DO Sensor Replacement

4. Insert the new DO sensor module. Make sure that the inside of the probe module sensor port and the o-ring on the sensor are clean, with no contaminants, such as grease, dirt, or hair. The DO sensor is keyed, or has a flat side, so that it cannot be aligned improperly.

   NOTE: Make sure the DO sensor bottoms out before the set screw is inserted.

5. Insert the set screw into the small hole in the side of the probe module bulkhead, and turn clockwise to rethread.

⚠ **CAUTION:** Make sure that you do not cross-thread the set screw. Use the hex key wrench to tighten the screw in properly, making sure that the screw does not stick out of the side of the probe module bulkhead. The probe sensor guard will not thread on properly and damage may result if the screw is allowed to stick out.

NOTE: The YSI 5563 DO sensor is shipped dry. A shipping membrane was installed to protect the electrode. A new membrane cap must be installed before the first use. Refer to Section *3.4.1 Sensor Installation.*

11.1.3 YSI 5564 pH and 5565 Combination pH/ORP Sensor Cleaning

Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces of these sensors or when the response of the sensor becomes slow.

1. Remove the sensor from the probe module.

2. Initially, simply use clean water and a soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb (YSI 5564 and YSI 5565) and platinum button (YSI 5565). Then use a moistened cotton swab to carefully remove any material that may be blocking the reference electrode junction of the sensor.

⚠ **CAUTION:** When using a cotton swab with the YSI 5564 or YSI 5565, be careful NOT to wedge the swab tip between the guard and the glass sensor. If necessary, remove cotton from the swab tip, so that the cotton can reach all parts of the sensor tip without stress.

NOTE: If good pH and/or ORP response is not restored by the above procedure, perform the following additional procedure:

1. Soak the sensor for 10-15 minutes in clean water containing a few drops of commercial dishwashing liquid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the cleaning solution.

3. Rinse the sensor in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water.

NOTE: If good pH and/or ORP response is still not restored by the above procedure, perform the following additional procedure:

1. Soak the sensor for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Be sure to follow the safety instructions included with the acid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the acid.

3. Rinse the sensor in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water. To be certain that all traces of the acid are removed from the sensor crevices, soak the sensor in clean water for about an hour with occasional stirring.

NOTE: If biological contamination of the reference junction is suspected or if good response is not restored by the above procedures, perform the following additional cleaning step:

1. Soak the sensor for approximately 1 hour in a 1 to 1 dilution of commercially available chlorine bleach.

2. Rinse the sensor with clean water and then soak for at least 1 hour in clean water with occasional stirring to remove residual bleach from the junction. (If possible, soak the sensor for period of time longer than 1 hour in order to be certain that all traces of chlorine bleach are removed.) Then re-rinse the sensor with clean water and retest.`

11.1.4 Temperature/Conductivity Sensor Cleaning

The single most important requirement for accurate and reproducible results in conductivity measurement is a clean cell. A dirty cell will change the conductivity of a solution by contaminating it. The small cleaning brush included in the YSI 5511 Maintenance Kit is ideal for this purpose.

To clean the conductivity cell:

1. Dip the brush in clean water and insert it into each hole 15-20 times.

2. Rinse the cell thoroughly in deionized or clean tap water.

NOTE: In the event that deposits have formed on the electrodes, perform the following additional procedure:

1. Use a mild detergent solution in combination with the brush. Dip the brush in the solution and insert it into each hole 15-20 times.

2. Rinse the cell thoroughly in deionized or clean tap water.

   NOTE: After cleaning, check the response and accuracy of the conductivity cell with a calibration standard.

   NOTE: If this procedure is unsuccessful, or if sensor performance is impaired, it may be necessary to return the sensor to a YSI authorized service center for service, Refer to *Appendix E Customer Service*.

   The temperature portion of the sensor requires no maintenance.

11.2 Upgrading YSI 556 MPS Software

1. Access the YSI Environmental Software Downloads page as described in *Appendix G EcoWatch* Step 1 through 3.

2. Click on the **YSI Instruments Software Updates** link (or scroll down until you see YSI 556 MPS).

3. Click on the file icon to the right of the **YSI 556 MPS** listing and save the file to a temporary directory on your computer.

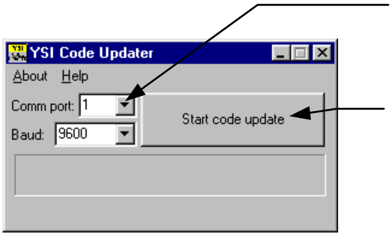
4. After the download is complete, run the file (that you just downloaded) and follow the on screen instructions to install the YSI Code Updater on your computer. If you encounter difficulties, contact YSI customer service for advice. Refer to *Appendix E Customer Service*.

5. If necessary, disconnect the YSI 5563 Probe Module from the YSI 556 MPS instrument.

6. Connect the YSI 556 MPS to a serial port of your computer via the 655173 PC interface cable. See Figure 8.6 Computer/Instrument Interface.

7. Press the **On/off** key on the YSI 556 MPS to display the run screen.

8. Run the YSI Code Updater software that you just installed on your computer. The following window will be displayed:



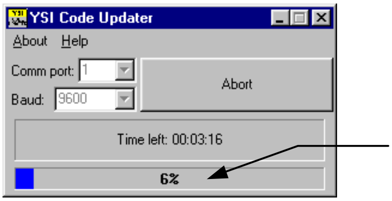
Comm port: 1
Baud: 9600

Select Comm port

Click on Start code update

9. Set the Comm port number to match the port that you connected the 655173 PC Interface Cable to, then click on the **Start Code Update button**.

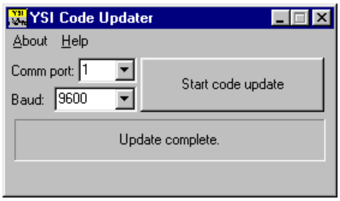
The YSI 556 MPS screen will blank out and a progress indicator will be displayed on the PC.



Comm port: 1
Baud: 9600
Time left: 00:03:16
6%

Progress Indicator

When the update is finished (indicated on the PC screen), the YSI 556 MPS will return to the Run screen. See Figure 7.1 Run Screen.



Comm port: 1

Baud: 9600

Update complete.

10. Close the YSI Code Updater window (on the PC) by clicking on the "X" in the upper right corner of the window.

11. Disconnect the YSI 556 MPS from the 655173 PC interface cable and reconnect it to the YSI 5563 Probe Module. Refer to Section *3.6 Instrument/Cable Connection*.

12. Storage

Proper storage between periods of usage will not only extend the life of the sensors, but will also ensure that the unit will be ready to use as quickly as possible in your next application.

12.1 General Recommendations for Short Term Storage

No matter what sensors are installed in the instrument, it is important to keep them moist without actually immersing them in liquid. Immersing them could cause some of them to drift or result in a shorter lifetime.

YSI recommends that short term storage of all multi-parameter instruments be done by placing approximately 1/2 inch of tap water in the transport/calibration cup that was supplied with the instrument, and by placing the probe module with all of the sensors installed into the cup. The use of a moist sponge instead of a 1/2 inch of tap water is also acceptable, as long as its presence does not compromise the attachment of the cup to the probe module. The transport/calibration cup should be sealed to prevent evaporation.

NOTE: Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body. See Figure 3.7 Transport/Calibration Cup Installation.

⚠ **CAUTION:** The water level has to be low enough so that none of the sensors are actually under water. Check the transport/calibration cup periodically to make certain that the water is still present or the sponge is still moist.

NOTE: If the storage water (tap water) is accidentally lost during field use, environmental water can be used.

12.2 General Recommendations for Long Term Storage

12.2.1 Probe Module Storage

1. Remove the pH or pH/ORP sensor from the probe module and store according to the individual sensor storage instructions found in Section *12.2.2 Sensor Storage*.

2. Seal the empty port with the provided port plug.

NOTE: Leave the conductivity/temperature sensor and dissolved oxygen sensor, with membrane cap still on, in the probe module.

3. Place 1/2″ of water, deionized, distilled or tap, in the transport/calibration cup.

⚠ **CAUTION:** The water level has to be low enough so that none of the sensors are actually under water. Check the transport/calibration cup periodically to make certain that the water is still present or the sponge is still moist.

4. Insert the probe module into the cup.

NOTE: Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body. See Figure 3.7 Transport/Calibration Cup Installation.

12.2.2 Sensor Storage

Temperature/Conductivity Sensor

No special precautions are required. Sensor can be stored dry or wet, as long as solutions in contact with the thermistor and conductivity electrodes are not corrosive (for example, chlorine bleach). However, it is recommended that the sensor be cleaned with the provided brush prior to long term storage. Refer to Section *11.1.4 Temperature/Conductivity Sensor Cleaning.*

pH and Combination pH/ORP Sensor

The key to sensor storage is to make certain that the reference electrode junction does not dry out. Junctions which have been allowed to dry out due to improper storage procedures can usually be rehydrated by soaking the sensor for several hours (overnight is recommended) in a solution which is 2 molar in potassium chloride. If potassium chloride solution is not available, soaking the sensor in tap water or commercial pH buffers may restore sensor function. However in some cases the sensor may have been irreparably damaged by the dehydration and will require replacement.

⚠ **CAUTION:** Do not store the sensor in distilled or deionized water as the glass sensor may be damaged by exposure to this medium.

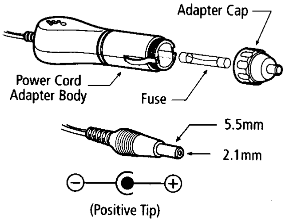
1. Remove the pH or pH/ORP sensor from the probe module.
2. Seal the empty port with the provided port plug.
3. Place the sensor in the storage vessel (plastic boot or bottle) which was on the sensor at delivery. The vessel should contain a solution which is 2 molar in potassium chloride.

   NOTE: Make certain that the vessel is sealed to prevent evaporation of the storage solution.

13. Troubleshooting

The following sections describe problems you may encounter when using the YSI 556 MPS and provides suggestions to overcome the symptom.

PROBLEM	POSSIBLE SOLUTION
Display Problems	
No display is visible after pressing the on/off key.	If C cells are used, make certain that they are installed properly with regard to polarity and that good batteries are used. If a rechargeable battery pack is used, place the pack in the instrument and charge for 30 minutes.
Instrument software appears to be locked up as evidenced by no response to keypad entries or display not changing.	First, attempt to reset the instrument by simply turning off and then on again. If this fails, remove battery power from the instrument for 30 seconds and then reapply power. When using C cells, remove the battery lid and one of the batteries; when using the rechargeable battery pack, remove the pack completely from the instrument. After 30 seconds replace the battery or battery pack and check for instrument function.
The 556 display flashes and the instrument speaker makes a continuous clicking sound.	The battery voltage is low. Change to new C cells or recharge the 6117 battery pack.
Water Damage to Instrument	
Leakage detected in battery compartment when using C cells	Dispose of batteries properly. Dry the battery compartment using compressed air if possible. If corrosion is present on battery terminals, contact YSI Customer Service.
Water has contacted rechargeable battery pack	Remove battery pack immediately. Send battery pack to YSI Product Service for evaluation. **CAUTION**: DO NOT REUSE BATTERY PACK UNTIL YSI PRODUCT SERVICE HAS EVALUATED IT.
Leakage suspected into the main cavity of the instrument case	Remove the batteries immediately. Return the instrument to YSI Product Service.

PROBLEM	POSSIBLE SOLUTION
Optional Cigarette Lighter Charger	
Power cord fuse blown  	1. Unscrew adapter's cap, remove tip and pull out fuse. 2. Replace fuse with a new 2-amp fast-blow fuse from an electronics store such as Radio Shack. 3. Reassemble the adapter and securely screw the cap back onto the adapter body.
File Problems	
Upload of files from YSI 556 MPS to PC fails	1. Make sure that cable is connected properly to both 556 and PC. 2. Make certain that the proper Comm port is selected in EcoWatch for Windows.
Barometer data is not stored with sensor data file.	Make sure **Store barometer** is active in the 556 **Logging setup** menu.
Site Descriptions in the **Site List** are "grayed-out" and not available for appending files with additional data.	There is a parameter mismatch between the current 556 setup and that initially used. Change the current logging and sensor setup to match the setup that was initially used to create the file.
Sensor Problems	
Dissolved Oxygen reading unstable or inaccurate. Out of Range message appears during calibration.	Sensor not properly calibrated. Follow DO cal procedures.
	Membrane not properly installed or may be punctured. Replace membrane cap.
	DO sensor electrodes require cleaning. Follow DO cleaning procedure. Use 5511 Maintenance kit.
	Water in sensor connector. Dry connector; reinstall sensor.
	Algae or other contaminant clinging to DO sensor. Rinse DO sensor with clean water.
	Barometric pressure entry is incorrect. Repeat DO cal procedure.
	Calibrated at extreme temperature. Recalibrate at (or near) sample temperature.
	DO sensor has been damaged. Replace sensor.
	Internal failure. Return probe module for service.

PROBLEM	POSSIBLE SOLUTION
Sensor Problems	
pH or ORP readings are unstable or inaccurate. Out of Range message appears during calibration.	Sensor requires cleaning. Follow sensor cleaning procedure.
	Sensor requires calibration. Follow cal procedures.
	pH sensor reference junction has dried out from improper storage. Soak sensor in tap water or buffer until readings become stable.
	Water in sensor connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace sensor.
	Calibration solutions out of spec or contaminated with other solution. Use new calibration solutions.
	ORP fails Zobell check. Take into account temperature dependence of Zobell solution readings.
	Internal failure. Return probe module for service.
Conductivity unstable or inaccurate. Out of Range message appears during calibration.	Conductivity improperly calibrated. Follow calibration procedure.
	Conductivity sensor requires cleaning. Follow cleaning procedure.
	Conductivity sensor damaged. Replace sensor.
	Calibration solution out of spec or contaminated. Use new calibration solution.
	Internal failure. Return probe module for service.
	Calibration solution or sample does not cover entire sensor. Immerse sensor fully.
Temperature, unstable or inaccurate	Water in connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace the 5560 sensor.
Installed sensor has no reading	The sensor has been disabled. Enable sensor.
	Water in sensor connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace the sensor.
	Report output improperly set up. Set up report output.
	Internal failure. Return probe module for service.

If these guidelines and tips fail to correct your problem or if any other symptoms occur, contact YSI Customer Service for Advice. Refer to *Appendix E Customer Service*.

14. Appendix A YSI 556 MPS Specifications

14.1 Sensor Specifications

Dissolved Oxygen	
Sensor Type	Steady state polarographic
Range: *% air sat'n* *mg/L*	▪ 0 to 500% air saturation ▪ 0 to 50 mg/L
Accuracy: *% air sat'n*	▪ 0 to 200% air saturation: ±2% of the reading or 2% air saturation; whichever is greater ▪ 200 to 500% air saturation: ±6% of the reading
mg/L	▪ 0 to 20 mg/L: ±2% of the reading or 0.2 mg/L; whichever is greater ▪ 20 to 50 mg/L: ±6% of the reading
Resolution: *% air sat'n* *mg/L*	▪ 0.1% air saturation ▪ 0.01 mg/L
Temperature	
Sensor Type:	YSI Precision™ thermistor
Range:	-5 to 45°C
Accuracy:	±0.15°C
Resolution:	0.01°C
Conductivity	
Sensor Type:	4-electrode cell with auto-ranging
Range:	0 to 200 mS/cm
Accuracy:	±0.5% of reading or ±0.001 mS/cm; whichever is greater–4 meter cable ±1.0% of reading or ±0.001 mS/cm; whichever is greater–20 meter cable
Resolution:	0.001 mS/cm to 0.1 mS/cm (range-dependent)
Salinity	
Sensor Type:	Calculated from conductivity and temperature
Range:	0 to 70 ppt
Accuracy:	±1.0% of reading or 0.1 ppt; whichever is greater
Resolution:	0.01 ppt

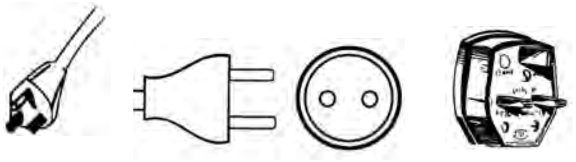
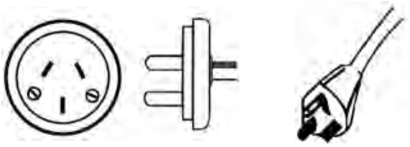
pH (optional)	
Sensor Type:	Glass combination electrode
Range:	0 to 14 units
Accuracy:	±0.2 units
Resolution:	0.01 units
ORP (optional)	
ORP Sensor Type:	Platinum button
Range:	-999 to +999 mV
Accuracy:	±20 mV
Resolution:	0.1 mV

Barometer (optional)	
Range:	500 to 800 mm Hg
Accuracy:	±3 mm Hg within ±15°C temperature range from calibration point
Resolution:	0.1 mm Hg

14.2 Instrument Specifications

Memory Size:	1.5 MB Flash Memory 49,000 data sets (@ 6 parameters per set plus time stamp) 100 Sites
Size:	11.9 cm width x 22.9 cm length (4.7 in. x 9 in.)
Weight with batteries:	0.92 kg (2.1 lbs)
Power:	4 alkaline C-cells; optional rechargeable pack
Cables:	4, 10, and 20 m (13.1, 32.8, 65.6 ft.) lengths
Warranty:	3-Years for the instrument; 1-Year for the probe modules and cable

15. Appendix B Instrument Accessories

ITEM #	ACCESSORY
5563-4	4m Cable with DO/temp/conductivity
5563-10	10m Cable with DO/temp/conductivity
5563-20	20m Cable with DO/temp/conductivity
5564	pH Kit
5565	pH/ORP Kit
6118	Rechargeable Battery Pack Kit for use in US
5094	Rechargeable Battery Pack Kit with universal charger and three adapter cables for use in international applications 
5095	Rechargeable Battery Pack Kit with universal charger and two adapter cables for use in international applications 
5083	Flow Cell – probe module is secured in the flow cell and groundwater is pumped through it
616	Charger, Cigarette Lighter – used to power up the instrument from a car’s cigarette lighter
4654	Tripod
614	Ultra Clamp, C Clamp –used to clamp the instrument to a table top or car dashboard
6081	Large Carrying Case, Hard-sided
5085	Hands-free Harness
5065	Carrying Case, Form-fitted, for use in the field – has a clear vinyl window, shoulder strap, belt loop strap and hand strap

16. Appendix C Required Federal Communications Notice

The Federal Communications Commission defines this product as a computing device and requires the following notice.

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A or Class B computing device in accordance with the specification in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna
- Relocate the computer with respect to the receiver
- Move the computer away from the receiver
- Plug the computer into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet, prepared by the Federal Communications Commission, helpful: "How to Identify and Resolve Radio-TV Interference Problems". This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No.0004-000-00345-4.

17. Appendix D Health and Safety

YSI Conductivity solutions: 3161, 3163, 3165, 3167, 3168, 3169

INGREDIENTS:

☐ Iodine
☐ Potassium Chloride
☐ Water

WARNING: INHALATION MAY BE FATAL.

⚠ ***CAUTION*****: AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY EVOLVE TOXIC FUMES IN FIRE.**

Harmful if ingested or inhaled. Skin or eye contact may cause irritation. Has a corrosive effect on the gastro-intestinal tract, causing abdominal pain, vomiting, and diarrhea. Hyper-sensitivity may cause conjunctivitis, bronchitis, skin rashes etc. Evidence of reproductive effects.

FIRST AID:
INHALATION: Remove victim from exposure area. Keep victim warm and at rest. In severe cases seek medical attention.
SKIN CONTACT: Remove contaminated clothing immediately. Wash affected area thoroughly with large amounts of water. In severe cases seek medical attention.
EYE CONTACT: Wash eyes immediately with large amounts of water, (approx. 10 minutes). Seek medical attention immediately.
INGESTION: Wash out mouth thoroughly with large amounts of water and give plenty of water to drink. Seek medical attention immediately.

YSI pH 4.00, 7.00, and 10.00 Buffer Solutions: 3821, 3822, 3823

pH 4 INGREDIENTS:

- Potassium Hydrogen Phthalate
- Formaldehyde
- Water

pH 7 INGREDIENTS:

- Sodium Phosphate, Dibasic
- Potassium Phosphate, Monobasic
- Water

pH 10 INGREDIENTS:

- Potassium Borate, Tetra
- Potassium Carbonate
- Potassium Hydroxide
- Sodium (di) Ethylenediamine Tetraacetate
- Water

⚠ ***CAUTION* - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

Inhalation may cause severe irritation and be harmful. Skin contact may cause irritation; prolonged or repeated exposure may cause Dermatitis. Eye contact may cause irritation or conjunctivitis. Ingestion may cause nausea, vomiting and diarrhea.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

YSI Zobell Solution: 3682

INGREDIENTS:

❑ Potassium Chloride
❑ Potassium Ferrocyanide Trihydrate
❑ Potassium Ferricyanide

⚠ ***CAUTION* - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

May be harmful by inhalation, ingestion, or skin absorption. Causes eye and skin irritation. Material is irritating to mucous membranes and upper respiratory tract. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities can cause weakness, gastrointestinal irritation and circulatory disturbances.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

18. Appendix E Customer Service

For information on Authorized Service Centers, refer to *Authorized Service Centers* in this appendix.

Equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected before being returned or presented for service. A cleaning certificate must accompany the equipment. Refer to *18.2 Cleaning Instructions* in this appendix.

18.1 YSI Environmental Authorized Service Centers

For information on the nearest authorized service center, please contact:

YSI Technical Support • 1725 Brannum Lane
Yellow Springs, Ohio • 45387 • Phone: +1 (937) 767-7241
Phone: 800-897-4151 (US) • Email: environmental@ysi.com

or visit our website for the most current information:

www.ysi.com

18.2 Cleaning Instructions

Equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected before being serviced. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the responsibility of the sender.

When service is required, either at the user's facility or at a YSI Service Center, the following steps must be taken to ensure the safety of service personnel.

- In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4-cup bleach to 1-gallon tap water is suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol if this is more convenient to the user.
- The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.
- If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.
- Any product being returned to the YSI Repair Center should be packed securely to prevent damage.
- Cleaning must be completed and certified on any product before returning it to YSI.

18.3 Packing Procedure

- Clean and decontaminate items to ensure the safety of the handler.
- Complete and include the Cleaning Certificate.
- Place the product in a plastic bag to keep out dirt and packing material.
- Use a large carton, preferably the original, and surround the product completely with packing material.
- Insure for the replacement value of the product.

18.4 Cleaning Certificate

Organization ___________________________________

Department ____________________________________

Address _______________________________________

City ________________ State __ Zip ________________

Country ____________________ Phone ______________

Model No. of Device __ Lot Number ________________

Contaminant (if known) ___________________________

Cleaning Agent(s) used ____________________________

Radioactive Decontamination Certified?

(Answer only if there has been radioactive exposure)

_______ Yes _______ No

Cleaning Certified By ______________________________

Name Date

18.5 Warranty

The instrument is warranted for three years against defects in workmanship and materials when used for its intended purposes and maintained according to instructions. The probe module and cables are warranted for one year. The dissolved oxygen, temperature/conductivity, pH, and pH/ORP combination sensors are warranted for one year. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered. The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, write or call your local YSI representative, or contact YSI Customer Service in Yellow Springs, Ohio. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI’s written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI’s written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI'S LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

19. Appendix F Ferrite Bead Installation

⚠ **WARNING:** If you are using your YSI 556 in a European Community (CE) country or in Australia or New Zealand, you must attach a ferrite bead to the 655173 PC Interface Cable and the YSI 6117 Charger Adapter Cable in order to comply with the Residential, Commercial and Light Industrial Class B Limits for radio-frequency emissions specified in EN55011 (CISPR11) for Industrial, Scientific and Medical laboratory equipment. These ferrite assemblies are supplied as part of cable kits.

1. Make a small loop (approximately 5 cm in diameter) in the cable near the YSI 556 MS-19 connector.
2. Lay the open ferrite bead assembly under the loop with the cable cross-over position within the cylinder of the ferrite bead.

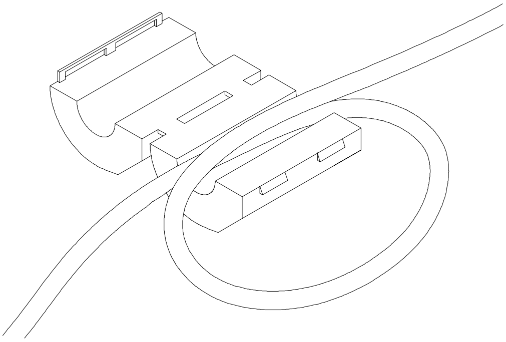


Figure 19.1 Ferrite Bead Installation

3. Snap the two pieces of the bead together making certain that the tabs lock securely.
4. When the installation is complete, the 655173 and YSI 6117 cables should resemble the following drawings.

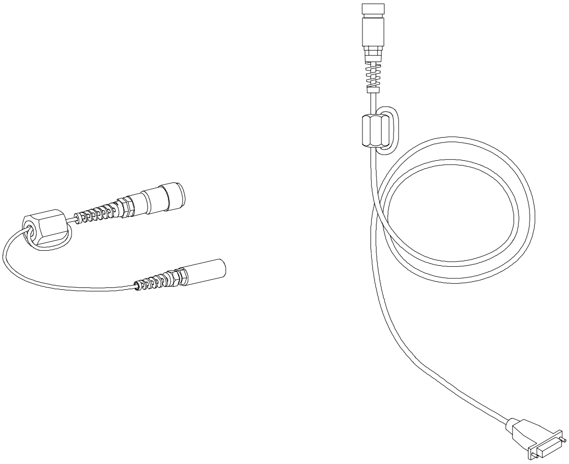


Figure 19.2 Cables with Ferrite Beads

20. Appendix G EcoWatch

EcoWatch™ for Windows™ must be used as the PC software interface to the YSI 556 MPS. EcoWatch is a powerful tool that can also be used with YSI 6-series sondes. Many features of the software will only be utilized by advanced users or are not relevant to the 556 MPS at all. This section is designed in tutorial format to familiarize you with the commonly used features of EcoWatch so that it will be possible to:

- Upload data from a 556 MPS to a PC
- Assemble plots and reports of your data
- Zoom in on certain segments of the plots of your data to facilitate analysis
- Show statistical data for your studies
- Export data in spreadsheet-compatible formats
- Print plots and reports

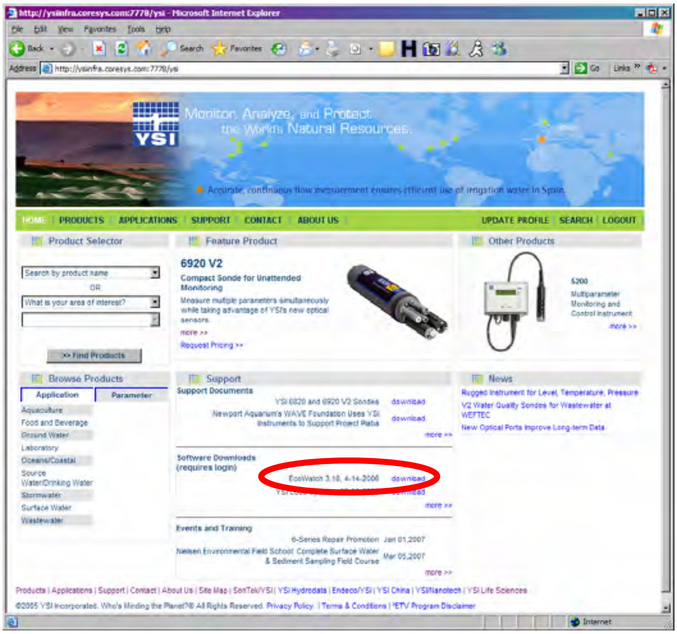
The advanced features of EcoWatch can be explored by downloading a 6-series manual from the YSI Web Site (www.ysi.com), purchasing a hard copy of the manual through YSI Customer Service (Item # 069300), or utilizing the on-line help feature of the software.

20.1 Installing EcoWatch for Windows

EcoWatch for Windows is available at no cost via a download from the YSI Web Site.

1. Access the YSI Web Site at www.ysi.com.

2. Click on the **Login** link and login (or register if you have not previously registered).



Accurate, continuous flow measurement ensures efficient use of irrigation water in Spain.

6920 V2

Compact Sonde for Unattended Monitoring

Measure multiple parameters simultaneously while taking advantage of YSI's new optical sensors.

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Aquaculture
Food and Beverage
Ground Water
Laboratory
Oceans/Coastal
Source Water/Drinking Water
Stormwater
Surface Water
Wastewater

Support Documents

YSI 6820 and 6920 V2 Sondes	download
Newport Aquarium's WAVE Foundation Uses YSI Instruments to Support Project Piaba	download

more >>

Software Downloads (requires login)

EcoWatch 3.18, 4-14-2006	download
YSI [illegible]	download

more >>

Events and Training

6-Series Repair Promotion	Jan 01,2007
Nielsen Environmental Field School: Complete Surface Water & Sediment Sampling Field Course	Mar 05,2007

more >>

Rugged Instrument for Level, Temperature, Pressure
V2 Water Quality Sondes for Wastewater at WEFTEC
New Optical Ports Improve Long-term Data

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3. Click on the EcoWatch link and save the file to a directory on your computer.

4. After the download is complete, run the EcoWatch file (that you just downloaded) and follow the on screen instructions to install the software on your computer.

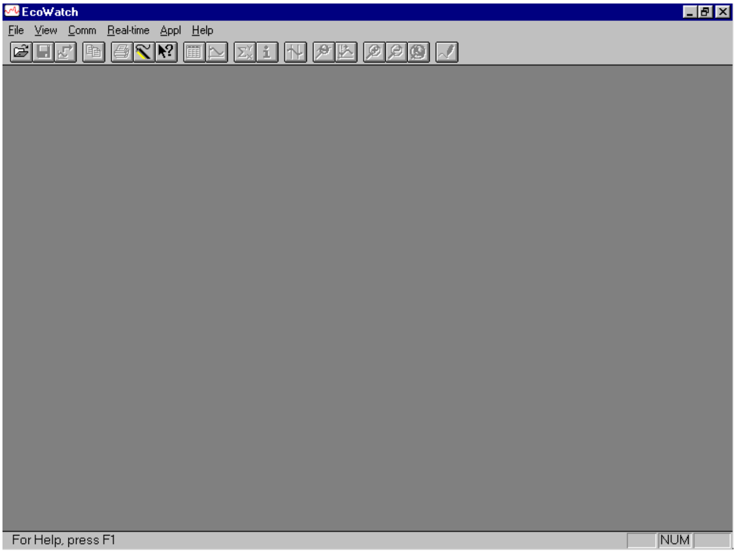
If you encounter difficulties in the download procedure, contact YSI Customer Service. Refer to ***Appendix E Customer Service***. Alternatively, you may purchase the software on CD ROM (Item #006075) by contacting YSI Customer Service.

20.2 EcoWatch Tutorial

This EcoWatch tutorial is designed to teach you the commonly used operations associated with the software when used with your 556 MPS.

After you have uploaded a file, Refer to Section 8.4 Upload to PC, you will see two files in the C:\ECOWWIN\DATA directory; the file you transferred and a file supplied by YSI designated SAMPLE.DAT. This SAMPLE.DAT file is referred to in the remainder of this tutorial section. After following the instructions below for the analysis of SAMPLE.DAT, you apply the same analysis to the data file which was uploaded from your 556 MPS to assure that you are familiar with the basic features and capabilities of EcoWatch for Windows.

To start the analysis of the SAMPLE.DAT file, note that a shortened menu bar is visible and many of the tools in the toolbar appear dimmed or "grayed out" before any file is opened (see below).



Full activation of EcoWatch features will be realized after a file is opened.

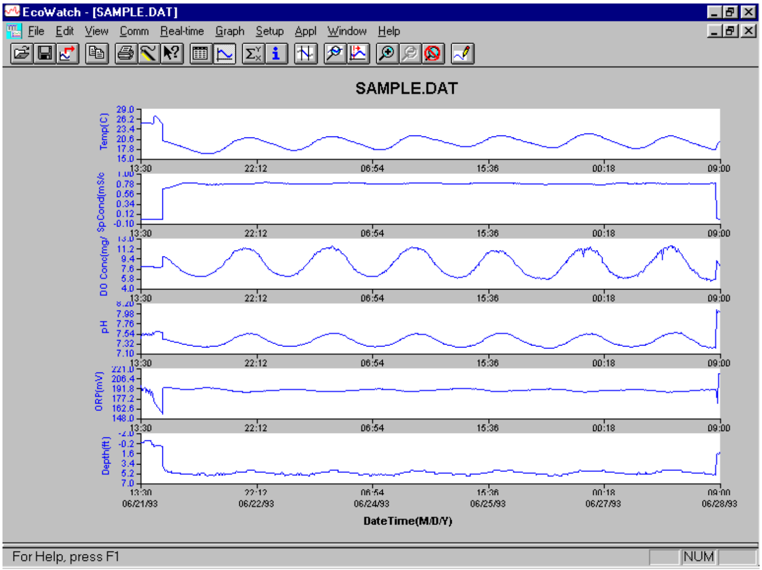
To open the sample data file:

5. 1. Click the **File** menu button in the toolbar.

6. 2. Select the **SAMPLE.DAT** file.

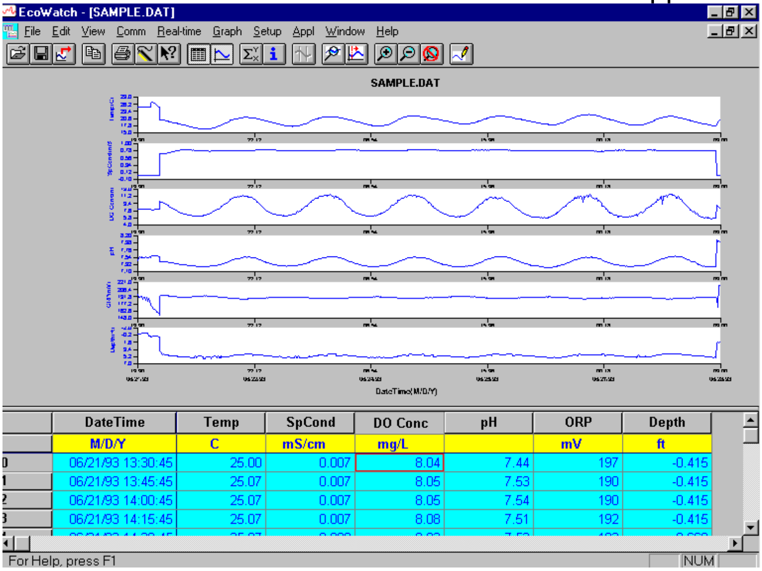
7. 3. Click **OK** to open the file.

The following display will appear:



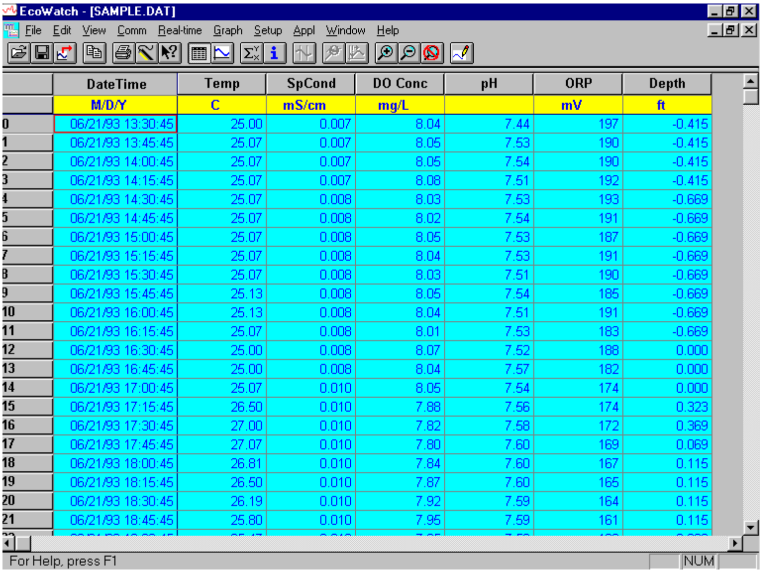
Note that the data in this file appears as a graph of temperature, specific conductance, dissolved oxygen, pH, ORP, and depth, all versus time. The graphs are scaled automatically so that all data fits comfortably on the computer screen. Note also that this data file was obtained with a 6-series sonde for which a depth sensor is available. Depth is NOT a current parameter for the 556 MPS.

The **Table** and **Graph** buttons on the toolbar are on/off switches that are used to display or hide the graph and table pages respectively. When displaying a graph and a table at the same time, you can control the relative size of the two pages by placing the cursor over the small bar that separates them and then dragging it to the desired location. Click the **Table** button to generate the following dual display of data.



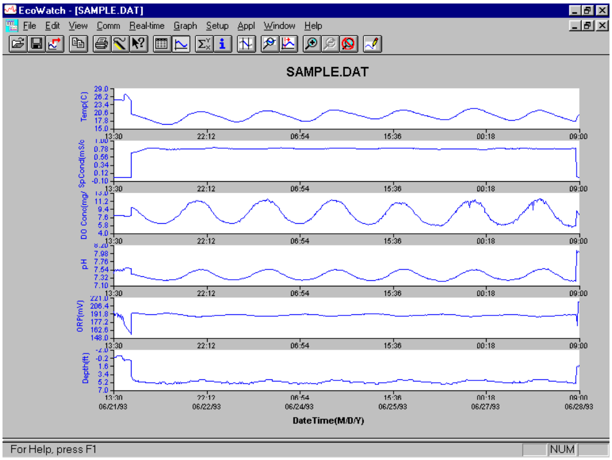
	DateTime	Temp	SpCond	DO Conc	pH	ORP	Depth
	M/D/Y	C	mS/cm	mg/L		mV	ft
0	06/21/93 13:30:45	25.00	0.007	8.04	7.44	197	-0.415
1	06/21/93 13:45:45	25.07	0.007	8.05	7.53	190	-0.415
2	06/21/93 14:00:45	25.07	0.007	8.05	7.54	190	-0.415
3	06/21/93 14:15:45	25.07	0.007	8.08	7.51	192	-0.415

Now click the **Graph** button (turn it off) to display only a report of your data as shown below. Note that the size of the report can be varied by clicking on the and buttons in the Toolbar.

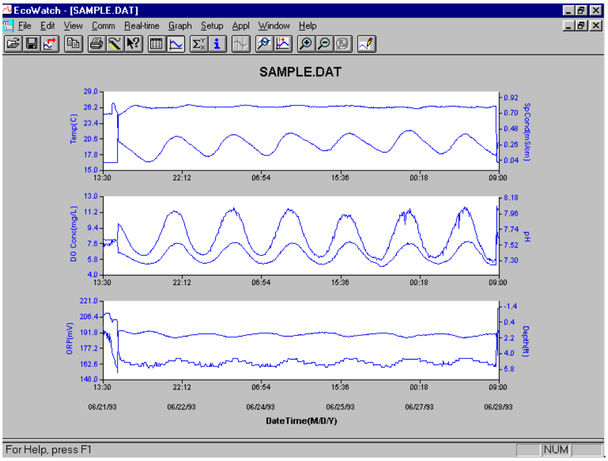


	DateTime	Temp	SpCond	DO Conc	pH	ORP	Depth
	M/D/Y	C	mS/cm	mg/L		mV	ft
0	06/21/93 13:30:45	25.00	0.007	8.04	7.44	197	-0.415
1	06/21/93 13:45:45	25.07	0.007	8.05	7.53	190	-0.415
2	06/21/93 14:00:45	25.07	0.007	8.05	7.54	190	-0.415
3	06/21/93 14:15:45	25.07	0.007	8.08	7.51	192	-0.415
4	06/21/93 14:30:45	25.07	0.008	8.03	7.53	193	-0.669
5	06/21/93 14:45:45	25.07	0.008	8.02	7.54	191	-0.669
6	06/21/93 15:00:45	25.07	0.008	8.05	7.53	187	-0.669
7	06/21/93 15:15:45	25.07	0.008	8.04	7.53	191	-0.669
8	06/21/93 15:30:45	25.07	0.008	8.03	7.51	190	-0.669
9	06/21/93 15:45:45	25.13	0.008	8.05	7.54	185	-0.669
10	06/21/93 16:00:45	25.13	0.008	8.04	7.51	191	-0.669
11	06/21/93 16:15:45	25.07	0.008	8.01	7.53	183	-0.669
12	06/21/93 16:30:45	25.00	0.008	8.07	7.52	188	0.000
13	06/21/93 16:45:45	25.00	0.008	8.04	7.57	182	0.000
14	06/21/93 17:00:45	25.07	0.010	8.05	7.54	174	0.000
15	06/21/93 17:15:45	26.50	0.010	7.88	7.56	174	0.323
16	06/21/93 17:30:45	27.00	0.010	7.82	7.58	172	0.369
17	06/21/93 17:45:45	27.07	0.010	7.80	7.60	169	0.069
18	06/21/93 18:00:45	26.81	0.010	7.84	7.60	167	0.115
19	06/21/93 18:15:45	26.50	0.010	7.87	7.60	165	0.115
20	06/21/93 18:30:45	26.19	0.010	7.92	7.59	164	0.115
21	06/21/93 18:45:45	25.80	0.010	7.95	7.59	161	0.115

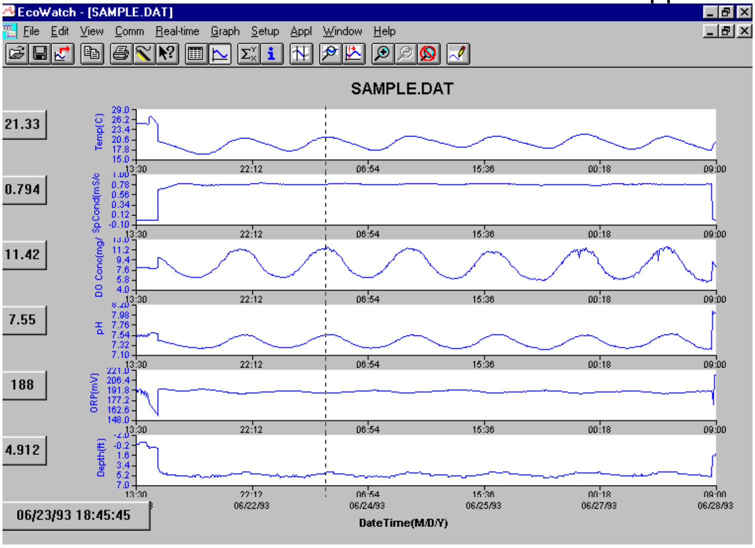
Now return to the original graphic display by toggling the **Table** button “off” and **Graph** button “on”.



From the **Setup** menu, click **Graph**. Click **2 Traces per Graph** and notice that the parameters are now graphed in pairs for easy comparison of parameters.

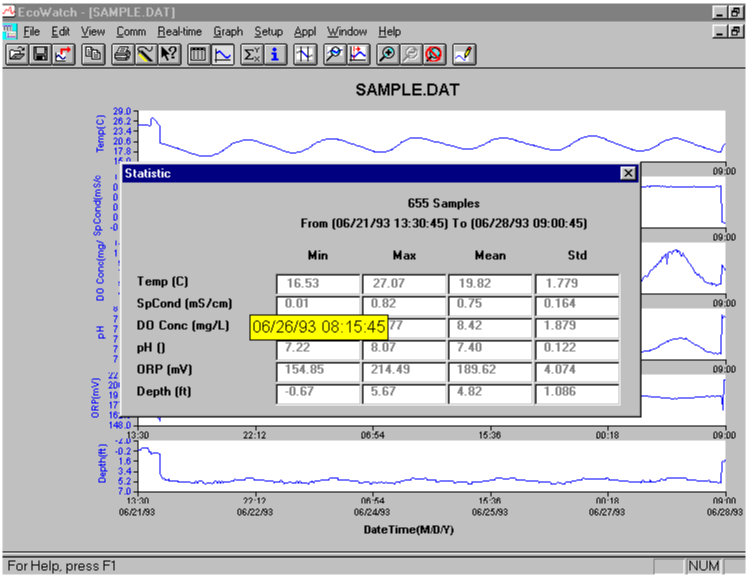


Click **1 Trace per Graph** to return the display to the original setting. Move the cursor to any position in the graph, then click and hold the right mouse button.



Note that the exact measurements for this point in time are displayed to the left of the graph. While holding down the right mouse button, move to another area on the graph. Notice how the measurements change as you move. When you release the mouse button, the display returns to normal.

To view statistical information for the study, click the **Statistics** Σ button on the toolbar. On the statistics window, click on any min or max value to display the time when it occurred.



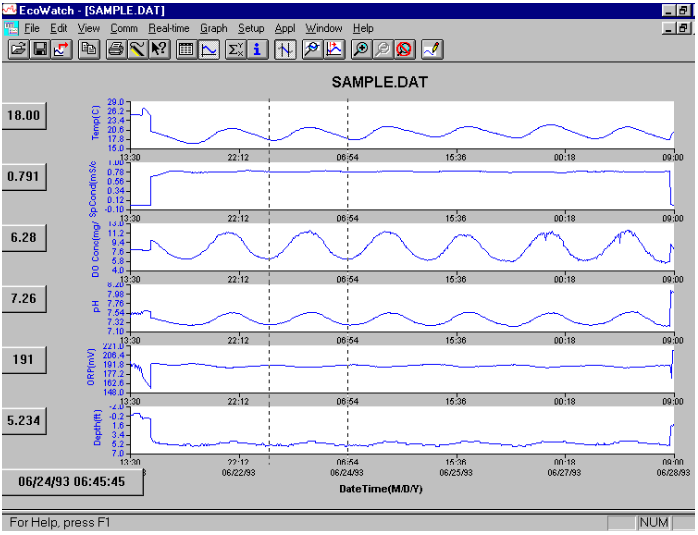
655 Samples

From (06/21/93 13:30:45) To (06/28/93 09:00:45)

	Min	Max	Mean	Std
Temp (C)	16.53	27.07	19.82	1.779
SpCond (mS/cm)	0.01	0.82	0.75	0.164
DO Conc (mg/L)	06/26/93 08:15:45	77	8.42	1.879
pH ()	7.22	8.07	7.40	0.122
ORP (mV)	154.85	214.49	189.62	4.074
Depth (ft)	-0.67	5.67	4.82	1.086

After viewing statistics, click the “x” at the upper right to close the window and return to the normal display.

Now click on the delimiter icon in the toolbar and then move the displayed icon to the graph. Click at the two points shown by dotted lines in the display below, being sure that the first click is to the left of the second.



18.00

0.791

6.28

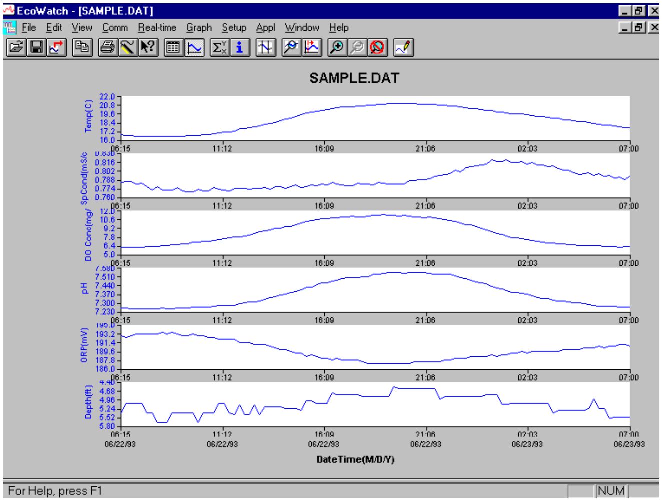
7.26

191

5.234

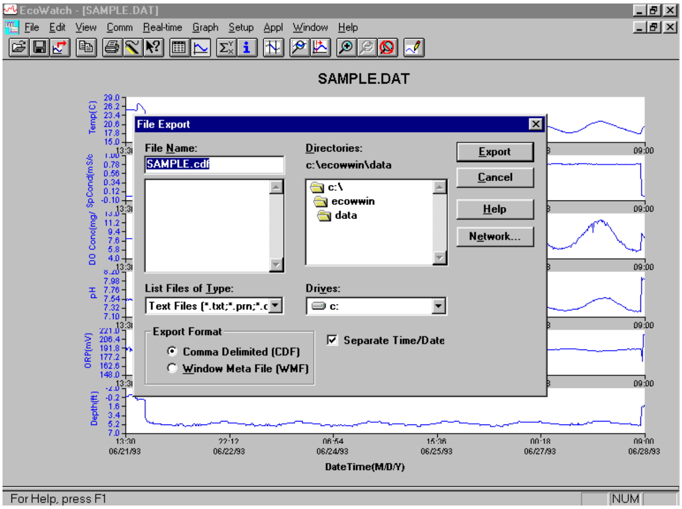
06/24/93 06:45:45

The data between the two selected points will then be graphed in higher resolution as shown below.



To return to the complete data set, select **Graph** from the toolbar and then click **Cancel Limits**.

Now select the icon from the Toolbar to create a new data file which will allow your data to be imported into spreadsheets. Select the default export settings for a Comma Delimited File (.CDF) and click OK. A new spreadsheet-importable file (SAMPLE.CDF) is now present in the same folder as the SAMPLE.DAT file.



File Export

File Name: SAMPLE.cdf

Directories: c:\ecowwin\data

c:\
ecowwin
data

List Files of Type: Text Files (*.txt;*.prn;*.c

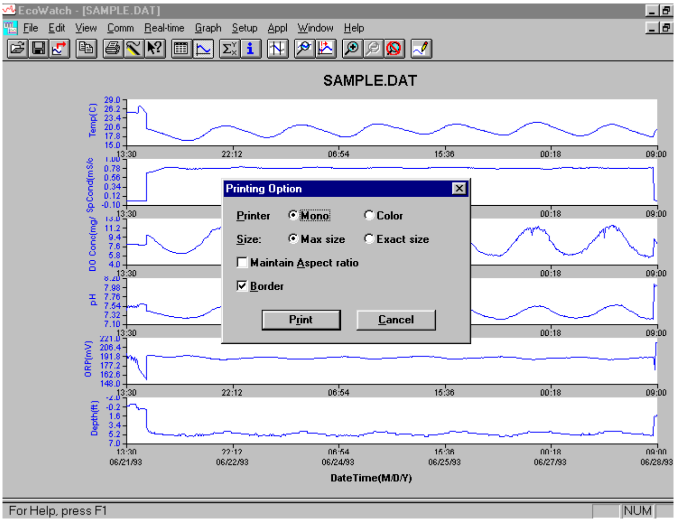
Drives: c:

Export Format
● Comma Delimited (CDF)
○ Window Meta File (WMF)

☑ Separate Time/Date

Export | Cancel | Help | Network...

Now select the 🖨 icon from the toolbar to print the plot. Accept the default settings and click OK to complete the printing operation.



Printing Option

Printer: ● Mono ○ Color

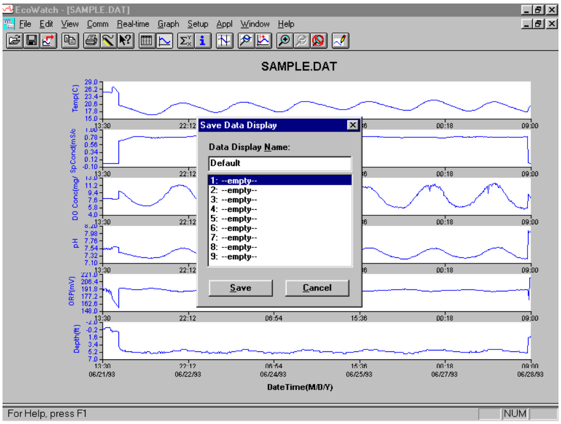
Size: ● Max size ○ Exact size

☐ Maintain Aspect ratio

☑ Border

Print | Cancel

Finally, end the tutorial by saving the **Data Display** in the format shown. From the **File** menu, click **Save Data Display**.

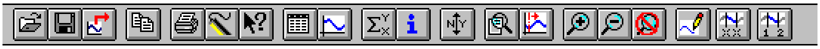


Then type "Default" for the file name and click **Save**. The parameters, colors, format, and x-axis time interval associated with the current display are now saved and can be accessed any time in the future. Nine different data displays may be saved for any data file. You can easily switch between various displays of the data. The data files can be accessed by clicking **Load Data Display** from the file menu and then selecting the desired presentation.

20.2.1 Summary of Toolbar Capability

The EcoWatch toolbar includes buttons for some of the most common commands in EcoWatch, such as **File Open**. To display or hide the toolbar, open the **View** menu and click on the **Toolbar** command. A check mark appears next to the menu item when the toolbar is displayed.

The toolbar is displayed across the top of the application window, below the menu bar.



Click To:

Open an existing data file (.DAT). EcoWatch displays the **Open** dialog box, in which you can locate and open the desired file.

Save the working Data Display of the active data file. EcoWatch displays the **Save Data Display** dialog box in which you can overwrite existing Data Display or save to a new one.

Export data as a graph in Window Meta File (.WMF) format or as data in Comma Delimited (.CDF) format.

Copy the whole graph page or data from the selection on the table to the clipboard.

Print the active graph page or table page depending on which one is currently active.

Open a new terminal window to communicate with the sonde.

Access context sensitive help (Shift+F1).

Toggle table window during file processing.

Toggle graph window during file processing.

Display study statistics.

Display study info.

Limit the data to be processed in a study.

Enlarge a selective portion of graph.

Center the graph under the cursor.

Enlarge graph or table 20%.

Reduce graph or table 20%.

Return graph or table to its normal state (unzoom)

Redraw the graph.

20.2.2 Other Capabilities

The above tutorial and function list for the toolbar provide basic information to allow you to view and analyze the field data which was stored in your 556 MPS. Some of the other commonly used capabilities of EcoWatch which the user may want to explore are listed below:

- Customize the units for each parameter, e.g., report uS/cm instead of mS/cm for conductivity.
- Customize the order of parameters in each plot or report.
- Customize the colors and fonts of each data display.
- Manually scale the y-axis sensitivity for each parameter.
- Merging of two or more data files with compatible parameter formats
- View information about the study such as number of points, instrument serial number, etc. which was stored in the 556 with the data.
- Print data reports in different statistical formats.
- Create plots of parameter vs. parameter rather than parameter vs. time.

These additional features of EcoWatch for Windows are explained in detail in the YSI 6-series manual (which can be downloaded at no cost from the YSI Web Site as described above) and the Help selection in the EcoWatch menubar. To purchase a hard copy of the 6-series manual, contact YSI Customer Service using the contact information in *Appendix E Customer Service*.

21. Appendix H Calibration Record Information

When your YSI 556 MPS sensors are initially calibrated, relevant information about the sensors will be stored in a separate file in the YSI 556 MPS memory.

NOTE: This file, by default, will have the name “556 Circuit Board Serial Number.glp.” The circuit board serial number is assigned at the factory and has a hexadecimal format such as 000080A4. Thus the default calibration record file would be designated 00080A4.glp. Refer to Section *10.7 GLP Filename* to change the filename.

The information in the calibration record will track the sensor performance of your instrument and should be particularly useful for programs operating under Good Laboratory Practices (GLP) protocols.

21.1 Viewing the Calibration Record (.glp) File

NOTE: Make certain that you have performed a calibration on at least one of the sensors associated with your YSI 556 MPS.

1. Follow the procedures outlined in Section *8.3 View File*.

21.2 Uploading the Calibration Record (.glp) File

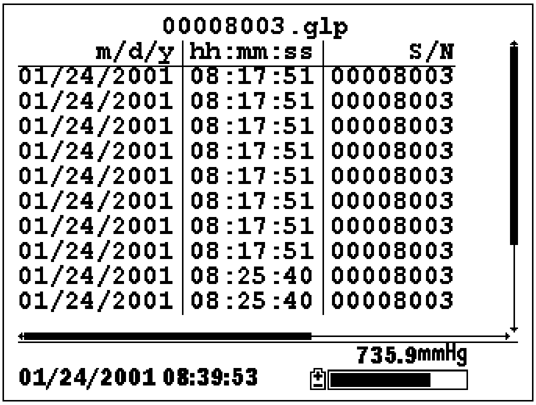
NOTE: Make certain that you have performed a calibration on at least one of the sensors associated with your YSI 556 MPS.

1. Follow the procedures outlined in Section *8.4 Upload to PC.*

21.3 Understanding the Calibration Record (.glp) File

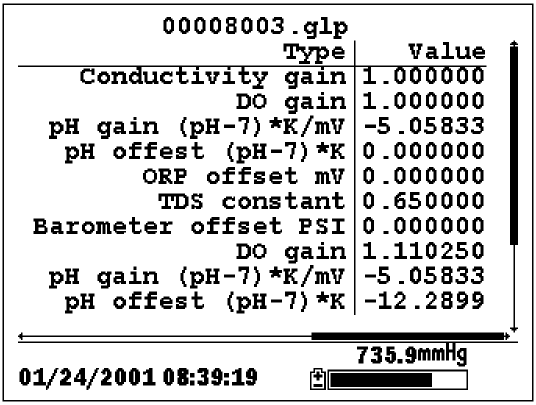
1. Open a calibration record file. Refer to Section *8.3 View File*.

2. Use the arrow keys to scroll horizontally and/or vertically to view all the data.



```
        00008003.glp
     m/d/y|hh:mm:ss|     S/N
01/24/2001|08:17:51|00008003
01/24/2001|08:17:51|00008003
01/24/2001|08:17:51|00008003
01/24/2001|08:17:51|00008003
01/24/2001|08:17:51|00008003
01/24/2001|08:17:51|00008003
01/24/2001|08:17:51|00008003
01/24/2001|08:17:51|00008003
01/24/2001|08:25:40|00008003
01/24/2001|08:25:40|00008003
                        735.9mmHg
01/24/2001 08:39:53
```

Figure 21.1 Calibration Record Screen 1



```
              00008003.glp
                      Type|   Value
       Conductivity gain|1.000000
                 DO gain|1.000000
     pH gain (pH-7)*K/mV|-5.05833
       pH offest (pH-7)*K|0.000000
           ORP offset mV|0.000000
            TDS constant|0.650000
  Barometer offset PSI|0.000000
                 DO gain|1.110250
     pH gain (pH-7)*K/mV|-5.05833
       pH offest (pH-7)*K|-12.2899
                        735.9mmHg
01/24/2001 08:39:19
```

Figure 21.2 Calibration Record Screen 2

NOTE: Each sensor (not parameter) is characterized by either 1 line (Conductivity, Dissolved Oxygen, ORP, TDS, or Barometer (Optional)) or 2 lines (pH) of calibration documentation.

The left hand portion of each calibration entry shows the date and time that a calibration of a particular sensor was performed. In addition, each calibration entry is characterized by the instrument serial number, as defined by YSI. See Figure 21.1 Calibration Record Screen 1. The right hand portion shows the YSI designation of the calibration constants and their values after their calibration has been performed. A more detailed description of the calibration constants is provided below:

- **Conductivity Gain** – A relative number which describes the sensitivity of the sensor. Basically, the value represents the calculated cell constant divided by the typical value of the cell constant (5 cm^{-1}).

- **DO Gain** – A relative number which describes the sensitivity of the sensor. Basically, the value represents the sensor current at the time of calibration divided by the typical value of the sensor current (15 uA).

- **pH Gain** – A number which basically represents the sensitivity of the pH sensor. To remove the effect of temperature on the slope of the relationship of probe output in mv versus pH, the value of pH/mv is multiplied by the temperature in degrees Kelvin (K).

- **pH Offset** – A number which basically represents the offset (or intercept) of the relationship of probe output in mv versus pH, the value of pH is multiplied by the temperature in degrees Kelvin (K).

Anytime you perform a calibration, information concerning the calibration constants will be logged to the Calibration Record file (.glp file). However, if the **Delete All Files** command is used, Refer to Section *8.6 Delete All Files*, the Calibration Record file will also be lost. It is critical that this file should be uploaded to your PC prior to issuing a **Delete All Files** command. Refer to Section *8.4 Upload to PC.*

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STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for much of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water-resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Sanford Sharpie® permanent markers.
2. On the inside cover of the log book the following information should be included:
    - Company name and address
    - Log-holders name if log book was assigned specifically to that person
    - Activity or location

- Project name
- Project manager's name
- Phone numbers of the company, supervisors, emergency response, etc.

3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."
4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.
5. Daily entries will be made chronologically.
6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.
7. Each page of the log book will have the date of the work and the note takers initials.
8. The final page of each day's notes will include the note-takers signature as well as the date.
9. Only information relevant to the subject project will be added to the log book.
10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.
2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.
3. Scope: Describe the general scope of work to be performed each day.
4. Weather: Record the weather conditions and any significant changes in the weather during the day.
5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified,

and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

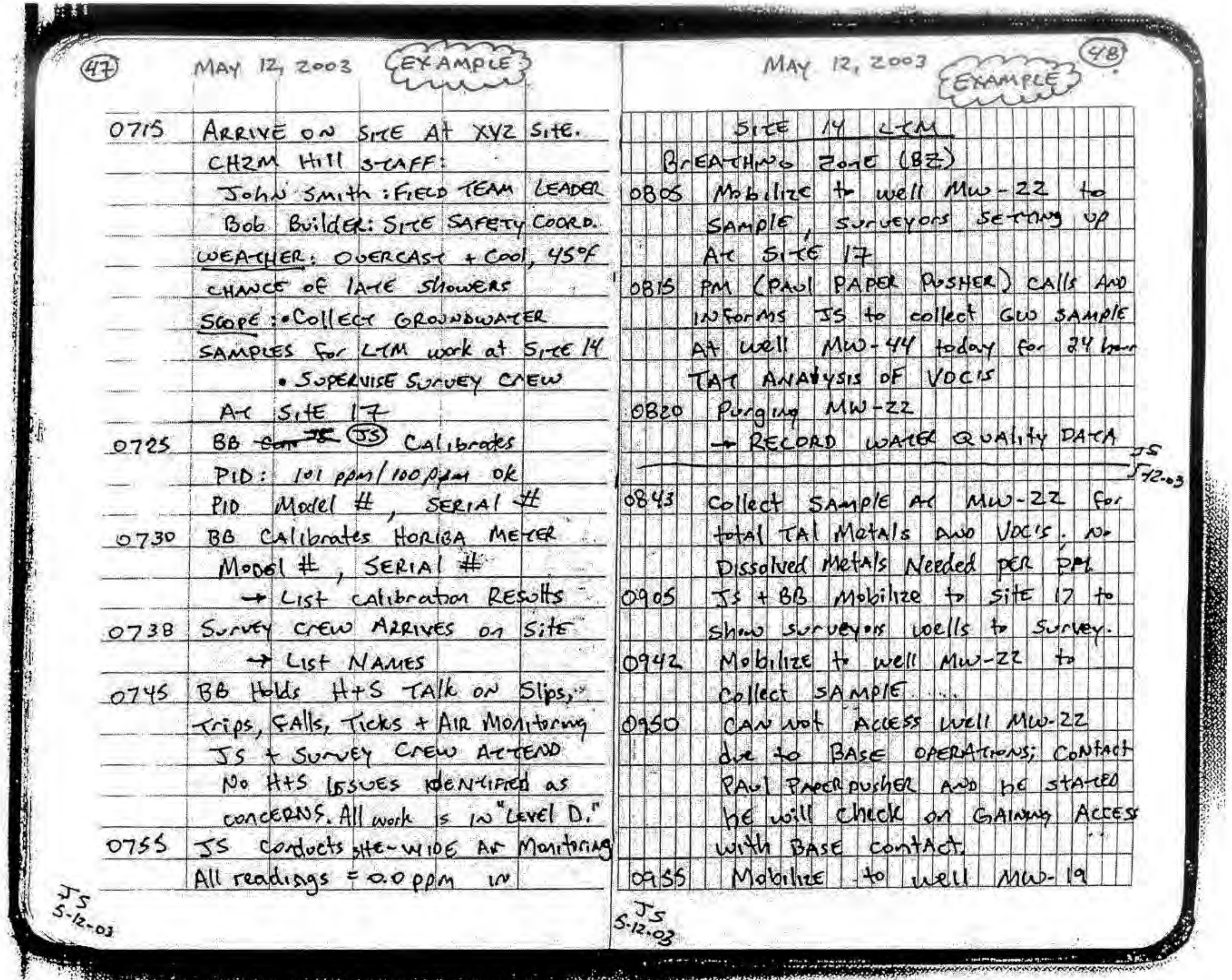
    - Description of the general sampling area – site name, buildings and streets in the area, etc.
    - Station/Location identifier
    - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
    - Sample matrix and type
    - Sample date and time
    - Sample identifier
    - Draw a box around the sample ID so that it stands out in the field notes
    - Information on how the sample was collected – distinguish between “grab,” “composite,” and “discrete” samples
    - Number and type of sample containers collected
    - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
    - Parameters to be analyzed for, if appropriate
    - Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).
2. Use tables to record sampling information and field data from multiple samples.
3. Sketch sampling locations and other pertinent information.
4. Sketch well construction diagrams.

V. Attachments

Example field notes.



㊼ MAY 12, 2003 EXAMPLE

0715 ARRIVE ON SITE At XYZ SitE.
CH2M Hill STAFF:
John Smith : FIELD TEAM LEADER
Bob Builder: SITE SAFETY COORD.
WEATHER: OVERCAST + Cool, 45°F
CHANCE OF lATE Showers
SCOPE: • Collect GROUNDWATER
SAMPLES for LTM work at SITE 14
• SUPERVISE SURVEY CREW
At SitE 17
0725 BB ~~Con JS~~ (JS) Calibrates
PID: 101 ppm/100 ppm ok
PID Model #, SERIAL #
0730 BB Calibrates HORIBA METER
MODEL #, SERIAL #
→ List calibration Results
0738 Survey crew ARRIVES on Site
→ List NAMES
0745 BB Holds H+S TAlk on Slips,
Trips, FAlls, Ticks + AIR Monitoring
JS + Survey Crew ATTEND
No H+S ISSUES IdENTIFIED as
concERNS. All work is in "Level D."
0755 JS conducts site-wide Air Monitoring
All readings = 0.0 ppm in

JS
5-12-03

MAY 12, 2003 EXAMPLE ㊽

SITE 14 LTM
BrEATHING ZONE (BZ)
0805 Mobilize to well MW-22 to
SAmple, surveyors setting up
At SITE 17
0815 PM (PAUL PAPER PUSHER) CAlls AND
INforms JS to collect GW SAMPLE
At well MW-44 today for 24 hour
TAT ANALYSIS OF VOC'S
0820 Purging MW-22
→ RECORD WATER QUAlity DATA

JS
5-12-03

0843 Collect SAmple At MW-22 for
total TAL Metals AND VOC'S, no
Dissolved Metals Needed per PM
0905 JS + BB Mobilize to site 17 to
show surveyors wells to survey.
0942 Mobilize to well MW-22 to
Collect SAMPLE
0950 CAN not ACCESS well MW-22
due to BASE OPERATIONS; CONTACT
PAUL PAPERPUSHER AND he stated
he will check on GAINING ACCESS
with BASE contAct.
0955 Mobilize to well MW-19

JS
5-12-03

Standard Operating Procedure

Locating and Clearing Underground Utilities

I. Purpose

The purpose of this SOP is to provide general guidelines and specific procedures that must be followed on Navy CLEAN projects for locating underground utilities and clearing dig locations in order to maximize our ability to avoid hitting underground utilities and to minimize liabilities to CH2M HILL and its subcontractors and health and safety risks to our project staff.

This SOP shall be used by Activity Managers and Project Managers to, in-turn, develop Activity-specific and project-specific utility location procedures. The activity and project-specific procedures will become part of work plans and project instructions and will be used to prepare scopes of work (SOWs) for the procurement of utility location subcontractors to meet the needs of individual projects.

This SOP also identifies the types of utility locating services that are available from subcontractors and the various tools that are used to locate utilities, and discusses when each type of service and tool may or may not be applicable.

II. Scope

Depending on the Navy/Marine Activity we typically find ourselves in one of two scenarios:

Scenario 1

The Activity provides utility locating (or dig clearance) services through the public works department or similar organization, or has a contract with an outside utility clearance service. Some of these services are provided in the form of dig permits which are required before you can dig or drill. In other cases, no official permit is required and the process is somewhat vague.

Scenario 2

The Activity does not get involved in any utility locating processes aside from possibly providing the most recent utility maps, and relies on CH2M HILL to clear the dig locations.

Table 1 provides an up to date summary of which scenarios apply to the various primary Activities served under the Navy CLEAN program.

Scenario 1 is preferred because under this scenario the Navy tends to assume the responsibility if the location is improperly cleared, a utility is struck, and property damage results. However, our experience has been that the clearance services provided by the Navy do not meet the standards that we consider to be adequate, in that they often simply rely on available base maps to mark utilities and do not verify locations using field geophysics. And if they do use locating tools, they do not provide adequate documentation or marking to confirm that a location has been cleared. So while the Navy's process may protect us from liability for property damage, it does not adequately protect our staff and subcontractors from health risks nor does it compensate us for down time, should a utility be hit.

Therefore, regardless of what services the Navy provides, in most cases we still need to supplement this effort with clearance services from our own third party utility location subcontractor following the procedures and guideline outlined in Section IV of this SOP. The cost implications of providing this service will range from $500 to several $1,000 depending on the size of the project.

The scope of services that we ask our subcontractors to provide can involve utility marking/mapping or the clearing of individual dig locations. In the former we ask our subs to mark all utilities within a "site" and often ask them to prepare a map based on their work. In the later, we ask them to clear (identify if there are any utilities within) a certain radius of a proposed dig/drill location.

The appropriate requested scope of services for a project will depend on the project. Clearing individual boreholes is often less expensive and allows the sub to concentrate their efforts on a limited area. However, if the scope of the investigation is fluid (all borehole locations are not predetermined) it may be best to mark and map an entire site or keep the subcontractor on call.

Clearance of individual dig locations should be done to a minimum 20-foot radius around the location.

An example SOW for a utility subcontractor procurement is provided in Attachment A.

III. Services and Equipment

This section provides a general description of the services available to help us locate subsurface utilities and describes the types of equipment that these services may (or may not) use to perform their work. It identifies the capabilities of each type of equipment to help the PM specify what they should require from our utility location subs.

Services

The services that are available to us for identifying and marking underground utilities are:

- The local public/private utility-run service such as Miss Utility
- Utility location subcontractors (hired by us)

Attachment B provides a detailed description of each type of organization. It also provides contact numbers and web sites for the various Miss-Utility-type organizations in the areas where we do work for the Navy and contacts and services provided by several subcontractors that we have used or spoken to in the past.

Equipment

Attachment C provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the PM determine if the equipment being used by a subcontractor is adequate.

It is important to make the potential subcontractors aware of the possible types of utilities (and utility materials) that are at the site, and to have them explain in their bid what types of equipment they will use to locate utilities /clear dig locations, and what the limitations of these equipment are.

A list of in-house experts that can be used to help you evaluate bids or answer questions you may have is provided in **Appendix C.**

IV. Procedures and Guidelines

This section presents specific procedures to be followed for the utility location work to be conducted by CH2M HILL and our subcontractors. In addition, a PM will have to follow the procedures required by the Activity to obtain their approvals, clearances and dig permits where necessary. These "dig permit" requirements vary by Activity and must be added to the project-specific SOP, or project instructions. It is preferable that the Activity perform their clearance processes before we follow up with our clearance work.

Activity Notification and Dig Permit Procedures

Identify Activity-specific permit and/or procedural requirements for excavation and drilling activities. Contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Activity Specific: To be provided by Activity or Project Manager

CH2M HILL Utility Clearance Procedures

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted by CH2M HILL as a follow-up to the services provided by the Navy. The use of as-built drawings and utility company searches must be supplemented with a geophysical or other survey by a qualified, independent survey contractor (subcontracted to CH2M HILL) to identify additional and undiscovered buried utilities.

Examples of the type of geophysical technologies include (these are further described in Attachment C):

- **Ground Penetrating Radar (GPR),** which can detect pipes, including gas pipes, tanks, conduits, cables etc, both metallic and non-metallic at depths up to 30 feet depending on equipment. Sensitivity for both minimum object size and maximum depth detectable depends on equipment selected, soil conditions, etc.
- **Radio Frequency (RF),** involves inducing an RF signal in the pipe or cable and using a receiver to trace it. Some electric and telephone lines emit RF naturally and can be detected without an induced signal. This method requires knowing where the conductive utility can be accessed to induce RF field if necessary.

- **Dual RF**, a modified version of RF detection using multiple frequencies to enhance sensitivity but with similar limitations to RF
- **Ferromagnetic Detectors**, are metal detectors that will detect ferrous and non-ferrous utilities. Sensitivity is limited, e.g. a 100 mm iron disk to a depth of about one meter or a 25 mm steel paper clip to a depth of about 20 cm.
- **Electronic markers,** are emerging technologies that impart a unique electronic signature to materials such as polyethylene pipe to facilitate location and tracing after installation. Promising for future installations but not of help for most existing utilities already in place.

The following procedures shall be used to identify and mark underground utilities during subsurface construction activities on the project:

- Contact utility companies or the state/regional utility protection service (such as Miss Utility) at least two (2) working days prior to intrusive activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation: this is a law. These services will only mark the location of public-utility-owned lines and not Navy-owned utilities. In many cases there will not be any public-utility-owned lines on the Activity. There may also be Base-access issues to overcome.
- Procure and schedule the independent survey.
- The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project site, based on the survey contractor's experience and expertise, types of utilities anticipated to be present and specific site conditions. ***The types of utilities must be provided to the bidding subcontractors in the SOW and procedures to be used must be specified by the bidder in their bid. It is extremely helpful to provide the sub with utility maps, with the caveat that all utilities are not necessarily depicted.***
- The survey subcontractor shall employ the same geophysical techniques used to identify the buried utilities, to survey the proposed path of subsurface investigation/construction work to confirm no buried utilities are present.
- Obtain utility clearances for subsurface work on both public and private property.
- Clearances provided by both the "Miss Utility" service and the CH2M HILL-subcontracted service are to be in writing, signed by the party conducting the clearance. The Miss Utility service will have standard notification forms/letters which typically simply state that they have been to the site and have done their work. The CH2M HILL subcontractor shall be required to fill out the form provided in Attachment D (this can be modified for a particular project) indicating that each dig/drill location has been addressed. ***This documentation requirement (with a copy of the form) needs to be provided in the subcontractor SOW.***
- Marking shall be done using the color coding presented in Attachment E. The type of material used for marking must be approved by the Activity prior to marking. Some base commanders have particular issues with persistent spray paint on their

sidewalks and streets. ***Any particular marking requirements need to be provided in the subcontractor SOW.***

- Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.
- Perform a field check prior to drilling/digging (preferably while the utility location sub is still at the site) to see if field utility markings coincide with locations on utility maps. Look for fire hydrants, valves, manholes, light poles, lighted signs, etc to see if they coincide with utilities identified by the subcontractor.
- Underground utility locations must be physically verified (or dig locations must be physically cleared) by hand digging using wood or fiberglass-handled tools, air knifing, or by some other acceptable means approved by CH2M HILL, when the dig location (e.g. mechanical drilling, excavating) is expected to be within 5 feet of a marked underground system. Hand clearance shall be done to a depth of four feet unless a utility cross-section is available that indicates the utility is at a greater depth. In that event, the hand clearance shall proceed until the documented depth of the utility is reached.
- Conduct a site briefing for employees at the start of the intrusive work regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon during drilling or change in color, texture or density during excavation that could indicate the ground has been previously disturbed).

IV. Attachments

A- Example SOW for Utility Location Subcontractor Procurement
B - Services Available for Identifying and Marking Underground Utilities
C – Equipment Used for Identifying Underground Utilities
D – Utility Clearance Documentation Form
E – Utility Marking Color Codes

Attachment A – Example SOW for Subcontracting Underground Utilities Locating Services

CTO-XXX

Scope of Work

Subsurface Utility Locating

Site XX

Navy Activity

City, State

A licensed and insured utility locator will be subcontracted to identify and mark out subsurface utilities for an environmental investigation/remediation project at Site XX of <<insert name of base, city, and state>>. The subcontractor will need to be available beginning at <<insert time>> on <<insert date>>. It is estimated that the work can be completed within XX days.

Proposed Scope of Work

The subcontractor will identify and mark all subsurface utilities (CHOOSE 1) that lie within a radius of 20 feet of each of XX sampling locations at Site XX shown on the attached Figure 1; (OR) that lie within the bounds of Site XX as delineated on the attached Figure 1. (If multiple sites are to be cleared, provide maps of each site with sample locations or clearance boundaries clearly delineated and a scale provided.)

Utilities will be identified using all reasonably available as-built drawings, electronic locating devices, and any other means necessary to maintain the safety of drilling and sampling personnel and the protection of the base infrastructure. The location of utilities identified from as-built drawings or other maps must be verified in the field prior to marking.

Base utility drawings for the Site(s) (CHOOSE 1) can be found at <<insert specific department and address or phone number on the base>> and should be reviewed by the subcontractor and referenced as part of the utility locating. (OR), will be provided to the subcontractor by CH2M HILL upon the award of the subcontract. (OR), are not available. Utility drawings shall not be considered definitive and must be field verified.

Field verification will include detection using nonintrusive subsurface detection equipment (magnetometers, GPR, etc) as well as opening manhole covers to verify pipe directions. As part of the bid, the Subcontractor shall provide a list of the various subsurface investigation tools they propose to have available and use at the site and what the limitations are of each tool.

A CH2M HILL representative shall be present to coordinate utility clearance activities and identify points and features to be cleared.

Field Marking and Documentation

All utilities located within **(CHOOSE 1)** ***a 20-ft radius of the XX proposed soil boring locations*** **(OR)** ***within the boundary of the site(s)*** as identified on the attached figure(s) will be marked using **paint** ***(some Bases such as the WNY may have restrictions on the use of permanent paint)*** and/or pin flags color coded to indicate electricity, gas, water, steam, telephone, TV cable, fiber optic, sewer, etc. The color coding shall match the industry standard as described on the attached form. In addition, the ***Buried Utility Location Tracking Form*** (attached) will be completed by the Subcontractor based upon what is identified in the field during the utility locating and submitted back to CH2M HILL (field staff or project manager) within 24 hours of completing the utility locating activities.

(OPTIONAL) ***The subcontractor shall also provide a map (or hand sketch) of the identified utilities to the Engineer within XX days of field demobilization. The map shall include coordinates or ties from fixed surface features to each identified subsurface utility.***

Bid Sheet/Payment Units

The subcontractor will bid on a time and materials basis for time spent on site and researching utility maps. Mobilization (including daily travel to the site) should be bid as a lump sum, as well as the preparation of the AHA and any required mapping. The per diem line item should be used if the field crew will require overnight accommodations at the project site.

Health and Safety Requirements

The utility locating subcontractor is to provide and assume responsibility for an adequate corporate Health and Safety Plan for onsite personnel. Standard personal safety equipment including: hard hat, safety glasses, steel-toed boots, gloves are recommended for all project activities. Specific health and safety requirements will be established by the Subcontractor for each project. The health and safety requirements will be subject to the review of CH2M HILL.

The subcontractor shall also prepare and provide to the Engineer, at least 48 hours prior to mobilization, an acceptable Activity Hazard Analysis (AHA) using the attached AHA form or similar.

It is also required that all subcontractor personnel who will be on site attend the daily 15-minute health and safety tailgate meeting at the start of each day in the field.

Subcontractor personnel showing indications of being under the influence of alcohol or illegal drugs will be sent off the job site and their employers will be notified. Subcontractor personnel under the influence of prescription or over-the-counter medication that may impair their ability to operate equipment will not be permitted to do so. It is expected that the subcontractor will assign them other work and provide a capable replacement (if necessary) to operate the equipment to continue work.

Security

The work will be performed on US Navy property. CH2M HILL will identify the Subcontractor personnel who will perform the work to the appropriate Navy facility point-of-contact, and will identify the Navy point-of-contact to the Subcontractor crew. The Subcontractor bears final responsibility for coordinating access of his personnel onto Navy property to perform required work. This responsibility includes arranging logistics and providing to CH2M HILL, in advance or at time of entry as specified, any required identification information for the Subcontractor personnel. Specifically, the following information should be submitted with the bid package for all personnel that will perform the work in question (this information is required to obtain a base pass):

- Name
- Birth Place
- Birth Date
- Social Security Number
- Drivers License State and Number
- Citizenship

Please be advised that no weapons, alcohol, or drugs will be permitted on the Navy facility at any time. If any such items are found, they will be confiscated, and the Subcontractor will be dismissed.

Quality Assurance

The Subcontractor will be licensed and insured to operate in the State of <<state>> and will comply with all applicable federal, state, county and local laws and regulations. The subcontractor will maintain, calibrate, and operate all electronic locating instruments in accordance with the manufacturer’s recommendations. Additionally, the Subcontractor shall make all reasonable efforts to review as-built engineering drawings maintained by Base personnel, and shall notify the CH2M HILL Project Manager in writing (email is acceptable) whenever such documentation was not available or could not be reviewed.

Subcontractor Standby Time

At certain periods during the utility locating activities, the Subcontractor’s personnel may be asked to stop work and standby when work may normally occur. During such times, the Subcontractor will cease activities until directed by the CH2M HILL representative to resume operations. Subcontractor standby time also will include potential delays caused by the CH2M HILL representative not arriving at the site by the agreed-upon meeting time for start of the work day. Standby will be paid to the

Subcontractor at the hourly rate specified in the Subcontractor's Bid Form attached to these specifications.

Cumulative Subcontractor standby will be accrued in increments no shorter than 15 minutes (i.e., an individual standby episode of less than 15 minutes is not chargeable).

During periods for which standby time is paid, the surveying equipment will not be demobilized and the team will remain at the site. At the conclusion of each day, the daily logs for the Subcontractor and CH2M HILL representative will indicate the amount of standby time incurred by the Subcontractor, if any. Payment will be made only for standby time recorded on CH2M HILL's daily logs.

Down Time

Should equipment furnished by the Subcontractor malfunction, preventing the effective and efficient prosecution of the work, or inclement weather conditions prevent safe and effective work from occurring, down time will be indicated in the Subcontractor's and CH2M Hill representative's daily logs. No payment will be made for down time.

Schedule

It is anticipated that the subsurface utility locating activities will occur on <<insert date>>. It is estimated that the above scope will be completed within XXX days.

Attachment B - Services Available for Identifying and Marking Underground Utilities

The services that are available to us for identifying and marking underground utilities are:

- The Activity's PWC (or similar organization)
- The local public/private utility -run service such as Miss Utility
- Utility location subcontractors (hired by CH2M HILL)

Each are discussed below.

Navy Public Works Department

A Public Works Department (PWD) is usually present at each Activity. The PWD is responsible for maintaining the public works at the base including management of utilities. In many cases, the PWD has a written permit process in place to identify and mark-out the locations of Navy-owned utilities [Note: The PWD is usually NOT responsible for the locations/mark-outs of non-Navy owned, public utilities (e.g., Washington Gas, Virginia Power, municipal water and sewer, etc.). Therefore, it is likely that we will have to contact other organizations besides the PWD in order to identify non-Navy owned, public utilities].

At some Activities, there may not be a PWD, the PWD may not have a written permit process in place, or the PWD may not take responsibility for utility locating and mark-outs. In these cases, the PWD should still be contacted since it is likely that they will have the best understanding of the utility locations at the Activity (i.e., engineering drawings, institutional knowledge, etc.). Subsequently, the PWD should be brought into a cooperative arrangement (if possible) with the other services employed in utility locating and mark-out in order to have the most comprehensive assessment performed.

At all Activities we should have a contact (name and phone number), and preferably an established relationship, with PWD, either directly or through the NAVFAC Atlantic, Midlant, or Washington NTR or Activity Environmental Office that we can work with and contact in the event of problems.

Miss Utility or "One Call" Services for Public Utility Mark-outs

Miss Utility or "One Call" service centers are information exchange centers for excavators, contractors and property owners planning any kind of excavation or digging. The "One Call" center notifies participating public utilities of the upcoming excavation work so they can locate and mark their underground utilities in advance to prevent possible damage to underground utility lines, injury, property damage and service outages. In some instances, such with southeastern Virginia bases, the Navy has entered into agreement with Ms. Utilities and is part of the response process for Miss

Utilities. Generally, a minimum of 48 hours is required for the public utility mark-outs to be performed. The “One Call” services are free to the public. Note that the “One Call” centers only coordinate with participating public utilities. There may be some public utilities that do NOT participate in the “One Call” center which may need to be contacted separately. For example, in Washington, DC, the Miss Utility “One Call” center does not locate and mark public sewer and water lines. Therefore, the municipal water and sewer authority must be contacted separately to have the sewer and water lines marked out. The AM should contact the appropriate one-call center to determine their scope of services.

For the Mid-Atlantic region, the following “One Call” service centers are available.

Name	**Phone**	**Website**	**Comments**
Miss Utility of DELMARVA	800-257-7777	www.missutility.net	Public utility mark-outs in Delaware, Maryland, Washington, DC, and Northern Virginia
Miss Utility of Southern Virginia (One Call)	800-552-7001	not available	Public utility mark-outs in Southern Virginia
Miss Utility of Virginia	800-257-7777 800-552-7007	www.missutilityofvirginia.com	General information on public utility mark-outs in Virginia, with links to Miss Utility of DELMARVA and Miss Utility of Southern Virginia (One Call)
Miss Utility of West Virginia, Inc	800-245-4848	none	Call to determine what utilities they work with in West Virginia
North Carolina One Call Center	800-632-4949	www.ncocc.org/ncocc/default.htm	Public Utility Markouts in North Carolina

Private Subcontractors

1. Utility-locating support is required at some level for most all CH2M HILL field projects in "clearing" proposed subsurface boring locations on the project site. Utility location and sample clearance can include a comprehensive effort of GIS map interpretation, professional land surveying, field locating, and geophysical surveying. Since we can usually provide our own GIS-related services for projects and our professional land surveying services are normally procured separately, utility-locating subcontractors will normally only be required for some level of geophysical surveying support in the field. This level of geophysical surveying support can range widely from a simple electromagnetic (EM) survey over a known utility line, to a blind geophysical effort, including a ground-penetrating radar (GPR) survey and/or a comprehensive EM survey to delineate and characterize all unknown subsurface anomalies.

   The level of service required from the subcontractor will vary depending on the nature of the site. At sites where utility locations are well defined on the maps and recent construction is limited, CH2M HILL may be confident with a limited effort from a traditional utility-locating subcontractor providing a simple EM survey. At sites where utility locations are not well defined, where recent constructions may have altered utility locations, or the nature of the site makes utility location difficult, CH2M HILL will require the services of a comprehensive geophysical surveying subcontractor, with a wide range of GPR and EM services available for use on an "as-needed" basis. Typical costs for geophysical surveying subcontractors will range from approximately $200 per day for a simple EM effort (usually one crew member and one instrument) to approximately $1,500 per day for a comprehensive geophysical surveying effort (usually a two-person crew and multiple instruments). Comprehensive geophysical surveying efforts may also include field data interpretation (and subsequent report preparation) and non-destructive excavation to field-verify utility depths and locations.

The following table provides a list of recommended geophysical surveying support subcontractors that can be used for utility-locating services:

Company Name and Address	Contact Name and Phone Number	Equipment[1]					Other Services[2]		
		1	2	3	4	5	A	B	C
US Radar, Inc.* PO Box 319 Matawan, NJ 07747	Ron LaBarca 732-566-2035			4					
Utilities Search, Inc.*	Jim Davis 703-369-5758	4				4	4	4	4
So Deep, Inc.* 8397 Euclid Avenue Manassas Park, VA 20111	703-361-6005	4					4	4	4
Accurate Locating, Inc. 1327 Ashton Rd., Suite 101 Hanover, MD 21076	Ken Shipley 410-850-0280	4	4						
NAEVA Geophysics, Inc. P.O. Box 7325 Charlottesville, VA 22906	Alan Mazurowski 434-978-3187	4	4	4	4	4	4	4	4
Earth Resources Technology. Inc. 8106 Stayton Rd. Jessup, MD 20794	Peter Li 240-554-0161	4	4	4	4	4	4	4	
Geophex, Ltd 605 Mercury Street Raleigh, NC 27603	I. J. Won 919-839-8515	4	4	4	4	4	4	4	4

Notes:

*Companies denoted with an asterisk have demonstrated reluctance to assume responsibility for damage to underground utilities or an inability to accommodate the insurance requirements that CH2M HILL requests for this type of work at many Navy sites.

[1] Equipment types are:

1. Simple electromagnetic instruments, usually hand-held
2. Other, more innovative, electromagnetic instruments, including larger instruments for more area coverage
3. Ground-penetrating radar systems of all kinds
4. Audio-frequency detectors of all kinds
5. Radio-frequency detectors of all kinds

[2] Other services include:

A. Data interpretation and/or report preparation to provide a permanent record of the geophysical survey results and a professional interpretation of the findings, including expected accuracy and precision.

B. Non-destructive excavation to field-verify the depths, locations, and types of subsurface utilities.

C. Concrete/asphalt coring and pavement/surface restoration.

Attachment C – Equipment Used for Identifying Underground Utilities

This attachment provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the AM and PM determine if the equipment being proposed by a subcontractor or Navy is adequate. A list of in-house experts that can be used to answer questions you may have is provided below.

CH2M HILL In-house Utility Location Experts

Tamir Klaff/WDC

Home Office Phone – 703-669-9611

Electromagnetic Induction (EMI) Methods

EMI instruments, in general, induce an electromagnetic field into the ground (the primary field) and then record the response (the secondary field), if any. Lateral changes in subsurface conductivity, such as caused by the presence of buried metal or by significant soil variations, cause changes in the secondary field recorded by the instrument and thus enable detection and mapping of the subsurface features. It should be noted that EMI only works for electrically conductive materials--plastic or PVC pipes are generally not detected with EMI. Water and gas lines are commonly plastic, although most new lines include a copper "locator" strip on the top of the PVC to allow for detection with EMI.

EMI technology encompasses a wide range of instruments, each with inherent strengths and weaknesses for particular applications. One major division of EMI is between "time-domain" and "frequency-domain" instruments that differ in the aspect of the secondary field they detect. Another difference in EMI instruments is the operating frequency they use to transmit the primary field. Audio- and radio-frequencies are often used for utility detection, although other frequencies are also used. Consideration of the type of utility expected, surface features that could interfere with detection, and the "congestion" of utilities in an area, should be made when choosing a particular EMI instrument for a particular site.

One common EMI tool used for utility location is a handheld unit that can be used to quickly scan an area for utilities and allows for marking locations in "real time". This method is most commonly used by "dig-safe" contractors marking out known utilities prior to excavation. It should be noted that this method works best when a signal (the primary field) can be placed directly onto the line (i.e., by clamping or otherwise connecting to the end of the line visible at the surface, or for larger utilities such as sewers, by running a transmitter through the utility). These types of tools also have a limited capability to scan an area for unknown utilities. Usually this requires having enough area to separate a hand held transmitter at least a hundred feet from the receiver. Whether hunting for unknown, or confirming known, utilities, this method will only detect continuous lengths of metallic conductors.

In addition to the handheld EMI units, larger, more powerful EMI tools are available that provide more comprehensive detection and mapping of subsurface features. Generally, data with these methods are collected on a regular grid in the investigation area, and are then analyzed to locate linear anomalies that can be interpreted as utilities. These methods will usually detect *all* subsurface metal (above a minimum size), including pieces of abandoned utilities. In addition, in some situations, backfill can be detected against native soils giving information on trenching and possible utility location. Drawbacks to these methods are that the secondary signals from utilities are often swamped (i.e., undetectable) close to buildings and other cultural features, and that the subsurface at heavily built-up sites may be too complicated to confidently interpret completely.

Hand-held metal detectors (treasure-finders) are usually based on EMI technology. They can be used to locate shallow buried metal associated with utilities (e.g., junctions, manholes, metallic locators). Advantages of these tools is the ease of use and real-time marking of anomalies. Drawbacks include limited depths of investigations and no data storage capacity.

Ground Penetrating Radar (GPR)

GPR systems transmit radio and microwave frequency (e.g., 80 megaHertz to 1,000 megaHertz) waves into the ground and then record reflections of those waves coming back to the surface. Reflections of the radar waves typically occur at lithologic changes, subsurface discontinuities, and subsurface structures. Plastic and PVC pipes can sometimes be detected in GPR data, especially if they are shallow, large, and full of a contrasting material such as air in a wet soil, or water in a dry soil. GPR data are usually collected in regular patterns over an area and then analyzed for linear anomalies that can be interpreted as utilities. GPR is usually very accurate in x-y location of utilities, and can be calibrated at a site to give very accurate depth information as well. A significant drawback to GPR is that depth of investigation is highly dependant on background soil conductivity, and it will not work on all sites. It is not uncommon to get only 1-2 feet of penetration with the signal in damp, clayey environments. Another drawback to GPR is that sites containing significant fill material (e.g., concrete rubble, scrap metal, garbage) will result in complicated anomalies that are difficult or impossible to interpret.

Magnetic Field Methods

Magnetic field methods rely on detecting changes to the earth’s magnetic field caused by ferrous metal objects. This method is usually more sensitive to magnetic metal (i.e., deeper detection) than EMI methods. A drawback to this method is it is more susceptible to being swamped by surface features such as fences and cars. In addition, procedures must usually be implemented that account for natural variations in the earth’s background field as it changes throughout the day. One common use of the method is to measure and analyze the gradient of the magnetic field, which eliminates most of the drawbacks to the method. It should be noted this method only detects ferrous metal, primarily iron and steel for utility location applications. Some utility detector combine magnetic and EMI methods into a single hand-held unit.

Optical Methods

Down the hole cameras may be useful in visually reviewing a pipe for empty conduits and/or vaults.

Attachment D – Utility Clearance Documentation Form

Attachment E – Utility Marking Color Codes

The following is the standard color code used by industry to mark various types of utilities and other features at a construction site.

White – Proposed excavations and borings

Pink – Temporary survey markings

Red – Electrical power lines, cables, conduits and lighting cables

Yellow – Gas, oil, steam, petroleum or gaseous materials

Orange – Communication, alarm or signal lines, cables, or conduits

Blue – Potable water

Purple – Reclaimed water, irrigation and slurry lines

Green – Sewer and storm drain lines

PMS 219

PMS 1795*

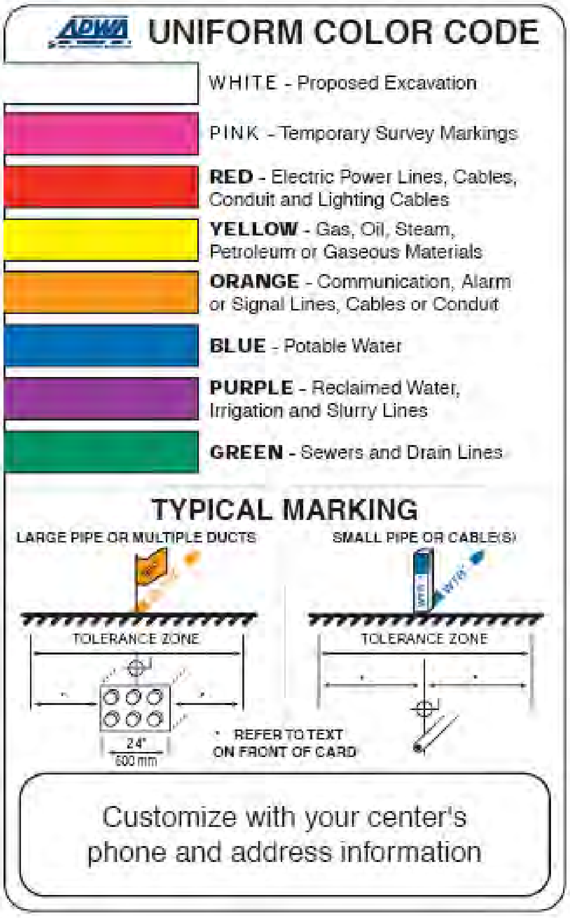
PMS 108

PMS 144*

13.5 parts process
2.5 parts reflex

PMS 253

PMS 3415



APWA UNIFORM COLOR CODE

⬜	WHITE - Proposed Excavation
■	PINK - Temporary Survey Markings
🟥	**RED** - Electric Power Lines, Cables, Conduit and Lighting Cables
🟨	**YELLOW** - Gas, Oil, Steam, Petroleum or Gaseous Materials
🟧	**ORANGE** - Communication, Alarm or Signal Lines, Cables or Conduit
🟦	**BLUE** - Potable Water
🟪	**PURPLE** - Reclaimed Water, Irrigation and Slurry Lines
🟩	**GREEN** - Sewers and Drain Lines

TYPICAL MARKING

* REFER TO TEXT ON FRONT OF CARD

Customize with your center's phone and address information

GUIDELINES FOR UNIFORM TEMPORARY MARKING OF UNDERGROUND FACILITIES

This marking guide provides for universal use and understanding of the temporary marking of subsurface facilities to prevent accidents and damage or service interruption by contractors, excavators, utility companies, municipalities or any others working on or near underground facilities.

ONE-CALL SYSTEMS
The One-Call damage prevention system shall be contacted prior to excavation.

PROPOSED EXCAVATION
Use white marks to show the location, route or boundary of proposed excavation. Surface marks on roadways do not exceed 1.5" by 18" (40 mm by 450 mm). The facility color and facility owner identity may be added to white flags or stakes.

USE OF TEMPORARY MARKING
Use color-coded surface marks (i.e., paint or chalk) to indicate the location or route of active and out-of-service buried lines. To increase visibility, color coded vertical markers (i.e., stakes or flags) should supplement surface marks. Marks and markers indicate the name, initials or logo of the company that owns or operates the line, and width of the facility if it is greater than 2" (50 mm). Marks placed by other than line owner/operator or its agent indicate the identity of the designating firm. Multiple lines in joint trench are marked in tandem. If the surface over the buried line is to be removed, supplementary offset markings are used. Offset markings are on a uniform alignment and clearly indicate the actual facility is a specific distance away.

TOLERANCE ZONE
Any excavation within the tolerance zone is performed with non-powered hand tools or non-invasive method until the marked facility is exposed. The width of the tolerance zone may be specified in law or code. If not, a tolerance zone including the width of the facility plus 18" (450 mm) measured horizontally from each side of the facility is recommended.

ADOPT UNIFORM COLOR CODE
The American Public Works Association encourages public agencies, utilities, contractors, other associations, manufacturers and all others involved in excavation to adopt the APWA Uniform Color Code, using ANSI standard Z535.1 Safety Colors for temporary marking and facility identification.

Rev. 4/99

Buried Utility Location Tracking Form

(Submit to CH2M HILL PM within 24 hrs of location activities)

Project Location:
CH2M HILL Project No.:
CH2M HILL Project Manager: Name/Phone:
Fax:
Email:
CH2M HILL Field Team Leader: Name/Phone:

CH2M HILL Purchase Order:

Utility Location Subcontractor:
Subcontractor POC:

Dates of location activities:

	Check each box using an "X" if a buried utility is present within 5 feet of a marked Station ID. If color of the flag or paint differs from listed color, note change in color on the form.																	
Station ID	**Gas (Yellow)**	**Electric (Red)**	**Fiber optic (Orange)**	**Cable (Orange)**	**Water (Blue)**	**San. Sewer (Green)**	**Storm Sewer (Green)**	**Steam (Yellow)**	**Petroleum (Yellow)**	**Compressed air (Yellow)**	**Other ___**	**Other ___**	**Other ___**	**Other ___**	**Date completed**	**Technician initials**	Notes (methods/tools use

The findings of the buried utility location activities summarized herein were conducted in strict accordance with the CH2M HILL scope of work.

______________________________ _____________
Subcontractor's Signature Date

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Purging and Sampling Monitoring Wells plus Guidance on Collecting Samples for Volatiles and other Organic Compounds

Version 2.0

Author - Pamela B. Marti
Date -

Unit Approval Martha Maggi, Groundwater/Forests & Fish Unit Supervisor
Date -

Section Approval – Will Kendra, Statewide Coordination Section Manager
Date -

QA Approval - William R. Kammin, Ecology Quality Assurance Officer
Date -

EAP078

APPROVED: 1/27/2014

Signatures on File

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
1/27/2014	2.0	Minor edits all sections, added Appendix B	All, added Append B	Pam Marti

TABLE OF CONTENTS

Page

Environmental Assessment Program

Standard operating procedure for purging and sampling monitoring wells.

1.0 Purpose and Scope

1.1 The Environmental Assessment Program (EAP) is responsible for measuring, assessing, and reporting information about the environmental condition and health of Washington’s land and water resources. This information is used by resource managers, policymakers, and others to help protect and manage Washington’s environment. As such there is a need to document and ensure that consistent and scientifically defensible practices, procedures, and techniques are used by EAP staff, and that the data and information they provide are of consistent and high quality.

1.2 The goals for collecting groundwater samples from monitoring wells are varied, but can include: characterizing ambient conditions, defining the nature and extent of groundwater problems; or determining trends in contaminant concentrations with time, location, or both.

1.3 Groundwater measurements and samples should be as representative of in situ conditions as possible. Several factors such as changes in temperature, pressure, and exposure to air can alter the groundwater chemistry during the sampling process. This SOP summarizes the general procedures and practices that EAP staff use to help ensure that representative groundwater samples are collected when sampling wells that do not typically have installed or dedicated pumps (e.g. monitoring wells).

2.0 Applicability

2.1 This SOP applies to EAP staff collecting and handling groundwater samples from monitoring wells or other wells that do not have a dedicated down-hole pump. It provides general information to help guide field staff in proper purging and sampling techniques. Field staff are encouraged to supplement the information in this SOP by reviewing the large body of existing literature on the science of groundwater sampling (see reference list). Alternative procedures are allowed as long as they are properly documented in the project Quality Assurance Project Plan (QAPP), and provide scientifically valid and legally defensible groundwater data.

2.2 Field staff should be familiar with other standard procedures related to activities described in this SOP (e.g. measurement of groundwater levels, use of GPS equipment, etc). Depending on the analyte(s) being sampled, there can also be special sample pre-treatment, filtering, post-treatment, and collection procedures that must be adhered to (see appendices for additional details). Digital versions of all EAP SOP’s can be found on Ecology’s quality assurance page at http://www.ecy.wa.gov/programs/eap/quality.html.

3.0 Definitions

3.1 Aquifer – An underground layer of saturated permeable/porous rock or sediments (e.g. gravel, sand or silt) that is capable of storing and releasing water to wells and springs.

3.2 Dissolved Oxygen – The relative amount of oxygen that is dissolved or carried in water.

3.3 Data Quality Objectives (DQO's) – Data Quality Objectives are qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

3.4 Depth-to-Water – The measured depth to the top of the groundwater surface in a well. Also referred to in this SOP as water level measurement.

3.5 EAP – Environmental Assessment Program

3.6 Ecology – Washington State Department of Ecology

3.7 EIM – Environmental Information Management System. A searchable database of environmental information (e.g. water quality results, etc) developed and maintained by the Washington State Department of Ecology.

3.8 Field Data Sheets – Weather resistant sheets ("Rite in the Rain" ® writing paper) used to document all field activities, sample data, methods, and observations for each collection site.

3.9 GPS - Global Positioning System

3.10 Measuring Point – A fixed and clearly marked point on a well casing from which depth-to-water/water level measurements are made. Fixed water level measuring points are established to ensure data comparability over time and among field samplers.

3.11 ORP – Oxidation-Reduction Potential. The electric potential required to transfer electrons from one compound or element (the oxidant) to another compound (the reductant). Used as a qualitative measure of the state of oxidation in water.

3.12 pH – A measure of the acidity or alkalinity of water. A pH value of 0 to 7 indicates that an acidic condition is present, while a pH value of 7 to 14 indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

3.13 Quality assurance project plan (QAPP) – A written plan that describes how a study will be conducted and its results assessed.

3.14 Specific Conductance (SC) – A measure of the water's ability to conduct an electrical current. Specific conductance is related to the concentration and charge of dissolved ions in water.

3.15 Static Water Level – The level of water in a well that is not being affected by the withdrawal or injection of water.

3.16 Water table elevation – The elevation of the top water surface of an unconfined aquifer.

4.0 Personnel Qualifications/Responsibilities

4.1 Staff new to groundwater sampling should review the most recent USGS National Field Manual for the Collection of Water-Quality Data (USGS, 1997); The Essential Handbook of Ground-Water Sampling (Nielsen, 2007), or an equivalent, for background information on the principles and techniques of groundwater monitoring. Staff should have a working understanding of the groundwater monitoring needs for their particular project prior to preparing the project Quality Assurance Project Plan (QAPP) and beginning field work.

4.2 Field staff should have a detailed working knowledge of the project QAPP to ensure that credible and useable data are collected, and should be briefed by the field lead on the sampling goals and objectives prior to arriving at the site.

4.3 This document supplements but does not replace the need for on-the-job training. All field staff should be familiar with the sampling equipment and instruments being used. The field lead is responsible for ensuring that all field staff adhere to prescribed sampling methods when conducting field work.

4.4 EAP staff who conduct groundwater sampling are responsible for complying with this SOP and the requirements of the EAP safety manual - particularly Chapter 1 'General Field Work' and the following sections of Chapter 2: 'Groundwater Sampling and Water-Level Measurements' and 'Hazardous Waste Sites' (Ecology, 2009).

5.0 General List of Equipment and Supplies

5.1 <u>Sample Measuring and Collecting Equipment</u>
5.1.1 Field data sheets
5.1.2 Water level measuring equipment (e.g. calibrated electric water level meter, graduated steel tape)
5.1.3 Water quality meters and probes (e.g. pH, SC, DO, temperature, ORP)
5.1.4 Probe calibration standards/reagents
5.1.5 Field analytical devices (e.g. spectrophotometer, turbidimeter, etc.)
5.1.6 Flow cell

5.1.7 Pump (submersible, peristaltic, bladder)
5.1.8 Power supply (generator, battery)
5.1.9 Extension cord
5.1.10 Sample tubing and connectors
5.1.11 Sample containers/bottles
5.1.12 Sample preservatives
5.1.13 Sample filters/tubing adapters (analyte specific)
5.1.14 Laboratory grade deionized water for quality assurance samples
5.1.15 Coolers with ice or ice packs
5.1.16 55-gallon barrels (to store and properly dispose of contaminated purge water)

5.2 Cleaning and Disinfecting Supplies

5.2.1 Deionized water
5.2.2 Laboratory grade soap (Liquinox®)
5.2.3 Dilute chlorine bleach solution
5.2.4 Cleaning solvents, if applicable

5.3 Safety Equipment

5.3.1 Nitrile gloves
5.3.2 Hearing protection
5.3.3 Safety goggles
5.3.4 Hard hat
5.3.5 First aid kit
5.3.6 Orange vest, Ecology issued
5.3.7 Traffic cones
5.3.8 Traffic signs, if applicable

5.4 Miscellaneous Equipment

5.4.1 Well location map
5.4.2 All applicable SOPs
5.4.3 Field paper work: property owner contact information, field data sheets, sample bottle labels and tags, chain-of-custody sheets.
5.4.4 Pencils, pens, etc.
5.4.5 Permanent marking pen or paint stick (for marking water level measuring point)
5.4.6 Calculator
5.4.7 Well keys, if applicable
5.4.8 Compass
5.4.9 GPS unit
5.4.10 Digital camera
5.4.11 Paper towels or clean rags
5.4.12 Plastic garbage bags
5.4.13 Plastic sheeting for ground cover
5.4.14 Buckets, plastic 5-gallon
5.4.15 1-liter container (to calibrate purge volume/rate)
5.4.16 Stop watch
5.4.17 Field bag (containing rain gear, rubber boots, work gloves, etc.)

5.4.18 Hand cleaner
5.4.19 Product/Water interface probe, if applicable

5.5 Tools
5.5.1 Steel hand measuring tape (engineer scale)
5.5.2 Socket wrench set
5.5.3 Allen wrench set
5.5.4 Pipe wrenches
5.5.5 Crescent wrenches
5.5.6 Set of screwdrivers
5.5.7 File
5.5.8 Knife
5.5.9 Hammer
5.5.10 Pliers
5.5.11 Hack saw
5.5.12 Crow bar/manhole hook
5.5.13 Shovel
5.5.14 Machete
5.5.15 Whiskbroom
5.5.16 Spare well cover bolts/nuts
5.5.17 Spare well caps/plugs
5.5.18 Spare pad locks/keys
5.5.19 Wire brush
5.5.20 WD-40 (to be used away from the well head)
5.5.21 Bailing device (e.g. cooking baster, peristaltic pump with battery)
5.5.22 Flashlight
5.5.23 Spare batteries (e.g. electric-tape, GPS, flashlight)
5.5.24 Tape (duct tape/electrical tape)
5.5.25 Well tagging equipment

6.0 Summary of Procedure

6.1 Project Planning

6.1.1 A Quality Assurance Project Plan (QAPP) must be completed and approved before collecting water quality samples for analysis. The QAPP details project goals, data quality objectives, quality assurance procedures, sample handling requirements (container requirements, preservation, holding times), and field and laboratory procedures. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies (Lombard, 2004) provides detailed guidance on developing EAP project plans. A QAPP can reference SOPs for standard field monitoring or measurement procedures; however, non-standard procedures or deviations should be described in detail in the QAPP.

6.1.2 Detailed information should be collected for each well location whenever practical, including: well construction logs, previous water level data, site access agreements, and other relevant information about the well being sampled. An example of a well reconnaissance field form is included in Appendix A.

6.1.3 Well location and construction information for wells that are sampled should be entered into Ecology's Environmental Information Management (EIM) system database.

6.1.3.1 If the well hasn't been previously inventoried, use a GPS receiver when first visiting the well to define a preliminary latitude and longitude coordinate as described in SOP EAP013, *Determining Coordinates via Hand-Held GPS Receivers* (Janisch, 2006). The field-collected coordinates can be refined using mapping tools when entering the well into the EIM system.

6.1.3.2 If the well hasn't been assigned a Department of Ecology unique well ID tag, then it should be tagged as described in EAP SOP081 *Procedures for Tagging Wells* (Pitz, 2011). Well tags are available from Ecology's Water Resources Program. Securely attach the tag to the well casing, or other permanent, easily-seen fixture of the well. Once a well is tagged, complete the well tag form and submit to Ecology's Water Resource Program along with a copy of the well log.

6.2 Sample Equipment Selection

6.2.1 Selecting equipment for purging and sampling a well requires site and project specific considerations to ensure that all collected samples meet the project objectives and data quality requirements. Groundwater chemistry can be altered by changes in temperature, pressure, and exposure to air that are brought on by the sampling process. Therefore, it is imperative to select sample equipment and follow sampling procedures that minimize these changes. General considerations for equipment selection are discussed below. More detailed information can be found in documents such as the USGS National Field Manual for the Collection of Water-Quality Data, and Nielsen (2007) The Essential Handbook of Ground-Water Sampling.

6.2.2 Factors to consider when selecting sample equipment include: the analytes being evaluated, the type and location of well being sampled, physical characteristics of the well (diameter and total depth), depth to water, the amount of water to be purged, geology adjacent to the screened interval and the groundwater chemistry.

6.2.2.1 Sample equipment must be compatible with the analytes being sampled. This includes the materials the sample equipment is made of, as well as its operation.

6.2.2.2 Sampling equipment can be a source of sample bias or error. Equipment that contacts the sample should be made of inert material to the extent possible. Materials commonly used include high quality stainless steel (pumps), and various forms of plastic (pumps, pump tubing and connectors). As explained by Nielsen (2007), sample materials should not sorb analytes from samples, desorb previously sorbed analytes into samples, leach matrix components that could affect analyte concentrations or cause artifacts, or be physically or chemically degraded by the water chemistry.

6.2.2.3 In general, the softer or more flexible forms of metal or plastic have been found to be more reactive than rigid forms. For example, soft tubing (e.g. silicone, polyvinyl chloride - Tygon®) is found to be more gas permeable and sorptive of organic compounds. It is suitable for sampling inorganic analytes only. The more rigid tubing (e.g. polytetrafluorethylene (Teflon®), polyethylene, and propylene) appear to offer greater performance over other materials for both inorganic and organic analytes (Table 1).

Table 1: General guidelines for selecting equipment on the basis of construction material and target analytes (USGS 1997)

Material	Description	Inorganic	Organic
Plastics			
Polytetrafluorethylene (Teflon® or Teflon-lined polyethylene)	Chemically inert for most analytes.	Yes (Potential source of fluoride)	Yes (Sorption of some organics)
Polypropylene	Relatively inert for inorganic analytes.	Yes	Do not use.
Polyethylene	Relatively inert for inorganic analytes.	Yes	Do not use.
Polyvinyl chloride (PVC)	Relatively inert for inorganic analytes.	Yes	Do not use.
Silicone (Silastic)	Very porous. Relatively inert of most inorganic analytes.	Yes (Potential source of silica)	Do not use.
Nylon	Relatively inert for inorganic analytes.	Yes	Do not use.
Metals			
Stainless Steel, 316-grade (SS 316)	SS-316 metal having the greatest corrosion resistance. (Used for submersible pump casings)	Yes (Potential source of Cr, Ni, Fe, and possibly Mn and Mo if corroded).	Yes (Do not use if corroded).
Stainless Steel, 304-grade (SS 304)	Similar to SS-316, but less corrosion resistant.	Do not use.	Yes (Do not use if corroded).
Other metals: brass, iron, copper, aluminum, and galvanized and carbon steel		Do not use. (except as noted for isotopes)	Yes (Do not use if corroded).

6.2.2.4 Pumps transport water from depth to the land surface by two methods, suction lift or positive pressure. The pumping mechanism for most suction-lift pumps (e.g. peristaltic and centrifugal pumps) is at land surface. Positive-pressure pumps (e.g. submersible and bladder) are placed below the static water level. Pump selection is analyte dependant. In general, suction lift pumps are not recommended for sampling volatile organics because of the vacuum that is created at the intake to draw the sample to the land surface. The vacuum can result in the loss of volatile organics or other dissolved gases.

6.2.2.5 The physical characteristics of a well may also dictate equipment selection. Smaller diameter wells are becoming increasingly common in groundwater investigations. Such wells limit the potential range of equipment that can be used for sample collection (e.g. peristaltic pump, small diameter bladder pump or bailer).

6.2.2.6 The depth to water may also dictate equipment selection. All sample pumps have a defined lift capability. This is the ability of the equipment to move water from the static water level depth to the top of the well casing. For example the lift capability of suction-based pumps (peristaltic and centrifugal pumps) is about 25 feet. Depth to water also effects pump operation, since the pumping rate typically decreases with increased depth to water.

6.2.2.7 Being able to control the pumping rate is an important consideration when selecting sample equipment. Sampling rates should be high enough to fill sample containers efficiently and with minimal exposure to the atmosphere, but low enough to minimize sample alteration by agitation or aeration. This is especially important for sensitive analytes, such as volatile organic compounds and trace metals, which should be taken at low flow rates.

6.3 Field Work Preparation

6.3.1. Prior to sampling, inventory consumable field supplies such as disposable gloves, calibration standards, tubing, filters, etc. Order necessary supplies. Allow ample time for delivery.

6.3.2. Arrangements must be made with Ecology's Manchester Environmental Laboratory before sampling. The Manchester Environmental Laboratory (MEL) Laboratory User's Manual (Ecology, 2008) contains detailed guidance on the planning steps necessary to request, track, ship, and analyze water quality samples collected in the field.

6.3.2.1. To notify the lab submit a Pre-sampling Notification Form and a Sample Container Request Form a minimum of 2 weeks prior to sampling. For large projects the lab should be informed 4-6 weeks prior to sampling.

6.3.2.2. Coordinate with the lab regarding any special arrangements such as contract lab analysis, special courier or delivery of samples.

6.3.2.3. Inventory sample bottles when they arrive to ensure the lab provided the correct type and number.

6.3.3. Establish the order the wells will be sampled. Sample order is either based on logistics or the known or suspected water quality of a sample location. For contaminated sites, wells should be sampled in order of increasing chemical concentrations (known or anticipated). This minimizes the possibility for cross-contamination of the sample equipment.

6.3.3.1. A few days before a planned sampling event contact the property owner, property operator or resident to confirm the sampling date and time and to discuss any site access issues.

6.3.3.2. Before going in the field prepare field data sheets for each well/sample location. It can be helpful to bring previous sample data for each well such as water level, pump intake placement, pump rate, total purge time, stabilized field parameter values, etc. Other sample paperwork should also be filled out as much as possible. Paperwork for a sample event typically includes: bottle labels and tags, and a Manchester Lab Chain-of-Custody/Lab Analysis Required Form (LAR). Examples of field data sheets are provided in Appendix A.

6.3.3.3. Field data sheets, bottle labels/tags, and laboratory paperwork should include the following information: station name and ID, laboratory number, requested analysis, and sample preservation method if applicable.

6.3.4. Inspect all equipment and verify that water quality field meters are in good working order, calibrate properly, and are fully charged. Calibration procedures are normally outlined in the meter user's manual.

6.3.5. Field equipment, especially equipment being placed in a well, that is going to be reused must be properly cleaned, disinfected, or decontaminated prior to and after use in each well. Cleaning procedure depends on the equipment being used (water level equipment, field parameter probes, down well sample equipment) and the type of well being sampled (e.g. observation well, regulated facility monitoring well).

6.3.5.1. It is recommended that gloves (Nitrile) be worn when cleaning sample equipment. This will help maintain sanitary conditions of the cleaned equipment and will protect the sampler from the cleaning products being used. When not in use, equipment should be placed on a clean surface, such as a clean plastic sheet. If the equipment is not re-used immediately it should be wrapped in plastic sheeting or aluminum foil. Equipment should never be placed on bare soil prior to using it in a well.

6.3.5.2. Water level measuring equipment: rinse the probe and any submerged tape with deionized water before and after use in a well. Wipe or air dry. If the well is suspected or known to be contaminated, the probe and any submerged tape should be wiped with a disinfectant-soaked towel or washed in a 0.1-0.2% laboratory grade soap (e.g. Liquinox) solution, followed by a tap water and deionized water rinse.

6.3.5.3. Water quality field probes may be rinsed with deionized water between sample locations. If the probes are slow to respond and additional cleaning is needed, then the probes should be cleaned and maintained according to the manufacturer's instructions.

6.3.5.4. Down well equipment, such as a submersible pump, should be washed in a laboratory grade soap (e.g. Liquinox) solution. Use a brush to scrub the exterior of the sample equipment. Flush the equipment with the 0.1-0.2% soap solution, then with tap water. Rinse with deionized water. If the pump can be disassembled, wash the separate parts in the detergent solution with a brush, followed by a tap water and deionized water rinse. Parts of the sample equipment that are difficult to submerge while cleaning, like a pumps electrical cable, can be wiped down with a disinfectant-soaked towel and then rinsed thoroughly with deionized water.

6.3.5.5. If the equipment is used in a contaminated well, additional cleaning may be required. The equipment may need a chemical rinse (e.g. acetone, nitric acid, methanol, isopropyl alcohol) depending on what analytes are being sampled. Rinse the equipment with deionized water. Place the equipment on a clean surface to air dry.

6.3.5.6. Equipment that is difficult to clean, such as pump tubing, should be replaced between sample locations. As mentioned previously pump tubing has the potential to provide a source of error because of the amount of contact with the sampled water. Therefore to help prevent possible cross-contamination it is advisable not to reuse sample tubing between sample locations. For long-term projects tubing may be dedicated to a well, but should not be used at other locations.

6.4. <u>Purging and Sampling Procedures</u>

6.4.1. All groundwater sampling follows the same basic standard procedures. These generally include checking and setting up the field sample equipment, collecting an initial water level measurement, installing sample equipment in the well, purging the well at a low flow rate, properly collecting, preserving and labeling all samples, and safely delivering the samples to the lab. Each step should be followed with care to ensure that collected groundwater samples meet-the objectives and data quality requirements of the project.

6.4.2. Upon arriving at a well, set out safety equipment such as traffic cones and signs as needed.

6.4.3. Check the site for hazardous conditions, either physical or chemical.

6.4.4. If needed, spread clean plastic sheeting on the ground around the well to keep sample equipment clean.

6.4.5. Set up and field check sample equipment: water level meter, water quality meters and flow cell, selected pump and power supply, etc.

6.4.5.1. Wear clean disposable powder-free gloves (e.g. Nitrile) when handling all equipment used for collecting and processing samples.

6.4.5.2. If you haven't already done so, calibrate field water quality meters according to the manufacturer's instruction. Field parameters should be measured in a closed-atmosphere flow cell. If for some reason it's not possible to use a flow cell at a particular location, it should be noted on the field data sheet.

6.4.5.3. If a gasoline-powered generator is used for the pump power supply, locate it as far from the well head or sample collection area as possible, preferably downwind.

6.4.6. Remove the well cover and cap. For monitoring wells on regulated facilities you will probably need a key.

6.4.6.1. If the well has not been sampled before, establish and document a water level measuring point using the procedures described in SOP EAP052, *Manual Well Depth and Depth-to-Water Measurements* (Marti 2009).

6.4.6.2. If the well is equipped with a pressure transducer or other down well instrumentation carefully note its position. Remove the instrumentation from the well according to SOP EAP074, *Use of Submersible Pressure Transducers during Groundwater Studies* (Sinclair and Pitz 2010). Note the removal time on the field data sheet.

6.4.7. Measure the static water level according to SOP EAP052 (Marti, 2009). Record the water level value, date, and time on the well specific field data sheet (Appendix A). The water level should be measured twice to confirm a stable and accurate measurement. The water level should be measured before inserting any other field equipment into the well.

6.4.7.1. If the well is suspected or known to have free floating product the water level and product thickness should be measured with an interface probe.

6.4.8. It can be helpful to know the amount of standing water in a well, particularly for projects where the purge water needs to be managed and properly disposed. To calculate the amount of standing water in one well volume, use the following information: measured water level, well diameter and total depth. The amount of standing water can be calculated using a variety of methods. One equation is:

Well volume: $V = 0.041 \times HD^2 =$ ____ gallons, where

V is volume of water in the well, in gallons,
H is height of water column in well (i.e. total well depth – measured depth to water), in feet, and
D is the inside diameter of the well casing, in inches

6.4.9. If the well is not equipped with a dedicated sampling system, install a decontaminated pump (e.g. submersible, bladder) or pump tubing (e.g. peristaltic). Slowly lower the equipment through the water column to avoid stirring up particulates.

6.4.9.1. If the well has been sampled before, the final pump intake should be placed at the same depth as used in previous sample events. Record the intake depth on the field data sheets.

6.4.9.2. If the well has not been previously sampled, position the pump intake at a depth prescribed by the project manager/field lead. In most cases the pump intake is set near or within the screened or open interval of the well. The final intake depth depends on the project objectives and should be specified in the QAPP.

6.4.10. Once the pump or pump tubing has been placed in the well, slowly lower the water level probe back into the well to measure water levels throughout purging. This is particularly important for low yield wells.

6.4.11. If the well has been sampled before, review past field data sheets for purge rates, total purge time, stabilized field parameter values, and amount of drawdown if any, prior to sample collection.

6.4.12. Start purging. Set the pump controller to the desired pumping rate. Depending on the target analytes pumping rates can vary from no greater than 1 L/min to as little as 150 mL/min.

6.4.12.1. Use water level measurements to help establish the optimum pump rate (which should not exceed 1L/min for low-flow sampling techniques). Purging should not cause a significant drawdown in the well. Significant drawdown is considered to be 5 percent of the total height of the water column or depth to the top of the screen. If unacceptable drawdown occurs at the initial set pumping rate, gradually decrease the pump rate until the water level stabilizes at an acceptable level. Record the final pump rate on the field data sheet.

6.4.12.2. Use the manufacturer supplied pump regulator rather than a secondary in-line valve system or other after-market device to adjust the pump flow. Managing the flow rate with an after-market device can cause sample agitation and alteration.

6.4.13. Purge water from wells that are not on regulated facilities or related to site cleanup work may be discharged directly to the ground as long as the water is not contaminated. Direct the purge water away from the wellhead and work area. Purge water from wells associated with a regulated facility or cleanup site that is contaminated should be collected and disposed of in accordance with Washington State regulations (Chapter 173-303-400 WAC).

6.4.14. During purging and sample collection the flow should be a smooth, solid stream of water with no air or gas bubbles in the tubing or flow cell. Gradually adjust the pumping rate to eliminate bubbles if present.

6.4.15. Once the flow is constant begin monitoring field parameter values in a flow cell at regular intervals (e.g. 2 to 5 minutes). The frequency of these measurements depends on the pump rate and the estimated time for the field parameters to stabilize. At a minimum, there should be a complete exchange of water in the flow cell between measurements.

6.4.16. Record the field parameter values, time of measurement, water level, and if tracking, the amount of purge water discharged. Note and provide qualifying remarks if parameter readings are anomalous or unstable due to instrument problems. Record observations on the pumped water's appearance (e.g. clarity, odor, etc.) during purging and sampling.

6.4.17. Continue purging until all field parameters stabilize as specified in 6.3.18 or in the project specific QAPP. Monitored field parameters for EAP studies include but are not limited to pH, specific conductance, dissolved oxygen, and water temperature. Field parameters should be specified in the project QAPP.

6.4.18. Field parameters are considered stable when 3 consecutive readings fall within the following stabilization criteria:

pH	± 0.1 standard units
Specific Conductance	± 10.0 µmhos/cm for values < 1000 µmhos/cm
	± 20.0 µmhos/cm for values > 1000 µmhos/cm
Dissolved Oxygen	± 0.05 mg/L for values < 1 mg/L
	± 0.2 mg/L for values > 1 mg/L
Temperature	± 0.1° Celsius
ORP	± 10 millivolts

6.4.18.1. If sampling for metals, turbidity should be measured and have either stabilized or be below 10 NTUs. Turbidity readings should be below 5 NTUs if metals samples will not be filtered.

6.4.19. Once field parameters stabilize conduct any end of purge field parameter analysis (e.g. confirmation of low dissolved oxygen, alkalinity, iron) as specified in the project QAPP.

6.4.20. Collect samples once field parameters stabilize and any other field data has been collected. Do not stop or significantly change the pumping rate during the final phase of purging or while sampling. Purging and sample withdrawal should form a continuous process.

6.4.21. Samples should be collected in a specific order as determined in the project QAPP. The order of sample collection, processing and preservation for specific analytes should be adhered to consistently throughout a project. The recommended sequence for sample collection and processing is often based on logistics for maintaining sample integrity.

6.4.21.1 Sample collection order is usually based on the analytes' sensitivity to change. Those analytes most sensitive to change (e.g. organics) are usually collected first, while analytes less sensitive to change (e.g. nutrients) may be collected last.

6.4.21.2 The sequence can be modified, depending on the types of samples to be collected and on data objectives. The relative importance of each analyte should be evaluated by project. Samples for analytes of most interest may be collected first to ensure that a representative sample is obtained. This is particularly important when sampling low-yielding wells which may not have a sufficient volume of water to fill all sample containers.

6.4.21.3 Modification in sample order may also be necessary to maintain sample integrity. For example, sulfate samples should be collected before samples preserved with sulfuric acid (e.g. nitrogen series, phenolics). This can prevent the accidental contamination of an unpreserved sulfate sample with sulfuric acid preservative used for another sample. Likewise, nitrogen series samples should be collected before samples preserved with nitric acid (e.g. total and dissolved metals).

6.4.21.4 When filtering samples for several analytical parameters they should be filtered in a specific order so that the analytical concentration will not be significantly affected as the pore size of the filter decreases as more water passes through it. For example the USGS recommends the following filter sequence: trace elements, mercury, major cations, major anions and nutrients (including alkalinity), radiochemicals, and stable isotopes (Wilde, 2004).

6.4.22. Change to clean disposable powder free gloves.

6.4.23. Prepare sample containers. To avoid possible container contamination, keep sample containers capped until it's time to fill them.

6.4.24. Sample containers should be filled by transferring water directly from the sampling apparatus (discharge tubing, filters, etc.) into the appropriate sample container. During sample collection the discharge line/filter should be close to but not touching the sample container.

6.4.24.1. Analyte specific sampling procedures are provided in Appendix B for volatile compounds and other organics. Sample procedure for metals and general/physical chemistry parameters are in preparation.

6.4.24.2. All samples requiring preservation must be preserved as soon as practical. Refer to analyte specific SOPs for proper preservation methods.

6.4.24.3. Collect quality control (QC) samples such as a field replicate from the well(s) specified in the project QAPP. Field replicate samples are collected by alternating the sample stream between two of the same type sample containers.

6.4.24.4. Collect any additional QC samples before leaving the site. These may include field blanks (e.g. filter, equipment, transport). The types and numbers of quality control samples should be specified in the project QAPP.

6.4.25. Label sample containers and immediately place in an ice filled cooler. Samples must remain at or below 6°C throughout handling, storage, and shipping. Do not freeze samples.

6.4.26. Record sample date and time, final water level, and total purge volume on the field data sheet. Record any final observations or comments related to sample collection.

6.4.27. Follow the procedures in the project QAPP or Manchester Lab Manual for sample handling and management (e.g. chain of custody, sample courier service or any special shipping requirements or restrictions).

6.4.27.1. Be conscious of analytical holding times and minimize the time between sampling and delivery to the laboratory.

6.4.28. If the well is equipped with a transducer or other down well instrumentation that was removed during sampling, replace the equipment according to SOP EAP074, *Use of Submersible Pressure Transducers during Groundwater Studies* (Sinclair and Pitz 2010). Note the reinstall time on the field data sheet,

6.4.29. When all work at the well site is complete, properly close and secure the well.

6.4.30. Note any physical changes to the well on the field data sheets, such as erosion or cracks in the protective concrete pad or alteration to the well casing.

6.4.31. All equipment used to collect groundwater samples should be cleaned or disinfected as previously described. Store the equipment for transport to the next sample location or at the conclusion of the field study.

6.5. Low Volume and Poor Recovery Wells - Purging and Sampling Procedures

6.5.1. Even with a low pumping rate, some wells experience significant drawdown or in extreme cases may even purge dry. Slow recovering wells or wells that purge dry require extra care in order to be purged and sampled with minimal disturbance to the water column and fine materials in and around the well screen.

6.5.2. For low volume and poor recovery wells, review past field data sheets if available for previous purge rates, amounts of drawdown, and purge volume prior to sample collection.

6.5.3. Measure the well's water level as described in steps 6.4.6. and 6.4.7.

6.5.4. If you suspect the well may be low yielding, calculate the amount of standing water in one well volume as described in step 6.4.8.

6.5.5. If the well is not equipped with a dedicated sampling system, install a decontaminated pump or pump tubing. Slowly lower the equipment through the water column to avoid stirring up particulates. The final pump intake depth should be near the bottom of the screened interval. To prevent stirring up particulates it is important not to touch the well bottom. Record the intake depth on the field data sheet.

6.5.6. Once the pump or pump tubing is in place, slowly lower the water level probe back into the well. It is important to frequently measure the water level throughout purging in low volume or poor recovery wells to enable the pump rate to be adjusted downward if necessary.

6.5.7. Start purging at a rate less than 0.5 liter per minute if the pump capacity allows. Record the pump rate on the field data sheet.

6.5.8. At regular intervals record field parameter values, water level, time of measurement, and amount of purge water discharged. Allow at least one complete exchange of water in the flow cell between measurements. Note and provide qualifying remarks if parameter readings are anomalous, the water level is dropping or if at some point the water level stabilizes. Record observations on the pumped waters appearance (e.g. clarity, odor, etc.) during purging and sampling.

6.5.9. Continue purging until field parameters stabilize per section 6.4.18. Attempts should be made to avoid purging low yielding wells dry. However, if this is not possible shut the pump off and allow the well to recover at least once before collecting samples. This generally constitutes an adequate purge, and the well can be sampled as soon as it has recovered sufficiently to produce an adequate volume of water to fill the sample containers. If time permits, purge the well a second time and allow it to recover before sampling. Samples should be collected within 24 hours of the final purge/recovery cycle.

6.5.9.1. It should be noted that there can be significant alterations in groundwater chemistry when a well is purged dry and allowed to recover before sampling. Groundwater chemistry can change as formation water surrounding or entering the screened interval of the well is exposed to air which can affect volatile organics and redox sensitive analytes. Increased turbidity can also be an issue when sampling metals and some general chemistry parameters (Nielsen, 2007).

6.5.10. Collect samples once field parameters stabilize and any end of purge analysis has been conducted.

6.5.10.1. If the well has been purged dry and allowed to recover, field parameters should be measured after sample collection if there is an adequate volume of water.

6.5.11. Sample containers should be filled in the order specified in the project QAPP. However, when sampling low-yielding wells which may not have a sufficient volume of water to fill all the sample containers, the relative importance of each analyte should be evaluated. Samples for analytes of most interest should be collected first to ensure a representative sample is obtained. Discuss with the lab the minimum volume of sample needed for each analyte.

6.5.12. Fill, preserve, label and store sample containers as described in steps 6.4.24. through 6.4.27. Follow analyte specific sampling procedures which are provided in Appendix B for volatile compounds and other organics. Sample procedure for metals and general/physical chemistry parameters are in preparation.

6.5.13. Record sample date and time, final water level, and total purge volume on the field data sheet. Record any final observations or comments related to sample collection such as elapsed time for complete purge of the well and recovery rate of the well.

6.5.14. Follow the procedures in the project QAPP or Manchester Lab Manual for sample handling and management (e.g. chain of custody, sample courier service or any special shipping requirements or restrictions). Be conscious of analytical holding times and minimize the time between sampling and delivery to the laboratory.

6.5.15. Replace any down well instrumentation according to EAP074, *Use of Submersible Pressure Transducers during Groundwater Studies* (Sinclair and Pitz 2010). Note the reinstall time on the field data sheet.

6.5.16. Properly close and secure the well.

6.5.17. Note any physical changes to the well on the field data sheets, such as erosion or cracks in the protective concrete pad or alteration to the well casing.

6.5.18. All equipment used to collect groundwater samples should be cleaned or disinfected as previously described. Store the equipment for transport to the next sample location or at the conclusion of the field study

7.0 Records Management

7.1 Monitoring wells that EAP samples must be documented to enable information about their location, construction, and subsequent monitoring data to be archived in Ecology’s Environmental Information Management (EIM) system and well log imaging databases. Consult the EIM help documents for a list of the well specific metadata required by EIM.

7.2 Station information and monitoring notes should be documented, during each site visit on site specific field data sheets. Examples are presented in Appendix A. All field entries should be neat and concise. The field lead is responsible for reviewing the form(s) for completeness before leaving a field site.

7.3 EAP staff have developed a number of data analysis spreadsheets, field forms, and other tools to standardize data collection and processing for groundwater monitoring projects. See the EAP Groundwater Assessment Sharepoint site for the most up-to-date version of these tools. Examples of some of the field forms are provided in Appendix A.

7.4 All hardcopy documentation, such as well reports and field data sheets, are kept and maintained by the project lead. At the completion of a project, hardcopies are boxed and moved to EAP archives.

8.0 Quality Control and Quality Assurance

8.1 To ensure that good quality data are obtained throughout a project, a Quality Assurance Project Plan (QAPP) must be completed and approved before performing any field work. The QAPP details project goals, data quality objectives, quality assurance program procedures, sample handling requirements, and field and laboratory procedures.

8.2 Both the equipment and procedures used in collecting and handling groundwater samples have limitations that introduce a certain level of error, variability and bias into the final analytical results. To minimize the level of error, all field staff should follow these general QA/QC procedures when collecting samples:

8.2.1. Follow the project QAPP and any applicable standard operating procedures (SOP) when collecting and handling samples.

8.2.2. Calibrate and maintain field water quality meters according to the manufacturer instructions. Document the calibration in the field notes.

8.2.3. Use equipment to purge and sample that is compatible with the characteristics of the well and analytes being sampled. Operate equipment in accordance with the manufacturer instructions, unless otherwise specified in the project QAPP.

8.2.4. Properly collect, handle, and store samples.

8.2.5. Collect the appropriate quality control samples. These may include a field replicate, and field blanks (e.g. filter, equipment, transport). The types and number of quality control samples should be specified in the project QAPP.

8.2.6. Follow the procedures in the project QAPP or Manchester Lab Manual for sample handling and management (e.g. chain of custody).

8.2.7. Document all data, observations, notes, deviations from project QAPP, etc. on the field data sheets and other project paperwork.

8.2.8. Properly clean, maintain, and store all field equipment after use.

8.2.9. Use consistent procedures from well to well.

9.0 Safety

9.1 Proper safety precautions must be observed when collecting groundwater samples. Field work should follow protocols described in the Environmental Assessment Program Safety Manual (Ecology 2006). A working knowledge of sections ‘Groundwater Sampling and Water-Level Measurements’ and ‘Hazardous Waste Sites’ in Chapter 2 is expected. Protocols in the EAP Safety Manual should be used to complement the judgment of an experienced field professional.

9.2 A Field Work Plan Form must be completed to document field personnel, sampling locations, overnight lodging, planned itinerary, contact person(s), and emergency contacts. If using a boat to access a site an Ecology Float Plan must be completed.

9.3 Always consider the safety situations when sampling a monitoring well. In addition to the possible chemical hazards if the water to be sampled is contaminated, there are many physical hazards associated with sampling monitoring wells. Monitoring wells are frequently located on or near active business or industrial sites, so field staff must remain aware of the typical hazards associated with these sites such as traffic. Many wells are located in parking lots, alleyways, or along roadways. Consult the EAP Safety Manual for further guidance regarding working near traffic. Other physical hazards can include heavy lifting, noise, electricity, steep, slippery, or uneven terrain, animals or insects, and the weather.

9.4 All EA Program field staff who work on hazardous waste sites are required to complete and maintain certification in FIRST AID/CPR and the 40-hour Hazardous Materials Safety & Health Training.

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Appendix A: Example Field Forms

EAP has developed several spreadsheet templates and field form to speed and where possible automate the tasks required to evaluate, install, and process groundwater sampling data. Examples of commonly used forms are included here. See EAP's Groundwater Assessment SharePoint site for up-to-date versions. These tools and forms can easily be modified to accommodate the needs of particular instruments or projects.

Well Reconnaissance Field Sheet

Date: ____________________ **Time:** ____________________

Field Crew: ________________

Well ID: ____________________________

Well Tag ID: _________________________

Well Owner Name: ____________________________________

Facility Name: ____

Current Phone Number: ______________________________

Current Mailing Address: ______________________________

____

____

Renter? ☐ **Name:** ______________________________

Permission granted to locate well? ☐

Permission granted to collect Water Level? ☐

Permission granted to sample well for Water Quality? ☐

Permission granted to tag well? ☐ **Tagged?** ☐

Call ahead required before site visit? ☐

Recon GPS Well Coordinates:

Recording Datum: **NAD83HARN** ☐ **NAD83** ☐ **NAD27** ☐

DDLAT: __________________ **DDLONG** __________________

Wellhead Photo #: ____________________________________

Comments: ____

____

____

____

____

____

____

Add sketch map of well location on back

Water Level Data Field Sheet **Well Tag #:** ____________ **Well Study Name:** ____________

DDLAT: ________ **DDLONG** ________ **T:** ________ **R:** ________ **SEC:** ________

Recording Datum: ________ **NAD83HARN:** ________ **NAD83:** ________

Well Owner: ____________ **Well Address** ____________

MP Height: ____________ **(ft)** **MP Date** ____/____/____ **Photo** ________

MP Description: ____________

Date	Time (PST or PDT)	Hold (ft)	Cut (ft)	Depth Below MP (ft)	Water Level (below LSD)	Status	Mthd.	Accu.	Remark
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									

Date	Time (PST or PDT)	Hold (ft)	Cut (ft)	Depth Below MP (ft)	Water Level (below LSD)	Status	Mthd.	Accu.	Remark
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									
/ /									

Status Codes

D	E	F	G	H	I	J	N	O	P	R	S	T	V	W	X	Z
Dry	Recently Flowing	Flowing	Nearby Flowing	Nearby Recently Flowing	Injector	Site Monitor	Discon-tinued measuring	Obstruction	Pump-ing	Recently Pumped	Nearby Pumping	Nearby Recently Pumping	Foreign Matter on Water	Well Des-troyed	Affected by Surface Water Site	Other

Method of Measurement Codes

A	B	C	E	G	H	L	M	N	R	S	T	V	Z
Airline	Analog	Cal. Airline	Estimate	Pressure Gage	Cal. Pressure Gage	Geophys Log	Mano-meter	Non-Recording Gage	Reported	Steel Tape	Electric Tape	Calibrated E-tape	Other

Measurement Accuracy Codes

0	1	2
±1 FT	±0.1 FT	±0.01 FT

Well Name: ______________________________ **Well Tag ID:** ______________________________

Groundwater Quality Sampling Field Sheet

Well Tag ID: ____________________ **Well Name:** ______________________________

Well Owner: ____

Well Address: ____

Date: ________ / ______ / ________ **Sample Time (PST/PDT):** ________________________________

Lab Sample #: ____________________________ **Crew:** ________________________

Pumping Rate: ________________________ **Meter:** ____________________________

Duplicate: ☐ **Equipment Blank:** ☐ **Reference:** ☐

Duplicate Lab Sample #: __________________ **Equipment Blank Lab #:** __________________

Purge Parameters:

Time	pH	Temp. (ºC)	Cond. (µS/cm)	DO (mg/L)	Water level (feet)

Groundwater Quality Sampling Field Sheet (cont.)

Well Tag ID: ______________________ **Well Name:** ______________________

Purge Parameters (cont.):

Time	pH	Temp (^oC)	Cond (µS/cm)	DO (mg/L)

Photometric O_2 : **Kit:** ______________ **Conc.** ______________

Photometric O_2 : **Kit:** ______________ **Conc.** ______________

Colormetric O_2 : ______________________________

Field Alkalinity : **Kit:** ______________ **Conc.** ______________

ORP: ______________________________

Other: ______________________________

Comments :

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Sample Container Request Form

Please FAX to Leon Weiks: (360) 871-8850
(Phone for Leon Weiks: (360) 871-8825)

Requestor: ______________________________

Project Name: ____________________

Phone: _________________________________

Today's Date: ____________________

Location for Delivery: _____________________

Date Needed by: __________________

Index #	Description	Qty.
1	1 gallon jar *	
2	1/2 gallon jar *	
3	1 liter jar * (wide mouth) (special request only)	
4	1 liter jar (narrow mouth) (oil & grease) **	
5	8 oz short jar *	
6	8 oz short jar **	
8	4 oz short jar *	
9	4 oz short jar **	
11	40 mL vial w/septum *	
13	2 oz short jar w/septum * (Volatiles: solids only)	
14	125 mL amber glass bottle * (carbamate)	
15	1 liter amber bottle * (narrow mouth)	
16	500 mL HDPE bottle (metals)	
17	1 gallon cubitainer	
19	125 mL clear Nalgene (nutrients or COD; bottle contains 1:1 sulfuric acid)	
20	125 mL amber Nalgene (filters and syringe also required for orthophosphate)	
21	125 mL polypropylene bottle (hardness - bottle contains acid) **For Hexachrome, request bottle without acid**	

Index #	Description	Qty.
22	500 mL poly bottle	
23	1000 mL poly bottle	
24	1000 mL amber poly	
25	250 mL amber poly bottle (Cyanide) (contains Sodium Hydroxide)	
26	60 mL poly bottle (TOC/DOC or TP; bottle contains 1:1 hydrochloric acid)	
27	250 mL glass or poly bottle (fecal coli)	
28	500 mL glass bottle or poly (multiple micro tests)	
29	250 mL glass or poly bottle **with thiosulfate** (fecal coliform - chlorinated)	
30	500 mL glass or poly bottle **with thiosulfate** (multiple micro tests - chlorinated)	
31	8 oz plastic jar (grain size only)	
32	1 liter jar ** with **sulfuric acid** (wide mouth, clear; for phenolics)	
33	sterile specimen cup (micro)	
34	2 oz short jar (TOC - NO septum)**	
35	Soil VOA/BTEX Airtight Sampling Capsules (3 per sample)	
36	Soil VOA/BTEX Sampling Handle (1 per sampling event)	
	Other Supplies	

*organic free with Teflon lined lids, with Certificate of Analysis. **same as "*" but does not include Certificate of Analysis.

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

PRE-Sampling Notification

Fax to Manchester Laboratory: (360) 871-8850

☐ Enforcement
☐ Monitoring
☐ Emergency
☐ Class II
☐ Preliminary Invest.
☐ Special turnaround

Project Name: ______________________________ **SIC:** ____________
Requested by: ______________________________ Sampling Date(s): ____________
Program: ______________________________ Date to Lab: ____________
Phone No.: ______________________________ Sample Pickup Location: ____________
QAPP: ☐Yes ☐ No Date results needed by: ____________

General Chemistry	W	S	O	Microbiology		W	S	O	Organic Chemistry	W	S	O
Alkalinity				Fecal Coliforms ☐ MF ☐ MPN					Base/Neutral/Acids (BNA)			
Conductivity				E. Coli MF ☐ "MUG" ☐ mTEC2					Polynuclear Aromatics (PAH)			
Hardness				E. Coli MPN								
pH				% Klebsiella					Volatile Organic Analysis (VOA)			
Turbidity									BTEX			
☐ Fluoride ☐ Chloride ☐ Sulfate									Pest/PCB's (Organochlorine)			
Cyanide ☐ Total ☐ Dissociable				**Metals**	W_T	W_D	S	O	Pesticides only (Organochlorine)			
Total Solids				Priority Pollutant Metals (13 elements)					PCB's only			
Total Nonvolatile Solids				TCLP metals					OP - Pests (Organophosphorous)			
Total Suspended Solids				Hardness					Herbicides (Chlorophenoxy)			
Total Nonvolatile Suspended									Nitrogen Pesticides			
Total Dissolved Solids				Mercury (Hg) ☐ Low Level ☐ Regular					PCL Pesticides (8085)			
Chlorophyll ☐ Filtered in field ☐ Filtered at lab				Other: List individual elements:					PBDEs			
% Solids									Hydrocarbon ID (match to source)			
% Volatile Solids (TVS)									TPH-ID (gas/diesel/oil)			
Total Organic Carbon									TPH-G_x			
Dissolved Organic Carbon									TPH-D_x			
Biochemical Oxygen Demand (BOD) 5 day												
BOD - Inhibited									TCLP-VOA			
BOD - Ultimate									TCLP-BNA			
Ammonia									TCLP-Herbicides			
Nitrate-Nitrite									TCLP-Pesticides			
Orthophosphate												
Total Phosphorous												
☐ TPN ☐ TKN				Asbestos								

Comments: Enter the number of samples in the appropriate box(es) above.
W = water S = soil/sediment O = other (please specify) W_{TR} = water total W_D = water dissolved

Project Name:

SIC: ____ ____ ____ ____ ____ **Program:**

☐ Preliminary Investigation ☐ For HW Designation **Date Results needed by:** ____________________

Send Results to: **Mail Stop:**

☐ Monitoring ☐ For NPDES **Name/Reference # of QAPP for this project:** ____________________

Sampling					Field Station Identification	Manchester Lab Sample Number	Matrix Code	Source Code	No. of Containers	General Chemistry																			Micro					Metals					Organic Chemistry														
Date			Time (Military) 0001 - 2400							Alkalinity	Conductivity	pH	Turbidity	☐ Chloride ☐ Sulfate	Fluoride	Total Suspended Solids	Total Dissolved Solids	☐ Total Solids ☐ % Sol ☐ Vol Sol	TOC	DOC	BOD5	Oil & Grease (HEM)	Ammonia	Nitrite/Nitrate	Total Phosphorus	Orthophosphate	TPN	Chlorophyll ☐ filters	Fecal Coliform ☐ MF ☐ MPN	Total Coliform ☐ MF ☐ MPN	E. Coli ☐ MF ☐ MPN	% Klebsiella	Enterococcus	PP Mets	Mercury (Hg) ☐ low level	Hardness	Individual Elements (please list)	☐ Total ☐ Dissolved	VOA	BTEX	TPHG	TPHD	HCID Only (Hydrocarbon ID)	PCB aroclors	☐ Pest 1 ☐ w/PCB aroclors	☐ Pest 2 ☐ w/PCB aroclors	☐ Pest 3 ☐ w/PCB aroclors	Carbamates	PESTMS	Herbicides	PBDE	BNA	PAH
Year:	Mo	Day	Hr	Min																																																	

Project Officer:

Phone Number:

Cell Number:

Samplers:

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments (Temperature, Preserv., etc.)

Recorder:

Comments:

Matrix Codes

Code Description
10 Water
11 Field Filtered Water
12 Filter from Water
13 Water to be filtered upon receipt at lab
40 Soil/Sediment
41 Frozen Soil/Sediment (PSEP)
45 Semi-Solid/Sludge
70 Tissue
80 Oil/Solvent
90 Waste
00 Other (Use only if no other apply)

Source Codes

Code Description
00 Unspecified Source
01 Unknown Liquid Media (Drum/Tank)
02 Unknown Liquid Media (Spill Area)
03 Unknown Liquid Media (Waste Pond)
10 Water (General)
12 Ambient Stream/River
13 Lake Reservoir
14 Estuary/Ocean
15 Spring/Seepage
16 Rain
17 Surface Runoff/Pond (general)
18 Irrigation Canal/Return Flow
20 Well (General)
21 Well (Industrial/Agricultural)
22 Well (Drinking Water Supply)
23 Well (Test/Observation)
24 Drinking Water Intake
25 Drinking Water (At Tap)
30 Effluent Wastewater (General)
31 Municipal Effluent
32 Municipal Inplant Waters
33 Industrial Surface Runoff/Leachate
34 Industrial Effluent
35 Industrial Inplant Waters
36 Industrial Surface Runoff/Pond
37 Industrial Waste Pond
38 Landfill Runoff/Pond/Leachate
40 Sediment (General)
42 Bottom Sediment or Deposit
44 Sludge (General)
45 Sludge (WastePond)
46 Sludge (Drum/Tank)
48 Soil (General)
49 Soil (Spill/Contaminated Area)

Code Description
50 Bore Hole Material
60 Air (General)
61 Ambient Air
62 Source or Effluent Air
63 Industrial or Workroom Air
70 Tissue (General)
71 Fish Tissue
72 Shellfish Tissue
73 Bird Tissue
74 Mammal Tissue
75 Macroinvertebrate
76 Algae
77 Periphyton
78 Plant/Vegetation
80 Oil/Solvent (General)
81 Oil (Transformer/Capacitor)
82 Oil/Solvent (Drum Tank)
83 Oil/Solvent (Spill Area)
84 Oil/Solvent (Waste/Pond)
90 Commercial Product Formulation
95 Well Drill Water
96 Well Drill Mud
97 Well Sealing Material
98 Gravel Pack Material

Appendix B:
Collecting Samples for Volatile Organics and other Organic Compounds

This Appendix applies to EAP staff collecting and handling groundwater samples for volatile organic compounds (VOCs) and other organic compounds (e.g. semi-volatiles, total petroleum hydrocarbons, polynuclear aromatic hydrocarbons, pesticides, polychlorinated biphenyls).

It describes common procedures and practices that EAP staff use to collect these samples from wells without dedicated sampling pumps. General information is provided here and in Section 6.0 of this SOP to help guide field staff in the selection of proper sample equipment and sampling techniques. There are several documents that provide detailed information on this topic, including the USGS National Field Manual for the Collection of Water-Quality Data (USGS, 1997) and The Essential Handbook of Ground-Water Sampling (Nielsen, 2007).

Sample Equipment Selection

Selecting equipment for purging and sampling a well for VOCs, other volatile analytes and organics requires specific considerations, preparations and precautions. All sample-contact components of the equipment used should be constructed of stainless steel or Teflon®. The manner of sample equipment operation must be compatible with characteristics of the well and the analytes being sampled to obtain data that will meet the project objectives and data quality requirements.

When sampling for volatile analytes sample equipment should be chosen to minimize changes in pressure, temperature and atmospheric exposure of the water pulled from the aquifer. For this reason these samples should be collected with positive pressure/displacement pumps. Positive pressure pumps most commonly used by EAP are stainless steel submersible or bladder pumps.

Although peristaltic pumps are regularly used to purge and sample monitoring wells they are not recommended for sampling volatile analytes. Peristaltic pumps are negative pressure or suction lift pumps that create a vacuum in the intake line that draws the sample to the land surface. The vacuum can result in the loss of volatile analytes.

Following are some basic considerations for the most commonly used sample equipment.

Submersible and Bladder Pumps

Submersible and bladder pumps have similar operating requirements. Both are lowered into the well's water column. The pumps should be slowly lowered through the water column to avoid stirring up particulates or aerating the water in the well casing.

It is recommended that the intake depth of the pump and pumping rate for wells that are sampled repeatedly remain the same for all sample events. Typically the pump intake is placed at the midpoint or the lowest historical midpoint of the saturated screen length. The pump intake depth will be determined by the project manager and should be specified in the QAPP.

Both submersible and bladder pump need to be completely submerged to operate properly. Consult with the pump manufacturer to determine the minimum height of the water column above the pump for it to operate properly. This can range from 1 foot to more than 5 feet.

If possible the pump intake should be at least two feet above the bottom of the well, to minimize mobilization and uptake of particulates present in the well bottom.

Ideally, the pumping rate should be set so as not to cause significant drawdown in the well. Wells should be pumped at a rate that is equal to or less than the natural flow conditions of the aquifer in the screened interval to avoid drawing the water level down.

Small diameter bladder pumps are available for sampling small diameter wells which are becoming increasingly common in groundwater investigations.

Careful considerations should be given to placing pumps in wells that are excessively contaminated with free product (LNAPL or DNAPL) because it may be difficult to adequately decontaminate severely contaminated pumps in the field. When wells of this type are encountered, alternative sampling methods should be considered such as a peristaltic pump or bailer.

Peristaltic Pumps

Peristaltic pumps are generally not recommended for sampling volatile analytes because of the potential loss of analytes due to pump operation.

If a peristaltic pump is being considered to sample volatile analytes, the intended use of the data should be a primary consideration.

- Use of the pump may be acceptable if the additional sample error that may be introduced by the negative pressure/vacuum created by the pumps operation does not affect any project decision making. For example, if contaminant concentrations are far above regulatory levels and groundwater monitoring will continue, then a peristaltic pump could be used. However, the data should only be used to qualitatively evaluate the presence of the contaminants.

- A peristaltic pump should not be used if minor differences in the groundwater concentrations of volatile analytes could affect project decisions. For example, do not use a peristaltic pump when monitoring groundwater remediation to determine if cleanup goals have been achieved. In these cases sample equipment should be selected that will provide more accurate results.

Peristaltic pumps may be used to sample if the physical characteristics of the well limits other sample equipment options, such as when sampling smaller diameter wells. Small diameter tubing used with a peristaltic pump is a possible option. However, the tubing used in the rotor head of the peristaltic pump should be less than a foot in length since it is found to be more gas permeable and sorptive of organic compounds. This tubing should be replaced at each sample location. PharMed tubing is now recommend for use in the pump rotor head since it has been found to be less permeable to gas and vapors as compared to other soft tubing options.

Peristaltic pumps may also be used in low yielding wells that do not have sufficient water to operate a submersible pump.

Bailers

Even though bailers are not recommended for most groundwater sampling, they are useful in specific situations.

The use of bailers is discouraged because the repeated entry and removal of the bailer disturbs the water column and may mobilize sediment that is present in the well. The repeated disturbance to the water column can also aerate the water in the well casing.

However, in wells that are excessively contaminated with oily compounds, bailers can be an acceptable alternative to pumps. Bailers are easier to clean or can be disposable.

If a bailer is used to sample for volatile organic compounds, it should be a closed-top Teflon® bailer with a bottom-emptying sample device. The bailer should be lowered and raised smoothly at a constant rate and with as little disturbance to the water column as possible.

Passive Samplers

Although EAP does not have direct experience with passive samplers the devices are an emerging technology for evaluating volatile organics and other analytes in groundwater.

Passive samplers are no-purge sampling devices designed to collect samples from a specific depth within a well that is in ambient equilibrium with the adjacent groundwater. There are a variety of passive samplers, these include: devices that rely on sorption or diffusion onto or across the sampler medium to devices that recover grab samples at discrete depths.

If considering a passive sampling device for your project, consult with the manufacturer to determine if the technology is compatible with the project goals and site conditions.

Sampling Considerations for Volatile Analytes

The following are general considerations when collecting samples for volatile analytes. Please refer to Section 6.0 of this SOP for instructions on basic monitoring well sampling procedures (e.g. water level measurement, well purging).

- Whenever possible, wells should be sampled in order of increasing chemical concentrations (known or anticipated). This minimizes the possibility for cross-contamination of sample equipment.

- Protect the sample area from potential sources of airborne contaminants (e.g. dust, vapors from fuel cans, engine exhaust, etc.). Record on the field data sheets suspected but unavoidable extraneous VOC sources that are encountered when sampling.

- While in the field try to keep unfilled sample bottles in a cool place (e.g. shade, ice-filled cooler). This will minimize the loss of volatile analytes when filling the sample bottles.

- If collecting samples for multiple analytes, VOC samples (and other sensitive analytes) are typically collected first since these analytes are most sensitive to the sampling process.At low purge rates direct sun light and hot ambient air temperatures may cause groundwater in the tubing and flow cell to heat up. This may cause the groundwater to degas which will result in loss of volatile analytes. If possible shade the equipment from sunlight.

Sampling Procedures

Although the procedures used to fill sample bottles may seem a minor consideration, filling them improperly can jeopardize the careful work that went into properly purging a well to produce minimally-disturbed, representative samples. Improper sampling techniques can cause changes in sample composition due to agitation and exposure to air which can result in the loss of contaminants by volatilization or degassing.

The more sensitive the parameter being collected (e.g. VOCs and redox-sensitive metals), the more cautious and rigorous the filling procedures should be.

Filling VOC bottles

- Groundwater samples for VOC analysis are collected in 40-mL amber/clear glass bottles with Teflon® septa lids. Contact the laboratory to determine the number of bottles required for analysis.

- Samples may be collected after the well is fully purged. Purging and sample withdrawal should form a continuous process.

- Pumping rates for sample collection should be high enough to fill sample bottles efficiently and with minimal exposure to atmospheric conditions, but low enough to minimize sample alteration or aeration. The flow should be smooth and uniform.
    - The recommend pumping rate for collecting VOC samples is generally 250 mL/min or less.
    - If using a bladder pump, the pumping rate should be set to deliver a pulse of water long enough to fill one 40-mL VOC bottle.

- Before filling the sample bottles check for air bubbles in the sample line. Tap the sample line or gradually adjust the pumping rate to dislodge and remove any bubbles that are present.

- Wear clean disposable powder free gloves when collecting and preserving the samples.

- Keep sample bottles capped until it's time to fill them. This will minimize exposure of the sample bottle to extraneous VOC contamination.

- Do not pre-rinse or field rinse VOC bottles before sample collection.

- VOC samples require chemical preservation.
    - Most VOC samples will only require the addition of hydrochloric acid (HCl). Usually 0.25 mL of 1:1 HCl is enough to lower the pH of the sample to ≤ 2. The HCl is added to inhibit biodegradation of VOCs in the sample.
    - If sampling a municipal drinking water source, free chlorine may be present. Before sampling determine the presence of free chlorine with a field test kit. If free chlorine is present preserve the VOC sample with 25 mg of ascorbic acid. The ascorbic acid is added to remove the free chlorine which if present may cause the formation of trihalomethanes. Continue to preserve the sample with the 1:1 HCl.

- Samples should be collected with as little disturbance as possible. When filling a VOC bottle, tip the bottle at a slight angle and allow a slow steady stream of water to run down the inner wall (Figure B-1). This will minimize agitation, aeration, and volatilization of VOCs while sampling.

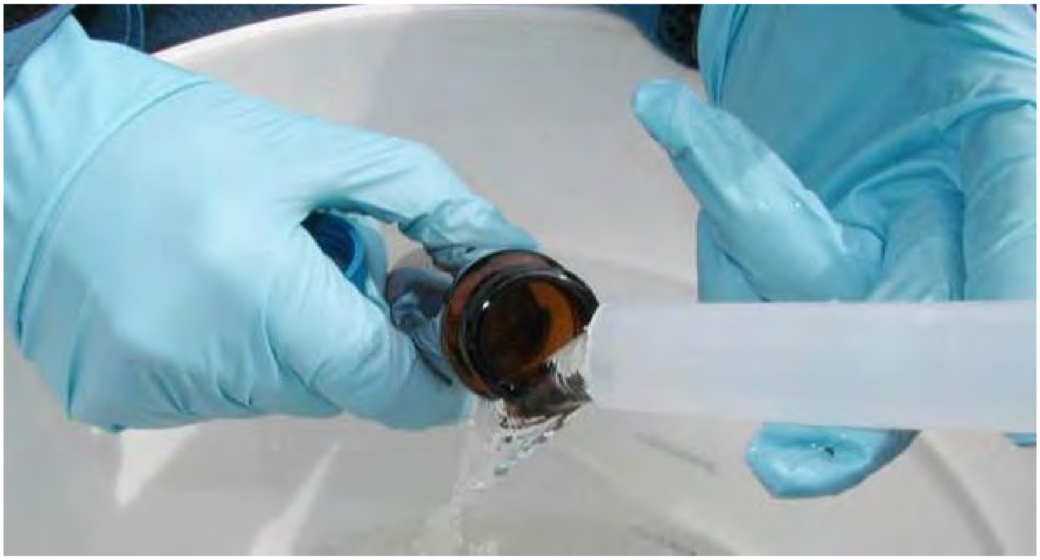

Figure B-1

- Carefully fill the bottle to just below the rim (Figure B-2).

Figure B-2

- If the sample bottle was not pre-preserved, add the preservative.
- Fill the cap with water and use it to top off the sample (Figure B-3).

Figure B-3

- Add just enough water to form a positive meniscus (Figure B-4). Take care to not over fill the bottle since you do not want to flush any preservative out of the bottle while topping it off.

Figure B-4

- Empty the cap of any remaining water before replacing it on the bottle.
- After securing the cap invert the bottle and tap it lightly to check for bubbles (Figure B-5 and B-6). Absolutely no bubbles or headspace should be present in the bottle. If any airspace remains, VOCs in the sample can volatilize and may be lost before analysis.

Figure B-5

Figure B-6 – Checking a filled VOC bottle for bubbles

- If any bubbles are present, carefully remove the cap and top off the bottle again with a minimal amount of well water as previously described to re-establish the meniscus. If bubbles are still present after topping off and recapping the bottle, set the sample aside. Collect a new sample using a clean bottle.

- If for some reason bubble free samples can't be obtained collect several samples and save the three with the fewest bubbles. Make a note on the field and laboratory forms indicating the samples contained one or more bubbles.

- Label the sample bottles and protect them in foam sleeves or bubble wrap before placing them in an iced filled cooler. Samples must remain at or below 6°C throughout handling, storage, and shipping. Never freeze the samples.

- Preserved VOC samples have a 14 day holding time.

Sampling Procedures for Semi-Volatiles and other Organics

These organics are typically less volatile than VOCs, however, they too are often susceptible to extraneous background contamination, possible cross-contamination, sorption and desorption reactions with sampling equipment and are usually analyzed at very low detection levels (µg/L).

Some substances that fall under this category include: base/neutral/acids (BNAs or semi-volatiles), total petroleum hydrocarbons (TPH), polynuclear aromatic hydrocarbons (PAHs), herbicides, pesticides, polychlorinated biphenyls (PCBs), and polybromide diphenyl ether congeners (PBDEs). The following table lists sample containers, preservation, and holding times for commonly sampled organics.

Table 1. Sample Containers, Preservation and Holding Times

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
VOCs	Groundwater	40 mL, no headspace	(3) 40 mL vials with septum	HCl. Ascorbic acid when chlorinated. Cool to ≤6°C. No headspace.	14 days
BNA (Semi-VOCs)	Groundwater	1 L	1 L amber glass bottle	Cool to ≤6°C	7 days
TPH-D	Groundwater	1 L	1 L narrow mouth glass bottle	Cool to ≤6°C	7 days unpreserved; 14 days preserved
PAH	Groundwater	1 L	1 L amber glass bottle	Cool to ≤6°C	7 days
Herbicides	Groundwater	1 L	1 L amber glass bottle	Cool to ≤6°C	7 days
Pesticides	Groundwater	1 to 4 L	1 L amber glass bottle	Cool to ≤6°C	7 days
PCBs	Groundwater	1 to 4 L	1 L amber glass bottle	Cool to ≤6°C	7 days
PBDEs	Groundwater	1 L	1 L amber glass bottle	Cool to ≤6°C	7 days

Sampling procedures for semi-volatiles and other organics are similar to those for VOCs.

- Equipment should be made of inert material to the extent possible.
- Samples may be collected once the well is fully purged.
- The pumping rate for larger sample containers is generally 0.5 L/min or less.
- Before filling sample bottles check for air bubbles in the sample line. Tap the sample line or gradually adjust the pumping rate to dislodge and remove any bubbles that are present.
- Collect samples in the order specified in the project QAPP.

- Do not pre-rinse or field rinse sample bottles for organic analysis.

- When filling a sample container tip it at a slight angle and allow a slow steady stream of water to run down the inner wall. This will minimize agitation and aeration while filling the container.

- Fill the bottle to the recommend volume. If the sample will be frozen, leave enough head-space to prevent the bottle from breaking due to ice expansion.

- These samples are not usually preserved or filtered; however, they should be cooled to 6°C or less immediately after collection.

STANDARD OPERATING PROCEDURE

Equipment Blank and Field Blank Preparation

I. Purpose

To prepare blanks to determine whether decontamination procedures are adequate and whether any cross-contamination is occurring during sampling due to contaminated air and dust.

II. Scope

The general protocols for preparing the blanks are outlined. The actual equipment to be rinsed will depend on the requirements of the specific sampling procedure.

III. Equipment and Materials

- Blank liquid (use ASTM Type II or lab grade water)
- Millipore™ deionized water
- Sample bottles as appropriate
- Gloves
- Preservatives as appropriate

IV. Procedures and Guidelines

A. Decontaminate all sampling equipment that has come in contact with sample according to SOP *Decontamination of Personnel and Equipment.*

B. To collect an equipment blank for volatile analysis from the surfaces of sampling equipment other than pumps, pour blank water over one piece of equipment and into two 40-ml vials until there is a positive meniscus, then seal the vials. Note the sample number and associated piece of equipment in the field notebook as well as the type and lot number of the water used.

For non-volatiles analyses, one aliquot is to be used for equipment. For example, if a pan and trowel are used, place trowel in pan and pour blank fluid in pan such that pan and trowel surfaces which contacted the sample are contacted by the blank fluid. Pour blank fluid from pan into appropriate sample bottles.

Do not let the blank fluid come in contact with any equipment that has not been decontaminated.

C. When collecting an equipment blank from a pump, run an extra gallon of deionized water through the pump while collecting the pump outflow into appropriate containers. Make sure the flow rate is low when sampling VOCs. If a Grundfos Redi-Flo2 pump with disposable tubing is used, remove the disposable tubing after sampling but before decon. When decon is complete, put a 3- to 5-foot segment of new tubing onto the pump to collect the equipment blank.

D. To collect a field blank, slowly pour ASTM Type II or lab grade water directly into sample containers.

E. Document and ship samples in accordance with the procedures for other samples.

F. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

- Wear gloves.
- Do not use any non-decontaminated equipment to prepare blank.
- Use ASTM-Type II or lab grade water.

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.
2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.
3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.
4. Remove respirator (if worn).
5. Remove inner gloves and discard.
6. At the end of the work day, shower entire body, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Spread plastic on the ground to keep equipment from touching the ground
3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.
4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.
5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)
6. Rinse with 1 gallon of tap water.
7. Rinse with 1 gallon of deionized water.
8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.
9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.
2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, Liquinox® solution (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

Disposal of Waste Fluids and Solids

I. Purpose and Scope

This SOP describes the procedures used to dispose of hazardous fluid and solid materials generated as a result of the site operations. This SOP does not provide guidance on the details of Department of Transportation regulations pertaining to the transport of hazardous wastes; the appropriate Code of Federal Regulations (49 CFR 171 through 177) should be referenced. Also, the site investigation-derived waste management plan should be consulted for additional information and should take precedence over this SOP.

II. Equipment and Materials

A. Fluids

- DOT-approved 55-gallon steel drums or Baker® Tanks
- Tools for securing drum lids
- Funnel for transferring liquid into drum
- Labels
- Paint Pens
- Marking pen for appropriate labels
- Seals for 55-gallon steel drums

B. Solids

- DOT-approved 55-gallon steel drums or rolloffs
- Tools for securing drum lids
- Paint Pens
- Plastic sheets
- Labels
- Marking pen for appropriate labels

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or rolloffs or Baker® Tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. The drums will be filled with the drilling and well installation wastes, capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will be labeled as they are filled in the field and labels indicating that the contents are pending analysis affixed.

The drum contents will be sampled to determine the disposal requirements of the drilling wastes. Check with the Environmental Manager (EM) assigned to the project prior to sample collection for frequency and analysis. Unless otherwise specified by the EM, the drum sampling will be accomplished through the collection and submittal of composite samples, one sample per 10 drums (check with disposal facility to determine sample frequency) containing the same media. Similar compositing will be performed in each rolloff to obtain a representative sample. The compositing of the sample will be accomplished by collecting a specific volume of the material in each drum into a large sample container. When samples from each of the drums being sampled in a single compositing are collected, the sample will be submitted for TCLP, ignitability, corrosivity, and reactivity analysis. Additional analysis may be required by your EM.

If rolloffs are used, compositing and sampling of soil will comply with applicable state and federal regulations.

B. Labels

Drums and other containers used for storing wastes from drilling operations will be labeled when accumulation in the container begins. Analysis pending labels should be used initially. Labels will include the following minimum information:

- Container number
- Container contents
- Origin (source area including individual wells, piezometers, and soil borings)
- Date that accumulation began
- Date that accumulation ended
- Generator Contact Information
- When laboratory results are received, drum labels will be completed or revised to indicate the hazardous waste constituents in compliance with Title 40 of the Code of Federal Regulations, Part 262, Subpart C if the results indicate hazardous waste or labeled as non-hazardous if applicable.

C. Fluids

Drilling fluids generated during soil boring and groundwater discharged during development and purging of the monitoring wells will be collected in 55-gallon, closed-top drums. When a drum is filled, the bung will be secured tightly. Fluids may also be transferred to Baker® Tanks after being temporarily contained in drums to minimize the amount of drums used.

When development and purging is completed, the water will be tested for appropriate hazardous waste constituents as per instruction from the project EM. Compositing and sampling of fluids will comply with applicable state and federal regulations.

D. Solids

The soil cuttings from well and boring drilling will constitute a large portion of the solids to be disposed of.

The solid waste stream also will include plastic sheeting used for decontamination pads, Tyveks, disposable sampling materials, and any other disposable material used during the field operations that appears to be contaminated. These materials will be placed in designated drums.

E. Storage and Disposal

The wastes generated at the site at individual locations will be transported to the drum storage area by the drilling services subcontractor. Drums should be stored on plastic sheeting with a short berm wall (hay bales or 2 x 4 planks or equivalent) to capture small spills. The drums should be staged such that the labels are all visible and there should be enough room to walk between rows of drums if applicable.

Waste solid materials that contain hazardous constituents will be disposed of at an offsite location in a manner consistent with applicable solid waste, hazardous waste, and water quality regulations. Transport and disposal will be performed by a commercial firm under subcontract.

The liquid wastes meeting acceptable levels of discharge contamination may be disposed of through the sanitary sewer system at the site. However, prior to disposal to the sanitary sewer system, approval and contract arrangements will be made with the appropriate authorities. Wastes exceeding acceptable levels for disposal through the sanitary sewer system will be disposed of through contract with a commercial transport and disposal firm.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Contact the project Environmental Manager prior to containerizing waste to determine containerization method and sampling frequency and analysis.
- Check that representative samples of the containerized materials are obtained.
- Be sure that all state and federal regulations are considered when classifying waste for disposal.

STANDARD OPERATING PROCEDURE

Installation of Surface-Cased Monitoring Wells

I. Purpose and Scope

The purpose of this procedure is to outline equipment and methods that will be used to install surface casings to isolate shallow intervals from deeper drilling. The guideline only addresses installation in unconsolidated materials. Installation of monitoring wells in bedrock is discussed in SOP *Installation of Bedrock Monitoring Wells* and installation of shallow, single-cased monitoring wells is discussed in SOP *Installation of Shallow Monitoring Wells.*

II. Equipment and Materials

Drilling

- Drilling rig (hollow stem auger, sonic, air rotary, or mud rotary).

Surface Casing

- 6-inch to 12-inch ID steel or Schedule 80 polyvinyl chloride (PVC) surface casing, depending upon application.
- Temporary bottom plug or grout shoe.
- Bentonite for grout: pure, additive-free powdered bentonite.
- Cement-Bentonite Grout. Proportion: 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 pounds of bentonite added per bag of cement to reduce shrinkage.

Well Installation

- PVC, Schedule 40, minimum 2-inch ID, flush-threaded well riser; alternatively, stainless-steel riser.
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted well screen; alternatively, stainless-steel screen.
- PVC or stainless steel bottom cap, threaded to match the well screen.
- Centering guides (if used); same material as the casing, except stainless steel may be used in lieu of PVC.
- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse – e.g., Morie #1) filter pack, and secondary (fine sand seal) filter pack. Grain size determined based on sediments observed during drilling.
- Bentonite seal: Pure, bentonite pellets or chips.

- Bentonite for grout: Pure, powdered bentonite.
- Cement-Bentonite Grout: Proportion 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 pounds of bentonite added per bag of cement to reduce shrinkage.
- Above-grade well completion: PVC or stainless-steel well cap, threaded or push-on type, vented.
- Flush-mount well completion: PVC or stainless-steel well cap, locking, leak-proof seal.
- Above-grade protective casing: Permanent isolation casing with heavy duty locking cover, painted with epoxy paint for rust protection, industrial lock.
- Flush-mount protective casing: Morrison 9-inch or 12-inch 519 manhole cover; rubber seal for cover; heavy duty locking cap on permanent isolation casing.

Well Development

- Surge block.
- Pump and associated development equipment.
- Calibrated meters to measure pH, temperature, specific conductance, and turbidity of development water.
- Containerization for water produced from well.

III. Procedures and Guidelines

A. Drilling Methods

Boreholes for the surface casing can be drilled with hollow-stem auger, air rotary, or mud rotary. Boreholes will be drilled to various diameters, depending upon applications. In the case of temporary surface casing, where grout will not be used to install the casing, the borehole for the casing will be drilled with a method by which the borehole will be as close to the diameter of the surface casing as possible to minimize the size of the annular space. This may be by a rotary method or by using a hollow-stem auger with as small an inside diameter as possible. For permanent surface casing, typically hollow-stem auger will be used.

1. Hollow-Stem Auger Drilling

Hollow-stem auger (HSA) drilling techniques can be used to drill boreholes for installation of surface casing. The borehole will be drilled into a clay layer of significant thickness. Minimum 8-1/4-inch ID HSA will be used to drill the borehole a minimum of 5 feet into a clay layer of significant thickness.

The use of water or other fluid to assist in hollow-stem auger drilling is to be avoided.

The bit of the auger is placed at the ground surface and then turned with the drilling rig. To collect split-spoon or other samples, the auger is advanced to the top of the sampling depth, and the sample is collected from below the auger head. The split spoon is advanced through repeated blows from a 140-pound or 300-pound hammer dropped from a height of 30 inches. Thin-walled tube samplers are advanced by pressing down on the rods with the weight of the drilling rig. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOPs *Soil Boring Sampling – Split Spoons* and *Soil Sampling*.

Material brought to the surface on the outside of the augers should be containerized at a convenient space away from the working area. Material may be stored on plastic sheeting and containerized at the completion of activities at the drilling location. Such material will be disposed of according to SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan (IDWMP).

Drilling equipment will be decontaminated before drilling in accordance with the procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

2. Rotary Drilling

Mud rotary or other rotary drilling techniques can be used to install surface casing.

To collect split spoon samples, the drill bit is advanced to the depth to be sampled, the bit is removed from the borehole, and the split-spoon sample is collected from the borehole.

Drill cuttings and fluids generated during rotary drilling activities will be contained until completion of activities at the drilling location. Such material will be disposed of according to SOP *Disposal of Waste Fluids and Solids* and the IDWMP.

Drilling equipment will be decontaminated before drilling in accordance with the procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

B. Surface-Casing Installation

Surface casing will be constructed of minimum 6-inch ID or greater black iron steel with a minimum wall thickness of 0.20 inches or Schedule 80 PVC. Casing lengths for permanent surface casings will be welded or connected by threaded connections sealed with Teflon tape, while casing lengths for temporary surface casings will be either threaded connections of casing installed as part of the rotary-drilling method. The steel casing and threaded couplings must be free of paint, varnish, or coatings of any kind, both inside and outside. Threaded connections must be free of oils or grease. Welding of the casing is permissible provided that the welds meet the Standards of the American Welding Society.

Surface casing will be decontaminated prior to installation in accordance with the procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

Permanent surface casing will be placed in the bottom of the borehole and the surface casing will be pressed into a low permeability layer, if present. The surface casing will be grouted in place by installing the grout through a tremie pipe connected to the grout shoe, or placed at the bottom of the annulus.

Alternatively, the surface casing may be installed and grouted in place by a grout displacement method. The bottom of the surface casing is fitted with a tight, drillable plug. The borehole is then filled with the estimated volume of cement-bentonite grout to fill the annular space, and the casing is lowered to the bottom of the borehole (displacement method). If the weight of the casing is not sufficient to displace the grout and allow the casing to sink to the bottom of the borehole, the casing may be filled with clean water.

Well installation will proceed inside the surface casing once the grout has been allowed to cure for approximately 16 to 24 hours. All water in the surface casing will be removed before drilling resumes in order to prevent carrying contamination downward into deeper intervals of the water-bearing unit. All water in the casing will be disposed of according to SOP *Disposal of Waste Fluids and Solids* and the IDWMP before drilling is resumed.

Temporary surface casing installed independently of the drilling process also will be placed in the bottom of the borehole and the surface casing will be pressed into a low permeability layer, if present. However, it will not be grouted into place.

C. Monitoring-Well Installation

Typically, the well is completed within the surface casing using mud rotary techniques. Sonic drilling methods may also be used through permanent surface casings.

If the borehole has been drilled to a depth greater than that at which the well is to be completed, the borehole will be backfilled with bentonite pellets or chips or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the correct depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be lowered to the bottom of the borehole. Centering guides, if used, will be placed at intervals around the well casing, at the base of the screen, and 5 feet above the top of the well screen.

Selection of final filter pack and well screen depths for the wells shall be made in the field.

A primary sand pack consisting of clean Morie No. 00 (or DSI No.1) silica sand for 0.010-inch slotted screen and Morie No. 01 (or DSI No.2) silica sand for 0.020-inch slotted screen will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. During placement of the sand, the position of the top of the sand will be continuously sounded using a stainless steel weight attached to a tape measure. The primary sand pack will extend from the bottom of the borehole to a minimum of 2 feet above the top of the well screen. A secondary (fine sand seal) sand pack will then be installed to a minimum of 1 foot above the primary sand pack.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. A hydration period of at least 30 minutes will be allowed following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the top of the bentonite seal to the ground surface. The cement-bentonite grout will be installed through a side-discharge tremie pipe plugged at the bottom. The openings in the tremie pipe will allow the grout to discharge laterally into the borehole and avoid disturbance the bentonite seal.

D. Monitoring-Well Completion

For monitoring wells that will be completed above-grade, the surface casing itself may serve as the protective casing. However, a separate steel protective casing may be used instead. The protective surface casing will be finished 2 to 3 feet above grade and fitted with a locking steel cap. A concrete pad with four guard posts will be installed.

The concrete pad will be square, approximately 2 feet per side (unless otherwise specified in the project plans), and poured into wooden forms. The concrete will be sloped away from the protective casing. The concrete pad will extend at least 6 inches below and 2 inches above the ground surface.

Four steel guard posts will be installed around the locking casing. Guard posts shall be concrete-filled, at least 2 inches in diameter, and extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, a 8 to 12-inch dia. manhole cover with a rubber gasket and drain will be installed. The top of the manhole will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 feet per side (unless otherwise specified in the project plans), will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic. The concrete pad will extend at least 6 inches below the ground surface.

Inside the manhole, a locking cap will be placed on the inner well casing.

Each well will be labeled on the exterior of the locking cap with a metal stamp indicating the permanent well number.

E. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer may not allow low turbidity results to be achieved.

The surging apparatus will include a tight-fitting surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, turbidity, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of one hour and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the IDWMP.

IV. Attachments

Schematic diagram of double-cased monitoring-well construction (MWDoubleDiag.xls)

STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Monitoring well installations are planned for shallow and/or deep unconsolidated aquifers and/or for bedrock aquifers. The SOPs *Installation of Shallow Monitoring Wells, Installation of Surface-Cased Monitoring Wells, Installation of Bedrock Monitoring Wells,* and *Installation of Monitoring Wells Using Sonic Drilling* provide more specifics.

III. Equipment and Materials

1. Drilling rig (hollow stem auger, sonic, air hammer, air rotary, or mud rotary)
2. Well-construction materials (i.e., surface casing, screens, riser, casing, caps, bottom plugs, centering guides, sand, bentonite, grout, and surface-finish materials)
3. Development equipment

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double-cased.
2. The threaded connections will be water-tight.
3. Well screens generally will be constructed of 10-slot or 20-slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact slot size and length will be determined by the field team supervisor. Stainless steel may be required under certain contaminant conditions.
4. Stick-up wells will be surrounded by four concrete-filled guard posts at least 2 inches in diameter.

5. A record of the finished well construction will be compiled.

6. All soils and liquids generated during well installations will be drummed for proper disposal.

Monitoring Well Installation

- 2″ monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.

- All monitoring wells penetrating a confining layer will be surface-cased from the ground surface to approximately 5 feet into the confining layer. Exceptions to this may be allowed under certain circumstances (e.g., evidence of significant natural gaps in the confining layer).

- Monitoring wells in unconsolidated materials will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, Schedule 40 PVC (or stainless steel) screen with threaded bottom plug and riser.

- Screens will be filter packed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. For rotary-drilled wells, the height of the sand pack also will be sounded with a weighted tape.

- The primary filter sand pack (typically Morie #00 or DSI #1 for a 10-slot screen) will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken. For wells deeper than 30 feet, the filter pack will be placed using a tremie pipe and flowing water.

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

- A secondary filter sand pack (typically a fine sand seal) 1-foot thick may be placed above the primary sand pack.

- Annular well seals will consist of 2 feet of pelletized, chip, or granular bentonite clay placed above the filter pack. If necessary, the pellets will be hydrated using potable water. For wells installed using hollow-stem augers, the bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. A high-solids bentonite slurry using powdered bentonite introduced with a side-discharging tremie pipe will be used for the bentonite seals in wells greater than 30 feet deep. For rotary-drilled wells, the height of the well seal also will be sounded with a weighted tape. High-solids slurries will have solids content of at least 20 percent.

- The top of the annular seal will be measured after the bentonite seal has been allowed to hydrate and before the grout is applied. The seal will be allowed to hydrate for at least 30 minutes before work in the well continues.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage. A grout density scale is recommended for determining the correct density. See attached grout volume and weights chart for calculation of grout volume.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the top of the bentonite seal to ground surface.
- After allowing the grout to settle and set up overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and 3 feet below grade, and will be painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- If information is available, begin developing in the least-contaminated well first.
- Development will include surging the well by either abruptly stopping flow and allowing water in the well column to fall back into the well or through the use of a surge block that is slightly smaller in diameter than the well casing inner diameter.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.

- The air-lift method may be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt. A Horiba-U22 meter, YSI meter with separate Hanna turbidity meter, or equivalent should be used to determine when the turbidity is low and parameters have stabilized.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums. CH2M HILL will label and date the drums as pending analysis, and transport the drums to a designated site for storage.

V. Attachments

Grout Volume and Weights Chart

VI. Key Check and Items

- Ensure that all equipment is properly decontaminated as needed.
- Only new, sealed materials (e.g., screens, risers, and sand) will be used in constructing the well.
- Care shall be taken when making downhole measurements to ensure that proper heights of sand, seal, and grout are achieved.

STANDARD OPERATING PROCEDURE

Installation of Shallow Monitoring Wells

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of shallow monitoring wells and piezometers in unconsolidated or poorly consolidated materials using hollow stem augers, air rotary, or mud rotary. Installing monitoring wells in unconsolidated materials using sonic drilling is discussed in SOP *Installation of Monitoring Wells Using Sonic Drilling.* Methods for drilling and installing bedrock monitoring wells and deep, surface-cased wells in unconsolidated materials are presented in SOPs *Installation of Bedrock Monitoring Wells* and *Installation of Surface-Cased Monitoring Wells,* respectively.

II. Equipment and Materials

Drilling

- Drilling rig (hollow stem auger, air rotary or mud rotary) and associated tools and equipment

Well Riser/Screen and Associated Materials

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainless-steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless-steel screen
- PVC bottom cap, threaded to match the well screen; alternatively, stainless steel
- PVC or stainless-steel centering guides (if used)
- Above-grade well completion: PVC well cap, threaded or push-on type, vented
- Flush-mount well completion: PVC well cap, locking, leak-proof seal
- Stainless steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse – e.g., Morie #1) filter pack, and secondary (fine sand seal) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets or chips

- Pure, additive-free powdered bentonite

- Coated bentonite pellets; coating must biodegrade within 7 days

- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage.

Protective Casing

- Above-grade well completion: 6-inch minimum ID black iron steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover, or equivalent; rubber seal to prevent leakage; locking cover inside of road box

Well Development

- Surge block
- Well-development pump and associated equipment
- Calibrated meters to ensure pH, temperature, specific conductance, ORP, and dissolved oxygen of development water
- Containers (e.g., DOT-approved 55-gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Typically, continuous-flight hollow-stem augers with a minimum 4.25-inch inside diameter (ID) will be used to drill shallow monitoring well boreholes for 2-inch diameter monitoring wells. Alternatively, air or mud rotary may be used.

The bit of the auger is placed at the ground surface and then turned with the drilling rig. To collect split spoon samples, the auger is advanced to the top of the sampling depth, and the split-spoon sample is collected from below the auger head. The split spoon is advanced through repeated blows from a 140- or 300-pound hammer dropped from a height of 30 inches. Thin-walled tube samplers are advanced by pressing down on the rods with the weight of the drilling rig. Split-spoon samples may be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOPs *Soil Boring Sampling – Split Spoons* and *Soil Sampling*.

The use of water to assist in hollow-stem auger drilling for monitoring well installation will be avoided, unless required for such conditions as running sands.

Hollow-stem augers, drilling bits, rods, split-spoon samplers, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Split-spoon samplers and other downhole soil sampling equipment will also be properly decontaminated before and after each use. SOP *Decontamination of Drill Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan (IDWMP).

Air or mud rotary drilling may be used instead of hollow-stem augers. The use of added mud should be kept to a minimum.

B. Monitoring-Well Installation

Shallow monitoring wells will be constructed inside the hollow-stem augers, once the borehole has been advanced to the desired depth, or in the mudded borehole once the drilling rods have been withdrawn. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or chips or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the augers to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field.

A primary sand pack consisting of clean Morie No. 00 (or DSI No.1) silica sand for 10-slot screen and Morie No. 01 (or DSI No.2) for 20-slot screen silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The augers will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the augers be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary, finer-grained (fine sand seal), sand pack will be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for a shallow water table and a small saturated thickness of the surficial aquifer.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

C. Well Completion

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square, approximately 2 feet per side (unless otherwise specified in the project plans), and poured into wooden forms. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing Guard posts would be concrete-filled, at least 2 inches in diameter, and would extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 feet per side (unless otherwise specified in the project plans), will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12 inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

D. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring-well construction (MWSingleDiag.xls)

FIELD SAMPLING PROTOCOLS TO AVOID CROSS-CONTAMINATION DURING WATER SAMPLING FOR PERFLUORINATED COMPOUNDS (PFCs)

1.0 PURPOSE

While EPA method 537 provides basic guidance on sampling for PFC's in drinking water, due to the potential for cross contamination this Standard Operating Procedure (SOP) addendum describes additional precautionary procedures/considerations when collecting groundwater or drinking water samples. Sampling specific SOPs should also be reviewed prior to conducting field sampling activities at PFC sites.

2.0 SCOPE

This procedure applies to all qualified personnel and subcontractors who collect or otherwise handle water samples for analysis of PFCs. This SOP should be reviewed by all on-site personnel prior to implementation of field activities.

3.0 GENERAL

Given the low detection limits associated with PFC analysis and the many potential sources of trace levels of PFCs, field personnel are advised to act on the side of caution by strictly following these protocols, frequently replacing nitrile gloves, and rinsing field equipment to help mitigate the potential for background contamination detections of PFCs. Specific items related to field sampling are discussed below.

4.0 PROCEDURES/CONSIDERATIONS

The following are procedures/considerations to be made during field activities at potential PFC release sites.

Field Equipment

- **Do not use Teflon®-containing materials** (e.g., Teflon® tubing, bailers, tape, plumbing paste, or other Teflon® materials) since Teflon® contains fluorinated compounds.
- High-density polyethylene (HDPE), low-density polyethylene (LDPE), and silicon materials are acceptable for sampling. Samples should not be stored in containers made of LDPE materials.
- To avoid plastic coating or glue materials, **do not use waterproof field books**. Field reports should be documented on loose paper on masonite or aluminum clipboards (i.e. plastic clipboards, binders, or spiral hard cover notebooks are not acceptable). Sharpies®/markers should be avoided.
- **Post-It Notes are not allowed** on project sites.

- **Do not use markers.** Pens should be used when documenting field activities in the field log and on field forms as well as labeling sample containers and preparing the Chain of Custody.
- **Do not use chemical (blue) ice packs** during the sampling program. This includes the use of ice packs for the storage of food and/or samples.

Field Clothing and Personal Protective Equipment

- **Do not wear water resistant, waterproof, or stain-treated clothing** during the field program. Field clothing made of synthetic and natural fibers (preferably cotton) are acceptable. Field clothing should be laundered avoiding the use of fabric softener. Preferably, field gear should be cotton construction and well laundered (a minimum of 6 times from time of purchase). New clothing may contain PFC related treatments. **Do not use new clothing** while sampling or sample handling.
- **Do not wear clothing or boots containing Gore-Tex™** during the sampling program as it consists of a PFC membrane.
- All safety footwear will consist of steel-toed boots made with polyurethane and polyvinyl chloride (PVC).
- **Do not wear Tyvek® clothing** on-site since it contains fluorinated compounds.
- Disposable nitrile gloves must be worn at all times. Further, a new pair of nitrile gloves should be donned prior to the following activities at each sample location:
  - Decontamination of re-usable sampling equipment;
  - Prior to contact with sample bottles or water containers;
  - Insertion of anything into the well (e.g. HDPE tubing, HydraSleeve bailer, etc.);
  - Insertion of silicon tubing into the peristaltic pump;
  - Completion of monitor well purging, prior to sample collection;
  - Handling of any quality assurance/quality control samples including field blanks and equipment blanks; and,
  - After the handling of any non-dedicated sampling equipment, contact with non-decontaminated surfaces, or when judged necessary by field personnel.

Sample Containers

- Samples should be collected in polypropylene or HDPE bottles fitted with an unlined (no Teflon®), polypropylene HDPE screw cap. This is an especially important point as many laboratories utilize Teflon-lined bottles.
- Container labels will be completed using pen (**NO MARKERS**) after the caps have been placed back on each bottle.

- Glass containers should also be avoided due to potential loss of analyte through adsorption.

Wet Weather

- Field sampling occurring during wet weather (e.g., rainfall and snowfall) should be conducted while wearing appropriate clothing that will not pose a risk for cross-contamination. Teams should avoid synthetic gear that has been treated with water-repellant finishes containing PFCs. Use rain gear made from polyurethane and wax-coated materials.

Equipment Decontamination

For GW sampling, it is highly recommended that disposable equipment be utilized. However, if equipment re-use is performed, field sampling equipment, including oil/water interface meters and water level indicators, that are utilized at each sample location will require cleaning between uses. Alconox® and Liquinox® soap is acceptable for use since the Material Safety Data Sheets do not list fluoro-surfactants as an ingredient. However, **Decon 90 must not be used** during decontamination activities. Water used for the decontamination of sampling equipment will be laboratory certified "PFC-free" water.

Personnel Hygiene

- Field personnel should not use cosmetics, moisturizers, hand cream, or other related products as part of their personal cleaning/showering routine on the morning of a sampling event, as these products may contain surfactants and represent a potential source of PFCs.
- Many manufactured sunblock and insect repellants contain PFCs and should not be brought or used on-site. Sunblock and insect repellants that are used on-site should consist of 100% natural ingredients.

Food Considerations

- No food or drink shall be brought on-site, with the exception of bottled water and hydration drinks (i.e., Gatorade® and Powerade®).

Blanks

- Utilization of blanks is a good quality check to monitor and control the effects of contamination. Trip blanks and field blanks are recommended.

REFERENCES

- Transport Canada, 2013. *Perfluorochemical (PFC) Field Sampling Protocol*. May.

- Delta Consultants, 2010. *Report of Investigation Activities at Select Firefighting Foam Training Areas and Foam Discharge Sites in Minnesota*. February.
- MPCA, 2008. *Closed Landfill Program Sampling Protocol for Monitoring Wells.* October.
- *Oregon State University, 2015. COLLECTION AND HANDLING OF SAMPLES FOR FLUOROCHEMICAL ANALYSIS. July.*
- *EPA, 2009. EPA Document #: EPA/600/R-08/092, METHOD 537. DETERMINATION OF SELECTED PERFLUORINATED ALKYL ACIDS IN DRINKING WATER BY SOLID PHASE EXTRACTION AND LIQUID CHROMATOGRAPHY/TANDEM MASS SPECTROMETRY (LC/MS/MS). Version 1.1. September*

STANDARD OPERATING PROCEDURE

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in piezometers and monitoring wells, even where a second phase of floating liquid (e.g., gasoline) is encountered, and on staff gages in surface-water bodies. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers (see SOP *Use of Data Loggers and Pressure Transducers)*.

II. Equipment and Materials

- Electronic water-level meter (Solinst® or equivalent) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Interface probe (Solinst® Model 122 Interface Meter or equivalent)

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the piezometer or well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Note the depth from a reference point indicated on the piezometer or well riser. Typically, this is the top of the PVC casing. If no reference is clearly visible, measure the depth to water from the northern edge of the PVC casing. If access to the top of the PVC casing is difficult, sight across the top of the locking casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface.

Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the logbook. Water levels will be measured to the nearest 0.01-foot. Also when specified in the project plans, measure and record the depth of the piezometer or well. The depth of the piezometer or well may be measured using the water-level probe with the instrument turned off.

Free product light or dense nonaqueous phase liquid may be present in the piezometer or well. If the presence of free product is suspected, the thickness of the product should be determined using appropriate equipment (e.g., Solinst® Model 122 Interface Meter). The depth to water also is determined with this equipment and the water-level meter should not be used in the piezometer or well as long as product is present. Typically, a constant sound is emitted from the device when free product is encountered and an alternating on/off beep sound is emitted when water is encountered.

The apparent elevation of the water level in the well or piezometer is determined by measuring both the apparent depth to water and the thickness of free product. The corrected water-level elevation is calculated by the following equation:

$$WL_c = Wl_a + (\text{Free-product thickness} \times 0.80)$$

Where WL_c = Corrected water-level elevation

Wl_a = Apparent water-level elevation

0.80 = Typical value for the density of petroleum hydrocarbon products.

If free product is detected on the surface of the water in the piezometer or well, the value of sampling should be reconsidered because of the potential for contaminating the sampling equipment.

Staff gages may be installed in some surface-water bodies. These facilities typically are constructed by attaching a calibrated, marked staff gage to a wood or metal post, driving the post into the bottom of the surface-water body, and surveying the elevation of the top of the post to a resolution or 0.01-foot. The elevation of the water in the surface-water body then can be determined by reading off the distance the water level is from the top of the post. A shield or other protection may be needed to calm the fluctuations in water level if the gage is installed at a location exposed to wind or wave.

IV. Attachments

None.

V. Key Checks

- Before each use, verify that the battery is charged by pressing the test button on the water-level meter.
- Verify that the unit is operating correctly by testing the probe in distilled or de-ionized water. Leave the unit turned off when not in use.

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures for Low-Concentration Samples

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I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result, only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- “This Side Up” labels
- “Fragile” labels
- Vermiculite
- Ziplock bags or bubble wrap
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

A. Prepare coolers for shipment:

- Tape drains shut.
- Affix "This Side Up" labels on all four sides and "Fragile" labels on at least two sides of each cooler.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with about 3 inches of vermiculite or absorbent pads.

B. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks.

C. Affix appropriate adhesive sample labels to each container. Protect with clear label protection tape.

D. Seal each sample bottle within a separate ziplock plastic bag or bubble wrap, if available. Tape the bag around bottle. Sample label should be visible through the bag.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in zip-lock bags and placed on and around the containers.

G. Fill remaining spaces with vermiculite or absorbent pads.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with tape to avoid seals being able to be peeled from the cooler.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Place airbill receipt inside the mailing envelope and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier. If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result, only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate vermiculite or other packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals

geotech

Geopump Peristaltic Pump

Installation and Operation Manual

Rev 03/03/2015 Part # 81350020

Table of Contents

DOCUMENTATION CONVENTIONS

This document uses the following conventions to present information:

WARNING

An exclamation point icon indicates a **WARNING** of a situation or condition that could lead to personal injury or death. You should not proceed until you read and thoroughly understand the **WARNING** message.

CAUTION

A raised hand icon indicates **CAUTION** information that relates to a situation or condition that could lead to equipment malfunction or damage. You should not proceed until you read and thoroughly understand the **CAUTION** message.

NOTE

A note icon indicates **NOTE** information. Notes provide additional or supplementary information about an activity or concept.

NOTICES

In order to ensure your Geopump has a long service life and operates properly, adhere to the following cautions and read this manual before use.

≠ **Disconnect from power source when not in use.**

≠ **Power input source must not exceed maximum ratings.**

≠ **Equipment must be wired to a negative ground system.**

≠ **Equipment may not operate properly with excess wiring not supplied by manufacturer .**

≠ **Avoid spraying fluid directly at equipment.**

≠ **Never submerge equipment.**

≠ **Avoid pulling on wires to unplug equipment wiring.**

≠ **Avoid using equipment with obvious physical damage.**

≠ **To prevent equipment damage, avoid dropping it.**

The Geotech Geopump Peristaltic Pump cannot be made dangerous or unsafe as a result of failure due to EMC interference.

WARNING

Do not operate this equipment if it has visible signs of significant physical damage other than normal wear and tear.

Notice for consumers in Europe:

This symbol indicates that this product is to be collected separately.

The following applies only to users in European countries:

≠ This product is designated for separate collection at an appropriate collection point. Do not dispose of as household waste.

≠ For more information, contact the seller or the local authorities in charge of waste management.

Section 1: System Description

Function and Theory

The Geotech Series I and II Peristaltic Pumps (Geopump) are designed for single and multi-stage pressure or vacuum pumping of liquids for field or laboratory use. Since the Geopump can operate to a depth of 27 feet (8m) at sea level, it is ideally suited for sample removal from shallow wells and all surface water sources.

The Geopump operates by mechanical peristalsis, therefore the sample only comes in contact with the tubing. This allows for sample integrity as well as easy cleaning and tubing replacement. Tubing can also be lowered to a specific depth without curling or floating on the surface of the water with the use of an optional stainless steel tubing weight.

Differences between the two models affect the number of pump heads which may be used with the Geopump at one time and the speed(s) at which the pump heads operate. Therefore, the instructions for general operations will be covered only once.

System Components

SERIES I Peristaltic Pumps are available in AC only, DC only, or an AC/DC combination. These units have one pumping station which can also be piggy-backed for multi-station pumping. The variable speed range is from 0 RPM to 350 RPM.

SERIES II Peristaltic Pumps are available in AC only, DC only, or an AC/DC combination. They have two pumping stations which can also be piggy-backed. The first pumping station is rated at 0 RPM to 350 RPM and the second station at 0 RPM to 600 RPM. Each pumping station works in conjunction with the other.

Section 2: System Installation

Standard Pump Head Instructions

1. Separate the pump halves. Hold the pump head as shown with the rollers in the 2, 6, and 10 o'clock positions and the rotor shaft facing down.

2. Place the tubing around the rollers.

3. Turn rotor counterclockwise until tubing completely surrounds the rotor.

4. The tubing is now in place. Next, position other pump half onto the motor shaft and snap shut. Be careful not to pinch tubing between plastic halves.

Easy-Load II Pump Head Instructions

1. Attach the Easy-Load II pump to the Geopump with the screws provided.
2. Set the lever to the left to open the pump. Place the tubing left to right.

3. Set the lever to the right to close the pump housing onto the tubing.

Section 3: System Operation

The Geopump arrives packed in a hard-shell peristaltic pump carry case with the pump head properly attached to the pump (purchased separately). See Section 8 on available pump parts.

To place the pump into service:

1. Remove the pump from the case and verify the pump is switched to “OFF” (red, open circle)

2. For AC/DC combination units, plug in the appropriate power cord into the outlet in the back of the pump and the other end of the power cord into the power source.

3. Insert the tubing into the pump head.

4. Put one end of the tubing into the sample source (well, river, ditch, lagoon, etc.) and the other end into the sample container.

5. Determine the desired direction of flow and set the toggle switch for the flow direction.

6. Turn the pump “ON” (the black filled circle).

7. Once pumping has begun, the speed dial can be adjusted to increase or reduce the fluid pumping speed as needed.

Section 4: System Maintenance

The Geopump has a strong reputation for durability and being virtually maintenance free. The following maintenance steps will assure your pump’s long-term reliability:

Pump Tubing:

Depending on the pump head design, different sizes of tubing may be used. Use of incorrect tubing, size, or type, will cause damage to the pump and/or the pump head and void the warranty. Geotech recommends regular tubing replacement for optimum performance. Using the proper size and type of tubing for the pump head is essential. If you are unsure of the tubing type for your application, please call Geotech.

Pump:

Keep your Geopump clean and dry. In the event that the Geopump is subjected to significant splashing or immersion, discontinue use and wipe the unit down immediately with a clean dry cloth.

To keep your Geopump reliable follow these simple guidelines:

≠ Do not drop your Geopump.
≠ Do not immerse your Geopump.
≠ Do not subject your Geopump to poor power supplies.
≠ Do not subject your Geopump to extreme heat or cold when in use.

Power Cords:

Always replace a kinked or damaged power cord. Replacement power cords are available for AD/DC combination units. Units with a hard-wired power cord are to be sent back to Geotech for proper repair. Refer to the Geotech Warranty and Repair page in the back of this manual.

Pump Head:

Clean the Geopump pump head periodically using a phosphate-free cleaning detergent and water solution.

Section 5: System Troubleshooting

Problem: Unit will not turn on.

Solution:

1. No power to unit: (rollers not moving):
   - Check power source and compatibility.
   - Check connections.

2. Speed control not set fast enough to overcome tubing resistance:
   - Check speed setting; if too low turn it up.

3. Check tubing size and type. Make sure it is the correct size and type for the pump head.

4. Check circuit breaker; if tripped press it in to reset.

Problem: Unit turns on, but not pumping (pump head rollers are moving).

Solution:

1. Verify fluid level in well (max suction lift unit can pump from is 27 feet (8m) below ground at sea level).

2. Water level is below down well tubing intake. Increase tubing length.

3. If using a combination of flexible and rigid tubing, check connection between tubing. A poor connection may cause a vacuum leak. Secure tubing connection.

4. Flexible tubing in pump head compromised or worn out:
   - Replace flexible tubing regularly.

5. Obstruction in tubing:
   - Check for clogs and kinks.
   - Clear any obstructions.

6. Using incorrect tubing type for pump head:
   - Tubing may have collapsed.
   - Replace with proper tubing type.

Problem: Pump head rollers are not moving .

Solution:

1. Pump head is loose from the pump housing:
   - Tighten pump head screws to engage pump head to gear.
   - Possible internal damage, call Geotech for consultation.

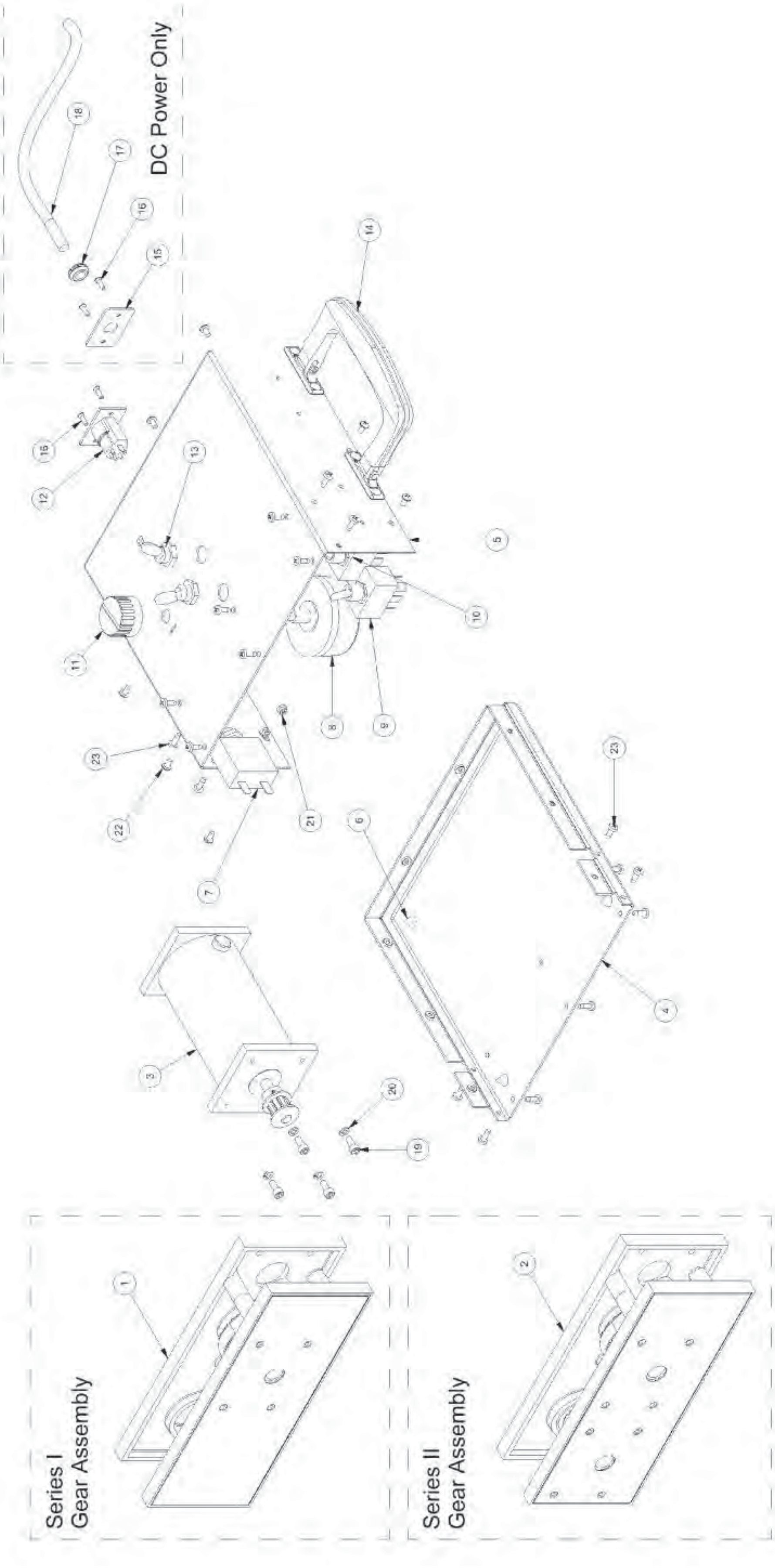
Section 6: System Specifications

Operating range	27 feet (8m) (at sea level)
Principle of Operation	Mechanical peristalsis
Dimensions	3.5 x 8 x 8 inches (9 x 20 x 20cm)
Power source (DC)	Any rated external 12-18 VDC @ 70 Watts
Power source (AC)	90-260 VAC, 47-65 Hz
Nominal operating current	3 amps DC
Over current Protection	5 amps DC
Power cord	12 VDC cord
Range of speed: Series I	0 to 350 RPM
Range of speed: Series II	First pumping station 0 to 350 RPM
	Second pumping station 0 to 600 RPM
Speed control	Step-less variable speed control
Liquid delivery rate	1.67 ml per revolution (for size 15 tubing)
Pumping options	Pressure or vacuum (reversible flow)
Pump head rotor	Cold rolled steel

OPTIONS

Models:	Geopump 1, Geopump 2
Tubing:	Silicone, Tygon, Viton, C-Flex
Pump Heads:	Standard, Easyload, Easyload 2

Section 7: System Schematics



Section 8: Parts and Accessories

Schematic Parts Listing (Section 7)

Item	QTY	Part Number	Part Description
1	1	51350001	Assy, Gear Housing, Series I
2	1	51350002	Assy, Gear Housing, Series II
3	1	51350003	Assy, Motor, PP
4	1	51350012	Assy, Housing, Bottom, PP
5	1	51350023	Housing, Top, Silk Screened
6	4	17500042	Foot, RBR, 9/32” Hole Dia
7	1	11350005	Breaker, Thermal, 5amp, Circuit 250V
8	1	51350011	Assy, Rheostat
9	1	11350020	Switch, Toggle, Dpdt, Frwd/Rvrs
10	1	11350021	Switch, Toggle, Dpst, On/Off
11	1	11350010	Knob, Plastic, Rheostat
12	1	51350033	Assy, Wiring Harness, PP
13	2	17500037	Boot, RBR, Toggle Switch, Grey
14	1	11350009	Handle, PE, NI
15	1	11350015	Plate, AL, 1.5x1.5, Hardwire, Cord, Painted
16	2	00114	Screw, SS8, 4-40x3/8”, FHD
17	1	11350019	Grommet, RBR, 5/16x1/2”, ¼” Thick Hole
18	1	17500040	Cord, SJOW, DC Power, 18-2
19	4	17500366	Screw, SS8, 8-32x3/8”, SHCS
20	4	17200081	Washer, SS8, #8, Lock
21	2	17200046	Nut, Hex, 4-40, Nyloc
22	8	17200078	Screw, SS8, 6-32x.25”, PNH, M/S
23	20	17200077	Screw, SS8, 6x3/8”, PNH, TEK Self Drilling

Additional Parts Listing

Part Number	Part Description
17500035	Adaptor, Cigarette to Clips
51350030	Power Supply, AC Adapter, PP, 18V, 70W, CE
57500008	Assy, Power Cord, DC w/Amp
51350015	Case, Peristaltic Pump with foam
51350026	Faceplate, Gear, Hsng, Series II, Painted
51350025	Faceplate, Gear, Hsng, Series I, Painted
17200079	Screw, SS8, 8-32x1.25”, Fillister, Peristaltic Pump
17200199	Screw, ZNC, 6-32x2.5”, Thumb, Peristaltic Pump
71350030	Screw, SS8, 8-32x3”, Phil

Old Style Non-CE Parts

Part Number	Part Description
57500007	Assy, Power Cord, AC, w/Amp
51350007	Assy, Diode, PP
57500009	Assy, Rectifier Bridge, PP-Logic
51350013	Assy, Transformer w/Jumper, PP
51350004	Assy, Wiring Harness, PP

DOCUMENT REVISIONS		
EDCF#	DESCRIPTION	REV/DATE
-	Previous Release	7/14/11
-	Update Declaration of Conformity to include header, SP	3/3/15

geotech

EC Declaration of Conformity

Manufacturer:

Geotech Environmental Equipment, Inc.
2650 E 40th Avenue
Denver, CO 80205

Declares that the following products,

Product Name: Geopump Peristaltic Pump

Model(s):
51350018 - GEOPUMP, CE, SERIES II, DC ONLY
51350021 - GEOPUMP, CE, SERIES I, DC ONLY
51350031 - GEOPUMP, CE, SERIES I
51350032 - GEOPUMP, CE, SERIES II

Year of manufacture: 2009

Conform to the principle safety objectives of 2006/95/EC Low Voltage Directive by application of the following standards:
EN 61010-1: 2010
EN 809-1 + A1:2010

Year of affixation of the CE Marking: 2009

Conform to the protection requirements of 2004/108/EC Electromagnetic Compatibility (EMC) by application of the following standards:
EN 61000-6-1: 2007
EN 61000-6-3: 2012
EN 61326-1: 2013

EMC conformity established: 08/14/2009

Production control follows the ISO 9001:2008 regulations and includes required safety routine tests.

This declaration issued under the sole responsibility of Geotech Environmental Equipment, Inc.

Joseph Leonard

Joe Leonard
Product Development

Serial number ________________

The Warranty

For a period of one (1) year from date of first sale, product is warranted to be free from defects in materials and workmanship. Geotech agrees to repair or replace, at Geotech's option, the portion proving defective, or at our option to refund the purchase price thereof. Geotech will have no warranty obligation if the product is subjected to abnormal operating conditions, accident, abuse, misuse, unauthorized modification, alteration, repair, or replacement of wear parts. User assumes all other risk, if any, including the risk of injury, loss, or damage, direct or consequential, arising out of the use, misuse, or inability to use this product. User agrees to use, maintain and install product in accordance with recommendations and instructions. User is responsible for transportation charges connected to the repair or replacement of product under this warranty.

Equipment Return Policy

A Return Material Authorization number (RMA #) is required prior to return of any equipment to our facilities, please call our 800 number for appropriate location. An RMA # will be issued upon receipt of your request to return equipment, which should include reasons for the return. Your return shipment to us must have this RMA # clearly marked on the outside of the package. Proof of date of purchase is required for processing of all warranty requests.

This policy applies to both equipment sales and repair orders.

FOR A RETURN MATERIAL AUTHORIZATION, PLEASE CALL OUR
SERVICE DEPARTMENT AT 1-800-833-7958.

Model Number: ________________

Serial Number: ________________

Date of Purchase: ________________

Equipment Decontamination

Prior to return, all equipment must be thoroughly cleaned and decontaminated. Please make note on RMA form, the use of equipment, contaminants equipment was exposed to, and decontamination solutions/methods used. Geotech reserves the right to refuse any equipment not properly decontaminated. Geotech may also choose to decontaminate the equipment for a fee, which will be applied to the repair order invoice.

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STANDARD OPERATING PROCEDURE

Multi RAE Photoionization Detector (PID)

I. Purpose

The purpose of this SOP is to provide general reference information for using the Multi RAE PID in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

II. Scope

This procedure provides information on the field operation and general maintenance of the Multi RAE PID. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

III. Definitions

Carbon Monoxide Sensor (CO) - Carbon Monoxide concentration in ppm.

Volatile Organic Compound (VOC) – VOC concentration in ppm

Lower Explosive Limit (LEL) - Combustible gas is expressed as a percent of the lower explosive limit.

Hydrogen Sulfide Sensor (H_2S) - Hydrogen Sulfide concentration in ppm.

Oxygen Sensor (OXY) - Oxygen concentration as a percentage.

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

IV. Procedures

The PID operates on the principle that most organic compounds and some inorganic compounds are ionized when they are bombarded by high-energy ultraviolet light. The air sample is drawn across a UV lamp using a pump or a fan. The energy of the lamp determines whether a particular chemical will be ionized. Each chemical compound has a unique photoionization potential (PIP). When the UV light energy is greater than the ionization potential of the chemical, ionization will occur. All PID readings are relative to the calibration gas, usually isobutylene.

It is important to calibrate the PID in the same temperature and elevation that the equipment will be used, and to determine the background concentrations in the field before taking measurements. For environments where background readings are high, factory zero calibration gas should be used.

Note: For volatile and semi-volatile compounds, knowing the PIP is critical in determining the appropriate instrument to use when organic vapor screening. Consult the QAPP and manufacturer's manual to determine that the proper instrument has been selected for the contaminate vapors of interest. If an expected compound at a site has a PIP less than 11.7 eV, it is possible to use a PID. If the ionization potential is greater than 11.7eV, a flame-ionization detector is required.

The following subsections will discuss Mini RAE calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

A. Calibration

For Multi RAE configured with O_2, LEL, H_2S, CO, sensors and a 10.6 eV PID Lamp.

Start up Instrument

- Press **Mode** button
- Observe displays:

On!……..

Multi RAE
Version X.XX

Model Number
SN XXXX

Date Time
Temp

Checking Sensor
Ids….

VOC Installed

CO Installed

H_2S Installed

OXY Installed

LEL Installed

H_2S VOC CO
LEL OXY

```
Alarm Limits=
```

```
XX XX.X XX
XX High XX.X
```

```
XX XX.X XX
XX Low XX.X
```

```
XX XX.X XX
 STEL
```

```
XX XX.X XX
 TWA
```

```
Battery = X.XV
Shut off at 4.2V
```

```
User Mode=
```

```
Alarm Mode=
```

```
Datalog Time Left
```

```
Datalog Mode
```

```
Datalog Period
```

```
Unit ready in…..
10 Seconds
```

- The pump will start, the seconds will count down to zero, and the instrument will be ready for use

Calibration Check and Adjustment

Allow instrument to warm up for 15 minutes.

- Depress the **[N/-]** key first, then while depressing the **[N/-]**, depress the **[Mode]** key also and depress both keys for 5 seconds.
- Display will read:

```
Calibrate
Monitor?
```

- Press the **[Y/+]** key
- Display will read:

Fresh Air
Calibration?

- If “Zero Air” is necessary, attach the calibration adapter over the inlet port of the Multi RAE Monitor and connect the other end of the tube to the gas regulator (HAZCO loaner regulator LREG.5, RAE Systems P/N 008-3011 or suitable .5 LPM regulator) on the Zero Air bottle (HAZCO P/N SGZA, RAE P/N 600-0024). If no Zero Air is available, perform the Fresh Air Calibration in an area free of any detectable vapor.
- Press the **[Y/+]** key
- Display will read:

Zero….
In progress…

CO Zeroed!
Reading = X

VOC Zeroed!
Reading = X

LEL Zeroed!
Reading = X

OXY Zeroed!
Reading = X

Zero Cal done!

H_2S Zeroed!
Reading = X

In each of the above screens, “X” is equal to the reading of the sensor before it was zeroed.

- Display will then read:

Multiple Sensor
Calibration?

- Press the **[Y/+]** key
- The display shows all of the pre-selected sensors and the “OK?” question:

CO H_2S
LEL OK? OXY

- Apply calibration gas – use either HAZCO Services Part Number R-SGRAE4 or Rae Systems Part Number 008-3002 – using a .5 LPM regulator and direct tubing.
- Press the **[Y/+]** key. Display will read:

Apply Mixed gas

Calibration
In progress …

- The display will count down showing the number of remaining seconds:

CO cal’ed
Reading=50

H_2S cal’ed
Reading=25

LEL cal’ed
Reading=50

OXY cal’ed
Reading=20.9

Calibration done
Turn off gas!

- Display will read:

Single Sensor
Calibration?

- Press the **[Y/+]**.
- Display will read:

CO VOC H_2S
LEL pick? OXY

- Attach 100 ppm Isobutylene (HAZCO P/N r-SGISO or Rae P/N 600-0002) using a 1.0 LPM regulator (HAZCO P/N LR10HS or Rae P/N 008-3021). Open regulator.
- Press the **[Mode]** key once, the V of VOC will be highlighted.
- Press the **[Y/+]**. The display will read:

Apply VOC Gas

Calibration
In progress…

- The display will count down showing the number of remaining seconds:, then display:

VOC cal’d
Reading=100

Calibration done
Turn off gas!

Single Sensor
Calibration?

- Press **[Mode]** key twice to return to main screen.

- **CALIBRATION IS COMPLETE!**

B. Operation

Due to the Multi RAE having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 9 to 14.

C. Site Maintenance

After each use, the meter should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

D. Scheduled Maintenance

Function	Frequency
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly
Replace sensors	Biannually or when calibration is unsuccessful

V. Quality Assurance Records

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the field logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g, Multi RAE had wide range fluctuations during air monitoring activities.)

VI. References

Multi RAE Plus Multiple Gas Monitor User Manual, RAE Systems, Revision B1, November 2003.

STANDARD OPERATING PROCEDURE

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

The purpose of this guideline is to provide methods for the decontamination of drilling rigs, downhole drilling tools, and water-level measurement equipment. Personnel decontamination procedures are not addressed in this SOP; refer to the site safety plan and SOP *Decontamination of Personnel and Equipment*. Sample bottles will not be field decontaminated; instead they will be purchased with certification of laboratory sterilization.

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Liquinox®
- Buckets
- Brushes
- Isopropanol, pesticide grade
- Personal Protective Equipment as specified by the Health and Safety Plan
- ASTM–Type II grade water or Lab Grade DI Water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

Before the onset of drilling, after each borehole, before drilling through permanent isolation casing, and before leaving the site, heavy equipment and machinery will be decontaminated by steam cleaning at a designated area. The steam-cleaning area will be designed to contain decontamination wastes and waste waters and can be an HDPE-lined, bermed pad. A pumping system will be used to convey decontaminated water from the pad to drums.

Surface casings may be steam cleaned in the field if they are exposed to contamination at the site prior to use.

B. Downhole Drilling Tools

Downhole tools will be steam cleaned before the onset of drilling, prior to drilling through permanent isolation casing, between boreholes, and prior to leaving the site. This will include, but is not limited to, rods, split spoons or similar samplers, coring equipment, augers, and casing.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for physical characterization, the sampler shall be cleaned by scrubbing with a detergent solution followed by a potable water rinse.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for chemical analysis, the sampler shall be decontaminated following the procedures outlined in the following subsection.

C. Field Analytical Equipment

1. Water Level Indicators

   Water level indicators that consist of a probe that comes into contact with the groundwater must be decontaminated using the following steps:

   a. Rinse with tap water
   b. Rinse with de-ionized water
   c. Solvent rinse with isopropanol (Optional)
   d. Rinse with de-ionized water

2. Probes

   Probes, for example, pH or specific ion electrodes, geophysical probes, or thermometers that would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise. For probes that make no direct contact, for example, OVM equipment, the probe will be wiped with clean paper-towels or cloth wetted with isopropanol.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- The effectiveness of field cleaning procedures may be monitored by rinsing decontaminated equipment with organic-free water and submitting the rinse water in standard sample containers for analysis.

STANDARD OPERATING PROCEDURE

Installation of Monitoring Wells by Sonic Drilling

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of groundwater monitoring wells and piezometers in unconsolidated or poorly consolidated materials using sonic drilling techniques. Sonic drilling technology potentially eliminates telescoping monitoring wells, allowing the installation of aquifer penetrating, single-cased wells.

II. Equipment and Materials

Drilling

- Sonic drilling rig
- Override casings and core barrel

Well Riser/Screen

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainless steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless steel screen.

Bottom Cap

- PVC, threaded to match the well screen; alternatively, stainless steel
- Centering guides (if used)

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal
- Stainless steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse – e.g., Morie #1) filter pack, and secondary (fine sand seal) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets
- Pure, additive-free powdered bentonite

- Coated bentonite pellets; coating must biodegrade within 7 days
- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 pounds of bentonite added per bag of cement to reduce shrinkage

Protective Casing

- Above-grade well completion: 6-inch minimum ID black iron steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: 8-inch or 12-inch dia. manhole cover, or equivalent; rubber seal to prevent leakage

Well Development

- Surge block
- Well-development pump and associated equipment
- Calibrated meters to measure pH, temperature, specific conductance, and turbidity of development water
- Containers (e.g., 55 gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Drill rods and core barrel with a minimum 6-inch inside diameter (ID) will be used to drill monitoring well boreholes. Continuous core soil samples (4-inches outside diameter) will be collected for lithologic classification and intervals may be selected for chemical analysis. Soil sampling procedures are detailed in SOP *Shallow Soil Sampling.*

The use of water and additives to assist in sonic drilling for monitoring well installation will be minimized, unless required for such conditions as running sands or drilling bedrock formations.

Override casings, core barrels, and other downhole drilling tools will be decontaminated prior to the initiation of drilling activities and between each borehole location. Core barrels and other downhole soil sampling equipment will also be decontaminated before and after each use. SOP *Decontamination of Drilling Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Field Sampling Plan.

B. Monitoring Well Installation

Sonic drilling technology eliminates the necessity to install double or triple cased wells since the borehole will be fully cased during drilling activities. Monitoring wells will be constructed inside the override casing(s), once the borehole has been advanced to the desired depth. Following setting the well screen, riser, filter pack, and bentonite seal, the well will be grouted as the temporary casing is withdrawn, preventing cross contamination. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the temporary casing to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

A primary sand pack consisting of clean Morie No. 00 (or DSI No.1) silica sand for 0.010-inch slotted screen and Morie No. 01 (or DSI No.2) silica sand for 0.020-inch slotted screen will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The inner-most override casing will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the innermost override casing be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will extend from the bottom of the borehole to a minimum of 2 feet above the top of the well screen. A secondary, finer-grained sand pack may be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for a shallow water table and small saturated thickness of the surficial aquifer.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to discharge laterally into the borehole and not disturb the bentonite pellet seal.

C. Well Completion

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 2 feet into the ground and 3 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square, approximately 2 feet per side (unless otherwise specified in the project plans), and poured into wooden forms. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover, or equivalent, with a rubber gasket and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 feet per side (unless otherwise specified in the project plans), will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12-inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

C. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a tight-fitting surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, turbidity and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of one hour until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring well construction (MWSingleDiag.xls)

Appendix B

Laboratory DoD ELAP Accreditation Letters

American Association for Laboratory Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

VISTA ANALYTICAL LABORATORY
1104 Windfield Way
El Dorado Hills, CA 95762
[redacted]

ENVIRONMENTAL

Valid To: September 30, 2017 Certificate Number: 3091.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2009 NELAC Standard, and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.0 of the DoD Quality Systems Manual for Environmental Laboratories) accreditation is granted to this laboratory to perform recognized EPA methods using the

Peter Unger

following testing technologies and in the analyte categories identified below:

Testing Technologies

High Resolution Gas Chromatography / Mass Spectrometry

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
Dioxins/Furans				
2,3,7,8-Tetrachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
2,3,7,8-Tetrachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,7,8-Pentachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
2,3,4,7,8-Pentachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,4,7,8-Hexachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,6,7,8-Hexachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
2,3,4,6,7,8-Hexachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,7,8,9-Hexachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,4,6,7,8-Heptachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,4,7,8,9-Heptachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
Total Tetrachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
Total Pentachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
Total Hexachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
Dioxins/Furans				
Total Heptachlorodibenzo-p-dioxin	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
Total Tetrachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
Total Pentachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
Total Hexachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
Total Heptachlorodibenzofuran	------------------------	EPA 1613B/8290	EPA 1613B/8290	EPA 1613B/8290
PCBs				
2-Chlorobiphenyl (1)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3-Chlorobiphenyl (2)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
4-Chlorobiphenyl (3)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2'-Dichlorobiphenyl (4)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3-Dichlorobiphenyl (5)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3'-Dichlorobiphenyl (6)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4-Dichlorobiphenyl (7)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4'-Dichlorobiphenyl (8)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,5-Dichlorobiphenyl (9)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,6-Dichlorobiphenyl (10)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3'-Dichlorobiphenyl (11)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4-Dichlorobiphenyl (12)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4'-Dichlorobiphenyl (13)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,5-Dichlorobiphenyl (14)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
4,4'-Dichlorobiphenyl (15)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3-Trichlorobiphenyl (16)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4-Trichlorobiphenyl (17)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',5-Trichlorobiphenyl (18)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',6-Trichlorobiphenyl (19)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3'-Trichlorobiphenyl (20)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,3,4-Trichlorobiphenyl (21)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4'-Trichlorobiphenyl (22)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,5-Trichlorobiphenyl (23)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,6-Trichlorobiphenyl (24)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4-Trichlorobiphenyl (25)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',5-Trichlorobiphenyl (26)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',6-Trichlorobiphenyl (27)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,4'-Trichlorobiphenyl (28)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,5-Trichlorobiphenyl (29)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,6-Trichlorobiphenyl (30)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4',5-Trichlorobiphenyl (31)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4',6-Trichlorobiphenyl (32)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4-Trichlorobiphenyl (33)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,5-Trichlorobiphenyl (34)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4-Trichlorobiphenyl (35)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',5-Trichlorobiphenyl (36)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4,4'-Trichlorobiphenyl (37)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4,5-Trichlorobiphenyl (38)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4',5-Trichlorobiphenyl (39)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3'-Tetrachlorobiphenyl (40)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4-Tetrachlorobiphenyl (41)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4'-Tetrachlorobiphenyl (42)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5-Tetrachlorobiphenyl (43)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5'-Tetrachlorobiphenyl (44)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,6-Tetrachlorobiphenyl (45)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	Potable Water	Nonpotable Water	Solid Hazardous Waste	Tissue
2,2',3,6'-Tetrachlorobiphenyl (46)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4'-Tetrachlorobiphenyl (47)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5-Tetrachlorobiphenyl (48)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5'-Tetrachlorobiphenyl (49)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,6-Tetrachlorobiphenyl (50)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,6'-Tetrachlorobiphenyl (51)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',5,5'-Tetrachlorobiphenyl (52)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',5,6'-Tetrachlorobiphenyl (53)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',6,6'-Tetrachlorobiphenyl (54)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4'-Tetrachlorobiphenyl (55)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4'-Tetrachlorobiphenyl (56)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5-Tetrachlorobiphenyl (57)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5'-Tetrachlorobiphenyl (58)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',6-Tetrachlorobiphenyl (59)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,4'-Tetrachlorobiphenyl (60)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,5-Tetrachlorobiphenyl (61)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,6-Tetrachlorobiphenyl (62)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4',5-Tetrachlorobiphenyl (63)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4',6-Tetrachlorobiphenyl (64)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,5,6-Tetrachlorobiphenyl (65)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4'-Tetrachlorobiphenyl (66)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,5-Tetrachlorobiphenyl (67)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,5'-Tetrachlorobiphenyl (68)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,6-Tetrachlorobiphenyl (69)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4',5-Tetrachlorobiphenyl (70)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,3',4',6-Tetrachlorobiphenyl (71)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',5,5'-Tetrachlorobiphenyl (72)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',5',6-Tetrachlorobiphenyl (73)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,4',5-Tetrachlorobiphenyl (74)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,4,4',6-Tetrachlorobiphenyl (75)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4,5-Tetrachlorobiphenyl (76)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,4'-Tetrachlorobiphenyl (77)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,5-Tetrachlorobiphenyl (78)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,5'-Tetrachlorobiphenyl (79)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',5,5'-Tetrachlorobiphenyl (80)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,4,4',5-Tetrachlorobiphenyl (81)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4-Pentachlorobiphenyl (82)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5-Pentachlorobiphenyl (83)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',6-Pentachlorobiphenyl (84)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4'-Pentachlorobiphenyl (85)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5-Pentachlorobiphenyl (86)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5'-Pentachlorobiphenyl (87)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,6-Pentachlorobiphenyl (88)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,6'-Pentachlorobiphenyl (89)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5-Pentachlorobiphenyl (90)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',6-Pentachlorobiphenyl (91)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,5'-Pentachlorobiphenyl (92)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,6-Pentachlorobiphenyl (93)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,6'-Pentachlorobiphenyl (94)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5',6-Pentachlorobiphenyl (95)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,2',3,6,6'-Pentachlorobiphenyl (96)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3',4,5-Pentachlorobiphenyl (97)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3',4,6-Pentachlorobiphenyl (98)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',5-Pentachlorobiphenyl (99)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',6-Pentachlorobiphenyl (100)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5,5'-Pentachlorobiphenyl (101)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5,6'-Pentachlorobiphenyl (102)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,5,'6-Pentachlorobiphenyl (103)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,6,6'-Pentachlorobiphenyl (104)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4'-Pentachlorobiphenyl (105)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5-Pentachlorobiphenyl (106)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5-Pentachlorobiphenyl (107)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5'-Pentachlorobiphenyl (108)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,6-Pentachlorobiphenyl (109)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',6-Pentachlorobiphenyl (110)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5,5'-Pentachlorobiphenyl (111)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5,6-Pentachlorobiphenyl (112)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5',6-Pentachlorobiphenyl (113)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,4',5-Pentachlorobiphenyl (114)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,4',6-Pentachlorobiphenyl (115)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,5,6-Pentachlorobiphenyl (116)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4',5,6-Pentachlorobiphenyl (117)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4',5-Pentachlorobiphenyl (118)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4',6-Pentachlorobiphenyl (119)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,5,5'-Pentachlorobiphenyl (120)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,3',4,5,'6-Pentachlorobiphenyl (121)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,3',4,5-Pentachlorobiphenyl (122)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4,4',5-Pentachlorobiphenyl (123)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4,5,5'-Pentachlorobiphenyl (124)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2',3,4,5,6'-Pentachlorobiphenyl (125)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,4',5-Pentachlorobiphenyl (126)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,5,5'-Pentachlorobiphenyl (127)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4'-Hexachlorobiphenyl (128)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5-Hexachlorobiphenyl (129)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5'-Hexachlorobiphenyl (130)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,6-Hexachlorobiphenyl (131)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,6'-Hexachlorobiphenyl (132)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,5'-Hexachlorobiphenyl (133)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,6-Hexachlorobiphenyl (134)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,6'-Hexachlorobiphenyl (135)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',6,6'-Hexachlorobiphenyl (136)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5-Hexachlorobiphenyl (137)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5'-Hexachlorobiphenyl (138)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',6-Hexachlorobiphenyl (139)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',6'-Hexachlorobiphenyl (140)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,5'-Hexachlorobiphenyl (141)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,6-Hexachlorobiphenyl (142)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,6'-Hexachlorobiphenyl (143)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5',6-Hexachlorobiphenyl (144)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,6,6'-Hexachlorobiphenyl (145)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,2',3,4',5,5'-Hexachlorobiphenyl (146)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5,6-Hexachlorobiphenyl (147)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5,6'-Hexachlorobiphenyl (148)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5',6-Hexachlorobiphenyl (149)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',6,6'-Hexachlorobiphenyl (150)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,5',6-Hexachlorobiphenyl (151)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,5,6,6'-Hexachlorobiphenyl (152)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',5,5'-Hexachlorobiphenyl (153)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',5',6-Hexachlorobiphenyl (154)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',4,4',6,6'-Hexachlorobiphenyl (155)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5-Hexachlorobiphenyl (156)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',6-Hexachlorobiphenyl (158)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5,5'-Hexachlorobiphenyl (159)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5,6-Hexachlorobiphenyl (160)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5',6-Hexachlorobiphenyl (161)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5,5'-Hexachlorobiphenyl (162)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5,6-Hexachlorobiphenyl (163)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5',6-Hexachlorobiphenyl (164)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',5,5',6-Hexachlorobiphenyl (165)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,4,4',5,6-Hexachlorobiphenyl (166)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3',4,4',5',6-Hexachlorobiphenyl (168)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5-Heptachlorobiphenyl (170)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,2'3,3',4,4',6-Heptachlorobiphenyl (171)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,5'-Heptachlorobiphenyl (172)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,6-Heptachlorobiphenyl (173)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,6'-Heptachlorobiphenyl (174)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5',6-Heptachlorobiphenyl (175)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,6,6'-Heptachlorobiphenyl (176)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4',5,6-Heptachlorobiphenyl (177)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,5',6-Heptachlorobiphenyl (178)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,6,6'-Heptachlorobiphenyl (179)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5,5'-Heptachlorobiphenyl (180)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5,6-Heptachlorobiphenyl (181)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5,6'-Heptachlorobiphenyl (182)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5',6-Heptachlorobiphenyl (183)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',6,6'-Heptachlorobiphenyl (184)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,5',6-Heptachlorobiphenyl (185)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,5,6,6'-Heptachlorobiphenyl (186)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5,5',6-Heptachlorobiphenyl (187)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4',5,6,6'-Heptachlorobiphenyl (188)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5,6-Heptachlorobiphenyl (190)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5',6-Heptachlorobiphenyl (191)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,5,5',6-Heptachlorobiphenyl (192)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4',5,5',6-Heptachlorobiphenyl (193)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5,5'-Octachlorobiphenyl (194)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5,6-Octachlorobiphenyl (195)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
2,2',3,3',4,4',5,6'-Octachlorobiphenyl (196)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',6,6'-Octachlorobiphenyl (197)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,5',6-Octachlorobiphenyl (198)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,5',6'-Octachlorobiphenyl (199)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,6,6'-Octachlorobiphenyl (200)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5',6,6'-Octachlorobiphenyl (201)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',5,5',6,6'-Octachlorobiphenyl (202)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5,5',6-Octachlorobiphenyl (203)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,4,4',5,6,6'-Octachlorobiphenyl (204)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,3,3',4,4',5,5',6-Octachlorobiphenyl (205)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (206)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl (207)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (208)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Decachlorobiphenyl (209)	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Monochlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Dichlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Trichlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Tetrachlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Pentachlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Hexachlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Heptachlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Octachlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Nonachlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Decachlorobiphenyl, Total	------------------------	EPA 1668A/1668C	EPA 1668A/1668C	EPA 1668A/1668C
Per- and Poly-fluorinated compounds				
Perfluorobutanesulfonic acid (PFBS)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
Perfluoroheptanonic acid (PFHpA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorohexanesulfononic acid (PFHxS)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorooctanesulfonic acid (PFOS)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorooctanoic acid (PFOA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorononaoic acid (PFNA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluoroheptanesulfonate (PFHpS)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorodecanesulfonate (PFDS)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluoropentanoic acid (PFPeA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluoroundecanoic acid (PFUdA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorodecanoic acid (PFDA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorododecanoic acid (PFDoA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorotridecanoic acid (PFTrDA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorotetradecanoic acid (PFTeDA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorohexadecanoic acid (PFHxDA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorobutanoic acid (PFBA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorohexanoic acid (PFHxA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
6:2 Fluorotelomer sulfanate (6:2 FTS)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
8:2 Fluorotelomer sulfanate (8:2 FTS)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
N-methylperfluoro-1-octanesulfonamide (N-MeFOSA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
N-ethylperfluoro-1-octanesulfonamide (N-EtFOSA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
Perfluorooctane sulfonamide (PFOSA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
N-methylperfluoro-1-octanesulfonamido ethanol (N-MeFOSE)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
N-ethylperfluoro-1-octanesulfonamido ethanol (N-EtFOSE)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
N-ethyl perfluorooctanesulfonamidoacetic acid (N-EtFOSAA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)
N-methyl perfluorooctanesulfonamidoacetic acid (N-MeFOSAA)	EPA 537 mod	EPA 537 mod	EPA 537 mod (VAL-PFAS)	EPA 537 mod (VAL-PFAS)

Parameter/Analyte	**Potable Water**	**Nonpotable Water**	**Solid Hazardous Waste**	**Tissue**
1,4-Dioxane				
1,4-Dioxane	---------------------	EPA 522 mod	------------------	------------------

Appendix C

Laboratory Standard Operating Procedures

SOP 49	**Revision: 8**	**Supersedes: 7**
PREPARATION AND ANALYSIS FOR THE DETERMINATION OF PER and POLY-FLUORINATED COMPOUNDS		
Analyst Review: [redacted]		
Management: [redacted]		
Quality Assuranc[redacted]		
Effective Date: 27 July 2016		

Revision	Description of Revision
1	Section 1.1: Removed aqueous matrix, Section 4.3: Modification from 537 method regarding peak symmetry, Section 8: Addition of equipment used for Soil/Tissue method, Section 13.2: Addition of the Soil/Tissue digestion and extraction, Section 13.5: Final volume modified, Section 14.1: Changed the Desolvation Temperature, deleted Section 14.3.2.1.3: following EPA 537 limits, Section 15: Calculations modified, Section 19.2: Soil/Tissue method reference, Table 1A and B: ICAL concentrations changed, Table 3A-C: Addition of table for the Acceptance Criteria for Performance Tests for Aqueous (A), Soil (B) and Tissue (C), Table 5: Table added (reporting limits)
2	Added Section 4.5: Modification of detection limit calculation
3	Deleted Table 3C. Combined Soil and Tissue into Table 3B. Updated IS recoveries in Table 3B.
4	Added Section 4.6: Modification from 537 method regarding forcing ICAL through zero, Added Section 4.7: Maintaining the OPR at a static, mid-level concentration. Section, Added Section 4.8: Modification from 537 method regarding rotating of CCAL points, Section 11.2.1: Changed 10 samples per batch to 20. Section 11.3: Removed section on rotating OPR between low, medium, and high concentrations. Section 11.4: Added MS/MSD per client request, Section 11.5: Duplicate preformed every sample batch, Section 11.4 and 11.5: Perform duplicate samples instead of MS/MSD, Section 11.6: FRB per client request, Section 11.7.1: Updated to reflect that a Second Source is run with every calibration curve, Added section 13.1.3: Aqueous samples with high particulate section, Section 13.5: Modification for the adjustment to final volume, Section 14.4.1: signal to noise modified, 14.5.2: natives within 0.1 min of IS retention time, Section 15.1 added sample weight to calculation, Added Table 3, Table 5A-B: Updated percent recoveries

5	Section 2: Added N-EtFOSAA and N-MeFOSAA to compound list, changed FOSA to PFOSA. Updated section 4.1. Added sections 4.2-4.5 in method modifications. Deleted section 4.6 in Method Modifications, as the calibration is now forced through zero. Added Sections 8.20 – 8.22 for new instrument. Added Section 9.2.7: Isopropyl Alcohol. Updated section 11.5 to only perform duplicates per request. Section 13.1.2 changed 250mL to 125mL. Section 13.2.1.1.3: Added vortexing step. Added Section 13.3.2 with volumes used for 100mg/3mL cartridge. 13.4.1: Added spiking of RS. Section 13.5.2: Changed final volume from 0.5mL to 1mL. Section 14.2.1: Changed the Ical to specify quadratic fit and forcing through zero. Sections 14.2.4 and 14.2.5: Added Coefficient of Determination and RSD requirements. Section 14.3.1: All CCCs at midlevel concentration. Added Section 14.5.6: Totals Added section 15.1 quantitation for natives using quadratic regression. Tables: Added N-EtFOSAA, N-MeFOSAA, d_5-N-EtFOSAA, d_3-N-MeFOSAA, 13C_3-PFPeA to appropriate tables, changed FOSA to PFOSA where required. Updated OPR, IPR and sample recovery limits. Updated curve concentrations. Table 3: Updated masses monitored where appropriate. Table 5: Updated recoveries to reflect only reporting those ISs in EPA methods.
6	Added Section 4.9: Two PFOS transitions are monitored for. Added Section 4.14: Using EDL to check sensitivity. Added Section 14.5.7: Estimated Detection Limits.
7	Updated 11.2.2: Changed the allowable limits for the method blank, 11.7.2: Second Source Standards must be within 25% of true value, 14.2.1: changed at least 5 points to at least 6 points in ICAL. Updated section 11.3.4 with internal standard requirements. Section 13.3: Updated wash solvent
8	Removed sections 13.3.2, 14.5.7 Modified Sections 13.3 Updated sections 2.2, 8.20-8.22, 12.1.3, 13.3.1.2, 13.4.1, 13.5.2, 14.1, 14.2.1, 12, 13.5.1, 13.5.2, 14.1. All tables have been updated with the most recent information. Added curve requirement to section 14.2.1.

1. PURPOSE

1.1 This SOP outlines and describes the preparative and analytical techniques used for the determination of per and poly-fluorinated compounds (PFAS).

2. SCOPE

2.1 All differences between EPA 537, ISO 25101 and actual laboratory techniques have been developed to reduce interference and increase sensitivity.

2.2 Data determined to be out-of-control from criteria stated within this SOP, is handled according to procedures addressed within the applicable section.

Compound	**CAS Registry No.***
Perfluorobutanesulfonic acid (PFBS)	375-73-5
Perfluoroheptanoic acid (PFHpA)	375-85-9
Perfluorohexanesulfonoic acid (PFHxS)	355-46-4
Perfluorohexanoic acid (PFHxA)	307-24-4
Perfluorooctanesulfonic acid (PFOS)	1763-23-1
Perfluorooctanoic acid (PFOA)	355-67-1
Perfluorobutanoic acid (PFBA)	375-22-4
Perfluoroheptanesulfonate (PFHpS)	60270-55-5
Perfluorodecanesulfonate (PFDS)	13419-61-9
Perfluoropentanoic acid (PFPeA)	2706-90-
Perfluorononaoic acid (PFNA)	375-95-1
Perfluoroundecanoic acid (PFUdA)	2058-94-8
Perfluorodecanoic acid (PFDA)	335-76-2
Perfluorododecanoic acid (PFDoA)	307-55-1
Perfluorotridecanoic acid (PFTrDA)	72629-94-8
Perfluorotetradecanoic acid (PFTeDA)	376-06-7
Perfluorohexadecanoic acid (PFHxDA)	67905-19-5
Perfluorooctadecanoic acid (PFODA)	16517-11-6
6:2 Fluorotelomer sulfanate (6:2 FTS)	27619-97-2
8:2 Fluorotelomer sulfanate (8:2 FTS)	39108-34-4
N-methylperfluoro-1-octanesulfonamide (N-MeFOSA)	31506-32-8
N-ethylperfluoro-1-octanesulfonamide (N-EtFOSA)	4151-50-2
Perfluorooctane sulfonamide (PFOSA)	754-91-6
N-methylperfluoro-1-octanesulfonamido ethanol (N-MeFOSE)	24448-09-7
N-ethylperfluoro-1-octanesulfonamido ethanol (N-EtFOSE)	1691-99-2
N-ethyl perfluorooctanesulfonamidoacetic acid (N-EtFOSAA)	2991-50-6
N-methyl perfluorooctanesulfonamidoacetic acid (N-MeFOSAA)	2355-31-9

*Chemical Abstract Service

3. SUMMARY OF METHOD

3.1 This procedure uses ultra performance liquid chromatography/tandem mass spectrometry (UPLC/MS/MS) for detection and quantitation of per and poly-fluorinated compounds, commonly referred to as PFAS.

3.2 All differences between the method and actual laboratory techniques have been developed to reduce interferences and increase sensitivity.

3.3 Detection limits are sample-specific and congener-specific.

4. MODIFICATIONS

4.1 Calibration standards made using methanol and water.

4.2 The extraction volume for aqueous samples is 125mLs.

4.3 The internal standard (IS) is not spiked directly into the sample bottle. The IS is spiked into a test tube containing methanol. Then the test tube is poured into the sample bottle.

4.4 Drinking water samples follow the IS recovery limits set in EPA Method 537; version 1.1, September 2009. IS recovery limits from all other matrices are derived from the EPA Draft Sludge Method, December 2011.

4.5 MS/MSDs and Duplicates performed by client request only.

4.6 SPE extracts are concentrated to near dryness and reconstituted in [redacted] [redacted] [redacted]

4.7 Symmetry of peaks not calculated due to the greatly improved chromatography of UPLC versus HPLC.

4.8 The SPE cartridge used is a polymeric weak anion cartridge and therefore requires the reagents used in the SPE procedure.

4.9 The calculation of the detection limit, SOP Section 15.2, differs from Section 9.2.7 in EPA Method 537, version 1.1, September 2009.

4.10 The OPR is spiked at a static, mid-level concentration.

4.11 Continuing calibration standards are not rotated between a mid and a high concentration.

4.12 Section 10.3.2 in EPA Method 537; version 1.1, September 2009 states that absolute areas of ISs must be compared to the most recent ICAL and CCAL. Vista utilizes embedded Estimated Detection Limits (EDL) on a per analyte basis to qualify system sensitivity as well as quantitation by isotope dilution.

5. CONTAMINATION AND INTERFERENCES

5.1 Solvents, reagents, glassware and other sample processing hardware may yield discrete artifacts or elevated baselines that may cause misinterpretation of the chromatographic data. All of these materials must be demonstrated to be free from interfering substances under the conditions of analysis by performing laboratory method blanks. Analysts should avoid using materials containing PTFE, where possible.

5.2 All differences between EPA 537, ISO 25101 and actual laboratory techniques have been developed to reduce interference and increase sensitivity.

5.3 The use of high purity reagents and solvents helps to minimize interference problems.

5.4 Interferants co-extracted from the sample will vary considerably from matrix to matrix.

6. DEFINITIONS

6.1 Definitions are presented in the Glossary.

7. SAFETY

7.1 Procedures shall be carried out in a manner that protects the health and safety of all Vista employees.

7.2 Each chemical compound should be treated as a potential health hazard. Exposure to these compounds should be reduced to the lowest possible level. All compounds or reagents should be handled only by highly trained personnel thoroughly familiar with handling and cautionary procedures and the associated risks.

7.3 Additional health and safety information can be obtained from material safety data sheets (MSDSs) available to all personnel involved in these analyses.

7.4 In the event of a known or potential compromise to the health and safety of a Vista associate, all work must stop and the incident reported immediately to management.

7.5 Contamination of the laboratory will be minimized by conducting most of the manipulations in a hood

7.6 The toxicity or carcinogenicity of each chemical used in this method has not been precisely determined; however, each compound should be treated as a potential health hazard. Exposure to these compounds should be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of MSDS should also be made available to all personnel involved in these analyses.

8. APPARATUS AND MATERIALS

Note: All materials used should be suitable for LC work, and comparable brand materials can be substituted where specific brands are mentioned.

8.1 Analytical Balances, capable of reading to 0.01g and 0.0001g

8.2 Solid Phase Extraction Manifold (Waters)

8.3 [redacted]

8.4 Silicone tubing, 1/16” diameter, various lengths (Nalgene)

8.5 Screw top polypropylene LC vials, 12x32mm (Waters)

8.6 HDPE Bottle various sizes (Nalgene)

8.7 Screw caps with pre-slit polypropylene septa, for 12x32mm vials (Waters)

8.8 Disposable polypropylene Pasteur pipets, various sizes

8.9 Chlorine test strips (Hach Aquacheck, or equivalent)

8.10 Organomation 24-Station N-Evaporator with water bath [redacted]

8.11 Polypropylene centrifuge tubes, 13 mm x 100 mm

8.12 Wiretrol II Precision Disposable Micropipettes

8.13 Sonicator, VWR, Model 150T

8.14 Eppendorf Centrifuge, Model 5804

[redacted]

8.16 Acquity PFC Isolator Column (Waters)

8.17 Acquity Ultra Performance LC (Waters)

8.18 Lenovo computer work station with MassLynx Software

8.19 Quattro Premier XE with Micromass Technology (Waters)

8.20 Shimadzu Nexera X2 UHPLC LC System (Shimadzu USA)

8.21 Dell Optiplex XE2 computer work station with Analyst and MultiQuant Software

8.22 4000 Q Trap (Sciex)

9. REAGENTS, SOLVENTS AND STANDARDS

9.1 Reagents (HPLC grade or above)

- 9.1.1 Trizma pre-set crystals (Supelco cat #T-7193)
- 9.1.2 Sodium Acetate, HPLC grade
- 9.1.3 Ammonium Acetate, HPLC grade
- 9.1.4 Ammonium Hydroxide, Concentrated
- 9.1.5 Formic Acid, Concentrated
- 9.1.6 Ultra-pure nitrogen gas
- 9.1.7 Ultra-pure argon gas
- [redacted] [redacted]

9.2 Solvents (HPLC Grade or above)

- 9.2.1 Reagent Water
- 9.2.2 Acetonitrile
- 9.2.3 Hexane
- 9.2.4 Methanol (MeOH)
- 9.2.5 Methylene chloride (DCM)
- 9.2.6 Acetone
- 9.2.7 Isopropyl Alcohol

9.3 Standards

- 9.3.1 All analytical standards are obtained from a certified vendor.
- 9.3.2 See SOP 15 and the current spike sheet for more information.

10. COLLECTION, PRESERVATION, AND HANDLING

10.1 HDPE or polypropylene bottles and jars must be used for collection.

10.2 Trizma is added to the sample bottles prior to the collection of drinking water samples in the amount of 5.0g/L.

10.3 Aqueous samples must be extracted or frozen within 14 days of collection and analyzed within 28 days of extraction.

Note: For DoD projects, samples shall not be frozen.

10.4 Solid and Tissue samples must be extracted within 60 days from collection and analyzed within 30 days of extraction.

10.5 Store at < 6^{o}C.

11. QUALITY CONTROL

11.1 Each time a modification is made to this method and the detection limit will be affected by the change, the laboratory is required to demonstrate that the MDL is lower than one-third the regulatory compliance level or one-third the method reporting limit (MRL) in the method, whichever is higher.

11.2 Method Blank (MB): Method blank is a matrix preparation that is free of native analyte that has been prepared and analyzed using the same procedures followed for the rest of the analytical batch. Simulate as close as possible the matrix to be extracted.

11.2.1 Daily or with each extraction batch of up to 20 samples, (whichever is more frequent).

11.2.2 For the determination of native PFAS, the levels measured in the method blank of all method analytes must be below 1/2 the LOQ.

11.2.3 If amount found is greater than the minimum level or one-third the regulatory compliance limit, whichever is greater; or if any potentially interfering compound is found in the blank at or above the minimum level for each congener, the data must be evaluated to determine whether the batch shall be re-extracted or the data are qualified appropriately.

11.2.4 If there is evidence of contamination within the MB, then the source of the contamination must be located. The data must be evaluated to determine whether the batch shall be re-extracted or the data is qualified appropriately.

11.3 Ongoing Precision and Recovery Samples (OPR): An ongoing precision and recovery sample is prepared by adding a known quantity of native standards to an interferant free matrix and used to assess method performance (precision and recovery).

11.3.1 Add the appropriate amount of native spike. The native spikes contain the compounds listed in Table 1.

11.3.2 An OPR is analyzed with every analytical batch.

11.3.3 The OPR % recoveries for native and internal standards must be within the limits shown in Table 5.

11.3.4 If the percent recovery of the native or, two or more of the internal standards of an isomer in the OPR is out of method limits, it is recommended that the sample(s) be re-extracted and/or re-analyzed.

11.4 Matrix Spike (MS/MSD): A matrix spike sample is prepared by adding the appropriate quantity of native standards to a sample matrix prior to extraction.

MS/MSD's are performed by client request

11.4.1 The relative percent difference (RPD) between MS/MSD samples should be ≤ 30%.

11.4.2 If RPD does not meet the acceptance criteria, the data is evaluated and qualified appropriately.

11.5 Duplicate Samples: Duplicate samples are two separate aliquots taken from the same source. Duplicate samples are analyzed independently to assess laboratory precision. Duplicate samples are performed by client request.

11.5.1 The relative percent difference between duplicate samples should be ≤ 30%

11.5.2 If the concentration is within a factor of 2 of the MRL, the relative percentage difference (RPD) must be ≤ 50%

11.5.3 If the RPD does not meet the acceptance criteria, the data are evaluated and qualified appropriately.

11.6 Field Reagent Blank (FRB): A field reagent blank is a matrix preparation that is free of native analyte transported to the field in sealed containers and returned with the samples. FRB's are performed upon client request.

11.6.1 Analysis of the FRB is only necessary if a Field Sample contains a method analyte at or above the MRL.

11.7 Second source standard: Analytes from a different source than that of the calibration standards. This is prepared and analyzed in the same way as a CCC.

11.7.1 This is analyzed with every calibration curve.

11.7.2 The calculated value for the second source standard must be within ±25% of the true value.

12. SAMPLE PREPARATION

12.1 pH Determination

12.1.1 Obtain a pH strip and place it directly into a small amount of sample in a disposable weigh boat. Move the strip back and forth for 30 seconds.

12.1.2 Check the color on the strip against the color chart on the pH container.

[redacted]

13. EXTRACTION PROCEDURES

13.1 Aqueous Samples

13.1.1 Record the combined weight of the bottle, cap and sample for each sample to be extracted. After the sample has been removed from the bottle, allow it to drain overnight and reweigh it and the cap to determine the amount of sample extracted.

13.1.2 For the method blank (MB) and OPR(s), transfer [redacted] reagent water into a bottle for each.

[redacted] [redacted].

13.1.4 Add the appropriate volume of Internal Standard (IS) solution and the appropriate volume of Native Standard (NS) solution to OPR, MS or MSD. Allow the spiked samples to equilibrate for at least 1 hour before extraction.

13.2 Solid/Tissue Samples

13.2.1 Digestion

Weigh out [redacted] solid or well ground fish/tissue into a polypropylene test tube.

Add the appropriate volume of Internal Standard (IS) solution and the appropriate volume of Native Standard (NS) solution to OPR, MS, or MSD.

Add [redacted] [redacted], then vortex.

Sonicate [redacted]

[redacted]

13.2.2 Neutralization

13.2.2.1 Add [redacted] Hydrochloric Acid, vortex briefly.

13.2.3 Extraction

13.2.3.1 [redacted]

13.2.3.2 [redacted]

13.2.3.3 Decant [redacted]

13.2.3.4 Repeat the extraction process (13.2.3.1.1-13.2.3.1.3)

13.3 SPE Cleanup

13.3.1 Assemble the SPE apparatus and attach the SPE cartridges as shown in the appendix A, Figure 1.

13.3.1.1 Condition the cartridges by eluting with methanol.

Discard eluant.

13.3.1.2 Condition the cartridge with reagent water. Discard eluant.

13.3.1.3 Load sample onto cartridge by way of siphon, [redacted].

13.3.1.4 Once sample has passed through, rinse bottle with reagent water and re-siphon.

13.3.1.5 Upon completion of siphon wash cartridge [redacted].

13.3.1.6 Dry the cartridge under vacuum [redacted].

13.4 Cartridge Elution

13.4.1 Elute [redacted]. Collect extracts eluted from the column into clean test tube containing the appropriate amount of RS.

13.5 Adjustment to Final Volume

13.5.1 Concentrate extract [redacted]

13.5.2 [redacted]

13.5.3 [redacted].

14. LC/MS ANALYSIS

14.1 Establish the necessary conditions. The LC conditions may be optimized for compound separation and sensitivity. Once optimized, the same LC conditions must be used for the analysis of all standards, blanks, OPR aliquots and samples. The following LC operating conditions are guidance and adjustments may be required

Instrument: Aquity UPLC/ Waters Quattro Premier XE
Column: [redacted]
Ionization: Negative Ion Electrospray
Acquisition: MRM mode, unit resolution
Injection Volume: 5-15µL

[redacted]	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
MS Conditions	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted] [redacted] [redacted] [redacted]

[redacted] [redacted] [redacted] [redacted]

Instrument: Shimadzu DGU-20Asr/Sciex 4000 Q trap
Column: [redacted]
Ionization: Negative Ion Electrospray
Acquisition: MRM mode, unit resolution
Injection Volume: 1-5 µL

General LC Conditions	
Column [redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
MS Conditions	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
MS Conditions	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

LC Gradient Program			***LC Gradient Program***	**Parameter**	
Time (min)	**Flow Mixture***				Events
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

LC Gradient Program			***LC Gradient Program***	**Parameter**	
Time (min)	**Flow Mixture***				Events
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

- [redacted]
- [redacted]

14.2 Initial Calibration (ICAL)

14.2.1 An initial calibration curve is created using a quadratic fit weighted 1/X over the calibration range and consisting of at least 6 points. This curve must be forced through zero. An initial calibration is repeated at least annually, whenever a new set of spiking calibration standards is created or whenever the continuing calibration falls outside the acceptance criteria. [redacted]

Note: If estimated concentrations below ICAL levels are not needed for a specific project or requirement, the curve may not be forced through zero.

14.2.2 Establish the operating conditions suggested in Section 14.1

14.2.3 The following retention time criterion must be met:

14.2.3.1 The absolute retention time of the last-eluted compound must be ±0.5% of its targeted value.

14.2.4 The Coefficient of determination for all native compounds must be greater than or equal to 0.96.

14.2.5 RSD requirements are ≤35% for all internal standards.

14.2.6 The following analyte recovery criteria must be met: Each calibration point for each analyte must calculate to be with 75-125%, except the lowest cal point which must calculate to within 70-130%.

14.3 Continuing Calibration

14.3.1 A continuing calibration check (CCC) must be analyzed at the beginning, after every 10 samples and at the end of each analytical run. All CCC’s are at a midlevel concentration.

14.3.2 The continuing calibration verification is acceptable if the following criteria are met:

14.3.2.1 The LC peak representing each native and labeled compound must be present with a S/N ≥10.

14.3.2.2 The percent recovery for native standards and the internal standards must be within the limits shown in Table 5.

14.3.2.3 The retention times for internal compounds must be within ± 15 seconds of the respective retention times in the most recent CCC.

14.4 Qualitative Determination

14.4.1 The signal to noise ratio (S/N) at the LC peak maximum for each native compound must be greater than or equal to 3 for each compound detected in a sample extract.

14.4.2 The retention time of the peak for a native compound must be within ±15 seconds of its RT in the most recent CCC standard.

14.5 Quantitative Determination

14.5.1 Calibration by Isotope Dilution: Isotope dilution calibration is used for the native PFAS for which labeled compounds are available.

14.5.2 Native compounds should have a retention time within 0.1 mins. of its equivalent internal standard.

14.5.3 Recovery of each internal standard versus the recovery standard must be within the limits shown in Table 5.

14.5.4 Recoveries below the limits may be accepted if the signal to noise is >10:1. If the signal to noise is not >10:1, samples must be re-extracted and re-analyzed or the data must be qualified.

14.5.5 If a chromatographic peak of any of the analytes saturates the detector, a dilution of the extract must be analyzed.

14.5.6 PFBS, PFHpS, PFHxS, PFOA, PFOS, N-MeFOSAA and N-EtFOSAA have both linear and branched isomers. All chromatographic peaks for these compounds are integrated and the areas totaled. Technical mixtures are referenced when available.

15. CALCULATIONS

15.1 The concentrations of native compounds are determined by quadratic regression:

$$NRR = \frac{A_x}{A_y} Q_y$$

Where:

NRR = *Normalized relative response*
A_x = *Area of the quantitation ion for the native compound in sample*
A_y = *Area of the quantitation ion for the labeled compound in sample*
Q_y = *Quantity of Internal Standard in sample*

15.1.1 Determine the calibration equation for each compound by regressing the NRR against the native compound concentration (See Appendix B).

15.1.2 The curve may be concentration weighted based on the analysts discretion.

15.2 The concentration of each internal standard is calculated as follows:

$$C_{Samp} = \frac{A_x Q_y}{A_y RRF \, S_W}$$

Where:

C_{Samp} = *Concentration of compound in sample*
A_x = *Area of the quantitation ion for the native compound in sample*
A_y = *Area of the quantitation ion for the labeled compound in sample*
Q_y = *Quantity, in pg, of Internal Standard in sample*
S_W = *Sample weight*
RRF = *Relative response factor, a sum of the response factors* (RF):

$$\sum RF = \frac{A_n C_l}{A_l C_n}$$

Where:

C_l = *Internal Standard Concentration at the curve point*
A_X = *Area of daughter m/z for native compound*
A_l = *Area of daughter m/z for labeled compound*
C_n = *Concentration of Native Standard at the curve point*

15.3 Internal standard recoveries are calculated by using the formula:

$$\%Rec = \frac{(A_{IS})(Q_{RS}) \text{ X } 100}{(A_{RS})(Q_{IS})(RRF_{IS})}$$

Where:
A_{IS} = *Area of the quantitation ion for the internal standard.*
A_{RS} = *Area of the quantitation ion for the recovery standard.*
Q_{IS} = *Quantity of the internal standard.*
Q_{RS} = *Quantity of the recovery standard.*
RRF_{IS} = *Calculated relative response factor for the internal std. analyte.*

15.4 Relative Response Factors can be calculated using the following formula:

$$\mathrm{RRF} = \frac{(\mathrm{A_N})(\mathrm{Q_{IS}})}{(\mathrm{A_{IS}})(\mathrm{Q_N})}$$

Where:
A_N = *Area of the quantitation ion for the native compound*
A_{IS} = *Area of the quantitation ion for the labeled compound.*
Q_{IS} = *Quantity of the internal standard in the calibration standard.*
Q_N = *Quantity of the native compound in the calibration standard*

15.5 RRF for unlabeled analytes (optional) (RRFN) and for labeled analytes (RRFIS):

$$\mathrm{RRF_N} = \frac{(\mathrm{A_X})(\mathrm{Q_{IS}})}{(\mathrm{Q_X})(\mathrm{A_{IS}})} \qquad \mathrm{RRF_{IS}} = \frac{(\mathrm{A_{IS}})(\mathrm{Q_{RS}})}{(\mathrm{Q_{IS}})(\mathrm{A_{RS}})}$$

Where:
A_X = *Sum of the integrated ion abundances of the quantitation ions for the unlabeled analyte*
A_{IS} = *Sum of the integrated ion abundances of the quantitation ions for the labeled standards*
A_{RS} = *Sum of the integrated ion abundances of the quantitation ions for the labeled recovery standards*
Q_{IS} = *Quantity of internal standard injected (pg)*
Q_{RS} = *Quantity of recovery standard injected (pg)*
Q_X = *Quantity of unlabeled analyte injected (pg)*

15.6 The RPD is calculated as follows:

$$RPD = \frac{(H - L)}{(H + L)/2} * 100$$

Where:
RPD = *Relative Percentage Difference*
H = *Highest area*
L = *Lowest area*

16. POLLUTION PREVENTION

16.1 The solvent evaporation techniques used in this method are amenable to solvent recovery, and the laboratory shall recover solvents wherever feasible.

16.2 Standards should be prepared in volumes consistent with laboratory use to minimize disposal of standard.

17. WASTE MANAGEMENT

17.1 Waste generated in the procedure must be segregated and disposed according to the facility hazardous waste procedures. Safety officer should be contacted if additional information is required.

17.2 The laboratory waste management is in compliance with all federal, state, and local regulations to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations

18. METHOD PERFORMANCE

18.1 This SOP is based on methods noted as references (Section 19).

19. REFERENCES

19.1 ISO 25101:2009 – Water Quality – Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanonate (PFOA) – Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry, 1st edition, Dated March 2009.

19.2 EPA 821-R-11-007- Draft Procedure for Analysis of Perfluorinated Carboxylic Acids and Sulfonic Acids in Sewage Sludge and Biosolids by HPLC/MS/MS, Draft, December 2011.

19.3 Method 537, Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS), Version 1.1, September 2009.

Table 1
Calibration Curve Concentration (pg/µL)

Compound	CS(-2)	CS(-1)	CS0	CS1	CS2	CS3	CS3.5*	CS4	CS4.5	CS5	CS6
PFBS (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFHpA (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFHxS (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFHxA (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFOS (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFOA (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFBA (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFHpS (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFDS (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFPeA (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFDA (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFNA (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFUdA (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFDoA (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFTrDA (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFTeDA (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFHxDA (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
PFODA (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
6:2 FTS (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
8:2 FTS (A)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200

Table 1 Continued

Compound	CS(-2)	CS(-1)	CS0	CS1	CS2	CS3	CS3.5*	CS4	CS4.5	CS5	CS6
N-MeFOSA (B)	0.625	2.5	5.0	10	25	50	125	250	375	500	1000
N-EtFOSA (B)	0.625	2.5	5.0	10	25	50	125	250	375	500	1000
PFOSA (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
N-MeFOSE (B)	0.625	2.5	5.0	10	25	50	125	250	375	500	1000
N-EtFOSE (B)	0.625	2.5	5.0	25	25	50	125	250	375	500	1000
N-EtFOSAA (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200
N-MeFOSAA (B)	0.125	0.5	1.0	2.0	5.0	10	25	50	75	100	200

* Calibration Verification Solution
** CS(-2) used for PFOS only
*** A and B reflects associated FV composition and injection

Table 2
Calibration Curve Concentration (pg/μL)

Internal Standard	CS-2	CS-1	CS0	CS1	CS2	CS3	CS3.5*	CS4	CS4.5	CS5	CS6
$^{13}C_3$-PFBA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_3$-PFPeA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_3$-PFBS	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_2$-PFHxA	5	5	5	5	5	5	5	5	5	5	5
$^{13}C_2$-PFDA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_4$-PFHpA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{18}O_2$-PFHxS	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_2$-6:2 FTS	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_2$-PFOA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_8$-PFOS	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_5$-PFNA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_2$-8:2 FTS	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_8$-PFOSA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_2$-PFUdA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_2$-PFDoA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
d_3-N-MeFOSA	150	150	150	150	150	150	150	150	150	150	150
d_7-N-MeFOSE	150	150	150	150	150	150	150	150	150	150	150
d_9-N-EtFOSE	150	150	150	150	150	150	150	150	150	150	150
d_5-N-EtFOSA	150	150	150	150	150	150	150	150	150	150	150
$^{13}C_2$-PFTeDA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_2$-PFHxDA	5	5	5	5	5	5	5	5	5	5	5

Internal Standard	**CS-2**	**CS-1**	**CS0**	**CS1**	**CS2**	**CS3**	**CS3.5***	**CS4**	**CS4.5**	**CS5**	**CS6**
d_5-N-EtFOSAA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
d_3-N-MeFOSAA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Recovery Standard	**CS-2**	**CS-1**	**CS0**	**CS1**	**CS2**	**CS3**	**CS3.5***	**CS4**	**CS4.5**	**CS5**	**CS6**
$^{13}C_6$-PFDA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_4$-PFBA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_2$-4:2FTS	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_5$-PFHxA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_3$-PFHxS	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_8$-PFOA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_4$-PFOS	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_9$-PFNA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_7$-PFUdA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
$^{13}C_2$-FOUEA	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5

* Calibration Verification Solution

Table 3
Exact Masses Monitored Waters Quattro Premier XE

Compound	Native Parent-Daughter	Internal Standard	Native Parent-Daughter
PFBS	299.0 – 79.7	$^{13}C_3$-PFBS	302.0 – 98.8
PFHpA	363.0 – 318.9	$^{13}C_4$-PFHpA	367.2 – 321.8
PFHxS	398.9 – 79.6	$^{18}O_2$-PFHxS	403.0 – 102.6
PFHxA	313.2 – 268.9	$^{13}C_2$-PFHxA	315.0 – 269.8
PFOS	499.0 – 79.9	$^{13}C_8$-PFOS	507.0 – 79.998.6
PFOA	413.0 – 368.7	$^{13}C_2$-PFOA	414.9 – 369.7
PFBA	213.1 – 168.8	$^{13}C_3$-PFBA	216.1 – 171.8
PFHpS	449.0 – 98.7	$^{13}C_2$-PFOA	414.9 – 369.7
PFDS	598.8 – 98.7	$^{13}C_2$-PFUdA	565.0 – 519.8
PFPeA	263.1 – 218.9	$^{13}C_3$-PFPeA	266.0 – 221.8
PFDA	513.0 – 468.8	$^{13}C_2$-PFDA	515.1 – 469.9
PFNA	463.0 – 418.8	$^{13}C_5$-PFNA	468.2 – 422.9
PFUdA	563.0 – 518.9	$^{13}C_2$-PFUdA	565.0 – 519.8
PFDoA	612.9 – 318.8	$^{13}C_2$-PFDoA	615.0 – 569.7
PFTrDA	662.9 – 618.9	$^{13}C_2$-PFDoA	615.0 – 569.7
		$^{13}C_2$-PFTeDA	715.0 – 669.7
PFTeDA	712.9 – 668.8	$^{13}C_2$-PFTeDA	715.0 – 669.7
PFHxDA	813.1 – 768.6	$^{13}C_2$-PFHxDA	815.0 – 769.7
PFODA	913.1 – 868.8	$^{13}C_2$-PFHxDA	815.0 – 769.7
6:2 FTS	427.1 – 407.0	$^{13}C_2$-6:2 FTS	429.1 – 408.9
8:2 FTS	527.0 – 506.9	$^{13}C_2$-8:2 FTS	529.1 – 508.7
N-MeFOSA	512.1 – 168.9	d_3-N-MeFOSA	515.2 – 168.9
N-EtFOSA	526.1 – 168.9	d_5-N-EtFOSA	531.1 – 168.9
PFOSA	498.1 – 77.8	$^{13}C_8$-PFOSA	506.1 – 77.7
N-MeFOSE	616.1 – 58.9	d_7-N-MeFOSE	623.1 – 58.9
N-EtFOSE	630.1 – 58.9	d_9-N-EtFOSE	639.2 – 58.8
N-EtFOSAA	584.2 – 419.0	d_5-N-EtFOSAA	589.3 – 419.0
N-MeFOSAA	570.1 – 419.0	d_3-N-MeFOSAA	573.3 – 419.0
Recovery Standard			
$^{13}C_6$-PFDA	519.1 – 473.7	NA	NA
$^{13}C_2$-FOUEA	459.1 – 393.9	NA	NA
$^{13}C_4$-PFBA	217 – 171.8	NA	NA
$^{13}C_2$-4:2 FTS	329.2 – 308.9	NA	NA

Compound	Native Parent-Daughter	Internal Standard	Native Parent-Daughter
$^{13}C_8$-PFOA	421.3 – 376.0	NA	NA
$^{13}C_5$-PFHxA	318.0 – 272.9	NA	NA
$^{13}C_3$-PFHxS	401.9 – 79.9	NA	NA
$^{13}C_4$-PFOS	503.0 – 79.9	NA	NA
$^{13}C_9$-PFNA	472.2 – 426.9	NA	NA
$^{13}C_7$-PFUdA	570.1 – 524.8	NA	NA

Table 4

Exact Masses Monitored Sciex 4000 Q trap

Compound	Native Parent-Daughter	Internal Standard	Native Parent-Daughter
PFBS	299.0 – 79.9	$^{13}C_{3}$-PFBS	301.9 – 79.95
PFHpA	363.0 – 318.9	$^{13}C_{4}$-PFHpA	367.0 – 321.9
PFHxS	399.0 – 79.91	$^{18}O_{2}$-PFHxS	403.0 – 102.9
PFHxA	313.0 – 268.9	$^{13}C_{2}$-PFHxA	315.0 – 269.9
PFOS	498.9 – 79.92	$^{13}C_{8}$-PFOS	507.0 – 78.01
PFOA	413.0 – 368.9	$^{13}C_{2}$-PFOA	415.0 – 369.9
PFBA	213.0 – 168.9	$^{13}C_{3}$-PFBA	216.0 – 172.0
PFHpS	449.0 – 80.0	$^{13}C_{2}$-PFOA	415.0 – 369.9
PFDS	599.0 – 98.9	$^{13}C_{2}$-PFUdA	565.0 – 520.0
PFPeA	263.0 – 218.9	$^{13}C_{3}$-PFPeA	266.0 – 221.9
PFDA	513.0 – 469.0	$^{13}C_{2}$-PFDA	515.0 – 470.0
PFNA	463.0 – 419.0	$^{13}C_{5}$-PFNA	468.0 – 422.9
PFUdA	563.0 – 519.0	$^{13}C_{2}$-PFUdA	565.0 – 520.0
PFDoA	613.0 – 569.0	$^{13}C_{2}$-PFDoA	615.1 – 570.0
PFTrDA	663.0 – 619.0	$^{13}C_{2}$-PFDoA	615.1 – 570.0
		$^{13}C_{2}$-PFTeDA	715.0 – 670.0
PFTeDA	713.0 – 669.0	$^{13}C_{2}$-PFTeDA	715.0 – 670.0
PFHxDA	813.0 – 769.0	$^{13}C_{2}$-PFHxDA	815.0 – 770.0
PFODA	913.0 – 868.8	$^{13}C_{2}$-PFHxDA	815.0 – 770.0
6:2 FTS	427.0 – 406.9	$^{13}C_{2}$-6:2 FTS	429.0 – 408.9
8:2 FTS	527.0 – 506.9	$^{13}C_{2}$-8:2 FTS	529.0 – 508.7
N-MeFOSA	512.0 – 168.91	d_{3}-N-MeFOSA	515.2 – 168.93
N-EtFOSA	526.0 – 168.92	d_{5}-N-EtFOSA	531.1 – 168.94
PFOSA	498.0 – 78.0	$^{13}C_{8}$-PFOSA	506.0 – 78.01
N-MeFOSE	616.1 – 59.1	d_{7}-N-MeFOSE	623.0 – 59.12
N-EtFOSE	630.2 – 59.11	d_{9}-N-EtFOSE	639.2 – 59.13
N-EtFOSAA	584.0 – 418.9	d_{5}-N-EtFOSAA	589.1 – 419.02
N-MeFOSAA	570.0 – 419.01	d_{3}-N-MeFOSAA	573.1 – 418.91
Recovery Standard			
$^{13}C_{6}$-PFDA	519.0 – 474.0	NA	NA
$^{13}C_{2}$-FOUEA	459.0 – 393.9	NA	NA
$^{13}C_{4}$-PFBA	217.0 – 171.9	NA	NA
$^{13}C_{2}$-4:2 FTS	329.0 – 308.9	NA	NA
$^{13}C_{8}$-PFOA	421.0 – 375.9	NA	NA
$^{13}C_{5}$-PFHxA	318.1 – 273.0	NA	NA

Compound	Native Parent-Daughter	Internal Standard	Native Parent-Daughter
$^{13}C_3$-PFHxS	402.0 – 80.01	NA	NA
$^{13}C_4$-PFOS	503.0 – 79.94	NA	NA
$^{13}C_9$-PFNA	472.0 – 427.0	NA	NA
$^{13}C_7$-PFUdA	570.0 – 525.0	NA	NA

Table 5
Acceptance Criteria for Performance Tests

Compound	CCC	IPR		OPR %	Labeled compound recovery in samples %
		RSD %	Ave %		
PFBA	75-125	20	70-130	70-130	NA
PFPeA	75-125	20	70-130	70-130	NA
PFBS	75-125	20	60-130	60-130	NA
PFHxA	75-125	20	70-130	70-130	NA
PFHpA	75-125	20	70-130	70-130	NA
PFHxS	75-125	20	70-130	70-130	NA
6:2 FTS	75-125	20	60-130	60-130	NA
PFOA	75-125	20	70-130	70-130	NA
PFHpS	75-125	20	60-130	60-130	NA
PFOS	75-125	20	70-130	70-130	NA
PFNA	75-125	20	50-130	50-130	NA
PFDA	75-125	20	70-130	70-130	NA
8:2 FTS	75-125	20	60-130	60-130	NA
PFOSA	75-125	20	20-130	20-130	NA
PFDS	75-125	20	40-130	40-130	NA
PFUdA	75-125	20	70-130	70-130	NA
PFDoA	75-125	20	70-130	70-130	NA
N-MeFOSA	75-125	20	5-130	5-130	NA

Compound	CCC	IPR		OPR %	Labeled compound recovery in samples %
		RSD %	Ave %		
N-MeFOSE	75-125	20	40-130	40-130	NA
PFTrDA	75-125	20	20-130	20-130	NA
N-EtFOSA	75-125	20	5-130	5-130	NA
N-EtFOSE	75-125	20	10-130	10-130	NA
PFTeDA	75-125	20	20-130	20-130	NA
PFHxDA	75-125	20	40-130	40-130	NA
PFODA	75-125	20	40-130	40-130	NA
N-EtFOSAA	75-125	20	70-130	70-130	NA
N-MeFOSAA	75-125	20	70-130	70-130	NA
$^{13}C_3$-PFBA*	60-150	20	60-150	60-150	60-150
$^{13}C_3$-PFPeA*	60-150	20	60-150	60-150	60-150
$^{13}C_3$-PFBS*	60-150	20	60-150	60-150	60-150
$^{13}C_2$-PFHxA*	60-150	20	60-150	60-150	60-150
$^{13}C_4$-PFHpA*	60-150	20	60-150	60-150	60-150
$^{18}O_2$-PFHxS*	60-150	20	60-150	60-150	60-150
$^{13}C_2$-6:2 FTS*	40-150	20	40-150	40-150	40-150
$^{13}C_2$-PFOA*	60-150	20	60-150	60-150	60-150
$^{13}C_8$-PFOS*	60-150	20	60-150	60-150	60-150
$^{13}C_5$-PFNA*	50-150	20	50-150	50-150	50-150
$^{13}C_2$-PFDA*	60-150	20	60-150	60-150	60-150

Compound	CCC	IPR		OPR %	Labeled compound recovery in samples %
		RSD %	Ave %		
$^{13}C_2$-8:2 FTS*	40-150	20	40-150	40-150	40-150
$^{13}C_8$-PFOSA*	20-150	20	20-150	20-150	20-150
$^{13}C_2$-PFUnA*	50-150	20	50-150	50-150	50-150
$^{13}C_2$-PFDoA*	30-150	20	30-150	30-150	30-150
d_3-N-MeFOSA*	10-150	20	10-150	10-150	10-150
d_7-N-MeFOSE*	5-150	20	5-150	5-150	5-150
d_9-N-EtFOSE*	5-150	20	5-150	5-150	5-150
d_5-N-EtFOSA*	10-150	20	10-150	10-150	10-150
$^{13}C_2$-PFTeDA*	20-150	20	20-150	20-150	20-150
$^{13}C_2$-PFHxDA*	20-150	20	20-150	20-150	20-150
d_5-N-EtFOSAA*	20-150	20	20-150	20-150	20-150
d_3-N-MeFOSAA*	20-150	20	20-150	20-150	20-150

***** *If two or more of the internal standards are exceeding limits, corrective action will be taken and deviation will be narrated.*

Table 6
Reporting Limits

Compound	RL Aqueous (ng/L)	RL Solid (ng/g)	RL Tissue (ng/g)
PFBS	8.0	2.0	2.0
PFHpA	8.0	2.0	2.0
PFHxS	8.0	2.0	2.0
PFHxA	8.0	2.0	2.0
PFOS	8.0	2.0	2.0
PFOA	8.0	2.0	2.0
PFBA	8.0	2.0	2.0
PFHpS	8.0	2.0	2.0
PFDS	8.0	2.0	2.0
PFPeA	8.0	2.0	2.0
PFDA	8.0	2.0	2.0
PFNA	8.0	2.0	2.0
PFUdA	8.0	2.0	2.0
PFDoA	8.0	2.0	2.0
PFTrDA	8.0	2.0	2.0
PFTeDA	8.0	2.0	2.0
PFHxDA	8.0	2.0	2.0
PFODA	8.0	2.0	2.0
6:2 FTS	8.0	2.0	2.0
8:2 FTS	8.0	2.0	2.0
N-MeFOSA	40	10	10
N-EtFOSA	40	10	10
PFOSA	8.0	2.0	2.0
N-MeFOSE	40	10	10
N-EtFOSE	40	10	10
N-MeFOSAA	8.0	2.0	2.0
N-EtFOSAA	8.0	2.0	2.0

*RL's based on 125mLs for aqueous samples and 1g for solids and tissues.

Glossary

Analyte — Compound of interest. The analytes are listed in Table 1.

Calibration Standard — A solution prepared from a stock solution and used to calibrate the response of the HPLC/MSMS.

Calibration Verification Standard (CCC) — Calibration Standard containing a known concentration of native analytes, internal standard and recovery standards. This is analyzed to verify the accuracy of the existing calibration for those analytes.

Field Reagent Blank — A field reagent blank is a matrix preparation that is free of native analyte transported to the field in sealed containers and returned with the samples

Internal Standard – A labeled compound used as a reference for quantitation of other labeled and native compounds.

IPR — Initial precision and recovery; four aliquots of a reference material spiked with analytes of interest are analyzed to establish the ability of the laboratory to generate acceptable precision and recovery. An IPR is performed anytime the method or instrumentation is modified.

Isotope dilution quantitation – Determination of a naturally occurring (native) compound by reference to the same compound in which one or more atoms has been isotopically enriched. This method employs ^{2}H or ^{13}C labeled analogs which are spiked into each sample

LC – Liquid chromatography

Labeled Compound – A molecule in which one or more of the atoms is isotopically enriched, thereby increasing the mass of the molecule

Laboratory Blank — See method blank.

May — This action, activity, or procedural step is neither required nor prohibited.

May Not — This action, activity, or procedural step is prohibited.

Method Blank — An aliquot of reagent water that is treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, internal standards, and surrogates that are used with samples. The method blank is used to determine if analytes or interferences are present in the laboratory environment, the reagents, or the apparatus.

Method Detection Limit (MDL) — The lowest concentration at which an analyte can be detected under routine operating conditions (see 40 CFR 136, Appendix B).

MS — Mass spectrometer or mass spectrometry.

Must — This action, activity, or procedural step is required.

Native Compound – A molecule in which all atoms have naturally occurring isotopic abundances

OPR — Ongoing precision and recovery sample (OPR); a laboratory blank spiked with known quantities of analytes. The OPR is analyzed exactly like a sample. Its purpose is to assure that the results produced by the laboratory remain within the limits specified in this method for precision and recovery.

Reagent Water — Water demonstrated to be free from the analytes of interest and potentially interfering substances at the method detection limit for the analyte.

Relative Standard Deviation (RSD) — The standard deviation times 100 divided by the mean. Also termed "coefficient of variation."

RPD – Relative Percent Difference shown

RF — Response factor.

RRF — Relative response factor.

Should — Although this action, activity, or procedural step is suggested, it is not required.

SICP — Selected ion current profile; the line described by the signal at an exact m/z.

Signal-to-noise ratio (S/N) – The height of the signal as measured from the mean of the noise to the peak maximum divided by the width of the noise.

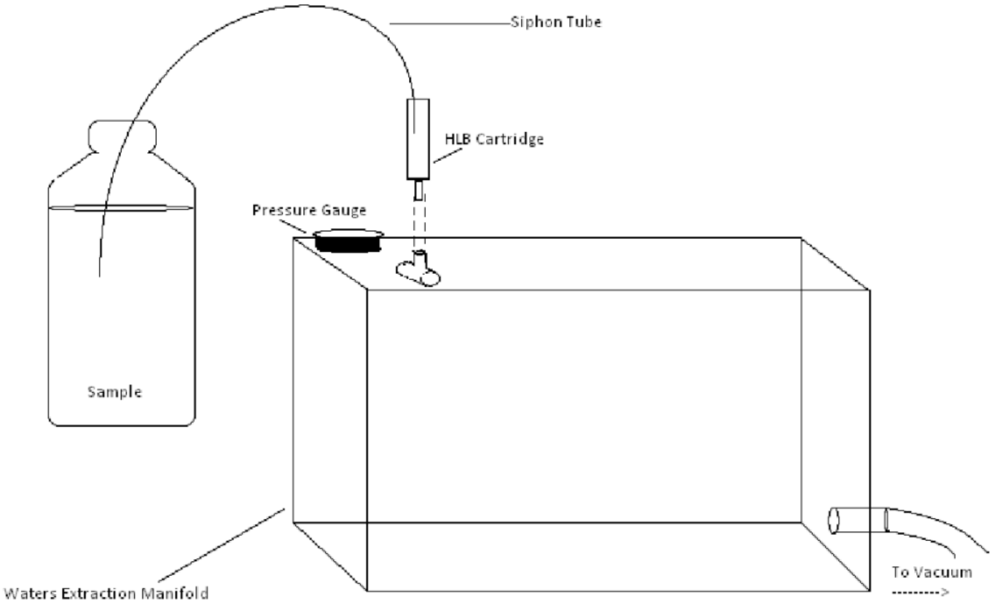
SPE — Solid-phase extraction; an extraction technique in which an analyte is extracted from an aqueous sample by passage over or through a material capable of reversibly adsorbing the analyte.

Stock Solution — A solution containing an analyte that is prepared using a reference material traceable to EPA, the National Institute of Science and Technology (NIST), or a source that will attest to the purity and authenticity of the reference material.

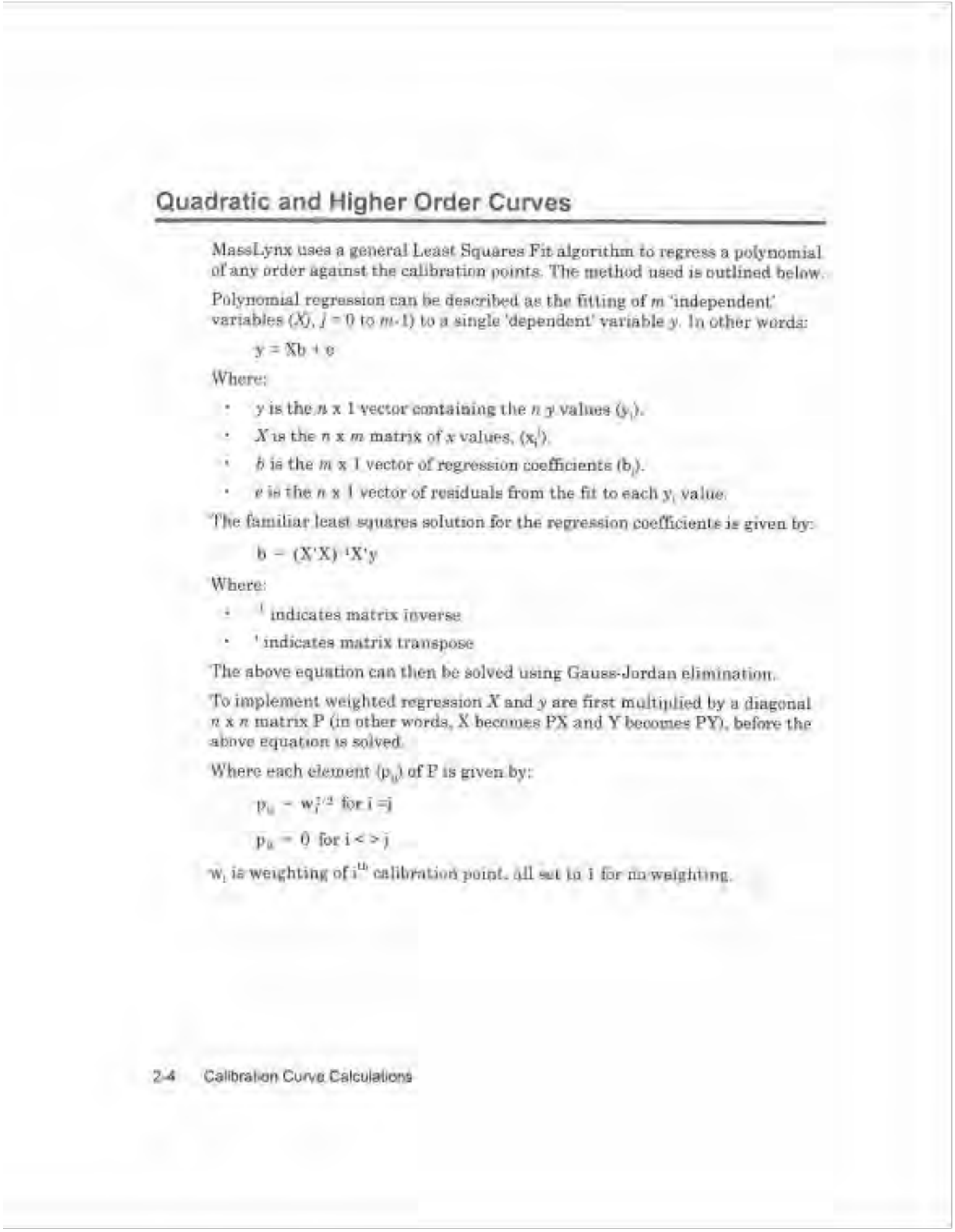
UPLC — Ultra performance liquid chromatography

Appendix A

Figure 1. Extraction Manifold Set-up



Appendix B:



Quadratic and Higher Order Curves

MassLynx uses a general Least Squares Fit algorithm to regress a polynomial of any order against the calibration points. The method used is outlined below.

Polynomial regression can be described as the fitting of *m* 'independent' variables (X_j, $j = 0$ to $m-1$) to a single 'dependent' variable y. In other words:

$$y = Xb + e$$

Where:

- y is the n x 1 vector containing the n y values (y_i).
- X is the n x m matrix of x values, (x_i^j).
- b is the m x 1 vector of regression coefficients (b_j).
- e is the n x 1 vector of residuals from the fit to each y_i value.

The familiar least squares solution for the regression coefficients is given by:

$$b = (X'X)^{-1}X'y$$

Where:

- $^{-1}$ indicates matrix inverse
- ' indicates matrix transpose

The above equation can then be solved using Gauss-Jordan elimination.

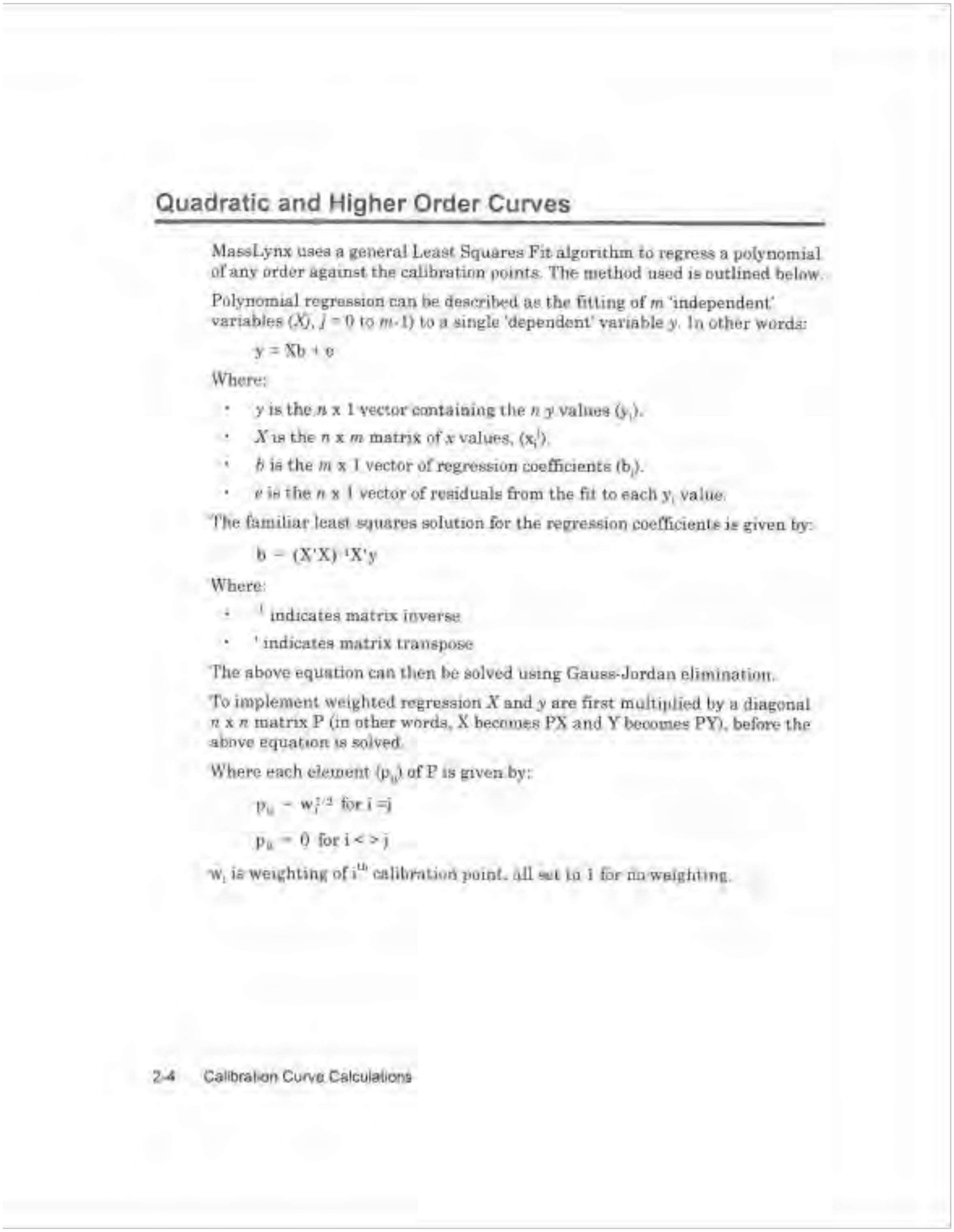
To implement weighted regression X and y are first multiplied by a diagonal n x n matrix P (in other words, X becomes PX and Y becomes PY), before the above equation is solved.

Where each element (p_{ij}) of P is given by:

$$p_{ij} = w_i^{1/2} \text{ for } i = j$$

$$p_{ij} = 0 \text{ for } i <> j$$

w_i is weighting of i^{th} calibration point, all set to 1 for no weighting.



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