FINAL

Remedial Investigation Work Plan
OU-2 Remedial Investigation
700 South 1600 East PCE Plume
Salt Lake City, Utah

Contract No. W912DQ-15-D-3014 Task Order 0005

Prepared for

U.S. Army Corps of Engineers
Kansas City District
601 East 12th Street
CENWK-PM-ES
Kansas City, MO 64106-2824

Department of Veterans Affairs
Veterans Health Administration Salt Lake City Health Care System
500 Foothill Drive
Salt Lake City, UT 84148

February 2018

CH2M HILL, Inc.
4246 South Riverboat Road
Suite 210
Taylorsville, Utah 84123

STATEMENT OF TECHNICAL REVIEW

OU-2 Remedial Investigation for 700 South 1600 East PCE Plume, Salt Lake City, UT

Final Remedial Investigation Work Plan

The CH2M HILL, Inc. team has completed the technical review of the submittal of the Final Remedial Investigation Work Plan. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Contractor Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, using justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with the law and existing U.S. Army Corps of Engineers policy.

Technical Reviewer	Signature	Date of Review
Gary Colgan		1/23/2018
	Signature	Date

Quality Control System Manager or Project Manager	
David Waite	
	2/19/2018
Signature	Date

Independent Technical Reviewer	
Peter Lawson	
	1/5/2018
Signature	Date

Contents

Section Page

Appendixes

Tables

Figures

Acronyms and Abbreviations

µg/L	microgram(s) per liter
AOU	Accelerated Operable Unit
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH2M	CH2M HILL, Inc.
CPT	cone-penetration testing
CSIA	compound-specific isotope analysis
CSM	conceptual site model
DCE	dichloroethene
DQO	data quality objective
EDMS	environmental data management system
EPA	U.S. Environmental Protection Agency
ESS	East Side Springs
FFA	Federal Facilities Agreement
FS	feasibility study
FSP	field sampling plan
GFM	groundwater flow model
GIS	geographic information system
HAPSITE	Inficon HAPSITE
HRS	Hazard Ranking System
IDW	investigative-derived waste
MCL	maximum contaminant level
NPL	National Priorities List
OU	operable unit
PA	preliminary assessment
PCE	tetrachloroethene
PVC	polyvinyl chloride
QAPP	quality assurance project plan
RI	remedial investigation
RIWP	remedial investigation work plan
RSL	regional screening level
SAP	sampling analysis plan
SI	site inspection
SLC	Salt Lake City
SOP	standard operating procedure
STM	solute transport model
TCE	trichloroethene

UDEQ	Utah Department of Environmental Quality
USACE-KC	U.S. Army Corps of Engineers, Kansas City District
VA	Department of Veterans Affairs
VHA	Veterans Health Administration
VISL	vapor intrusion screening level
VOC	volatile organic compound
ZIST	Zone Isolation Sampling Technology

Introduction and Purpose

The Department of Veterans Affairs (VA) has identified two operable units (OU) for the 700 South 1600 East Tetrachloroethene (PCE) Plume Superfund site (the site) in Salt Lake City. Accelerated Operable Unit 1 (AOU-1) is defined as an area where risks from tetrachloroethene (PCE) and trichloroethene (TCE) (a breakdown product of PCE) are present in the groundwater within 50 feet of the surface or discharges as springs/seeps and could present a vapor intrusion risk. This area is called the East Side Springs (ESS). OU-2 is an area where PCE-contaminated groundwater is found, in the area near the Veteran's Health Administration (VHA) Salt Lake City Health Care System. The exact boundaries of the PCE Plume have not been determined, but VA is using the analytical results from U.S. Environmental Protection Agency (EPA) monitoring wells as an approximation until the completion of Phase 1 of the remedial investigation (RI).

This RI Work Plan (RIWP) details the approach that will be taken to conduct the OU-2 RI at the site. The RIWP describes the objectives, approaches, and rationales for the planned work of the first phase (Phase 1) and the general investigation methods for the RI and any additional phases. The RIWP includes Appendix A, the sampling and analysis plan (SAP) for Phase 1, and Appendix B, standard operating procedures (SOPs), which provide details about methodology for all phases of the RI. Appendix C contains the investigation derived waste (IDW) management plan for all phases, and Appendix D includes the accident prevention plan, which includes the site safety and health plan (Appendix D). The field sampling plan (FSP) (Appendix A.1), an appendix of the SAP, details the methods and approach for Phase 1 of the RI, while the quality assurance project plan (QAPP), the other appendix of the SAP, is to ensure that data collected meet project requirements for quality. The project activities will be performed for the Veterans Health Administration (VHA) and the U.S. Army Corps of Engineers, Kansas City District (USACE-KC).

In addition, additional field methods (Section 5.3) may be used in subsequent phases of the OU-2 RI if, per the Federal Facilities Agreement (FFA), modifications are made to the work plan or, per the site management plan, minor field modifications are made after discussion with EPA and Utah Department of Environmental Quality (UDEQ). The items presented in Section 5.3 allow for regulatory review and acceptance now, so that later modifications can refer to them without further review. The FSP (Appendix A.1) provides specific details for Phase 1 activities. The SOPs (Appendix B) provide specific methods for investigation tools included in the RIWP and FSP (Appendix A.2), including the Phase 2 toolbox (Section 5.3). The QAPP (Appendix A.2) also addresses investigation tools included in the RIWP and FSP (Appendix A.1), including the toolbox (Section 5.3) (Phase 1 and future phases of the RI).

Field activities presented in the RIWP (Phase 1) include the following:

- Installation of approximately four shallow groundwater monitoring wells (to depths ranging up to 120 feet below ground surface [bgs]) and one monitoring well cluster (individual monitoring wells in adjacent boreholes screened at different depth intervals) in a transect along 1400 East
- Soil gas surveys around the east and south sides of Building 7 at the VA Medical Center, along the sewer line extending from VA Medical Center Building 7 to Sunnyside Avenue, and along a short portion of Foothill Drive in front of the VA Medical Center, and soil sampling if warranted (based on the results of previous soil gas sampling)
- Installation of four deep monitoring wells (to a maximum depth of 500 feet bgs) in a transect near Guardsman Way and two deep monitoring wells downgradient of Guardsman Way, with push-ahead groundwater sampling during deep monitoring well drilling
- Installation of six shallow groundwater monitoring well clusters in the ESS area

- Geotechnical sample collection and testing during well installation
- Aquifer slug testing
- Short duration (8-hour) aquifer pumping tests
- Geophysical logging
- Groundwater monitoring of new and existing monitoring wells
- Surface water sampling in the ESS area and along Red Butte Creek where it intersects the groundwater table

Additional field methods (described in Section 5.3) that may be used in subsequent phases of the RI include the following:

- Source investigation including additional soil gas testing, surface and near-surface soil sampling, and subsurface soil sampling (using direct-push drilling)
- Installation and sampling of additional groundwater monitoring wells
- Aquifer pumping test at the drinking water supply well SLC-18
- Cone-penetration testing (CPT)
- Additional surface water sampling
- Ecological site reconnaissance
- Well maintenance, as necessary

Field activities will be described in data summary reports and will also be included in an interim RI report.

Site Background

The site is in Salt Lake City, Utah near the University of Utah and the front of the Wasatch Mountains (Figures 2-1 and 2-2). PCE was initially detected at a concentration of 32 micrograms per liter (µg/L) during routine sampling of the Mount Olivet Cemetery irrigation well in 1990 (Figure 2-2) (UDEQ, 2000). In 1998 and 1999, EPA installed seven monitoring wells in the area east and southeast of Mount Olivet Cemetery (Figure 2-2). In the investigation that followed, a sewer line originating from the former dry cleaning facility in the VA Medical Center was identified as a potential source (Bowen Collins, 2004). In 2010, PCE was detected in several surface water springs downgradient of the plume along the Wasatch Fault scarp (UDEQ, 2012; MWH, 2012). Other previously evaluated areas include the former Fort Douglas Military Reservation (Fort Douglas), the former Utah Army National Guard vehicle maintenance facility, and the former U.S. Forest Service helicopter pad (Figure 2-2). The previously evaluated areas are discussed in further detail in Section 2.3, and in the updated conceptual site model (CSM) prepared for the VHA Salt Lake City Health Care System (EA, 2017a).

2.1 Regulatory History

Following the initial detection of PCE in the Mount Olivet Cemetery irrigation well, the site (originally the Mount Olivet Cemetery Plume site) was investigated under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). UDEQ Division of Environmental Response and Remediation under agreement with EPA conducted a site inspection (SI) from 1996-1999. Results from sampling in 1997 showed an increased concentration of PCE in the Mount Olivet Cemetery irrigation well (184 µg/L) and detectable levels of PCE in the Salt Lake City (SLC) Department of Public Utilities Drinking Water Well No. 18 (SLC-18). In 1998-1999, six monitoring wells (five individual wells and one nested shallow/deep well) were installed at the site by an EPA Superfund Technical Assessment and Response Team contractor. Results of the initial SI indicated the plume was greater than 900 feet wide at monitoring well EPA-MW-01 and limited to the shallow aquifer with groundwater flow to the northwest (UDEQ, 2000). The sewer line originating from the former dry cleaning facility at the VA Medical Center was identified as a potential source area at this time (UDEQ, 2000). A 2003 sanitary sewer survey documented multiple physical defects in the sewer line that may have contributed to the release of PCE (EPA, 2012).

In 2004, a SI conducted by UDEQ and EPA detected PCE in the drinking water well SLC-18 at a concentration of 2.23 µg/L (UDEQ, 2012). Although the measured value in SLC-18 was below the 5 µg/L National Drinking Water Standard maximum contaminant level (MCL) for PCE, the well was temporarily removed from service. During this event, PCE was also measured in the Mount Olivet Cemetery irrigation well at a concentration of 128 µg/L (UDEQ, 2012). As a result of the SI, EPA returned to the site in 2005 to prepare a Hazard Ranking System (HRS) package to propose the site for inclusion on the National Priorities List (NPL). The decision to list the site on the NPL was deferred in 2006 to allow local officials to seek congressional funding to address the contamination.

In June 2010, approximately 800 barrels of crude oil was released from a Chevron pipeline into Red Butte Creek and Liberty Park Pond. As a result of this event, SLC Department of Public Utilities sampled 11 surface water springs along the Wasatch Fault line to delineate the extent of crude oil contamination. PCE was measured in 6 of the 11 sampled springs with concentrations ranging between 2.5 µg/L and 40.4 µg/L (EPA, 2012). The area containing the surface water PCE detections was defined as the ESS area in subsequent investigations. The surface water detections were downgradient of the PCE plume at the site and the plume was identified as a probable source of the surface water PCE contamination. As a result of these detections, the site was placed on the Comprehensive Environmental Response, Compensation, and Liabilities Information System in January 2011.

A preliminary assessment/site inspection (PA/SI) was conducted by the Division of Environmental Response and Remediation in 2011. The PA/SI determined that vapor intrusion of PCE and its breakdown products in spring water and shallow groundwater posed a potential human health threat (UDEQ, 2011). In September 2012, EPA released the HRS Site Score and determined the site was eligible for NPL designation (EPA, 2012). HRS Documentation identified the sewer line originating from the VA Medical Center as the source of the groundwater contamination and determined there was insufficient evidence to identify additional potential sources (EPA, 2012). The site was listed on the NPL on May 24, 2013, with the VA Medical Center named as the potential responsible party (EPA, 2014).

2.2 Location and General Site Setting

The site is southwest of the University of Utah campus at the intersection of 700 South and 1600 East in Salt Lake City, Utah. Some major streets in the vicinity of the 700 South and 1600 East PCE plume include 500 South to the north, Michigan Avenue to the south, 1100 East to the west, and Foothill Drive to the east (Figure 2-2). The Mount Olivet Cemetery, East High School, and University of Utah athletics facilities, in addition to residential neighborhoods, are in the vicinity of the 700 South and 1600 East PCE plume. Surface water features in the vicinity of the 700 South and 1600 East PCE plume include Mount Olivet Reservoir, the mouth of Red Butte Creek, Liberty Park Pond, named springs, and multiple unnamed seeps and springs. A brief discussion of the geology and hydrology of the site is provided below and in Table 2-1.

Geologically, the site is within the Salt Lake Valley, an alluvial basin bounded by the Wasatch Range, the Oquirrh Mountains, the Traverse Mountains, and the Great Salt Lake. The valley is within the Basin and Range physiographic province, which is characterized by north to northeast trending mountain ranges separated by broad alluvial basins. The Salt Lake Valley is bounded to the east by the Wasatch Fault, an active fault zone composed of multiple seismically-independent segments (EA, 2017a).

The site is on Quaternary age unconsolidated sediments deposited by alluvial fans, streams, deltas, and other lacustrine processes related to Ancient Lake Bonneville (Figure 2-3). Overall, the surficial geology grades from coarse-grained alluvial fans deposits on the east to finer-grained lacustrine deposits to the west. The topography of the site slopes to the southwest at an approximate grade of 4 percent until the grade steepens to 10 percent near the Wasatch Fault scarp west of 1300 East Street, where springs and seeps emanate from the hillside (that is, the ESS area) (Figure 2-2). The site is roughly bisected by the west and east spurs of the East Branch of the Wasatch Fault Line (EA, 2017a).

Groundwater flow in the Salt Lake Valley occurs in complex basin-fill deposits consisting of multiple aquifers and confining layers (EA, 2017a). Regional groundwater flow on the east side of the valley generally moves from the northeast to the southwest, from the primary recharge zone near the Wasatch Mountains toward the Jordan River and then discharges to the Great Salt Lake (Thiros et al., 2010). Groundwater flow in the vicinity of the VA Medical Center and the site is more complex, with previous reports indicating local groundwater flow toward the northwest and the west-northwest (UDEQ, 2000; EA, 2017a). Groundwater pumping at University of Utah Well #1 during the summer and early fall may have influenced groundwater flow in the site, however, there is considerable uncertainty in the understanding of local groundwater flow in the site (EA, 2017a). For a more thorough discussion of the geology, lithology, and hydrology of the site, see the updated CSM (EA, 2017a).

Table 2-1. Summary of Key Components of the Conceptual Site Model

Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume Salt Lake City, Utah

CSM Component	Important Aspects
Geology	
Geologic Setting	• Part of the Basin and Range Physiographic Province – Characterized by generally parallel, north-to northeast-trending mountain ranges separated by broad alluvial basins – Bounded on the east by the Wasatch Range • Located within the Salt Lake Valley Alluvial Basin – Bounded on the northeast by consolidated rocks in the Wasatch Range – Bisected by the Wasatch Fault ▪ Consists of several seismically independent segments active in Holocene time – Basin-fill deposits consist of unconsolidated to semi-consolidated Tertiary-age deposits overlain by unconsolidated Quaternary-age deposits • VA Medical Center located on Quaternary-age unconsolidated sediments deposited as alluvial fan and lacustrine features associated with Ancient Lake Bonneville
Site Lithology	• Surficial geology changes from east to west across the site – Consists of coarse-grained alluvial fan deposits near the VA Medical Center – Lacustrine deposits become more fine-grained to the west until the East Bench Fault – Bedrock depth assumed to exceed 1,000 feet bgs • Sediment lithology is coarse- to fine-grained upper-basin fill consisting of gravel, sand, silty sand, clay lenses, and interbedded sequences of sediment
Surface Topography	• Located in a developed urban area • Slopes to the southwest at a 4 percent grade • Grade steepens to 10 percent west of the East Bench segment of the Wasatch Fault • VA Medical Center located at an elevation of approximately 4,735 feet amsl
Hydrogeology	
Hydrostratigraphy	• Groundwater occurs in basin-fill sediments • Discontinuous clay layers may create locally perched groundwater • Groundwater can generally be divided into three aquifers – A deep unconfined aquifer, generally east of the Wasatch Fault, which may be subdivided into shallower and deeper parts – A shallow unconfined aquifer, generally west of the Wasatch Fault, overlying the artesian aquifer – A confined (artesian) aquifer beneath the shallow unconfined aquifer • The deeper part of the deep unconfined aquifer (east of the Wasatch Fault), and the confined aquifer (west of the Wasatch Fault), form the principal aquifers for most of the water supply wells in the Salt Lake Valley
Recharge Zones	• Primary recharge area is near the mountain fronts and associated fault zones • Secondary recharge occurs where water flows through shallow basin-fill alluvial sediments into deeper basin-fill sediments • VA Medical Center and the site PCE plume are within both primary and secondary recharge areas, in which dissolved constituents can be transported downward.
Groundwater Levels	• Depth-to-groundwater: – 124 to 175 feet bgs (4,555 to 4,491 feet amsl) in the unconfined aquifer near the VA Medical Center – 1–5 feet bgs in the discharge areas in the center of the valley and in the ESS area

Table 2-1. Summary of Key Components of the Conceptual Site Model
Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume Salt Lake City, Utah

CSM Component	Important Aspects
Groundwater Levels *(continued)*	• Potentiometric surface elevations – Approximately 4,520 feet amsl (EPA-MW-05) near VA property in the shallower part of the unconfined aquifer. The shallower part of the unconfined aquifer will be evaluated as part of the RI field work – Approximately 4,491 feet amsl near VA property (EPA-MW-01D) in the deeper part of unconfined aquifer
Horizontal Hydraulic Gradients and Flow Directions	• In general, groundwater is moving from recharge areas near the Wasatch Mountains to the west toward discharge areas near the ESS, Jordan River, and the Great Salt Lake • Data from the current monitoring well network is insufficient to reliably characterize the direction of groundwater flow in the vicinity of the VA Medical Center • Shallow groundwater in the ESS area (west of 1300 East) flows towards the southwest
Horizontal Hydraulic Conductivity and Transmissivity	• Shallow part of the unconfined aquifer (east of Wasatch Fault) – Transmissivity ranges from 50 to 4,000 ft^2/day – Hydraulic conductivity for coarser grained deposits estimated to be approximately 200 feet/day – Specific yield estimated to average 0.15 – Local transmissivity values are an order of magnitude greater than average transmissivity values for the aquifer • Deeper part of the unconfined aquifer (east of Wasatch Fault) – Transmissivity ranges from 1,000 to 50,000 ft^2/day – Specific yield estimated to average 0.15
Horizontal Groundwater Velocity	• Estimated to range from 0.6 feet/day to 1.9 feet/day for the unconfined aquifer (east of the Wasatch Fault)
Vertical Hydraulic Conductivity	• Ranges from 0.01 to 1 foot/day in the unconfined aquifer where fine-grained deposits are present
Water Quality and Geochemistry	
Geochemical Conditions	• Class II – Drinking Water Quality Groundwater • TDS concentrations in the basin-fill aquifers range from 512 to 2,588 mg/L • Groundwater across the site area is aerobic and pH neutral • Groundwater at AOU-1 is pH neutral with variable dissolved oxygen content
Contaminant Distribution	• PCE source area not well defined • PCE plume extent above the maximum contaminant level is uncertain • PCE and daughter products have been detected in springs and seeps and shallow groundwater in the ESS area • Historical PCE concentrations in the upper part of the shallow unconfined aquifer have ranged from 0.8 to 320 µg/L • Historical PCE concentrations in the deeper part of the unconfined aquifer have ranged from non-detect to 12 µg/L based on data from monitoring well EPA-MW-01D, though analytical data from the Mount Olivet irrigation well suggest that higher PCE concentrations could be present in the deeper part of the unconfined aquifer • Maximum PCE concentration measured in shallow groundwater in the ESS area was 52 µg/L (July 2016) • Historically maximum concentration measured in seeps and springs was 74 µg/L (May 2016) • TCE has been detected at depths ranging from 130 to 470 feet bgs

Source: EA, 2017a and references contained therein.

Notes:
amsl = above mean sea levelft^2 = square feet TDS = total dissolved solids
mg/L = milligram(s) per liter

2.3 Previously Evaluated Sites

Previous evaluations identified the VA Medical Center, Building 7 (Building 7) as the likely source of the PCE plume at the site based on historical records of PCE use and the direction of local groundwater flow (UDEQ, 2000, 2012). Additional areas have also been previously evaluated including the former Fort Douglas, a former Utah Army National Guard vehicle maintenance facility, and a former U.S. Forest Service helicopter pad (UDEQ, 2000; Beacon, 2001; EPA, 2012). These previously evaluated areas are discussed in further detail in the following subsections and in the CSM developed for the VHA Salt Lake City Health Care System (EA, 2017a) (Figure 2-2).

2.3.1 VA Medical Center, Building 7

Historical records indicate the VA Medical Center operated a dry cleaning facility at Building 7 that used PCE as a solvent (UDEQ, 2000). A sanitary sewer survey conducted in 2003 revealed multiple physical defects inside the sewer piping including cracks and historic breaks (EPA, 2012). In 2005, the Department of Veterans Affairs stated that PCE was used at the facility, that there appeared to be no documentation of tanks used to store spent solvents, and that condensate from the distillation process was emptied into a drain line attached to the sanitary sewer (EPA, 2012). Two signed affidavits from Salt Lake City Public Utilities employees described discolored water and solvent odors originating from the sanitary sewer line during the 1980s (UDEQ, 2012).

Previous investigations have detected PCE in soil gas in the vicinity of Building 7 and along the sanitary sewer line. A 1996 soil-gas sample collected near the loading dock area of Building 7 tested positive for PCE (1.9 µg/L) (EPA, 2012). Soil sampling in 2004 failed to detect contaminated soils at the same location, however, a correlative soil gas investigation in 2007 detected PCE in three sample locations around the loading dock area at Building 7 (IHI, 2005, 2007). The 2007 soil gas investigation also detected PCE in a soil gas measurement collected near a manhole along the sanitary sewer line, although the remaining 44 passive soil gas samplers installed approximately 4 inches bgs along the sewer line did not measure PCE above the detection limit (IHI, 2007). The results are considered qualitative due to the passive soil gas sample method employed in the 2007 investigation.

2.3.2 Former Fort Douglas Military Reservation

The former Fort Douglas is approximately 3,600 feet northeast of the VA Medical Center Building 7. A soil gas evaluation conducted by EPA Superfund Technical Assessment and Response Team in 1996 detected PCE in one of three soil gas samples collected from the former Fort Douglas area. In the 2012 HRS documentation, EPA determined that the absence of PCE contamination in a monitoring well situated between the former Fort Douglas and VA Medical Center indicated it was unlikely that Fort Douglas was a contributing source of PCE to contamination downgradient of the VA Medical Center (EPA, 2012). The lack of continuous PCE detection in the drinking water-supply well SLC-18 also indicated potential groundwater contamination from Fort Douglas did not directly impact the PCE plume at the site (EPA, 2012).

2.3.3 Former Utah Army National Guard Vehicle Maintenance Facility

The Utah Army National Guard operated a vehicle maintenance facility on Guardsman's Way east of Mount Olivet Cemetery. Various solvents were used at the facility, including one which could have contained up to 0.5 percent PCE (EPA, 2012). After the initial detection of PCE in the Mount Olivet Well the facility was evaluated as a potential source (UDEQ, 2000). A May 1995 soil gas survey detected 1 µg/L of TCE near the facility. TCE can be a breakdown product of PCE, but is also a solvent used to degrease. A follow-up survey conducted in June of that year did not detect PCE or other chlorinated solvents in 15 soil gas samples collected near the maintenance facility and the VA Medical Center.

The maintenance facility was ultimately eliminated as a potential primary source due to the presence of PCE-contaminated groundwater upgradient of the facility (EPA, 2012).

2.3.4 Former U.S. Forest Service Helicopter Pad

The U.S. Department of Agriculture (USDA) Forest Service operated a heliport and fueling facility southeast of Mount Olivet Cemetery. The U.S. Department of Agriculture stored gasoline and aviation gasoline in three underground storage tanks. The tanks were closed in the early 1990s and the site has since been converted to a University of Utah softball field (EPA, 2012; EA, 2017a). There are no recorded available about the use or storage of solvents onsite and the facility has not been investigated as a potential source (EPA, 2012).

2.4 Data Gaps

The CSM prepared for the VA Medical Center identified the following data gaps:

- Source area identification
- Delineation of plume boundaries and PCE concentrations
- Characterization of the site geology, hydrostratigraphy, and hydrogeology
- Identification of potential exposure points
- Evaluation of natural attenuation “lines of evidence” for PCE

The RI will investigate the identified data gaps as discussed below. Further detail regarding the principal study questions, proposed analytical approach, and the plan for obtaining data is provided in Section 4. The CSM will be updated through the creation of the interim RI Phase 1 report discussed in Section 5.4.

2.4.1 Source Area Identification

Although the VA Medical Center Building 7 has been identified as the likely source of the PCE plume, additional investigation is required to (1) definitively trace the PCE plume back to this location, (2) identify or eliminate other potential primary sources, and (3) determine if secondary sources downgradient of the primary source may be contributing to PCE and TCE contamination at the site. Soil gas survey data collected in the vicinity of the VA Medical Center and the Sunnyside sewer line in Phase 1 of the RI will be used to determine to what extent a source can be identified. In addition, groundwater sampling and surface water sampling results obtained in Phase 1 of the RI may be used to address this data gap and/or direct further sampling efforts.

2.4.2 Delineation of Plume Boundaries and PCE Concentrations

The dimensions of the site PCE plume are not well-defined. Methods to address this data gap include monitoring well installation and groundwater sampling, soil gas analysis, and collection of surface water samples from springs and seeps along the Wasatch Fault. Additional sampling including expanded surface water sampling, additional soil gas surveys, and direct-push soil sampling may be conducted depending upon results from the initial phase sampling. The investigation methods proposed to increase the understanding of the dimensions of the PCE Plume during Phase 1 are presented in Sections 5.1 and 5.2. Sample methods that may be utilized in future phases of the RI are discussed in Section 5.3.

2.4.3 Characterization of the Site Geology, Hydrostratigraphy, and Hydrogeology

Understanding local groundwater flow is essential to characterizing this site. This data gap will be addressed by installing and instrumenting additional groundwater monitoring wells and the testing and sampling of existing wells. Site geology will be characterized through borehole logs, detailed lithology descriptions recorded during the installation of new monitoring wells, and geotechnical and geophysical measurements. The hydrogeology and hydrostratigraphy of the site will be characterized through the installation of multi-level monitoring wells, geophysical measurements, aquifer testing on new and existing monitoring wells, the installation and monitoring of pressure transducers to monitor long-term fluctuations in water levels, and through collecting groundwater samples and field parameter data from new and existing wells. More information about these various investigation techniques is included in Section 5. Data collected during Phase 1 will be used to develop a groundwater flow and transport plume model. After the new monitoring wells have been installed, a groundwater flow and transport model QAPP will be developed for regulatory review and comment.

2.4.4 Identification of Potential Exposure Points

Potential exposure points for the site include exposure to groundwater through drinking water, contact with contaminated surface water in residential areas and storm drains, and contact with contaminated soil-gas through vapor intrusion. Vapor intrusion and direct contact of surface water are addressed in the AOU-1 RI. OU-2 will focus on exposures through groundwater. Groundwater data will be essential to identifying the potential risk associated with exposure through irrigation and drinking water. Surface water, shallow groundwater, shallow soil, and soil-gas data will provide additional information on the potential human health risks at the site. Ecological risks within AOU-1 will be addressed through the ecological risk screening for AOU-1, which will be presented in the AOU-1 RI report. Ecological risk screening for OU-2 will be evaluated in Phase 2 of the OU-2 RI, as described in Section 5.3.5.

2.4.5 Evaluation of Natural Attenuation "Lines of Evidence" for PCE

Hydrogeological and geochemical data will be collected during Phase 1 of the RI, to support evaluation of the extent to which natural attenuation degrades contamination. The CSM (EA, 2017a) includes additional discussion of the evidence required to demonstrate that natural attenuation processes are active. The information collected during Phase 1 of the OU-2 RI in the ESS area will also be useful in the AOU-1 focused feasibility study.

2.5 Operable Units

The site includes AOU-1 and OU-2. AOU-1 delineates the extent of impacts and risks from vapor intrusion and direct contact with surface water within the ESS area (Figure 2-2). OU-2 addresses the source of PCE and contaminated groundwater at the site. Groundwater and surface water data from the AOU-1 RI will be included in the OU-2 RI and will help delineate the nature and extent of the impacted groundwater at the site.

2.5.1 Accelerated Operable Unit 1

AOU-1 focuses on potential vapor intrusion risk in the ESS area (Figure 2-2) and is defined as the approximate area where depth to groundwater is less than 50 feet bgs and the groundwater contains PCE (First Environment, 2015). AOU-1 was established to address the public health concerns related to the vapor intrusion of PCE and its daughter products from contaminated shallow groundwater. As such, AOU-1 assessed multiple media within this area: PCE-contaminated groundwater within approximately 50 feet bgs, surface water, and indoor air. Field work associated with AOU-1 is presented in the *Remedial Investigation Work Plan AOU-1: East Side Springs 700 South 1600 East PCE Plume, Salt Lake City, Utah* (First Environment, 2015) and the supplemental RI work conducted by CH2M HILL, Inc. (CH2M) (CH2M, 2017).

2.5.2 Operable Unit 2

OU-2 includes PCE-contaminated groundwater in the footprint of AOU-1, extending upgradient to the northeast onto the VHA Salt Lake City Health Care System. The extent of PCE-contaminated groundwater is not well known at this time. The OU-2 RI will be conducted in multiple phases to evaluate the entire PCE plume, including additional contaminated groundwater delineation work in the ESS area (AOU-1) to further define the groundwater flow and extent of contaminant migration. The goals of the RI at OU-2 are the following:

- Characterize the hydrogeology
- Delineate the nature and extent of PCE groundwater contamination
- Investigate remnant PCE sources
- Assess potential exposure pathways and risks, including expanding the ecological risk screening presented in the AOU-1 RI
- Support the development and detailed analysis of remedial alternatives during the subsequent feasibility study (FS)

The data quality objectives for OU-2 are discussed in further detail in Section 4.1.

This RIWP describes the field activities that will be conducted as part of Phase 1 of the RI as well as additional field methods that may be used in field work in Phase 1 and subsequent phases of the OU-2 RI. The overall concept for OU-2 is independent of how the work is proposed to be phased but Phase 1 and potential future phases are presented.

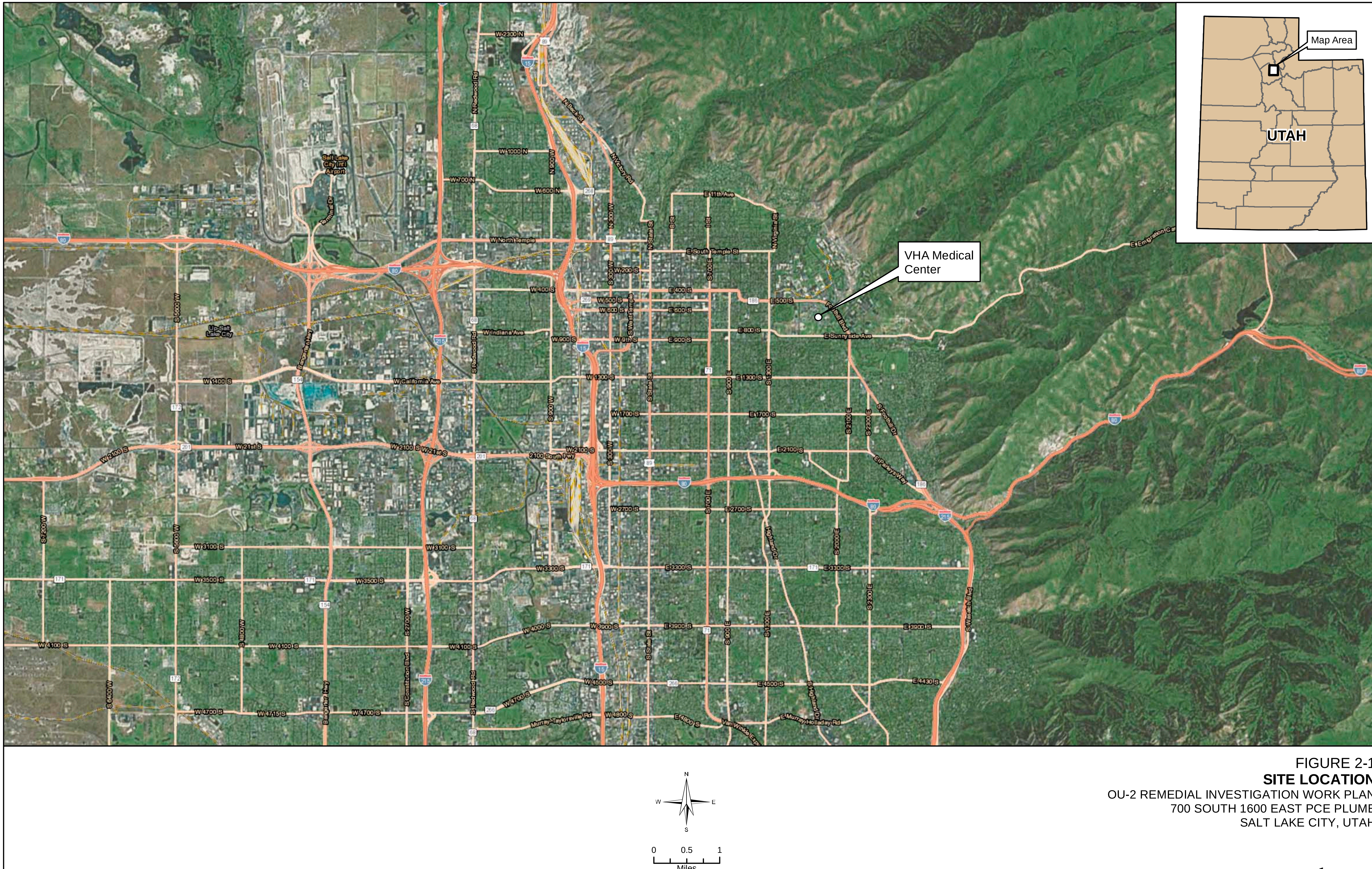
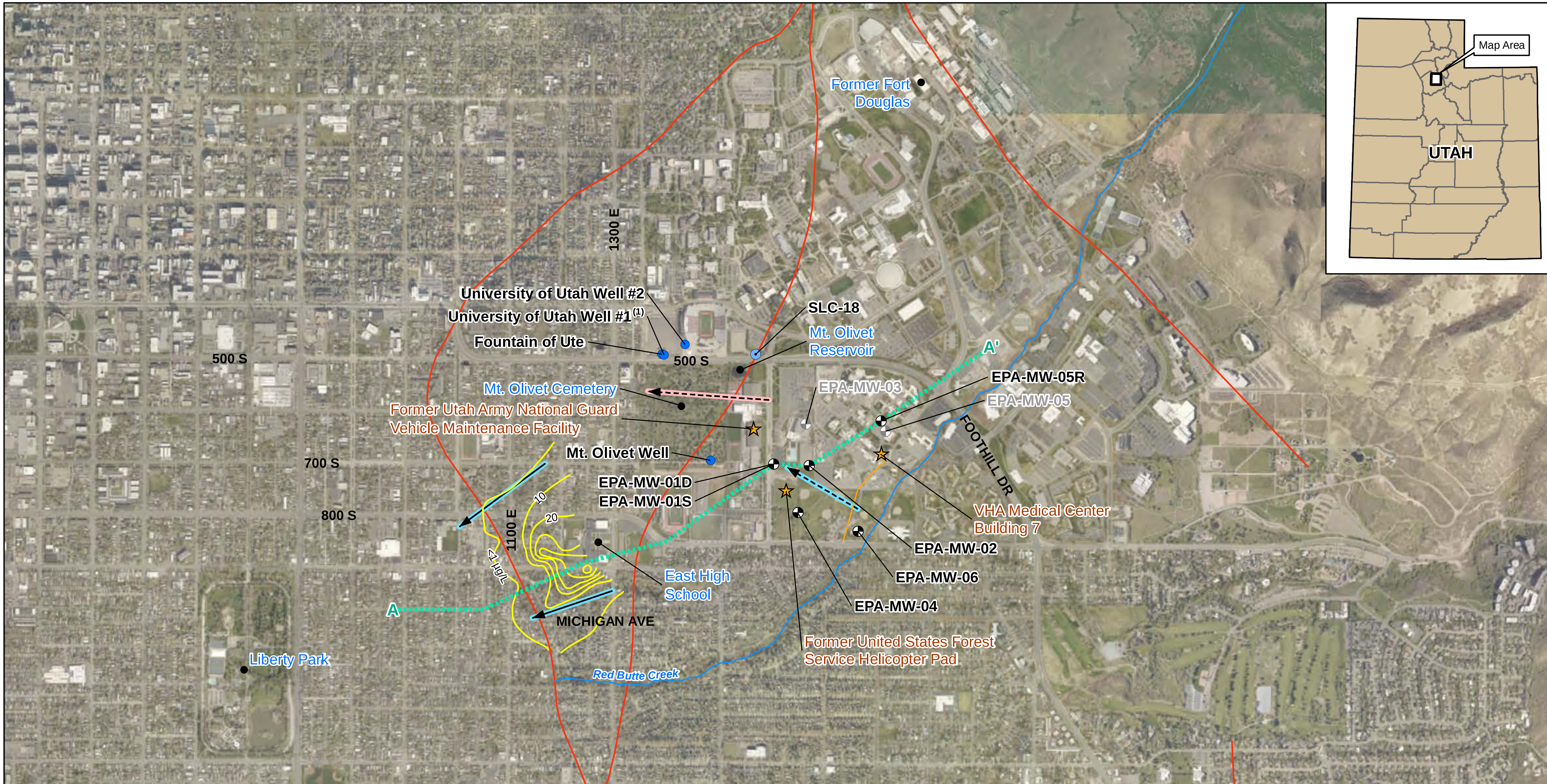


FIGURE 2-1
SITE LOCATION
OU-2 REMEDIAL INVESTIGATION WORK PLAN
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

File Path: R:\ENBG\00_Proj\V\VA-SLC_665353\MapFiles\OU2_Remedial_Investigation_Work_Plan\SiteLocation.mxd jquan 1/19/2017 1:52:18 PM

ch2m



Legend

- Monitoring Well
- Abandoned Monitoring Well
- Drinking Water Supply Well
- Irrigation Well
- Previously Evaluated Area
- Landmark
- Sewer Line
- Red Butte Creek
- Fault Line
- PCE Contour Line (µg/L) (2)
- East Side Springs Area Groundwater Flow Direction (3)
- Shallower Groundwater Flow Direction (4)
- Deeper Groundwater Flow Direction (4)
- Cross Section

Notes:
(1) Location of University of Utah Well #1 is approximate; well is located less than 100 feet east of Fountain of Ute.
(2) PCE contours in shallow groundwater within AOU-1 are based on samples collected from 2/22/2016 and 3/8/2016 (EA, 2016).
(3) Shallow groundwater flow direction within AOU-1 determined from water level data collected from 2/22/2016 and 3/8/2016 (EA, 2016).

(4) The shallower and deeper groundwater flow directions are based on data and uncertainties presented in the Conceptual Site Model (EA, 2017a).

µg/L = micrograms per liter
AOU = Accelerated Operable Unit
PCE = tetrachloroethene

EA Engineering, Science, and Technology, Inc., PBC (EA). 2016. 700 South 1600 East PCE Plume AOU-1 East Side Springs 2016 Groundwater, Surface Water, and Soil Sampling Technical Memorandum. Prepared for VASLCHCS. Final. September.

EA. 2017a. Conceptual Site Model Update for the 700 South 1600 East PCE Plume AOU-1: East Side Springs, Salt Lake City, Utah. February.

N W E S

0 750 1,500
Feet

FIGURE 2-2
SITE MAP
OU-2 REMEDIAL INVESTIGATION WORK PLAN
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

ch2m

File Path: \\brookside - R:\ENBG\00_Proj\V\VA-SLC_665353\MapFiles\OU2_Remedial_Investigation_Work_Plan\December2017\SiteMap.mxd jquan 2/22/2018 12:28:15 PM

Legend

Proposed shallow monitoring well location (See Note 3)

Proposed deep monitoring well location (See Note 5)

EPA monitoring well

Water Level

Finer grained alluvial sediments classified as clay (CL), gravelly clay (GC), or sandy clay (SC)

Coarser grained alluvial sediments

S: shallow

D: deep

TD = total depth

ft bgs = feet below ground surface

? = Uncertainty

(4355') = Elevation in feet above mean sea level

100'

8X VERTICAL EXAGGERATION

800'

North

NOTES:

1. Proposed well locations are approximate and may change according to site conditions and access agreements.
2. Water level data from April 2016, as presented in Conceptual Site Model (EA, 2017a).
3. The total depth and screen interval for shallow monitoring well locations will be determined based on the drilling log and identification of "first water." Monitoring wells labeled S/D are clustered 2-inch wells.
4. Monitoring well IDs will be numbered sequentially in order of installation.
5. The total depth, screen interval, and monitoring well type for the proposed deep monitoring well locations will be determined based on the drilling log, natural gamma logging, and push-ahead groundwater sampling.

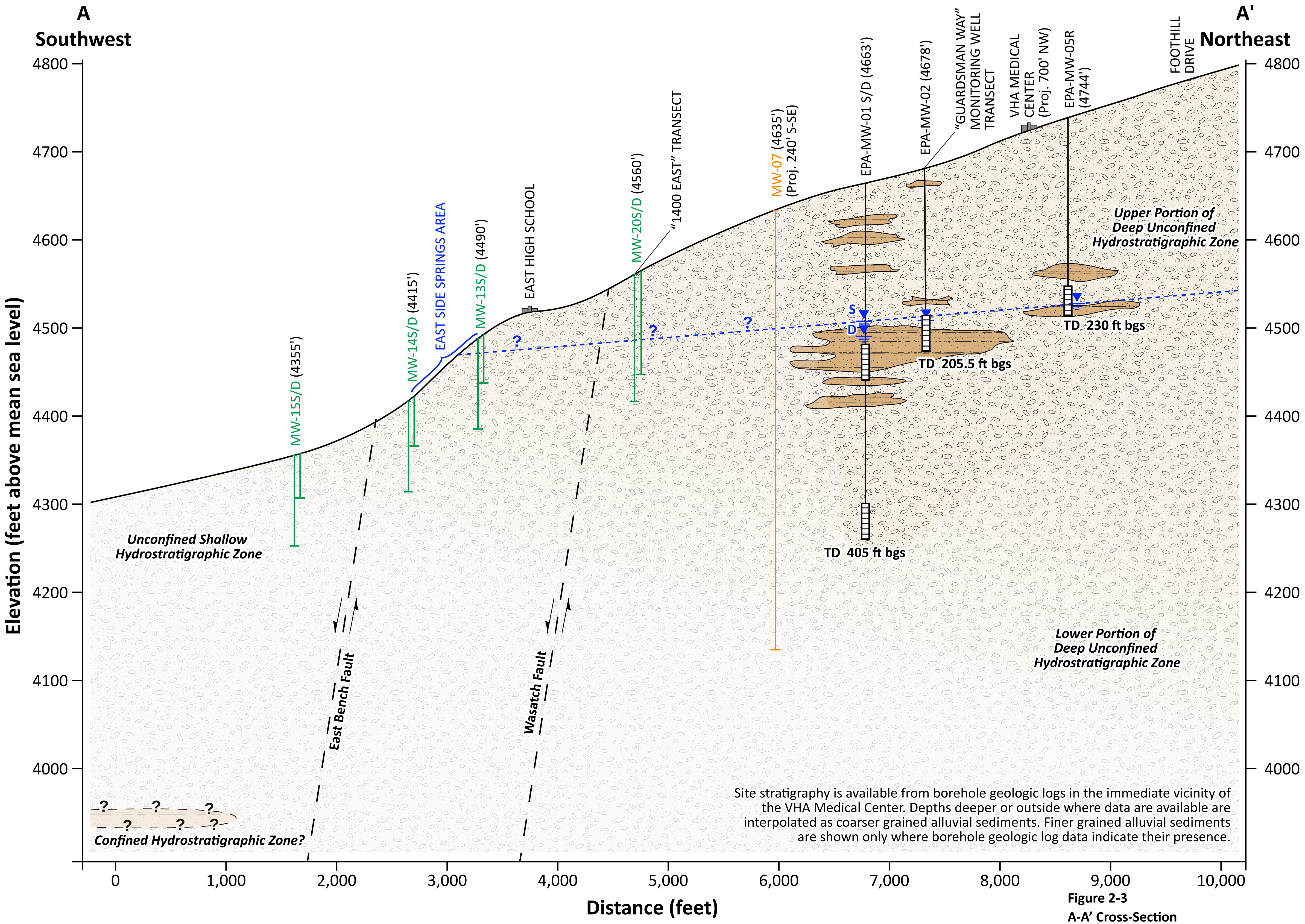


Figure 2-3
A-A' Cross-Section
OU-2 Remedial Investigation Work Plan
700 South 1600 East PCE Plume
Salt Lake City, Utah

ch2m

VHA_CrossSection_Fig2.3_v8.ai 01.03.18 tdaus

SECTION 3

Preliminary Identification of Response Actions

The FS, which will follow completion of the RI, will present a detailed evaluation of remedial actions that could be implemented to address contamination at the site. The evaluation presented in the FS could benefit from data collected during the RI phase of work. Therefore, this RI presents a preliminary evaluation of general remedial response actions and associated technologies for the sole purpose of identifying preliminary data needs. Table 3-1 lists possible technologies that may be evaluated in the FS and includes an assessment of what, if any, data could be collected during the RI that will benefit the subsequent FS.

Table 3-1. Evaluation of Potential Feasibility Study Data Needs
Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume Salt Lake City, Utah

Possible Remedial Technologies	Potential Feasibility Study Data Needs
Administrative and physical controls	Additional records review and site reconnaissance to identify existing wells in the OU-2 study area.
MNA	The following types of information could support evaluation of MNA in the FS: • Concentrations trends in groundwater for PCE and daughter products • Oxidation-reduction (Redox) conditions in groundwater • General water quality parameters • Mineralogical analysis of reactive iron (magnetic susceptibility) to assess abiotic degradation of PCE
Vertical groundwater containment barriers (slurry wall, sheet piling, vibrating barrier wall, etc.)	None
Groundwater extraction, ex-situ treatment and discharge	Aquifer tests would support the assessment of potential pumping rates and zones of influence for pumping wells. Groundwater contaminant concentration data along with general water quality data would support assessment of treatment methods.
In-situ physical groundwater treatment (air sparging, downhole air stripping)	Hydrostratigraphic data such as lithology and depth to contaminated groundwater will support assessment of in-situ physical treatment in the FS.
In-situ groundwater chemical treatment (oxidation or reduction)	Hydrostratigraphic data and aquifer test results could help assess the feasibility of injections. General water quality data, including redox conditions, could help assess the effectiveness of in-situ chemical treatment along with challenges such as precipitation of solids.
In-situ groundwater biological treatment (for example, enhanced reductive dechlorination)	Hydrostratigraphic data and aquifer test results could help assess the feasibility of injections. Information on geochemistry and native microbiology would also help evaluate likelihood of successful bioremediation.
Source area soil physical treatment (for example, SVE or SVE with dual-phase extraction)	Vadose zone lithological data and physical properties data (such as porosity) will support evaluation of SVE in the FS. See "Groundwater extraction, ex-situ treatment and discharge" regarding management of extracted groundwater.
Source area soil excavation with onsite or offsite treatment	Soil sampling data to delineate area and depth of contamination.
Source area in-situ soil thermal treatment	Vadose zone lithological data and physical properties data (such as porosity) will support evaluation of thermal treatment in the FS.

Notes:
MNA = monitored natural attenuation
SVE = soil vapor extraction

Work Plan Rationale

This section describes the data quality objectives (DQOs) for the site and defines the RIWP approach and supporting documents.

4.1 Data Quality Objectives

Consistent with the EPA *Guidance on Systematic Planning Using the Data Quality Objectives* (2006), a seven-step process was followed to define DQOs. These DQOs serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the RI. The seven-step process includes the following:

- State the Problem
- Identify the Goal of the Study
- Identify Information Inputs
- Define the Boundaries of the Study
- Develop the Analytic Approach
- Specify Performance or Acceptance Criteria
- Develop the Plan for Obtaining Data

Table 4-1 summarizes the results of the DQO process for the entire OU-2 RI. Phase 1 of the RI is intended to address all DQOs to a certain degree. However, given there are inherent uncertainties in site characterization, it should be understood that additional phases of the RI may be required to conclusively answer each of the seven questions that form the basis for the DQOs. The rightmost column in Table 4-1 (Plan for Obtaining Data) refers to specific types of sampling and analysis, which form the basis of the detailed sampling plan and quality assurance/quality control procedures presented in the FSP (Appendix A.1) and the QAPP (Appendix A.2), respectively. The DQO process is iterative and may be revisited as new information is developed during the RI.

4.2 Approach and Documents

Supporting documents included as part of this RIWP include the SAP (Appendix A), SOPs (Appendix B) IDW management plan (Appendix C), and the accident prevention plan (Appendix D).

4.2.1 Sampling and Analysis Plan

The SAP (Appendix A) covers the planned RI field program and includes the FSP (Appendix A.1) and the QAPP (Appendix A.2).

4.2.1.1 Field Sampling Plan

The FSP (Appendix A.1) supports field and laboratory activities specifically associated with Phase 1 of the RI. The FSP presents the rationale for sample locations, requested analyses for analytical testing, and documents sample handling and analysis procedures. Field methods discussed in the FSP include: monitoring well installation and sampling; aquifer testing on new and existing monitoring wells; geophysical, geotechnical, and groundwater flow logging; groundwater monitoring of new and existing monitoring wells; surface water sampling of Red Butte Creek and seeps and springs in the ESS area; and soil gas surveys in the vicinity of the VA Medical Center and the sewer line extending from the VA Medical Center to Sunnyside Avenue. SOPs for the methods of investigation are included in Appendix B.

4.2.1.2 Quality Assurance Project Plan

The QAPP (Appendix A.2) addresses the collection and evaluation of data for the RI and presents the quality assurance objectives, procedures for sample collection and sample custody, details on analytical methods, and data reduction, validation, reporting, and assessment procedures. The QAPP addresses all sampling proposed as part of Phase 1 of the RI, as well as other samples that may reasonably be expected to be collected during later phases of the RI.

4.2.2 Investigation Derived Waste Management Plan

The IDW management plan addresses the sampling, storage, and disposal of waste generated through field activities at the site. The IDW management plan is included as Appendix C.

4.2.3 Accident Prevention Plan

The accident prevention plan is included as Appendix D. The site safety and health plan (Appendix A of the accident prevention plan) documents the project organization, field tasks and hazard controls for field activities.

4.3 Groundwater Modeling

Data from the monitoring wells installed during Phase 1 of the RI work will be used to develop a future, comprehensive groundwater flow model (GFM) and an associated solute transport model (STM) during the RI. The development of the GFM/STM will be guided by a groundwater model QAPP. The objectives of the groundwater QAPP will include the following:

- Explain the associated scope and objectives of the models to project stakeholders
- Describe the anticipated modeling code and graphical user interface
- Define the GFM and STM construction methodology and calibration approach
- Summarize recommended uses of these numerical models to support the OU-2 RI

The draft groundwater model QAPP will be prepared as a primary document per the FFA, with input from the Groundwater Modeling Workgroup. The draft submittal to EPA and UDEQ is expected by the end of 2018 as depicted in the site management plan.

The GFM/STM will be predictive numerical groundwater models that will, in conjunction with other site data and professional judgment, help guide decisions that will move the site response action forward through the CERCLA process. The GFM will evaluate local groundwater use, mountain-front recharge, groundwater recharge from precipitation and applied water, and groundwater/surface water interaction to gain insight into the extent to which they affect the transport characteristics of the mobile-phase PCE plume. The GFM/STM will also include sufficient detail to gain important insights into the controlling subsurface parameters and processes that affect the transport characteristics of the mobile-phase PCE plume, such as major permeable zones and major fault influences on groundwater flow. The development and results of the GFM/STM will be summarized in a groundwater model report, separate from the RI report, with an expected submittal date in 2019. The groundwater model report will be a primary document per the FFA.

Table 4-1. Data Quality Objectives
Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Principal Study Questions	Information Inputs	Spatial Study Boundaries	Analytical Approach	Performance or Acceptance Criteria	Plan for Obtaining Data
Overall Problem Statement: PCE-contaminated groundwater is presumed present beneath VHA property and is present in areas hydraulically downgradient of VHA property. PCE-contaminated groundwater was also drawn toward SLC-18 when the well was in operation. People could be exposed to the PCE-contaminated groundwater through (1) existing or new water supply wells including SLC-18 if it is brought back online,[a] or (2) vapor intrusion and direct-contact pathways associated with shallow-groundwater and springs in the ESS area (currently being managed as part of AOU-1).[b] Additional data are needed to characterize the hydrogeology and nature and extent of PCE contamination, to assess potential transport and exposure pathways and risks, and to allow development and detailed analysis of remedial alternatives during the subsequent Feasibility Study.					
Question 1: What is the source(s) of PCE plume identified by the 1998 EPA monitoring wells? Is there still sufficient mass of PCE in the vadose zone to act as an ongoing source of PCE in groundwater?	Historical documents and aerial photography for potential source areas Soil gas, soil, and groundwater VOC data Soil and soil gas screening levels applicable to the migration-to-groundwater pathway. If more site-specific evaluation is needed, additional inputs could include: • Vadose zone lithological data • Vadose zone soil hydraulic properties data • Saturated zone hydraulic properties and groundwater flow data • Precipitation data	Vicinity of identified possible source areas including: • VHA Medical Center Building 7 and Sunnyside Sewer Line • Former Fort Douglas • Former Utah National Guard Vehicle Maintenance Facility • Former U.S. Forest Service Helicopter Pad	If soil gas data suggest the presence of PCE in vadose zone soil above soil gas screening levels, collect vadose zone soil samples. If vadose zone soil samples exceed migration-to-groundwater screening levels, evaluate whether more site-specific analysis, such as one-dimensional, numerical, unsaturated flow and transport modeling would support remedial decision making. If source area soil gas or soil data suggest that other pathways (soil direct exposure or vapor intrusion) could be significant, assess whether additional data are necessary to support human health risk assessment or remedial decision making.	Chemical analyses need to be sensitive enough for comparison to EPA soil screening levels for migration to groundwater for PCE and daughter products.	Identify potential source areas based on historic records, analytical data and aerial photos. Design source investigations to target potential source areas or areas where data are inadequate to define the nature and extent of contamination. Collect sufficient data to delineate the nature and extent of source; conduct a baseline risk assessment and develop and evaluate remedial alternatives. Methods may include: • Soil gas sampling • Soil sampling via GeoProbe • Groundwater sampling via HydroPunch or monitoring wells
Question 2: What is the lateral and vertical extent of the PCE plume identified by the 1998 EPA monitoring wells? How far downgradient does the PCE plume extend?	• Groundwater sampling results from existing and new wells • MCLs or applicable screening levels for defining the extent of contamination • Hydrogeological data including lithology, samples from unsaturated and saturated intervals, and water levels	Proposed OU-2 RI field investigation area	Based on Phase 1 groundwater monitoring results and professional judgment, consider additional groundwater sampling locations if the interpolated contours of groundwater PCE above MCLs shows data gaps and too much uncertainty.	Adequately spaced data (roughly 1,000 feet horizontally and 50 feet vertically) are required to delineate plume to MCLs. A network of monitoring wells is needed including: centerline wells to understand plume behavior along primary flow paths, perimeter wells to delineate and monitoring plume stability, and sentinel wells to monitor for future plume expansion both horizontally and vertically. The installation of additional wells will be phased depending on available funds. Chemical analyses need to be sensitive enough for comparison to MCLs or applicable screening levels (Table 5-3).	Develop sufficient monitoring network to delineate plume horizontally and vertically, and monitor plume behavior and stability. Methods will include: • Shallow and deep multi-level monitoring wells installed with sonic drilling methods • Groundwater sampling via low-flow sampling • Hydrogeological data including soil lithology, depths of saturated intervals, and water levels will also be collected
Question 3: Is the PCE and daughter products measured in the ESS related to the PCE contamination plume identified by the 1998 EPA monitoring wells?	• Groundwater sampling results from new wells upgradient of 1300 East • MCLs or applicable screening levels for defining the extent of contamination • Hydrogeological data including lithology, water levels, and sampling results	Area east of 1300 East, spanning from approximately Michigan Avenue to the south and 700 South to the north	Based on Phase 1 groundwater monitoring results, determine whether groundwater monitoring wells in this area contain PCE concentrations greater than the MCL or greater than the previously observed PCE concentrations in shallow groundwater west of 1300 East.	Adequately spaced data are required on the east side of 1300 East, perpendicular to the assumed direction of groundwater flow. The spacing should be generally proportional to the north-south extent of groundwater contamination west of 1300 East. Chemical analyses need to be sensitive enough for comparison to MCLs or applicable screening levels (Table 5-3).	Develop sufficient monitoring network across the north-south extent of the area upgradient of the known contamination on the west side of 1300 East. Methods will include: • Monitoring wells installed with sonic drilling methods • Groundwater sampling via low-flow sampling methods Collect hydrogeological data including soil lithology, depths of saturated intervals, and water levels

Table 4-1. Data Quality Objectives
Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Principal Study Questions	Information Inputs	Spatial Study Boundaries	Analytical Approach	Performance or Acceptance Criteria	Plan for Obtaining Data
Overall Problem Statement: PCE-contaminated groundwater is presumed present beneath VHA property and is present in areas hydraulically downgradient of VHA property. PCE-contaminated groundwater was also drawn toward SLC-18 when the well was in operation. People could be exposed to the PCE-contaminated groundwater through (1) existing or new water supply wells including SLC-18 if it is brought back online,[a] or (2) vapor intrusion and direct-contact pathways associated with shallow-groundwater and springs in the ESS area (currently being managed as part of AOU-1).[b] Additional data are needed to characterize the hydrogeology and nature and extent of PCE contamination, to assess potential transport and exposure pathways and risks, and to allow development and detailed analysis of remedial alternatives during the subsequent Feasibility Study.					
Question 4: What hydrogeological features control PCE fate and transport? If the PCE plume identified by the 1998 EPA monitoring wells extends to ESS (refer to Question 3), what factors control the plume in fault zone/hillside? Does the entire plume discharge to the hillside or does some component continue deeper to the west?	• Lithology and hydrostratigraphy data (grain size distribution, fraction organic carbon, extent and thickness of perching layers) • Structural geology (fault trace and orientation) • Interpretation of borehole geophysical data from new monitoring wells • Water levels and horizontal and vertical hydraulic gradients • Recharge and pumping history • Aquifer test results and estimated hydrogeological properties including transmissivity, hydraulic conductivity, storativity, vertical and horizontal hydraulic gradients • Geochemistry data including major ion chemistry and stable isotopes • Previous groundwater modeling and new Phase 1 modeling	Proposed OU-2 RI field investigation area	Integrate information inputs into a sitewide CSM. If professional judgment shows too much uncertainty in specific locations or regarding specific factors, additional data collection will be considered.	Hydrogeological data collection and groundwater modeling conducted under the supervision of a qualified Utah Professional Geologist will be acceptable.	• Collect lithology and hydrostratigraphy data from new monitoring wells and assimilate information from existing wells • Aggregate pumping history information from major Salt Lake City and University of Utah production wells • Obtain available water level data from wells with pressure transducers. • Collect water level data from new and existing wells • Perform aquifer tests on selected wells to characterize hydraulic connectivity in area impacted by the PCE plume • Collect VOC, major ion, and stable isotope data from selected wells and surface water
Question 5: What is the nature of the hydraulic connection between the PCE plume and production wells (SLC-18, University of Utah wells, and Mount Olivet well)?	• Groundwater sampling results from existing and new wells • Lithology and hydrostratigraphy data (grain size distribution, fraction organic carbon, and extent and thickness of perching layers) • Structural geology (fault trace and orientation) • Interpretation of borehole geophysical data from new monitoring wells • Water levels and horizontal and vertical hydraulic gradients • Recharge and pumping history • Aquifer test results and estimated hydrogeological properties including transmissivity, hydraulic conductivity, storativity, and vertical and horizontal hydraulic gradients • Previous groundwater modeling and new Phase 1 modeling	Area between plume and production wells	If professional judgment shows gaps in understanding the connection between the plume and production wells, additional data collection will be considered. Upon development of the new groundwater flow model, calibrated to aquifer property data, evaluate whether operation of nearby production wells at rates consistent with historical operations could reasonably influence groundwater flow conditions at the site.	See Performance or Acceptance Criteria for Questions #2, #3, and #4.	See Plan for Obtaining Data for Questions #2, #3, and #4. In addition, pump testing using new monitoring wells may provide more information regarding the zone of influence of SLC-18.

Table 4-1. Data Quality Objectives
Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Principal Study Questions	Information Inputs	Spatial Study Boundaries	Analytical Approach	Performance or Acceptance Criteria	Plan for Obtaining Data
Overall Problem Statement: PCE-contaminated groundwater is presumed present beneath VHA property and is present in areas hydraulically downgradient of VHA property. PCE-contaminated groundwater was also drawn toward SLC-18 when the well was in operation. People could be exposed to the PCE-contaminated groundwater through (1) existing or new water supply wells including SLC-18 if it is brought back online,[a] or (2) vapor intrusion and direct-contact pathways associated with shallow-groundwater and springs in the ESS area (currently being managed as part of AOU-1).[b] Additional data are needed to characterize the hydrogeology and nature and extent of PCE contamination, to assess potential transport and exposure pathways and risks, and to allow development and detailed analysis of remedial alternatives during the subsequent Feasibility Study.					
Question 6: Besides vapor intrusion in AOU-1, drinking water wells, or potential source-area soil and soil gas, are there other potential human or ecological exposure pathways?	Water sampling results from selected areas of Red Butte Creek	Red Butte Creek sampling locations, in the area where surface water has previously shown to be impacted by PCE, springs are present, and where Red Butte Creek is accessible at ground surface	Evaluate the overall site CSM to assess whether surface water exposure pathways could exist, and, if so, consider additional surface water data collection.	Chemical analyses need to be sensitive enough to determine whether surface water in Red Butte Creek has been impacted by the PCE identified by the EPA monitoring wells. For these purposes, chemical analyses need to be sensitive enough for comparison to MCLs or applicable screening levels (Table 5-3).	Collect sufficient data to support human-health risk assessment related to OU-2 surface water. Methods could include: • Collection of surface water samples in Red Butte Creek
Question 7: Collect data to support possible remedial technologies, including MNA, hydraulic containment, and bioremediation. Determine which natural attenuation processes are operating, and estimate the rate of degradation of PCE and daughter products formed.	• See Information Inputs for source area(s) and nature and extent of contamination in Questions #1, #2, and #3 • See Information Inputs for geotechnical and hydrogeological data in Questions #2, #3, and #4 • PCE daughter product concentrations and concentration time-series • Reduction/oxidation geochemical data • Data supporting evaluation of natural attenuation • Biological data supporting the assessment of reductive dechlorination • Data supporting evaluation of potential remedial technologies	Entire project area	Evaluate data to assess potential remedial technologies, including the occurrence of natural attenuation processes and estimated degradation rates.	See Performance or Acceptance Criteria for Questions #1 through #5. In addition, a wide variety of definitive quantitative data and qualitative data are required to build lines of evidence for natural attenuation, as required by EPA MNA guidance.	Collect data regarding source area(s) and nature and extent of contamination, as summarized in Questions #1, #2, and #3 Collect geotechnical and geophysical data, as summarized in Questions #4 and #5 Collect data supporting evaluation of biological and abiotic attenuation processes. Methods may include: • PCE daughter product concentrations • Dissolved oxygen measurements • Oxidation-reduction potential measurements • Sulfate/sulfide, ferrous iron, concentrations of dissolved gases • Compound specific isotope analyses • Magnetic susceptibility tests

[a] The currently available information supports the conclusion that exposures to PCE-contaminated groundwater through the use of water-supply wells is controlled by Salt Lake City temporarily removing SLC-18 from service.
[b] Investigations, removal actions, and remedies associated with shallow groundwater within AOU-1 are being addressed separately under the FFA and will be incorporated by reference into OU-2 CERCLA documents.

Notes:
MNA = monitored natural attenuation
VOC = volatile organic compound

Remedial Investigation Tasks

This section discusses tasks and fieldwork included in Phase 1 of the RI, and further detailed in the FSP (Appendix A.1) and SOPs (Appendix B). The section also lists and provides limited details about investigative tools and sampling methods that may be used in subsequent phases of the RI (toolbox for future phases), with additional details presented in the SOPs (Appendix B). This section also discusses data reduction, tabulation, evaluation, and reporting.

As described in Section 1, the RI will be implemented in multiple phases. Each earlier phase will inform work to be undertaken in a subsequent phase. Information gathered in the implementation of tasks within this RIWP could require a modification of subsequent tasks, including additional field work or other supporting field work. VA will propose modifications per FFA Section 10.10 *Subsequent Modification of Final Document*.

Changes to the RIWP that do not change a remedial action objective or DQO and are necessitated by the condition or opportunities encountered in the field will be addressed per the site management plan Section 6.1 *Minor Field Modifications*. As an example, changes to proposed well locations or planned tasks may be required based on information gathered from previously installed work or tasks. These changes to the RIWP will be accomplished by following either of the two processes identified above, depending on the scope of the modification.

Sections 5.1 and 5.2 describe the implementation strategy, tools, and methods for Phase 1. Investigation strategies, tools and methods that may be implemented during subsequent phases of the RI (Phase 2) are described in Section 5.3.

5.1 Phase 1 Strategic Approach

The proposed well locations and features referenced in descriptions of the Phase 1 investigation are shown on Figure 5-1. A diagram depicting Phase 1 work flow is presented on Figure 5-2. The purpose of providing the work flow diagram is to demonstrate how initial data collected during Phase 1 will begin to address DQOs and guide additional investigation. For example, soil gas data around VHA Building 7 and the sewer line will guide potential collection of soil samples. The work flow diagram also summarizes the proposed investigation work during Phase 1 and Phase 2.

5.1.1 Mobilization

The RI activities will begin with a site visit by the project manager, field team leader, and VHA and USACE team members to observe site conditions, select the final locations for monitoring well installation, and develop a plan for setup of field facilities. Regulatory participation will be solicited per the requirements of the FFA.

Mobilization activities include the following:

1. Determine the technical specifications for necessary field support equipment and services
2. Identify suppliers, obtain competitive bids, and provide technical support for the procurement process
3. Coordinate with suppliers to deliver and set up field facilities and services
4. Identify, assemble, load, transport, unload, and arrange the equipment at the site for each identified field events

The field facilities and services listed below will be provided for the duration of field activities, including mobilization and demobilization time:

- Required facilities (for example, office trailer, portable toilets, wireless internet service, rental container box for storage, and rental IDW frac tanks)
- Sampling and monitoring equipment and supplies

Prior to direct-push sampling or monitoring well installation, underground utility locations will be determined for all proposed well installation locations. Boring locations will be marked and cleared by Utah Blue Stakes and a private utility locater. VA Medical Center requires the location of any boring on VA Medical Center property (soil gas or monitoring well installation) to first be cleared for utilities by physically locating all utilities in the proposed area of disturbance by potholing to locate the utility. Potholing typically requires advancing a small diameter excavation to a depth below the utility in question, using high pressure water or air with the soil/water being removed with a hydrovac. Other methods of locating the utilities such as hand augering may be used in areas where potholing is problematic or may affect the sample results. The specifics of utility location will be presented to VHA campus engineering, and approved, before the work. The approved procedure will then be submitted to EPA and UDEQ before the start of the activity to determine if an adjustment to the RIWP is warranted.

The VHA will obtain access permits to private or government property as needed to complete the planned field activities. CH2M will secure right-of-way access for monitoring well installation on Salt Lake City streets and will obtain any required permits for field work. The proposed monitoring well locations may be adjusted on the basis of access permissions, utilities, and field conditions.

5.1.2 Building 7 and Sanitary Sewer Line

Soil gas surveys will be conducted using a direct-push drilling rig at three locations: outside VA Medical Center Building 7, along the sewer line from Building 7 to Sunnyside Avenue, and along a short portion of Foothill Drive in front of the VA Medical Center (Figure 5-3). The purpose of the soil gas surveys is to facilitate addressing DQO 1, identify potential sources of the PCE plume in EPA wells.

The goal of this survey is to assess whether adsorbed or free-phase volatile organic compounds (VOCs) are present in unsaturated soil at concentrations that may result in groundwater VOC concentrations above MCLs or applicable screening levels. A soil gas survey, as opposed to direct measurement of VOCs in soil, offers the following advantages:

- Discrete soil samples measure VOC concentrations in a small aliquot and VOC concentrations are heterogeneous over small vertical and horizontal distances. Soil gas samples integrate VOC concentrations over a much larger volume of soil than discrete soil samples. Thus, a smaller number of soil gas samples may be needed than if soil samples were collected without prior knowledge of the distribution of VOCs.
- Soil gas samples are more amenable to field analysis than soil samples because they do not require extraction before analysis. Field analysis offers the advantage of real-time decision making regarding sample locations and depths.
- Soil samples cannot be readily collected from directly under the sanitary sewer pipeline or buildings because of difficulties in drilling under the pipe or inside buildings. The soil gas survey can be safely performed adjacent to the sewer pipeline or buildings.

The soil gas sampling depth is anticipated to be at a depth equivalent to or below the sewer line; however, the depth of the sewer line is not completely understood. The depth of manholes for the sanitary sewer line within the soil gas survey area will be gauged before work; soil gas samples will be collected below that depth. Soil gas sampling depth is not expected to exceed 15 feet bgs. The soil gas survey around Building 7 and the sewer line will provide data regarding a potential PCE source on VHA property. The previous 2007 soil gas activities in the area of Building 7 and the sewer line only collected samples at a maximum of 1 foot deep (IHI Environmental, 2007) and was not adequate to assess potential source areas. The soil gas samples on the north side of the VHA property are intended to investigate an isolated area where a single soil gas sample in 2012 detected a trace amount of PCE in soil gas (URS Operating Services, 2012).

5.1.3 1400 East Transect

The purpose of the 1400 East transect is to better define the relationship between PCE measured in the EPA monitoring wells (for example, EPA-MW-01S/D) and PCE measured in the ESS area. These wells will facilitate addressing DQOs 2 and 3 (Table 4-1). A series of four shallow monitoring wells (MW-18, -19, -21, and -22), one monitoring well cluster with shallower and deeper intervals (MW-20S/D), and one deep monitoring well (MW-08), will be installed along 1400 East (Figure 5-1), roughly perpendicular to the approximate groundwater flow path from the VHA Medical Center toward the ESS area. With the exception of MW-20D and MW-08, the depth of these monitoring wells will target first water, anticipated to be within 100 feet bgs. Since contaminated groundwater in the ESS area is extremely shallow (from ground surface to about 30 feet bgs), the first water bearing zone beneath the 1400 East transect should correlate with shallow groundwater in the ESS area. In addition, geochemical groundwater data (cation-anion ratios, stable oxygen, and hydrogen isotope data) from the 1400 East transect will be compared to groundwater data collected from the newly installed monitoring wells within AOU-1 (EA, 2017b). The comparison of geochemical data will help determine if the wells within the 1400 East Transect are sampling the same water-bearing zone as the contaminated shallow groundwater within AOU-1. Additional information about the 1400 East transect monitoring wells is provided in Table 5-1 and Section 5.2.2.

The monitoring wells within the 1400 East Transect will be installed upgradient of AOU-1. The maximum detected concentration of PCE and TCE in shallow groundwater within AOU-1 were 46 µg/L and 6.5 µg/L, respectively (EA, 2017b). The maximum detected concentration of PCE and TCE in surface water within AOU-1 were 74 µg/L and 2.3 µg/L, respectively (EA, 2017c). This hotspot of PCE/TCE contamination is located along 900 South, between 1100 East and 1300 East. Results of the 1400 East Transect will highlight the connection between EPA 1998 monitoring wells and the PCE/TCE contamination previously identified within AOU-1.

5.1.4 Guardsman Way Transect

The purpose of the deep monitoring wells comprising the Guardsman Way transect is to refine the lateral and vertical extent of the groundwater PCE plume currently defined by the EPA 1998 monitoring wells and facilitate addressing DQOs 2, 4, 5, and 7 (Table 4-1). To complete the Guardsman Way transect, which incorporates monitoring wells EPA-MW-04 and EPA-MW-02, four additional deep monitoring wells (MW-03R, MW-09, MW-10, and MW-11) will be installed at the site (Figure 5-1). Additional information about the Guardsman Way transect wells is provided in Table 5-1 and Section 5.2.2.

5.1.5 Mount Olivet Monitoring Well (MW-07)

The Mount Olivet monitoring well (MW-07) will be installed close to the location of the Mount Olivet irrigation well, which is near the southeastern corner of the cemetery. The Mount Olivet monitoring well is expected be installed just south of the cemetery boundary. The Mount Olivet monitoring well is also a deep monitoring well, serving to address the same DQOs as the Guardsman Way transect monitoring wells. Since the Mount Olivet irrigation well is screened across multiple water-bearing zones, it is difficult to know which water-bearing zones are responsible for previously identified PCE contamination. As such, the Mount Olivet replacement monitoring well aims to better delineate the depth of groundwater contamination that is contributing to the contamination in the Mount Olivet irrigation well, as well as provide insight about the hydraulic connection between the Mount Olivet irrigation well and the PCE plume. Additional information about the Mount Olivet monitoring well is provided in Table 5-1 and Section 5.2.2.

5.1.6 East Side Springs Area Well Pairs

Phase 1 includes installation of six shallow monitoring well pairs (MW-12S/D, MW-13S/D, MW-14S/D, and MW-15S/D, MW-16S/D, and MW-17S/D) in the ESS area (Figure 5-1). The purpose of paired monitoring wells in the ESS area is to refine the lateral and vertical extent of PCE in groundwater and facilitate addressing DQOs 2, 3, 4, 6, and 7 (Table 4-1). Additional information about the ESS area well pairs is provided in Table 5-1 and Section 5.2.2.

5.2 Phase 1 Tools and Methods

The following subsections describe investigation tools and methods to be used to implement the Phase 1 of the investigation.

5.2.1 Soil Gas Survey for Building 7 and Sanitary Sewer Line

Two types of soil gas samples will be collected during investigation of Building 7 and the sanitary sewer line:

- Samples will be collected in Tedlar bags using a lung-box. These samples will be collected for field analysis.
- Samples will be collected for laboratory analysis (EPA Method TO-15 full scan) in individually-certified clean, 1-liter SUMMA canisters.

Tedlar bag samples will be analyzed in the field for PCE, TCE, and cis-1,2-dichloroethene (DCE) using a portable gas chromatography/mass spectrometer (Inficon HAPSITE [HAPSITE]). Before HAPSITE analysis, each Tedlar bag sample will be screened with a calibrated portable photoionization detector to assess whether sample dilution is necessary to make certain measured VOC concentrations are within the HAPSITE calibration range. This will result in an accurate VOC measurement (rather than an estimated VOC measurement) that can be calculated using the known dilution factor.

The soil gas sample locations shown on Figure 5-3 are the initial planned locations. The real-time HAPSITE data for PCE, TCE, and cis-1,2-DCE will be compared to the threshold levels listed in Table 5-2 to assess if additional locations should be investigated. Additional samples may be collected between the initial sample locations, which are placed at approximately 30-foot centers, to infill in areas of elevated concentrations along the pipeline. In addition, samples may be collected by stepping out from the pipe to assess the lateral extent of the contamination in a direction perpendicular to the pipeline alignment. These additional samples could potentially be collected along the path of any subsurface piping that crosses below the sanitary sewer line, based on soil gas data from the initial sample locations in that area.

Description of the soil gas sampling approach, frequency, and methods are provided in Section 3.5 of the FSP (Appendix A.1). Additional details describing installing, testing, and collecting samples from soil gas probes are provided in Appendix B (SOP B.14).

The regional screening levels (RSLs) for soil based on the migration-to-groundwater pathway are the starting point for calculating the soil gas screening levels. Based on the assumption that VOCs adsorbed to soil will be in equilibrium with VOCs in soil gas, the soil gas concentration corresponding to the soil RSL can be calculated. The equilibrium partitioning calculations are based on methods included in the EPA Soil Screening Guidance (1997a) and described specifically in the Arizona Department of Environmental Quality Soil Vapor Sampling Guidance (2011):

$$SGSL_{pgw} = \frac{RSL_{pgw}\, \rho_b \cdot 1000}{[K_{oc} f_{oc} \rho_b / H_o + \theta_w / H_o + (\theta_t - \theta_w)]}$$

where:

$SGSL_{pgw}$ = Concentration in soil vapor (micrograms per cubic meter)
RSL_{pgw} = Total concentration in soil (micrograms per kilogram)
f_{oc} = Mass fraction of natural soil organic carbon content (g-organic carbon/g-soil)
K_{oc} = Soil organic carbon-water partitioning coefficient (milliliters per gram)
ρ_b = Dry Bulk Density (kilograms per liter)
H_o = Henry's Law Constant (dimensionless)
θ_t = Total soil porosity (volume of voids/volume total)
θ_w = Volumetric Water Content (volume of water/volume of soil)

Table 5-2 summarizes the inputs and results for the calculations for the three compounds that will be analyzed by the HAPSITE (PCE, TCE, and cis-1,2-DCE). The assumptions in Table 5-2 are the same as the default values applied by EPA in calculating the RSLs for soil. Although the samples sent for offsite analysis by EPA Method TO-15 will be analyzed for the full suite of TO-15 compounds, screening levels are provided in Table 5-2 for only the three compounds analyzed by the HAPSITE. This is because decisions regarding the need to step out from the initial sampling locations or infill between sampling locations will be made in the field using the HAPSITE data.

The soil screening levels for the migration-to-groundwater pathway (RSL_{pgw}) are based on conservative, default, simplifying assumptions. Thus, when a soil-gas VOC concentration exceeds a soil-gas screening level ($SGSL_{pgw}$) derived from the soil RSL_{pgw}, it does not necessarily mean that a significant vadose zone VOC source is present. Rather, this condition suggests that further investigation may be necessary.

In addition to the migration-to-groundwater screening levels, soil gas VOC results will also be compared to vapor-intrusion screening levels, specifically the EPA vapor intrusion screening levels (VISLs) for soil gas ($VISL_{sg}$) (EPA, 2017a). EPA derives the VISLs by applying a conservative, default soil-gas-to-indoor-air attenuation factor to the indoor-air regional screening levels (RSL_{ia}). The soil gas VISLs summarized in Table 5-2 include values based on both commercial/industrial and residential exposure assumptions. Land use within the soil gas survey area consists of commercial, light-industrial, and other institutional uses on the VA Medical Center property and intermittent, recreational uses in Sunnyside Park. The commercial/industrial $VISL_{sg}$ values are appropriate for evaluating current exposures in these areas. Residential values were included in case the need arises to assess hypothetical future exposure risks and to provide a lower-limit value for assessing analytical method sensitivity. A soil gas VOC concentration above a $VISL_{sg}$ does not necessarily mean that vapor intrusion is occurring and significant, rather that further investigation may be necessary.

5.2.1.1 Soil Sampling Associated with Soil Gas Survey

As indicated on Figure 5-2, soil sampling related to soil gas will be performed during Phase 1 if a soil gas concentration at a given location exceeds 10 times the residential soil gas screening level (that is, the EPA residential $VISL_{sg}$) provided in Table 5-2 or from obvious areas of data anomalies. A concentration of 10 times the screening levels is within the CERCLA risk range of 1.0×10^{-6} to 1.0×10^{-4} for residential use. The depth and location of the soil sample correlative to an exceeding soil gas measurement will be determined in the field after review of the data and consultation between the field team leader and project manager. It is expected that the correlative soil sample will be collected at or below the depth of the soil gas measurement. Soil samples for VOC analysis will be collected using EnCore disposable samplers via direct-push technology methods as described in SOP B.14 (Appendix B).

Soil samples will be compared to migration-to-groundwater RSLs (RSL_{pgw}). The RSLs tabulated in the EPA tables will be adjusted using a default dilution-attenuation factor of 20, which is consistent with EPA guidance (EPA, 2017b) (Table 5-3). These screening levels are conservative benchmarks for assessing the possibility that remaining vadose zone contamination could still sustain a groundwater contaminant plume at concentrations above applicable MCLs or screening levels.

5.2.2 Monitoring Well Logistics

The following subsections describe proposed monitoring well locations, and various drilling, well installation, well development, and groundwater sampling methods.

5.2.2.1 Monitoring Well Locations

Table 5-1 summarizes the well location and well placement rationale, as presented on Figure 5-1.

Table 5-1. Rationale for Phase 1 Monitoring Well Locations
Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Label	Proposed Location	Rationale
Phase 1 Deep Monitoring Wells		
MW-03R	West Boundary of VHA Property, Adjacent to Valdez Drive	Replace monitoring well EPA-MW-03. EPA-MW-03 was abandoned/destroyed during construction of the ice arena at the Salt Lake City Sports Complex. Part of the Guardsman Way transect.
MW-07	Near southeast corner of Mount Olivet Cemetery	Provide additional monitoring in the vicinity of Mount Olivet Cemetery irrigation well, as the Mount Olivet well is screened in multiple locations and limited access is provided to this well.
MW-08	Near southwest corner of Mount Olivet Cemetery	Investigate groundwater system across the eastern spur of the East Branch of the Wasatch Fault. With MW-07, examine groundwater flow across fault. Delineate PCE plume in uncharacterized area. Northern-most monitoring point of the 1400 East transect.
MW-09	Southeast (upgradient) of SLC-18	Investigate groundwater flow direction between SLC-18 and VHA property. Part of the Guardsman Way transect.
MW-10	Near Sunnyside Avenue, south of EPA-MW-04	Define the EPA wells plume boundaries. Southernmost monitoring point of the Guardsman Way transect.
MW-11	University of Utah property	Define the EPA wells plume boundaries. Northernmost monitoring point of the Guardsman Way transect. Location based on discussions and access with the University.

Table 5-1. Rationale for Phase 1 Monitoring Well Locations
Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Label	Proposed Location	Rationale
Phase 1 Shallow Monitoring Wells		
MW-12S/D[a]	South of 800 South, along 1000 East	Refine the lateral and vertical extent of the groundwater PCE within the ESS area; form southwest-trending transects across the fault and along the shallow groundwater horizontal hydraulic gradient.
MW-13S/D[a]	North of 900 South at the southwest corner of East High School	
MW-14S/D[a]	South of 900 South at the cul-de-sac located on Alpine Place	
MW-15S/D[a]	Intersection of Belmont Avenue and McClelland Street	
MW-16S/D[a]	Corner of 800 South and Elizabeth Street	
MW-17S/D[a]	West of 1300 East at the bend of Gilmer Drive	
MW-18	A transect running parallel to 1400 East, crossing Sunnyside Avenue near the center of the transect	Form a north-south transect along 1400 East to investigate shallow groundwater and the relationship between PCE at the ESS area and the EPA 1998 monitoring wells.
MW-19		
MW-20S/D[a]		
MW-21		
MW-22		

[a] Shallow monitoring wells labeled S/D are clustered 2-inch wells drilled approximately 6 to 10 feet apart.

5.2.2.2 Drilling

Rotosonic drilling technology will be used for borehole drilling and monitoring well installation. This method allows advancement to the depths required for investigation along with providing continuous core, which enables accurate visual logging of geologic units and contacts, and generates less waste and noise than other drilling methods. As drilling progresses, the field geologist will document and log recovered core using the field forms included in Appendix A of the FSP (Appendix A.1), following the methods outlined in SOP B.4 (Appendix B) and detailed in Section 5.1.1 of the FSP (Appendix A.1). Soil sampling for geotechnical analysis will follow the guidance described in SOP B.4 (Appendix B). The field geologist will hold a baccalaureate degree in geosciences from an accredited university and have a minimum of 5 years of experience in logging subsurface conditions. The work will be supervised by Mr. Gary Colgan, the senior technical consultant, who is a hydrogeologist with more than 30 years of experience.

Monitoring wells that are considered shallow will be installed to total depths of approximately 120 feet bgs using a track-mounted remote-controlled Rotosonic drill rig (mini-Sonic). The borehole diameter for the shallow monitoring wells will range between 6 and 8 inches in diameter. Monitoring wells that are considered deep will be installed to total depths of approximately 500 feet bgs using a tractor-trailer-mounted Rotosonic drill rig. The borehole diameter for the deep monitoring wells will range between 8 and 12 inches in diameter. The shallow wells will be along 1400 East and in the ESS area, where depth to groundwater can vary from ground surface to perhaps as deep as 100 feet bgs. In the area of the deep wells within the Guardsman Way monitoring well transect, depth to water ranges up to approximately 175 feet bgs. The depth to water across the study area and the range of potential depths for well screens are illustrated on Figure 2-3. At many locations, wells are proposed to be screened in multiple intervals to provide additional data for vertical delineation of the plume, and to better characterize the complex hydrogeology at the site.

Push-Ahead Groundwater Sampling

During deep monitoring well drilling, groundwater samples will be collected using the push-ahead sampling method outlined in SOP B.4 (Appendix B). This data will provide a preliminary vertical-delineation of the lithological profile, help evaluate the total depth of PCE contamination, and assist in determining where to screen the monitoring well. The sample interval and frequency for push-ahead groundwater sampling is described in Section 5.1.6 of the FSP (Appendix A.1).

No soil samples from the Phase 1 well borings will be analyzed for VOCs or other contaminants. The wells are located outside of known source areas. Soil samples will be collected from the Phase 1 well borings for geotechnical analysis, as described in Section 5.2.3.1.

5.2.2.3 Monitoring Well Installation

Monitoring well installation and construction will proceed after the successful drilling of each borehole; the final well design will be determined in the field after consultation among the field team leader, senior technical consultant, and the project manager. Well screen intervals will target single hydrostratigraphic units (that is, the screened intervals will not cross multiple water-bearing zones). Screened intervals will be targeted on a well-by-well basis, considering the following factors:

- Lithology from boring logs
- Identification of hydrostratigraphic units
- Depth to groundwater
- Natural gamma logging (for deep monitoring wells)
- Screening-level PCE, TCE, and cis-1,2-DCE data collected from push-ahead groundwater sampling for deep monitoring wells (Section 5.2.2.2), with the goal of collecting one or two groundwater samples containing PCE concentrations less than 5 µg/L before terminating drilling
- Monitoring well location and purpose (for example, if the monitoring well intended to be centerline well to understand plume behavior along primary flow paths, a perimeter well to delineate plume and monitor plume stability, or a well for hydraulic testing to support the CSM and modeling)

It should be noted that a single borehole location, depending on chosen well design, cannot necessarily serve all potential purposes (for example, both chemical monitoring at three or more intervals and hydraulic testing). Additional details regarding these parameters are provided in the FSP (Appendix A.1).

The shallow wells are to be constructed inside the drill casing with 2-inch-diameter Schedule 40 polyvinyl chloride (PVC) casing and screen. The screen intervals are anticipated to be approximately 10 feet in length. Details of screen size and type of filter pack will be finalized upon observation of the geology, but is anticipated to consist of 0.010 slot or 0.020 slot Schedule 40 PVC screen surrounding by a filter pack of either #20/40 or #10/20 mesh silica sand. The filter pack will extend from approximately 1 foot below to 2 feet above the screened interval. Above the filter pack, 3/8-inch bentonite chips will be used to seal and backfill the remaining borehole. The bentonite chips shall extend to approximately 3.5 feet bgs. The 2-inch-diameter wells will be completed as flush-mount completions. The shallow wells will be installed as clustered pairs, with each well in an adjacent borehole. The deeper hole will be drilled first to identify the target zones to screen as the deep and shallow wells.

For the deep monitoring wells, one of the following four deep well types are anticipated to be constructed inside the drill casing:

- Multiple 7/8-inch-diameter in-line Zone Isolation Sampling Technology (ZIST)-type wells; screen intervals 2 to 5 feet in length

- Two nested 2-inch-diameter wells with 0.020-slot Schedule 80 PVC; screen intervals 10 to 20 feet in length
- Single 5-inch-diameter wells with 0.040-slot Schedule 80 PVC screens; screen intervals 10 to 20 feet in length
- One 7/8-inch-diameter in-line ZIST type well (2 to 5 feet in length) and one single 5-inch diameter well with a 0.040-slot Schedule 80 PVC screen (5 to 20 feet in length)

The type of well construction will be determined using data from the boring log, natural gamma logging (at pre-designated monitoring locations), VOC data from the push-ahead sampling, and other factors described in Section 5.1.7 of the FSP (Appendix A.1). The well, filter pack, and seal materials for the different well designs vary; Section 5.1.7 in the FSP (Appendix A.1) provides additional information. Well installation and completion methods are outlined in SOP B.4 (Appendix B), and well construction details will be recorded in the field form included in Appendix A of the FSP (Appendix A.1).

5.2.2.4 Monitoring Well Development

Development of each monitoring well will be completed between 48 hours and 7 days after well construction is completed. The goal of monitoring well development is to draw fine-grain particles out of the filter pack material to establish good connectivity between the formation and the well. During monitoring well development, a minimum of either five borehole volumes of water, plus the volume of potable water added during well construction, or two times the volume of potable water added during well construction, whichever is greater, will be removed. Monitoring well development methods are outlined in SOP B.4 (Appendix B). Groundwater quality parameters (such as specific conductivity, temperature, turbidity, and pH) will be monitored for stabilization as described further in Appendixes A and B.

5.2.3 Geotechnical, Geophysical, and Groundwater Flow Logging

5.2.3.1 Geotechnical Testing

Soil samples will be collected in several Rotosonic boring locations for geotechnical analysis. The geotechnical analyses include the following:

- Fraction of Organic Carbon (ASTM D2974)
- Laboratory mineralogical analysis (magnetic susceptibility)
- Laboratory physical properties:
  - Sieve (ASTM D6913)
  - Dry bulk density (ASTM D2937)
  - Hydrometer (ASTM D422a)
  - Unified Soil Classification System soil classification/Atterberg limits/gradation (ASTM D2487/ASTM D4318/ASTM D1140)
  - Vertical permeability (ASTM D2434)
  - Moisture content (ASTM D2216)

The fraction of organic carbon is a key parameter that will help account for the effect of adsorption which affects the rate of contaminant migration for contaminants like PCE that adsorb to organic matter in soil. The magnetic susceptibility analysis will provide data essential to evaluating the potential for the abiotic chemical degradation of chlorinated solvents. The Atterberg Limit, vertical permeability, dry bulk soil density, sieve analysis, and hydrometer tests will provide basic lithologic/geotechnical property data to help identify and characterize hydrostratigraphic units. For sample intervals where permeability testing is necessary, a Shelby tube will be used to collect the geotechnical sample, as described in

Section 3.3.2 of SOP B.4 (Appendix B). Additional details about geotechnical testing methods are provided in Section 5.1.4 of the FSP (Appendix A.1).

5.2.3.2 Geophysical Logging

To assist with monitoring well design, natural gamma logging will be performed before well construction activities begin, while drill casing is in the borehole at selected locations. Other geophysical logging tools (for example, nuclear magnetic resonance) will not work while steel casing is in place, and may be used following PVC well construction, if well design permits. Geophysical logging may not be performed at every monitoring well location; the decision to perform geophysical logging will be made in the field following borehole lithology review and consultation among the field team leader, senior technical consultant, VA, USACE and project manager.

Geophysical logging will be performed with two runs of the instrument (from the top of the borehole to the bottom of the borehole, and then back to the top). The geophysical logging tools may include the following parameters:

- Natural Gamma (pre-well construction)
- Nuclear magnetic resonance (post-well construction)

The geophysical logging will be used to complement borehole lithology descriptions and further characterize hydrostratigraphic units. In Phase 2, additional geophysical logging tools may be used, as described in Section 5.3.3. Additional details about geophysical methods are provided in Section 5.1.5 of the FSP (Appendix A.1) and SOP B.5 (Appendix B).

5.2.3.3 Groundwater Flow Logging

Groundwater flow logging will be considered during Phase 2, but is referenced here for completeness. The proposed well screen intervals do not exceed 20 feet in length, thus groundwater flow logging may not provide information capable of further delineating water-bearing zone. Section 5.3.3 and SOP B.5 (Appendix B) contain more information.

5.2.4 Aquifer Testing

Aquifer testing will be performed to accomplish the following objectives:

- To quantify the hydraulic properties governing groundwater flow
- To characterize whether water-bearing zones of interest approximate unconfined, confined, or leaky confined aquifer behavior
- To characterize hydraulic connectivity between water bearing zones
- To examine the subsurface for recharge or no-flow boundaries

Accomplishing these objectives will refine understanding of the conceptual site model, and will support numerical groundwater flow and solute transport modeling.

This testing will consist of two types of testing methods: slug and aquifer pumping tests. The following subsections describe the locations and rationale for the planned testing. Section 5.4 of the FSP (Appendix A.1) and SOPs B.6 and B.7 (Appendix B) provide specific details about the aquifer testing methods.

5.2.4.1 Slug Testing

Slug testing will be performed on shallow, narrow-diameter (2-inch diameter or less) monitoring wells. The monitoring wells to be tested during Phase 1 will be determined following installation of the monitoring well network, so as to best characterize aquifer properties along the currently understood hydraulic gradient and across the Wasatch Fault. The determination of which wells to test will be made in consultation among VHA, USACE, EPA, and UDEQ after all monitoring wells have been installed. Additional slug testing may be performed in subsequent phases of investigation, if needed.

5.2.4.2 Aquifer Tests

Aquifer tests are planned for new deep monitoring well locations constructed with 5-inch diameter screen and casing that will allow for passage of an electric submersible pump at least 3 to 4 inches in diameter (that is, to allow for pumping at sufficient rates to produce drawdown that may propagate to observation wells).

The aquifer test monitoring wells, associated observation monitoring wells, and potential concurrent groundwater sampling, will be determined upon consultation among VHA, USACE, EPA, and UDEQ following installation of the monitoring well network. The monitoring wells will be tested after well development according to the methods described in Section 5.4 of the FSP (Appendix A.1), and SOP B.7 (Appendix B). Additional testing may occur upon future phases of well installation, if needed.

5.2.5 Groundwater Monitoring

Groundwater monitoring will include collecting groundwater samples and water level measurements for new and existing monitoring wells in the site.

5.2.5.1 Groundwater Sampling

Low-flow sampling, outlined in SOP B.9 (Appendix B), will be used to purge and sample wells instrumented with bladder pumps, unless well conditions require low-yield well sampling methods (for example, standard purge or purge/sample on recovery), as outlined in SOP B.10 (Appendix B). Wells instrumented with ZIST pumps will be sampled using the methods outlined in SOP B.11 (Appendix B).

Groundwater sampling methods are described further in Section 5.2 of the FSP (Appendix A.1). Phase 1 groundwater sampling frequency and analytical parameters are described in the FSP (Appendix A.1). The analytical parameters will be refined with regulatory input after the first four rounds of sampling are complete.

5.2.5.2 Water Level Measurements

Water level measurements will be recorded from new and existing monitoring wells in the site. An electric water level meter will be used to record water level measurements during each groundwater sampling event. The method for collecting groundwater elevation measurements during sampling is outlined in SOP B.8 (Appendix B). Pressure transducers will be emplaced to provide for continuous, long-term water level data in both shallow and deep wells. Wells that transducers will be installed in will be selected following complete installation of the monitoring well network and in consultation among VHA/USACE, EPA, and UDEQ.

The primary objective of transducer emplacement in the shallow monitoring wells is to provide long-term information regarding water levels in the AOU-1 area and groundwater flow (particularly vertical hydraulic gradients that may give indication of whether the faults act as flow barriers). The primary objective of transducer emplacement in the deep monitoring wells is to provide long-term information regarding water levels and potential changes in hydraulic gradient associated with area production wells.

The transducers will be downloaded quarterly and during each sampling event before purging and sample collection.

5.2.6 Monitoring Well Surveying

Monitoring wells will have the ground surface and top of casing surveyed for horizontal location and vertical elevation, accurate to 0.1 foot horizontally and 0.01 foot vertically. A mark will be made on the north side of the PVC casing upon completion of well installation activities and will be used as the location for all subsequent future water level measurements. The surveyor shall provide data in the horizontal datum North American Datum 1983 State Plane Utah North FIPS 4301 (International Feet), and in the vertical datum North American Vertical Datum 1988.

5.2.7 Surface Water Sampling

Surface water samples will be collected from five locations in the ESS area and three locations along Red Butte Creek (Figure 5-4). Surface water samples will be collected concurrently with groundwater sampling events to potentially better correlate groundwater and surface water concentrations. The five locations in the ESS area include the area with the highest concentrations of PCE found in surface water during the 2016 sampling (EA, 2017c) (southwest and west of East High School) and Benson Spring northwest of East High School. The three Red Butte Creek locations (SW-47, SW-51, and SW-52) are located along a stretch of Red Butte Creek between 1300 East and McClelland Street. In this area, Red Butte Creek is above ground and is believed to be a gaining stream, based on the presence of Bowen Spring at the eastern (upstream) sampling location (EA, 2017a). Section 3.4 of the FSP (Appendix A.1) describes the sample frequency and analytical parameters for surface water sampling. Surface water sample methods are discussed in Section 5.3 of the FSP (Appendix A.1) and SOP B.19 (Appendix B).

5.2.8 Records Review

Identifying previous investigations and previously evaluated areas through historical records review will inform source characterization efforts by informing the selection of sample methods and locations. A records review of previous environmental investigations, historical chemical use data, aerial photography, and historical analytical data (for example, historical soil and soil gas data) will provide additional information relevant to determining the source of the PCE plume. A major component of the records review would be to document all past uses of PCE and/or TCE in the vicinity of or upgradient of the site. Review of these types of information can identify locations where PCE and/or TCE was or may have been used. For example, PCE and TCE have been commonly used as a parts-cleaning solvent in automotive repair shops, machine shops, and similar operations. Records reviews may identify areas where such operations occurred.

Soil and soil gas data may be available from environmental investigations related to RCRA or voluntary cleanups, property transfers or other purposes. Review of these data, including comparison to migration-to-groundwater screening levels, may provide additional insight on potential VOC source areas.

The following facilities are previously evaluated areas for the PCE plume at the site. Additional information regarding the regulatory history of the site and the previously evaluated areas are provided in Section 2.1.

- VA Medical Center Building 7. Discharge of distillation condensate from a dry cleaner formerly present on VHA property to the sewer has been suggested as a source of the PCE plume. This facility has been identified as the likely source of the PCE plume at the site based on historical records of PCE use and the direction of local groundwater flow.
- Previous military activities on past and present Fort Douglas property, including the Army Reserve.

- Former Utah National Guard Vehicle Maintenance Facility. This facility was investigated as a potential source after the initial detection in the Mount Olivet Well.
- Former U.S. Forest Service Helicopter Pad. This site was operated as a heliport and fueling facility by the U.S. Forest Service.

Other, previously unidentified sources may be identified through the records review.

5.3 Toolbox for Future Phases

Items in this section are not planned as part of Phase 1 of the RI. However, they may potentially be included in future phases. A brief summary is included here for informational purposes. If any items are eventually used, additional details will be provided in a Minor Field Modification to the RIWP. Because these tasks build upon items already outlined in the RIWP and are summarized here, a Modification, as outlined in the FFA, is not anticipated to be required to incorporate these potential tasks into the RIWP in the future.

5.3.1 Source Investigation

One of the principal study questions for the RI (Table 4-1) is "What is the source(s) of the PCE plume? Is there still sufficient mass of PCE in the vadose zone to act as an ongoing source of PCE in groundwater?" Adequate characterization of the source or sources of PCE in groundwater is a key component of the RI to determine whether there is an ongoing source to evaluate remedial alternatives in the FS. Currently, there is very limited information regarding potential PCE source(s).

Potential source(s) will be located over or hydraulically upgradient of the known extent of the PCE plume. The Phase 1 groundwater investigation will provide better resolution on characterization of the head of the PCE plume, thereby supporting evaluation of possible source areas.

A subsequent phase of the RI (investigations following the Phase 1 field activities presented in an interim RI report described in the FSP [Appendix A.1]), will include a more detailed evaluation of information regarding the potential source areas and recommendations for site-specific source investigation. The methods that may be applied for additional source investigation are described in the following subsections.

5.3.1.1 Soil Gas Testing

Additional soil gas samples may be collected in future phases of the RI from temporary or permanent soil gas probes.

The locations, numbers and types of soil-gas samples and analyses would be specified in a future addendum to the FSP (Appendix A.1).

5.3.1.2 Surface and Near-Surface Soil Sampling

The current knowledge regarding the PCE release associated with the former VHA dry cleaning facility suggests that PCE may have entered the subsurface through discharges of distillation condensate to the sewer and possible discharge outside Building 7. Thus, there is currently no basis for sampling surface or near-surface soil above the elevation of the sewer line. Should the objectives of future investigations require collection of surface or near-surface soil samples, the samples will be collected in conformance with SOP B.16 (Appendix B). Screening levels for soil direct exposure (RSL_{soil}) are included in Table 5-3 to support evaluation of sensitivity for soil analytical methods in the QAPP (Appendix A.2).

5.3.1.3 Cone Penetration Testing

CPT may be used to refine stratigraphy and depth to groundwater in the ESS area and collect groundwater grab samples using a HydroPunch tool. Details for a CPT component to additional phases of the RI would be provided in an addendum to the FSP (Appendix A.1). The methods for CPT are provided in SOP B.15 (Appendix B).

5.3.1.4 Subsurface Soil Sampling

During Phase 1, subsurface soil samples may be collected in areas where soil-gas results exceed 10 times the residential soil gas screening level (the EPA residential $VISL_{sg}$) discussed in Section 5.2.1.1. During subsequent phases of the RI, additional soil samples may need to be collected based on different criteria; however, soil samples for VOC analysis will be collected using EnCore disposable samplers via direct-push technology methods, as described in SOP B.14 (Appendix B).

Additional geotechnical soil testing parameters may be required to support source investigation.

If needed, the types, numbers and locations for such tests would be specified in a future FSP (Appendix A.1) addendum.

5.3.1.5 Monitoring well installation

Analysis of data from Phase 1 may necessitate drilling and installation of additional shallow and/or deep monitoring wells. The drilling, well construction and development, and sampling methods described in Phase 1 are applicable for additional monitoring wells installed during Phase 2 investigations.

5.3.1.6 Pumping Test at SLC-18

A longer-term pumping test at drinking water well SLC-18, using existing and new monitoring wells as observation wells, may be pursued in subsequent phases of the RI. The purpose of this test would be to assess hydraulic connectivity and correlate flow zones among monitoring wells and SLC-18, and further understand the capture zone of this well relative to potential source areas. Details supporting this pumping test would be provided in a future addendum to the FSP (Appendix A.1).

5.3.2 Groundwater Sampling

Additional groundwater monitoring events will be conducted in future phases of the RI to monitor the plume extent and migration, delineate plume boundaries and PCE concentrations, and help identify the source of the PCE plume. Future groundwater monitoring may include ongoing monitoring of new and existing wells in the site, collection of HydroPunch groundwater samples, installation of shallow groundwater sampling points through direct push methods (SOP B.12 in Appendix B) in the ESS area, and sampling of additional deep monitoring wells added during later phases of the investigation. Details for additional groundwater sampling through any other the above described methods during additional phases of the RI would be provided in an addendum to the FSP (Appendix A.1).

5.3.2.1 Compound-specific Isotope Analysis

Compound-specific isotope analysis (CSIA) is an analytical method that measures the ratios of naturally occurring stable isotopes (typically carbon, hydrogen, and/or chlorine) in specific contaminant compounds in environmental samples. CSIA can be used to gain information about potential contaminant sources, the extent of degradation, comingling of contaminant plumes, and the origins of some chemicals.

Application of CSIA at the 700 South 1600 East PCE Plume may offer insight into natural attenuation of PCE in site groundwater, and the relationship between PCE observed at the EPA wells and in the ESS area. Use of CSIA in future phase of the RI would be presented in an addendum to the FSP (Appendix A.1), discussing methodology, applicability, and limitations.

5.3.3 Geophysical and Flow Logging

Additional geophysical and flow logging methods may be used following completion of monitoring well installations to complement borehole lithology descriptions and further characterize hydrostratigraphic units. Whether a specific tool may provide data useful for site characterization depends on the results of Phase 1 efforts, such as final well design and measurement of groundwater levels.

The supplemental geophysical tools include the following:

- **Deviation logging** – used for water level measurement corrections; useful when hydraulic gradient is very flat
- **Fluid resistivity/conductivity logging** – used to evaluate geologic formations/fracture as water enters a borehole or PVC-cased well; useful in open boreholes or long-screen PVC-cased wells
- **Temperature logging** – used to provide information on the source and movement of groundwater into and out of the borehole; useful in open boreholes or long screen PVC-cased wells
- **Induction Resistivity logging** – used to determine electrical conductivity/resistivity of the rock surrounding a borehole; useful in dry open boreholes or long screen PVC-cased wells

The supplemental groundwater flow logging tools include the following:

- Electromagnetic borehole flow meter (provide cumulative flow into well screen and vertical gradients inside well screen; useful in open boreholes or long-screen PVC-cased wells)
- Heat pulse flow meter (provide flow rate and direction; useful in open boreholes or long-screen PVC-cased wells)

Additional details about supplemental geotechnical testing and flow logging methods are provided in SOP B.5 (Appendix B).

5.3.4 Surface Water Sampling

Additional surface water sampling events, specifically within the ESS area, may be included in future phases of the RI to assist in evaluating the lateral and downgradient extent of PCE contamination, refining groundwater flow paths, and developing a groundwater flow model. Future surface water sampling events may also include sampling of stormwater run-off. Surface water sample methods are discussed in SOP B.19 (Appendix B).

5.3.5 Ecological Site Reconnaissance

A future phase of the RI may include a qualitative ecological reconnaissance within portions of the OU-2 study area. Ecological reconnaissance will be conducted in accordance with *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1997b). There are no potential ecological exposures in areas where OU-2 consists solely of PCE contaminated groundwater hundreds of feet bgs. Hence, ecological reconnaissance will not be conducted in such areas. If surface or near surface OU-2 contamination is found in source areas or areas of shallow groundwater or surface water outside AOU-1, ecological reconnaissance may be conducted in such areas.

The objective of ecological reconnaissance is to provide a snapshot of habitat quality and potential ecological receptors for locations associated with surface or near surface OU-2 contamination. Potential ecological habitats will be ranked in five categories. Ratings for each category are summarized in Table 5-4 and details of rating criteria are outlined below.

The site reconnaissance visit will be conducted by a biologist to document the existing biological resources on the site and in the immediate vicinity. The following will be documented:

- Existing land use and habitats
- Natural vegetation communities and habitats – including qualitative evaluation of the quality and/or potential stress of the existing habitats
- Potential wetlands
- Common plants and wildlife species observed during the reconnaissance survey
- Completion of the Biological Checklists (found in Appendix A of the *Representative Sampling Guidance Document, Volume 3: Biological,* which is included as Appendix B to the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* [EPA, 1997b]).

5.3.6 Monitoring Well Maintenance

New and existing monitoring wells will be maintained throughout the RI to ensure continued operation. The monitoring well condition will be inspected and recorded prior to each groundwater sampling event. Any required or completed maintenance (for example, replacing the inner lid, repairing or replacing the pump, repair of tubing) will be noted on the groundwater monitoring form. A field form for well maintenance is included in Appendix A of the FSP (Appendix A.1). Monitoring well maintenance will be conducted in future phases of the RI, as needed, to maintain the groundwater monitoring well network. Monitoring wells that need to be replaced or are no longer needed will be abandoned to prevent the well from acting as a conduit for potential cross-contamination between hydrogeologic units. Monitoring well abandonment is described in SOP B.4 (Appendix B).

Table 5-4. Qualitative Habitat Assessment Categories
Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume Salt Lake City, Utah

Habitat Value	Habitat Character	Receptors	Likely to Support Threatened and Endangered Species
• None • Low • Low-moderate • Moderate • High	• Hardened • Disturbed • Natural Area (Urban)	• Pollinators • Songbirds • Small Mammals • Mid-Sized Mammals	• Highly likely • Moderately likely • Not likely

Locations will be assigned a Habitat Value rating based on the following parameters:

- **None:** No identified habitat value for native flora or fauna.
- **Low:** Capacity for intermittent support of small mammals, songbirds, and/or pollinators. Little to no native flora present.
- **Low-moderate:** Capacity to provide some seasonal food sources and cover from predators. Native flora present, not dominant.
- **Moderate:** Capacity to provide some seasonal food sources, cover from predators, and habitat to breed/rear young. Native flora present at levels that provide moderate species diversity and structure (for example, fills niches of herbaceous/graminoid, shrub, and woody canopy).
- **High:** Capacity to support a diverse suite of flora species as typical pre-settlement / disturbance conditions. Supports diversity of large and small bird species, small, mid and larger mammals throughout the year.

Locations will be assigned a Habitat Character rating based on the following parameters:

- **Hardened:** Site primarily characterized by being located in a well-developed residential area. Includes moderately high percent coverage occupied by asphalt, concrete, and structures (for example, housing/commercial buildings).
- **Disturbed:** Still located within residentially developed areas, although includes pockets of naturalized, or minimally maintained areas that could potentially provide habitat to urban wildlife and pollinators.
- **Natural Area:** Located in an area that includes remnant connective corridors for wildlife use and includes remnants of native vegetation communities (for example, gambel oak/maple forests or riparian forest dominated by willow, cottonwood, and other native woody species).

Based on degree of hardening, presence or absence of water source(s), presence or absence of native vegetation, availability of vegetal cover and diversity of structure (for example, herbaceous, shrub and canopy), estimates will be made regarding potential wildlife species that could be supported at a given location. The following ecological receptors and requirements for occupancy were used:

- **Songbirds:** Assumed intermittently present with the inclusion of moderate canopy cover and increasing use with the presence of a diverse structural component of native flora and developed vegetation community. In addition, surface water was assumed to be a valuable resource for this category.
- **Small Mammals:** Assumed small mammals (for example, mice, squirrels, rodents) intermittently present with the inclusion of moderate herbaceous and shrub layer with increasing abundance in less maintained and natural areas dominated by native flora.
- **Mid-sized Mammals:** Assumed mid-sized mammals (for example, fox, coyote, marmot, etc.) intermittently present with the inclusion of a moderate herbaceous and shrub layer in increasing abundance in less maintained and natural areas dominated by native flora.
- **Pollinators:** Assumed use and habitat with the presence of introduced and native perennial forb species and some species of insect pollinated shrubs/trees.
- **Large Mammals:** Not likely to occur in a densely urbanized area. Would require more connectivity to larger areas that include natural resources and well developed native plant communities.

5.4 Data Reduction, Tabulation, Evaluation, and Reporting

5.4.1 Database Development and Management

A data management system has been set up to manage chemical, geological, hydrogeological, and geospatial data; well-construction data; and project documents. Project field documentation will include field logbooks, field forms, photographs, and chain-of-custody forms. Field documentation is discussed in more detail in Section 5.11.1 of the FSP (Appendix A.1). The system is composed of the following major elements:

- An Environmental Data Management System (EDMS) built in the EarthSoft EQuIS system. EQuIS will house the following data types:
  - Location information for wells and other sampling points
  - Well construction information
  - Simplified lithological information for boring logs
  - Water level data
  - Field parameters (for example, pH and specific conductivity)
  - Sample information including location, date and time, sampling method, and matrix
  - Analytical chemistry data
  - Provision for web-based access to the EQuIS EDMS wherein data users, including USACE-KC and VHA personnel can access the analytical chemistry and other data in spatial context.
- A geographic information system (GIS) built in the Environmental Systems Research Institute ArcGIS system. The GIS will be used to house and visualize geospatial data including project specific location information for wells, sample points, etc., and reference entities such as roads, buildings, water bodies, etc. The GIS will be integrated into the EQuIS EDMS and will be accessed through a map widget.
- A document management system consisting of the following:
  - A Microsoft SharePoint website containing draft and final documents, native files, and scanned field documentation including field logbooks, field forms, photographs, and chain-of-custody forms
  - A Microsoft Access document-management database showing the status of each document and containing hyperlinks to the SharePoint site

The data management plan (SOP B.20 in Appendix B) further describes the systems and processes that will support data management during the OU-2 RI.

5.4.2 Phase 1 Data Summary Reports

Data summary reports will be submitted after each of the following Phase 1 field activities:

- Installation of new monitoring wells
- Each of four surface and groundwater sampling rounds
- Soil gas survey

Data summary reports will summarize field activities, describe any deviation and corrective action reports from the RIWP, and present raw data and field logs. The data summary reports will provide the necessary information to scope the next phase of field work and will collectively include:

- A summary of the field program activities including any deviations from the RIWP
- Boring, well construction, and well development logs from all new wells and a summary of well construction details
- Summary of data and interpretation of slug and aquifer tests
- Tabular results of geotechnical testing
- Geophysical and groundwater flow logs and a brief interpretation of results
- Graphical representation of groundwater analytical results and a potentiometric groundwater flow map
- Northeast-trending cross section, and other cross sections as appropriate, illustrating lithology, screen intervals, and PCE concentrations in clustered shallow and deep wells
- Surface water sampling logs and validated analytical results
- Groundwater sampling logs and validated analytical results
- Brief evaluation of hydrogeologic data gaps and recommendations for additional phases of the RI

5.4.3 Interim and Final Remedial Investigation Report

An interim RI report will be prepared after completion of Phase 1 activities and will include the following components:

- Summary of field data collection
- Verification of field forms
- Validated analytical data
- Summary of groundwater model results (detailed results of groundwater model will be provided as a stand-alone technical memorandum), physical characteristics of the site, nature and extent of contamination at the site, and potential contaminant fate and transport
- Recommendations for additional investigation activities

The interim report will focus on remedial investigation activities and will discuss any identified data gaps.

After the nature and extent of the PCE plume has been determined, a final OU-2 remedial investigation report will be prepared in accordance with EPA/540/G-89/004-OSWER Directive 9355.3-01 "Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), Interim Final," October 1988. Data summary reports described in Section 5.4.2 will be included in the interim and final OU-2 RI reports. In addition, the final OU-2 RI will include the results of a baseline risk assessment (Section 5.4.4). The baseline risk assessment will include both a human health risk assessment and ecological risk assessment and will be used to evaluate risks from exposure to contamination under baseline conditions.

5.4.4 Baseline Risk Assessment

The conceptual site model development for OU-2 is in the earliest stages and there is currently limited information about the nature and extent of contaminated media and complete or potentially complete exposure pathways for human or ecological receptors. For example, while hypothetical drinking water exposure from PCE-contaminated groundwater is a potentially complete human exposure pathway, there is currently no information supporting the assessment of whether direct or indirect exposures to contaminated soil, for example, are potentially complete and significant. A preliminary conceptual site exposure model (Figure 5-5) has been prepared to summarize the current knowledge regarding potential human exposures pathways.

Given the limited information currently available, development of a formal risk-assessment work plan will be delayed until after completion of the initial RI phases so that the plan can be tailored to address relevant environmental media, exposure pathways and receptors. The risk assessment work plan will include the following human health risk assessment elements:

- Data Evaluation
  - Data Selection, including what matrices, analytes, methods, location and dates will be included along with information on site-relatedness of detected analytes.
  - Data Quality Assessment
  - Sample Quantitation Limit Evaluation
  - Data Reduction
  - Environmental Modeling
  - Contaminants of Potential Concern
- Exposure Assessment
  - Exposure Setting
  - Exposure Pathways
  - Exposure Point Concentrations
  - Quantification of Exposure
- Toxicity Assessment
  - Non-cancer Effects: toxicity values and non-cancer hazard estimation methods
  - Cancer Effects: toxicity values and cancer risk estimation methods
- Uncertainty Analysis
- Risk Description
- Scientific Management Decision Points

The scope of the ecological risk assessment will depend on the outcome of the ecological site reconnaissance (Section 5.3.5) and could include a scoping, screening or baseline ecological risk assessment. Given the highly-developed, urban nature of the OU-2 study area, a scoping ecological risk assessment is most likely.

Table 5-2. Preliminary Screening Levels for Soil Gas

Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Analyte	**Method**	**CAS No.**	**Soil Protection of Ground Water (DAF=20) (mg/kg)**		**Concentration Protection of Groundwater ($SGSL_{pgw}$) (µg/m^3)**		**Henry's Law Constant (dimensionless)**	**Soil organic carbon-water partitioning coefficient (K_{oc}) (L/kg)**	**Resident Air (ug/m^3)**	**Industrial Air (ug/m^3)**	**Soil Gas Vapor Intrusion Screening Level ($VISL_{sg}$) (µg/m^3)**		**Lowest Soil Gas Screening Level (µg/m^3)**
			Risk-based	**MCL-based**	**Risk-based**	**MCL-based**					**Residential**	**Industrial**	
cis-1,2-Dichloroethene	HAPSITE/TO-15	156-59-2	2.2E-01	4.2E-01	1.2E+05	2.4E+05	1.7E-01	4.0E+01	NA	NA	NA	NA	**1.2E+05**
Tetrachloroethene	HAPSITE/TO-15	127-18-4	1.0E-01	4.6E-02	1.6E+05	7.3E+04	7.2E-01	9.5E+01	4.2E+00	1.8E+01	1.4E+02	6.0E+02	**1.4E+02**
Trichloroethene	HAPSITE/TO-15	79-01-6	3.6E-03	3.6E-02	4.1E+03	4.1E+04	4.0E-01	6.1E+01	2.1E-01	8.8E-01	7.0E+00	2.9E+01	**7.0E+00**

Notes:

µg/m^3 = microgram(s) per cubic meter

CAS No. = Chemical Abstracts Service Number

DAF = dilution attenuation factor

L/kg = liter(s) per kilogram

MCL = maximum contaminant level

mg/kg = milogram(s) per kilogram

NA = not applicable

$SGSL_{pgw}$ = soil gas equilibrium concentration - protection of groundwater

$VISL_{sg}$ = soil gas vapor intrusion screening level

Risk based screening levels are based on an excess lifetime cancer risk of 10^{-6} or a noncancer hazard quotient of 0.1

U.S. Environmental Protection Agency (EPA). 2017a. Vapor Intrusion Screening Levels. Vapor Intrusion. https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-levels-visls.

U.S. Environmental Protection Agency (EPA). 2017b. Regional Screening Levels (RSLs). https://www.epa.gov/risk/regional-screening-levels-rsls.

Table 5-3. Preliminary Screening Levels for Soil and Groundwater

Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Analyte	CAS No.	Soil - Direct Exposure (RSL_{soil}) (mg/kg)		Soil Protection of Groundwater (DAF=20) (RSL_{pgw}) (mg/kg)		Lowest Soil Screening Level (mg/kg)	Water (µg/L)		Water Screening Level [a] (µg/L)
		Resident	Industrial	Risk-based	MCL-based		Risk-based	MCL	
1,1,1-Trichloroethane	71-55-6	8.1E+02	3.6E+03	5.6E+00	1.4E+00	**1.4E+00**	8.0E+02	2.0E+02	**2.0E+02**
1,1,2,2-Tetrachloroethane	79-34-5	6.0E-01	2.7E+00	6.0E-04		**6.0E-04**	7.6E-02		**7.6E-02**
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	76-13-1	6.7E+02	2.8E+03	5.2E+01		**5.2E+01**	1.0E+03		**1.0E+03**
1,1,2-Trichloroethane	79-00-5	1.5E-01	6.3E-01	2.6E-04	3.2E-02	**2.6E-04**	4.1E-02	5.0E+00	**5.0E+00**
1,1'-Biphenyl	92-52-4	4.7E+00	2.0E+01	1.7E-02		**1.7E-02**	8.3E-02		**8.3E-02**
1,1-Dichloroethane	75-34-3	3.6E+00	1.6E+01	1.6E-02		**1.6E-02**	2.8E+00		**2.8E+00**
1,1-Dichloroethene	75-35-4	2.3E+01	1.0E+02	2.0E-01	5.0E-02	**5.0E-02**	2.8E+01	7.0E+00	**7.0E+00**
1,2,3-Trichlorobenzene	87-61-6	6.3E+00	9.3E+01	4.2E-02		**4.2E-02**	7.0E-01		**7.0E-01**
1,2,4,5-Tetrachlorobenzene	95-94-3	2.3E+00	3.5E+01	1.6E-02		**1.6E-02**	1.7E-01		**1.7E-01**
1,2,4-Trichlorobenzene	120-82-1	5.8E+00	2.6E+01	2.4E-02	4.0E+00	**2.4E-02**	4.0E-01	7.0E+01	**7.0E+01**
1,2,4-Trimethylbenzene	95-63-6	5.8E+00	2.4E+01	4.2E-02		**4.2E-02**	1.5E+00		**1.5E+00**
1,2-Dibromo-3-Chloropropane	96-12-8	5.3E-03	6.4E-02	2.8E-06	1.7E-03	**2.8E-06**	3.3E-04	2.0E-01	**2.0E-01**
1,2-Dibromoethane	106-93-4	3.6E-02	1.6E-01	4.2E-05	2.8E-04	**4.2E-05**	7.5E-03	5.0E-02	**5.0E-02**
1,2-Dichlorobenzene	95-50-1	1.8E+02	9.3E+02	6.0E-01	1.2E+01	**6.0E-01**	3.0E+01	6.0E+02	**6.0E+02**
1,2-Dichloroethane	107-06-2	4.6E-01	2.0E+00	9.6E-04	2.8E-02	**9.6E-04**	1.7E-01	5.0E+00	**5.0E+00**
1,2-Dichloropropane	78-87-5	1.6E+00	6.6E+00	5.4E-03	3.4E-02	**5.4E-03**	4.4E-01	5.0E+00	**5.0E+00**
1,3,5-Trimethylbenzene	108-67-8	7.8E+01	1.2E+03	3.4E-01		**3.4E-01**	1.2E+01		**1.2E+01**
1,4-Dichlorobenzene	106-46-7	2.6E+00	1.1E+01	9.2E-03	1.4E+00	**9.2E-03**	4.8E-01	7.5E+01	**7.5E+01**
1,4-Dioxane	123-91-1	5.3E+00	2.4E+01	1.9E-03		**1.9E-03**	4.6E-01		**4.6E-01**
2,3,4,6-Tetrachlorophenol	58-90-2	1.9E+02	2.5E+03	3.6E-01		**3.6E-01**	2.4E+01		**2.4E+01**
2,4,5-Trichlorophenol	95-95-4	6.3E+02	8.2E+03	8.0E+00		**8.0E+00**	1.2E+02		**1.2E+02**
2,4,6-Trichlorophenol	88-06-2	6.3E+00	8.2E+01	2.4E-02		**2.4E-02**	1.2E+00		**1.2E+00**
2,4-Dichlorophenol	120-83-2	1.9E+01	2.5E+02	4.6E-02		**4.6E-02**	4.6E+00		**4.6E+00**
2,4-Dimethylphenol	105-67-9	1.3E+02	1.6E+03	8.4E-01		**8.4E-01**	3.6E+01		**3.6E+01**
2,4-Dinitrophenol	51-28-5	1.3E+01	1.6E+02	8.8E-02		**8.8E-02**	3.9E+00		**3.9E+00**
2,4-Dinitrotoluene	121-14-2	1.7E+00	7.4E+00	6.4E-03		**6.4E-03**	2.4E-01		**2.4E-01**
2,6-Dinitrotoluene	606-20-2	3.6E-01	1.5E+00	1.3E-03		**1.3E-03**	4.9E-02		**4.9E-02**
2-Butanone (Methyl Ethyl Ketone)	78-93-3	2.7E+03	1.9E+04	2.4E+00		**2.4E+00**	5.6E+02		**5.6E+02**
2-Chloronaphthalene	91-58-7	4.8E+02	6.0E+03	7.8E+00		**7.8E+00**	7.5E+01		**7.5E+01**
2-Chlorophenol	95-57-8	3.9E+01	5.8E+02	1.8E-01		**1.8E-01**	9.1E+00		**9.1E+00**
2-Hexanone	591-78-6	2.0E+01	1.3E+02	1.8E-02		**1.8E-02**	3.8E+00		**3.8E+00**
2-Methylnaphthalene	91-57-6	2.4E+01	3.0E+02	3.8E-01		**3.8E-01**	3.6E+00		**3.6E+00**
2-Methylphenol	95-48-7	3.2E+02	4.1E+03	1.5E+00		**1.5E+00**	9.3E+01		**9.3E+01**
2-Nitroaniline	88-74-4	6.3E+01	8.0E+02	1.6E-01		**1.6E-01**	1.9E+01		**1.9E+01**
3,3'-Dichlorobenzidine	91-94-1	1.2E+00	5.1E+00	1.6E-02		**1.6E-02**	1.3E-01		**1.3E-01**
4,4'-DDD	72-54-8	1.9E-01	2.5E+00	3.0E-02		**3.0E-02**	6.3E-03		**6.3E-03**
4,4'-DDE	72-55-9	2.0E+00	9.3E+00	2.2E-01		**2.2E-01**	4.6E-02		**4.6E-02**
4,4'-DDT	50-29-3	1.9E+00	8.5E+00	1.5E+00		**1.5E+00**	2.3E-01		**2.3E-01**

Table 5-3. Preliminary Screening Levels for Soil and Groundwater

Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Analyte	**CAS No.**	**Soil - Direct Exposure (RSL_{soil}) (mg/kg)**		**Soil Protection of Groundwater (DAF=20) (RSL_{pgw}) (mg/kg)**		**Lowest Soil Screening Level (mg/kg)**	**Water (µg/L)**		**Water Screening Level [a] (µg/L)**
		Resident	**Industrial**	**Risk-based**	**MCL-based**		**Risk-based**	**MCL**	
4,6-Dinitro-2-methylphenol	534-52-1	5.1E-01	6.6E+00	5.2E-03		**5.2E-03**	1.5E-01		**1.5E-01**
4-Chloro-3-methylphenol	59-50-7	6.3E+02	8.2E+03	3.4E+00		**3.4E+00**	1.4E+02		**1.4E+02**
4-Chloroaniline	106-47-8	2.7E+00	1.1E+01	3.2E-03		**3.2E-03**	3.7E-01		**3.7E-01**
4-Methyl-2-pentanone	108-10-1	3.3E+03	1.4E+04	2.8E+00		**2.8E+00**	6.3E+02		**6.3E+02**
4-Methylphenol (3/4-Methylphenol)	106-44-5	6.3E+02	8.2E+03	3.0E+00		**3.0E+00**	1.9E+02		**1.9E+02**
4-Nitroaniline	100-01-6	2.5E+01	1.1E+02	3.2E-02		**3.2E-02**	3.8E+00		**3.8E+00**
Acenaphthene	83-32-9	3.6E+02	4.5E+03	1.1E+01		**1.1E+01**	5.3E+01		**5.3E+01**
Acetone	67-64-1	6.1E+03	6.7E+04	5.8E+00		**5.8E+00**	1.4E+03		**1.4E+03**
Acetophenone	98-86-2	7.8E+02	1.2E+04	1.2E+00		**1.2E+00**	1.9E+02		**1.9E+02**
Aldrin	309-00-2	3.9E-02	1.8E-01	3.0E-03		**3.0E-03**	9.2E-04		**9.2E-04**
Aluminum	7429-90-5	7.7E+03	1.1E+05	6.0E+04		**7.7E+03**	2.0E+03		**2.0E+03**
Anthracene	120-12-7	1.8E+03	2.3E+04	1.2E+02		**1.2E+02**	1.8E+02		**1.8E+02**
Antimony	7440-36-0	3.1E+00	4.7E+01	7.0E-01	5.4E+00	**7.0E-01**	7.8E-01	6.0E+00	**6.0E+00**
Arsenic	7440-38-2	6.8E-01	3.0E+00	3.0E-02	5.8E+00	**3.0E-02**	5.2E-02	1.0E+01	**1.0E+01**
Atrazine	1912-24-9	2.4E+00	1.0E+01	4.0E-03	3.8E-02	**4.0E-03**	3.0E-01	3.0E+00	**3.0E+00**
Barium	7440-39-3	1.5E+03	2.2E+04	3.2E+02	1.6E+03	**3.2E+02**	3.8E+02	2.0E+03	**2.0E+03**
Benzaldehyde	100-52-7	1.7E+02	8.2E+02	8.2E-02		**8.2E-02**	1.9E+01		**1.9E+01**
Benzene	71-43-2	1.2E+00	5.1E+00	4.6E-03	5.2E-02	**4.6E-03**	4.6E-01	5.0E+00	**5.0E+00**
Benzo(a)anthracene	56-55-3	1.1E+00	2.1E+01	2.2E-01		**2.2E-01**	3.0E-02		**3.0E-02**
Benzo(a)pyrene	50-32-8	1.1E-01	2.1E+00	5.8E-01	4.8E+00	**1.1E-01**	3.4E-03	2.0E-01	**2.0E-01**
Benzo(b)fluoranthene	205-99-2	1.1E+00	2.1E+01	6.0E+00		**1.1E+00**	2.5E-01		**2.5E-01**
Benzo(k)fluoranthene	207-08-9	1.1E+01	2.1E+02	5.8E+01		**1.1E+01**	2.5E+00		**2.5E+00**
Beryllium	7440-41-7	1.6E+01	2.3E+02	3.8E+01	6.4E+01	**1.6E+01**	2.5E+00	4.0E+00	**4.0E+00**
BHC, alpha-	319-84-6	8.6E-02	3.6E-01	8.4E-04		**8.4E-04**	7.2E-03		**7.2E-03**
BHC, beta-	319-85-7	3.0E-01	1.3E+00	3.0E-03		**3.0E-03**	2.5E-02		**2.5E-02**
BHC, gamma- (Lindane)	58-89-9	5.7E-01	2.5E+00	4.8E-03	2.4E-02	**4.8E-03**	4.2E-02	2.0E-01	**2.0E-01**
Bis(2-chloroethoxy)methane	111-91-1	1.9E+01	2.5E+02	2.6E-02		**2.6E-02**	5.9E+00		**5.9E+00**
Bis(2-chloroethyl)ether	111-44-4	2.3E-01	1.0E+00	7.2E-05		**7.2E-05**	1.4E-02		**1.4E-02**
Bis(2-chloroisopropyl)ether	108-60-1	3.1E+02	4.7E+03	5.2E-01		**5.2E-01**	7.1E+01		**7.1E+01**
Bis(2-Ethylhexyl)Phthalate	117-81-7	3.9E+01	1.6E+02	2.6E+01	2.8E+01	**2.6E+01**	5.6E+00	6.0E+00	**6.0E+00**
Bromochloromethane	74-97-5	1.5E+01	6.3E+01	4.2E-02		**4.2E-02**	8.3E+00		**8.3E+00**
Bromodichloromethane	75-27-4	2.9E-01	1.3E+00	7.2E-04	4.4E-01	**7.2E-04**	1.3E-01	8.0E+01(F)	**1.3E-01**
Bromoform	75-25-2	1.9E+01	8.6E+01	1.7E-02	4.2E-01	**1.7E-02**	3.3E+00	8.0E+01(F)	**3.3E+00**
Bromomethane	74-83-9	6.8E-01	3.0E+00	3.8E-03		**3.8E-03**	7.5E-01		**7.5E-01**
Butyl Benzyl Phthalate	85-68-7	2.9E+02	1.2E+03	4.8E+00		**4.8E+00**	1.6E+01		**1.6E+01**
Cadmium (Diet)	7440-43-9	7.1E+00	9.8E+01			**7.1E+00**			**NA**
Cadmium (Water)	7440-43-9			1.4E+00	7.6E+00	**1.4E+00**	9.2E-01	5.0E+00	**5.0E+00**
Caprolactam	105-60-2	3.1E+03	4.0E+04	5.0E+00		**5.0E+00**	9.9E+02		**9.9E+02**

Table 5-3. Preliminary Screening Levels for Soil and Groundwater

Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Analyte	CAS No.	Soil - Direct Exposure (RSL_{soil}) (mg/kg)		Soil Protection of Groundwater (DAF=20) (RSL_{pgw}) (mg/kg)		Lowest Soil Screening Level (mg/kg)	Water (µg/L)		Water Screening Level [a] (µg/L)
		Resident	Industrial	Risk-based	MCL-based		Risk-based	MCL	
Carbon Disulfide	75-15-0	7.7E+01	3.5E+02	4.8E-01		**4.8E-01**	8.1E+01		**8.1E+01**
Carbon Tetrachloride	56-23-5	6.5E-01	2.9E+00	3.6E-03	3.8E-02	**3.6E-03**	4.6E-01	5.0E+00	**5.0E+00**
Chlordane	12789-03-6	1.7E+00	7.7E+00	5.4E-02	5.4E+00	**5.4E-02**	2.0E-02	2.0E+00	**2.0E+00**
Chlorobenzene	108-90-7	2.8E+01	1.3E+02	1.1E-01	1.4E+00	**1.1E-01**	7.8E+00	1.0E+02	**1.0E+02**
Chloroethane	75-00-3	1.4E+03	5.7E+03	1.2E+01		**1.2E+01**	2.1E+03		**2.1E+03**
Chloroform	67-66-3	3.2E-01	1.4E+00	1.2E-03	4.4E-01	**1.2E-03**	2.2E-01	8.0E+01(F)	**2.2E-01**
Chloromethane	74-87-3	1.1E+01	4.6E+01	9.8E-02		**9.8E-02**	1.9E+01		**1.9E+01**
Chromium	7440-47-3				3.6E+06	**3.6E+06**		1.0E+02	**1.0E+02**
Chrysene	218-01-9	1.1E+02	2.1E+03	1.8E+02		**1.1E+02**	2.5E+01		**2.5E+01**
cis-1,2-Dichloroethene	156-59-2	1.6E+01	2.3E+02	2.2E-02	4.2E-01	**2.2E-02**	3.6E+00	7.0E+01	**7.0E+01**
Cobalt	7440-48-4	2.3E+00	3.5E+01	5.4E-01		**5.4E-01**	6.0E-01		**6.0E-01**
Copper	7440-50-8	3.1E+02	4.7E+03	5.6E+01	9.2E+02	**5.6E+01**	8.0E+01	1.3E+03	**1.3E+03**
Dibenz(a,h)anthracene	53-70-3	1.1E-01	2.1E+00	1.9E+00		**1.1E-01**	2.5E-02		**2.5E-02**
Dibenzofuran	132-64-9	7.3E+00	1.0E+02	3.0E-01		**3.0E-01**	7.9E-01		**7.9E-01**
Dibromochloromethane	124-48-1	8.3E+00	3.9E+01	4.6E-03	4.2E-01	**4.6E-03**	8.7E-01	8.0E+01(F)	**8.7E-01**
Dichlorodifluoromethane (Freon 12)	75-71-8	8.7E+00	3.7E+01	6.0E-01		**6.0E-01**	2.0E+01		**2.0E+01**
Dieldrin	60-57-1	3.4E-02	1.4E-01	1.4E-03		**1.4E-03**	1.8E-03		**1.8E-03**
Diethyl Phthalate	84-66-2	5.1E+03	6.6E+04	1.2E+01		**1.2E+01**	1.5E+03		**1.5E+03**
Di-n-Butyl Phthalate	84-74-2	6.3E+02	8.2E+03	4.6E+00		**4.6E+00**	9.0E+01		**9.0E+01**
Di-n-octyl Phthalate	117-84-0	6.3E+01	8.2E+02	1.1E+02		**6.3E+01**	2.0E+01		**2.0E+01**
Endosulfan	115-29-7	4.7E+01	7.0E+02	2.8E+00		**2.8E+00**	1.0E+01		**1.0E+01**
Endrin	72-20-8	1.9E+00	2.5E+01	1.8E-01	1.6E+00	**1.8E-01**	2.3E-01	2.0E+00	**2.0E+00**
Ethylbenzene	100-41-4	5.8E+00	2.5E+01	3.4E-02	1.6E+01	**3.4E-02**	1.5E+00	7.0E+02	**7.0E+02**
Fluoranthene	206-44-0	2.4E+02	3.0E+03	1.8E+02		**1.8E+02**	8.0E+01		**8.0E+01**
Fluorene	86-73-7	2.4E+02	3.0E+03	1.1E+01		**1.1E+01**	2.9E+01		**2.9E+01**
Heptachlor	76-44-8	1.3E-01	6.3E-01	2.4E-03	6.6E-01	**2.4E-03**	1.4E-03	4.0E-01	**4.0E-01**
Heptachlor epoxide	1024-57-3	7.0E-02	3.3E-01	5.6E-04	8.2E-02	**5.6E-04**	1.4E-03	2.0E-01	**2.0E-01**
Hexachlorobenzene	118-74-1	2.1E-01	9.6E-01	2.4E-03	2.6E-01	**2.4E-03**	9.8E-03	1.0E+00	**1.0E+00**
Hexachlorobutadiene	87-68-3	1.2E+00	5.3E+00	5.4E-03		**5.4E-03**	1.4E-01		**1.4E-01**
Hexachlorocyclopentadiene	77-47-4	1.8E-01	7.5E-01	2.6E-03	3.2E+00	**2.6E-03**	4.1E-02	5.0E+01	**5.0E+01**
Hexachloroethane	67-72-1	1.8E+00	8.0E+00	4.0E-03		**4.0E-03**	3.3E-01		**3.3E-01**
Indeno(1,2,3-cd)pyrene	193-39-5	1.1E+00	2.1E+01	2.0E+01		**1.1E+00**	2.5E-01		**2.5E-01**
Iron	7439-89-6	5.5E+03	8.2E+04	7.0E+02		**7.0E+02**	1.4E+03		**1.4E+03**
Isophorone	78-59-1	5.7E+02	2.4E+03	5.2E-01		**5.2E-01**	7.8E+01		**7.8E+01**
Isopropylbenzene (Cumene)	98-82-8	1.9E+02	9.9E+02	1.5E+00		**1.5E+00**	4.5E+01		**4.5E+01**
Lead	7439-92-1	4.0E+02	8.0E+02		2.8E+02	**2.8E+02**	1.5E+01	1.5E+01	**1.5E+01**

Table 5-3. Preliminary Screening Levels for Soil and Groundwater

Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

Analyte	CAS No.	Soil - Direct Exposure (RSL_{soil}) (mg/kg)		Soil Protection of Groundwater (DAF=20) (RSL_{pgw}) (mg/kg)		Lowest Soil Screening Level (mg/kg)	Water (µg/L)		Water Screening Level [a] (µg/L)
		Resident	Industrial	Risk-based	MCL-based		Risk-based	MCL	
Manganese (Diet)	7439-96-5					**NA**			**NA**
Manganese (Non-diet)	7439-96-5	1.8E+02	2.6E+03	5.6E+01		**5.6E+01**	4.3E+01		**4.3E+01**
Mercury	7487-94-7	2.3E+00	3.5E+01			**2.3E+00**	5.7E-01	2.0E+00	**2.0E+00**
Methoxychlor	72-43-5	3.2E+01	4.1E+02	4.0E+00	4.4E+01	**4.0E+00**	3.7E+00	4.0E+01	**4.0E+01**
Methyl acetate	79-20-9	7.8E+03	1.2E+05	8.2E+00		**8.2E+00**	2.0E+03		**2.0E+03**
Methyl Tert-Butyl Ether	1634-04-4	4.7E+01	2.1E+02	6.4E-02		**6.4E-02**	1.4E+01		**1.4E+01**
Methylene chloride	75-09-2	3.5E+01	3.2E+02	5.4E-02	2.6E-02	**2.6E-02**	1.1E+01	5.0E+00	**5.0E+00**
m-Xylene	108-38-3	5.5E+01	2.4E+02	3.8E-01		**3.8E-01**	1.9E+01		**1.9E+01**
Naphthalene	91-20-3	3.8E+00	1.7E+01	1.1E-02		**1.1E-02**	1.7E-01		**1.7E-01**
Nickel	7440-02-0	1.5E+02	2.2E+03	5.2E+01		**5.2E+01**	3.9E+01		**3.9E+01**
Nitrate	14797-55-8	1.3E+04	1.9E+05			**1.3E+04**	3.2E+03	1.0E+04	**1.0E+04**
Nitrate + Nitrite (as N)	NA					**NA**		1.0E+04	**1.0E+04**
Nitrite	14797-65-0	7.8E+02	1.2E+04			**7.8E+02**	2.0E+02	1.0E+03	**1.0E+03**
Nitrobenzene	98-95-3	5.1E+00	2.2E+01	1.8E-03		**1.8E-03**	1.4E-01		**1.4E-01**
N-Nitroso-di-n-propylamine	621-64-7	7.8E-02	3.3E-01	1.6E-04		**1.6E-04**	1.1E-02		**1.1E-02**
N-Nitrosodiphenylamine	86-30-6	1.1E+02	4.7E+02	1.3E+00		**1.3E+00**	1.2E+01		**1.2E+01**
o-Xylene	95-47-6	6.5E+01	2.8E+02	3.8E-01		**3.8E-01**	1.9E+01		**1.9E+01**
Pentachlorophenol	87-86-5	1.0E+00	4.0E+00	1.1E-03	2.8E-02	**1.1E-03**	4.1E-02	1.0E+00	**1.0E+00**
Phenol	108-95-2	1.9E+03	2.5E+04	6.6E+00		**6.6E+00**	5.8E+02		**5.8E+02**
p-Xylene	106-42-3	5.6E+01	2.4E+02	3.8E-01		**3.8E-01**	1.9E+01		**1.9E+01**
Pyrene	129-00-0	1.8E+02	2.3E+03	2.6E+01		**2.6E+01**	1.2E+01		**1.2E+01**
Selenium	7782-49-2	3.9E+01	5.8E+02	1.0E+00	5.2E+00	**1.0E+00**	1.0E+01	5.0E+01	**5.0E+01**
Silver	7440-22-4	3.9E+01	5.8E+02	1.6E+00		**1.6E+00**	9.4E+00		**9.4E+00**
Styrene	100-42-5	6.0E+02	3.5E+03	2.6E+00	2.2E+00	**2.2E+00**	1.2E+02	1.0E+02	**1.0E+02**
Tetrachloroethene (PCE)	127-18-4	8.1E+00	3.9E+01	3.6E-02	4.6E-02	**3.6E-02**	4.1E+00	5.0E+00	**5.0E+00**
Thallium	7440-28-0	7.8E-02	1.2E+00	2.8E-02	2.8E+00	**2.8E-02**	2.0E-02	2.0E+00	**2.0E+00**
Toluene	108-88-3	4.9E+02	4.7E+03	1.5E+00	1.4E+01	**1.5E+00**	1.1E+02	1.0E+03	**1.0E+03**
Total 1,3-dichloro propene (cis- & trans-)	542-75-6	1.8E+00	8.2E+00	3.4E-03		**3.4E-03**	4.7E-01		**4.7E-01**
Toxaphene	8001-35-2	4.9E-01	2.1E+00	2.2E-01	9.2E+00	**2.2E-01**	7.1E-02	3.0E+00	**3.0E+00**
trans-1,2-Dichloroethene	156-60-5	1.6E+02	2.3E+03	2.2E-01	6.2E-01	**2.2E-01**	3.6E+01	1.0E+02	**1.0E+02**
Trichloroethene	79-01-6	4.1E-01	1.9E+00	2.0E-03	3.6E-02	**2.0E-03**	2.8E-01	5.0E+00	**5.0E+00**
Trichlorofluoromethane (Freon 11)	75-69-4	2.3E+03	3.5E+04	6.6E+00		**6.6E+00**	5.2E+02		**5.2E+02**
Vanadium	7440-62-2	3.9E+01	5.8E+02	1.7E+02		**3.9E+01**	8.6E+00		**8.6E+00**
Vinyl Acetate	108-05-4	9.1E+01	3.8E+02	1.7E-01		**1.7E-01**	4.1E+01		**4.1E+01**
Vinyl Chloride	75-01-4	5.9E-02	1.7E+00	1.3E-04	1.4E-02	**1.3E-04**	1.9E-02	2.0E+00	**2.0E+00**
Zinc	7440-66-6	2.3E+03	3.5E+04	7.4E+02		**7.4E+02**	6.0E+02		**6.0E+02**

[a]Screening level is the MCL where available, otherwise the screening level is the risk-based value.

Table 5-3. Preliminary Screening Levels for Soil and Groundwater

Remedial Investigation Work Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah

		Soil - Direct Exposure (RSL_{soil}) (mg/kg)		Soil Protection of Groundwater (DAF=20) (RSL_{pgw}) (mg/kg)		Lowest Soil Screening Level (mg/kg)	Water (µg/L)		Water Screening Level [a] (µg/L)
Analyte	**CAS No.**	**Resident**	**Industrial**	**Risk-based**	**MCL-based**		**Risk-based**	**MCL**	

Notes:

µg/L = microgram(s) per liter

DAF = dilution attenuation factor

MCL = maximum contaminant level

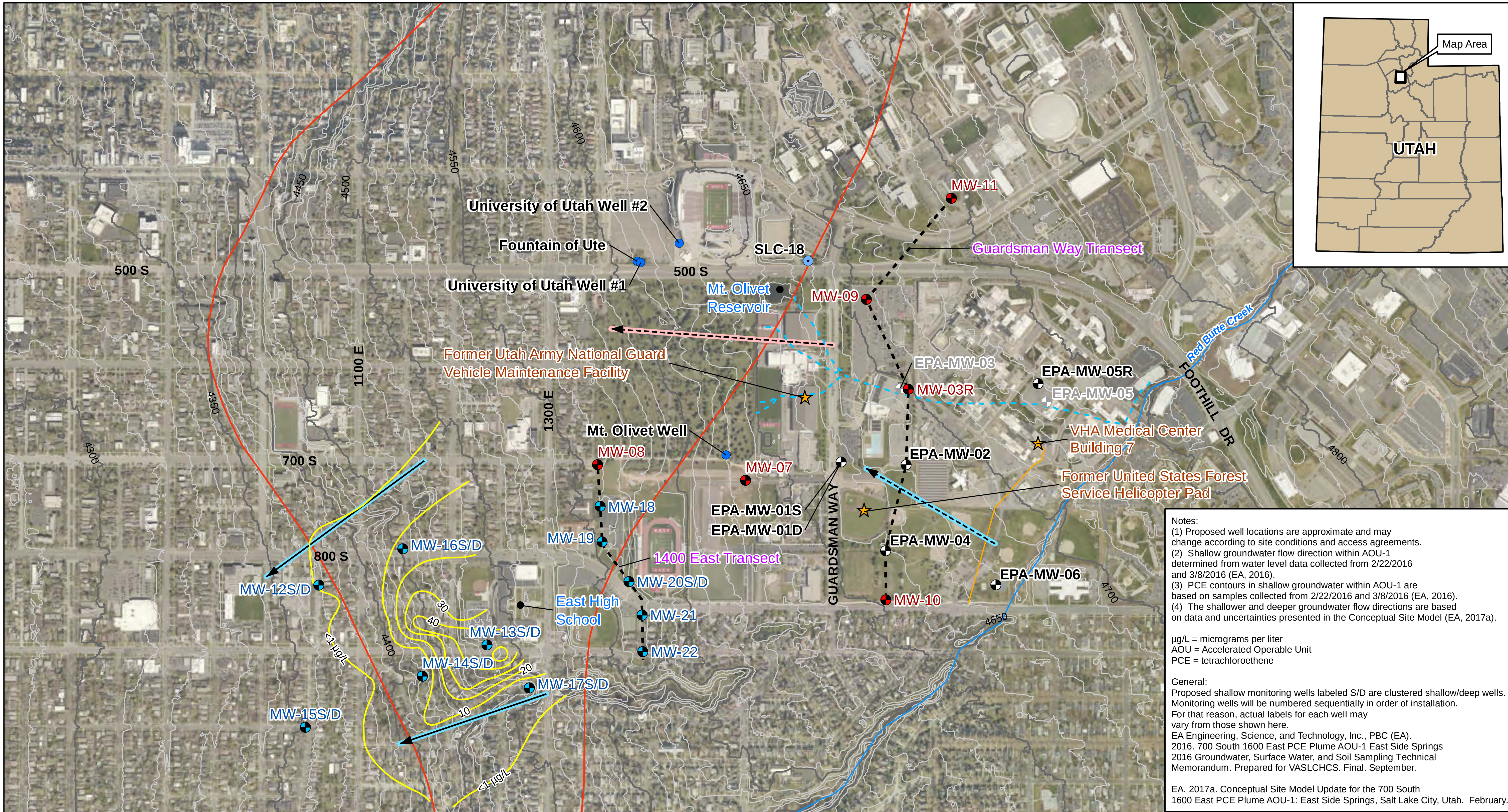
mg/kg = milligram(s) per kilogram

RSL_{pgw} = regional screening level - protection of groundwater

RSL_{pgw} = regional screening level - soil

Risk-based screening levels are based on an excess lifetime cancer risk of 10^{-6} or a noncancer hazard quotient of 0.1

U.S. Environmental Protection Agency (EPA). 2017b. Regional Screening Levels (RSLs) – User's Guide. Risk Assessment. Accessed December 22, 2017. https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide-november-2017.



Notes:
(1) Proposed well locations are approximate and may change according to site conditions and access agreements.
(2) Shallow groundwater flow direction within AOU-1 determined from water level data collected from 2/22/2016 and 3/8/2016 (EA, 2016).
(3) PCE contours in shallow groundwater within AOU-1 are based on samples collected from 2/22/2016 and 3/8/2016 (EA, 2016).
(4) The shallower and deeper groundwater flow directions are based on data and uncertainties presented in the Conceptual Site Model (EA, 2017a).

µg/L = micrograms per liter
AOU = Accelerated Operable Unit
PCE = tetrachloroethene

General:
Proposed shallow monitoring wells labeled S/D are clustered shallow/deep wells. Monitoring wells will be numbered sequentially in order of installation. For that reason, actual labels for each well may vary from those shown here.
EA Engineering, Science, and Technology, Inc., PBC (EA). 2016. 700 South 1600 East PCE Plume AOU-1 East Side Springs 2016 Groundwater, Surface Water, and Soil Sampling Technical Memorandum. Prepared for VASLCHCS. Final. September.

EA. 2017a. Conceptual Site Model Update for the 700 South 1600 East PCE Plume AOU-1: East Side Springs, Salt Lake City, Utah. February.

Legend
- Existing Monitoring Well
- Abandoned Monitoring Well
- Production Well
- Irrigation Well
- Previously Evaluated Area
- Landmark
- Proposed Transect Line
- Red Butte Canal (Historical)
- Red Butte Creek
- Fault Line
- Proposed Deep Monitoring Well[1]
- Proposed Shallow Monitoring Well[1]
- East Side Springs Area Groundwater Flow Direction [(2)]
- Shallower Groundwater Flow Direction [(4)]
- Deeper Groundwater Flow Direction [(4)]
- PCE Contour Line (µg/L)[3]
- Sewer Line
- Major Elevation Contour
- Minor Elevation Contour

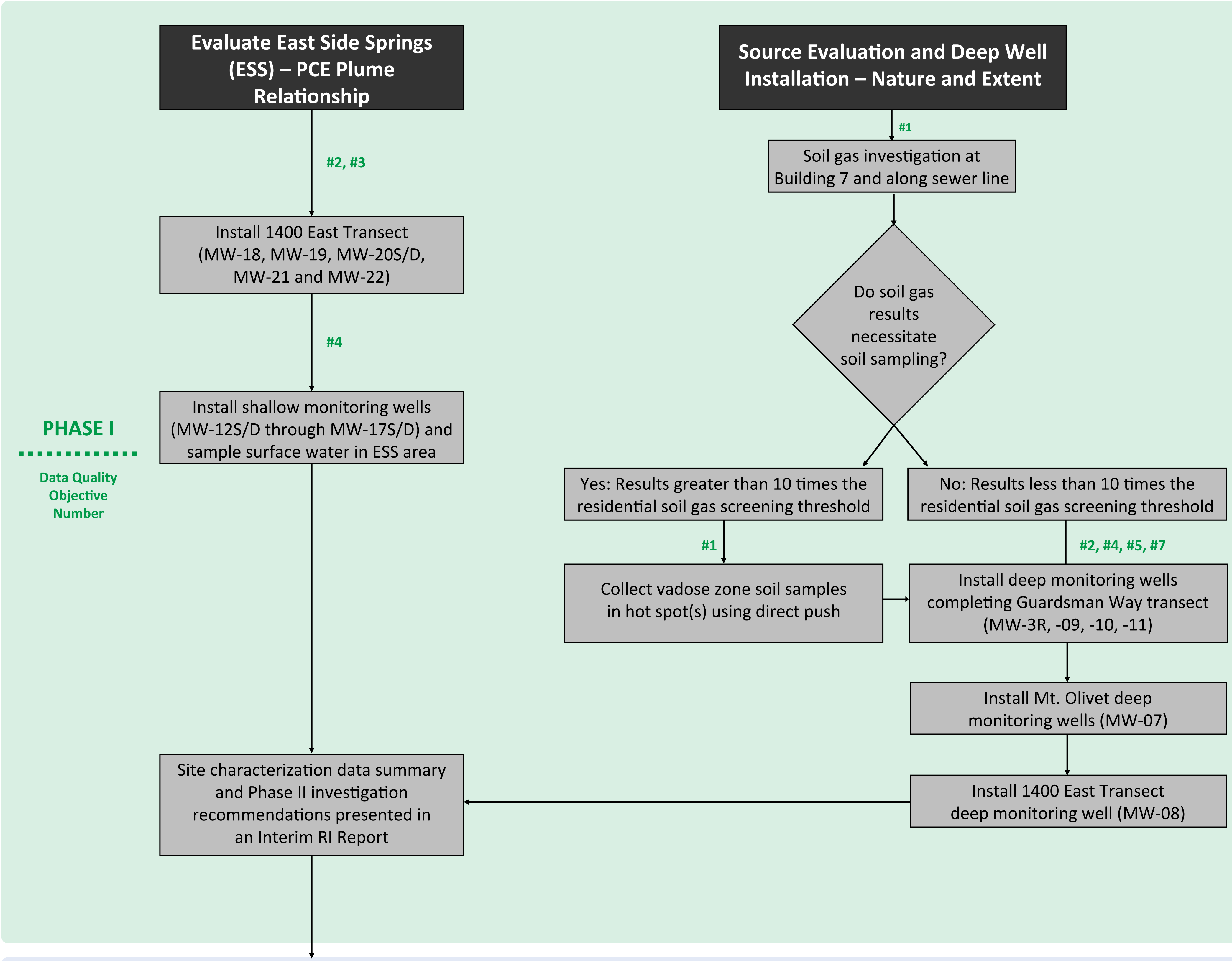
N S E W

0 400 800
Feet
1 inch = 800 feet

FIGURE 5-1
PROPOSED MONITORING WELL LOCATIONS AND SHALLOW PCE CONTOURS
OU-2 REMEDIAL INVESTIGATION WORK PLAN
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

ch2m

File Path: R:\ENBG\00_Proj\V\VA-SLC_665353\MapFiles\OU2_Remedial_Investigation_Work_Plan\December2017\PCE_Contours_and_Well_Locations.mxd jquan 2/22/2018 12:31:38 PM



Data Quality Objectives (DQO) Summary

DQO #1	What is the source(s) of PCE plume identified by the 1998 EPA monitoring wells? Is there still sufficient mass of PCE in the vadose zone to act as an ongoing source of PCE in groundwater?
DQO #2	What is the lateral and vertical extent of the PCE plume identified by the 1998 EPA monitoring wells? How far downgradient does the PCE plume extend?
DQO #3	Is the PCE and daughter products measured in the East Side Springs Area related to the PCE contamination plume identified by the 1998 EPA monitoring wells?
DQO #4	What hydrogeological features control PCE fate and transport? If the PCE plume identified by the 1998 EPA monitoring wells extends to East Side Springs area (refer to Question 3), what factors control the plume in fault zone/hillside? Does entire plume discharge to hillside or does some component continue deeper to the west?
DQO #5	What is the nature of the hydraulic connection between the PCE plume and production wells (SLC-18, University of Utah wells, Mount Olivet well)?
DQO #6	Besides vapor intrusion in AOU-1, drinking water wells, or potential source-area soil and soil gas, are there other potential human or ecological exposure pathways?
DQO #7	Collect data to support possible remedial technologies, including MNA, hydraulic containment, and bioremediation. Determine which natural attenuation processes are operating, and estimate the rate of degradation of PCE and daughter products formed.

PHASE II

Data Quality Objective Number

- Further delineation of source (#1)
- Further delineation of plume (#2, #7)
- Investigate other possible sources (#1)
- Additional monitoring wells in soil gas hot spot(s) (#1)
- Further evaluation of influence of Wasatch Fault on groundwater flow (#4)
- Aquifer testing (#4, #5)
- Additional soil and groundwater sampling rounds (#5, #6, #7)

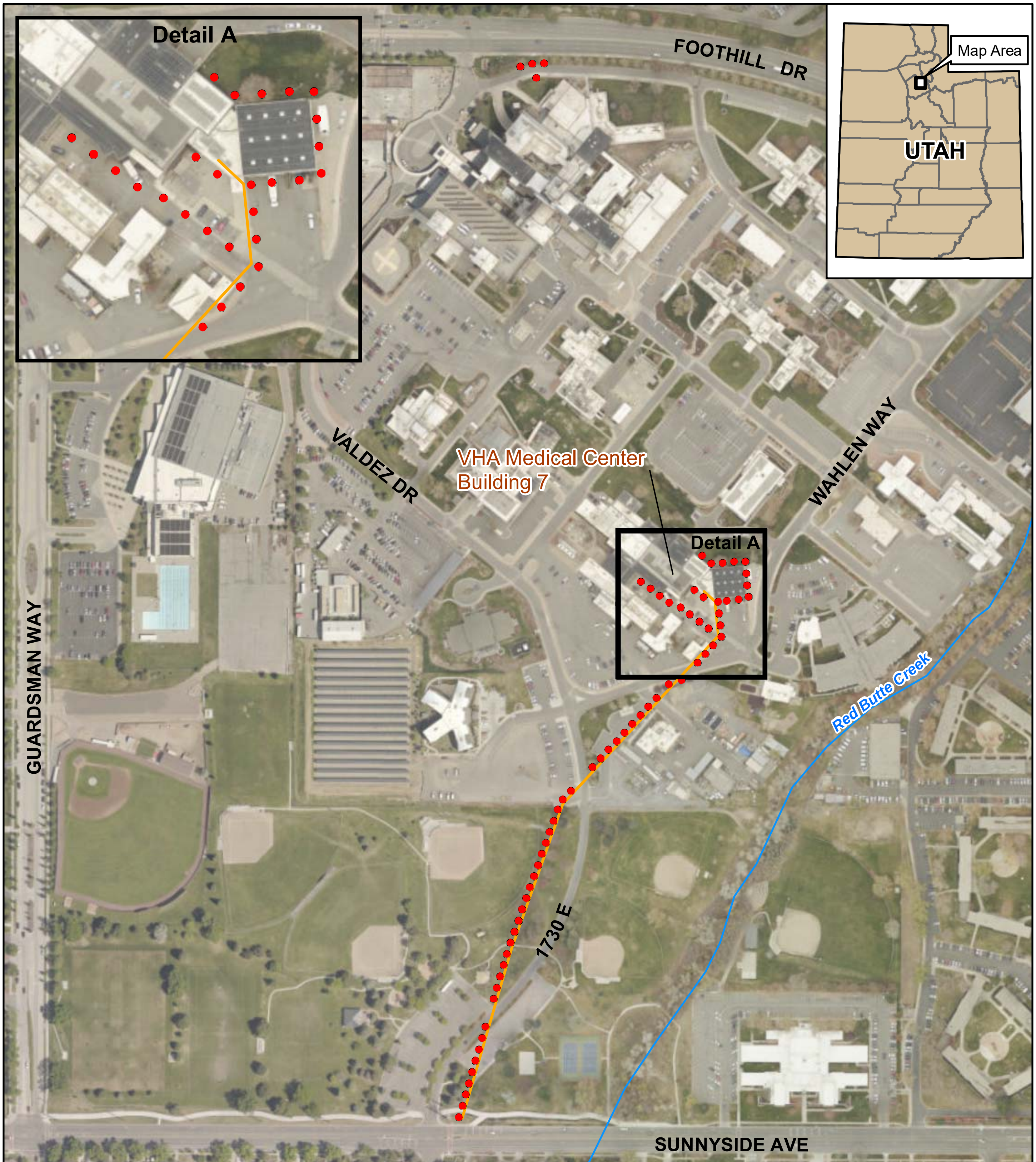
Notes:

AOU = Accelerated Operable Unit
CPT = cone penetration testing
DQO = data quality objective
EPA = U.S. Environmental Protection Agency
ESS = East Side Springs
MCL = maximum contaminant level
PCE = tetrachloroethene
RI = remedial investigation
RIWP = remedial investgation work plan
UDEQ = Utah Department of Environmental Quality

Figure 5-2
Phase I Work Flow Diagram
OU-2 Remedial Investigation Work Plan
700 South 1600 East PCE Plume
Salt Lake City, Utah

ch2m

VHA_WorkFlow_Fig5-2_v3.ai 02.15.18 tdaus



Legend

- Initial Soil Gas Sampling Location
- Sewer Line
- Red Butte Creek

Notes:
- Proposed soil gas sampling locations are approximate and may change based on site conditions. The initial set of sampling locations are shown. Additional locations may be sampled based on results from the initial locations.

N W E S

0 350
Feet
1 inch = 350 feet

FIGURE 5-3
INITIAL SOIL GAS SAMPLING LOCATIONS
OU-2 REMEDIAL INVESTIGATION WORK PLAN
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

ch2m

R:\ENBG\00_Proj\V\VA-SLC_665353\MapFiles\OU2_Remedial_Investigation_Work_Plan\December2017\Initial_Soil_Gas_Sampling_Locations_85x11.mxd jquan 12/28/2017 11:37:05 AM

Legend

- ● Landmark
- ● Proposed Surface Water Sampling Location (1)
- Shallow Groundwater Flow Direction (2)
- PCE Contour Line (µg/L) for Groundwater (3)
- Red Butte Creek
- Fault Line

Notes:
1) Proposed surface water sample locations are approximate and may change according to site conditions and access agreements. Proposed surface water sampling is contingent upon results of groundwater sampling along proposed 1400 East Transect.
(2) Shallow groundwater flow direction within AOU-1 determined from water level data collected from 2/22/2016 and 3/8/2016 (EA, 2016).
(3) PCE contours in shallow groundwater within AOU-1 are based on samples collected from 2/22/2016 and 3/8/2016 (EA, 2016).

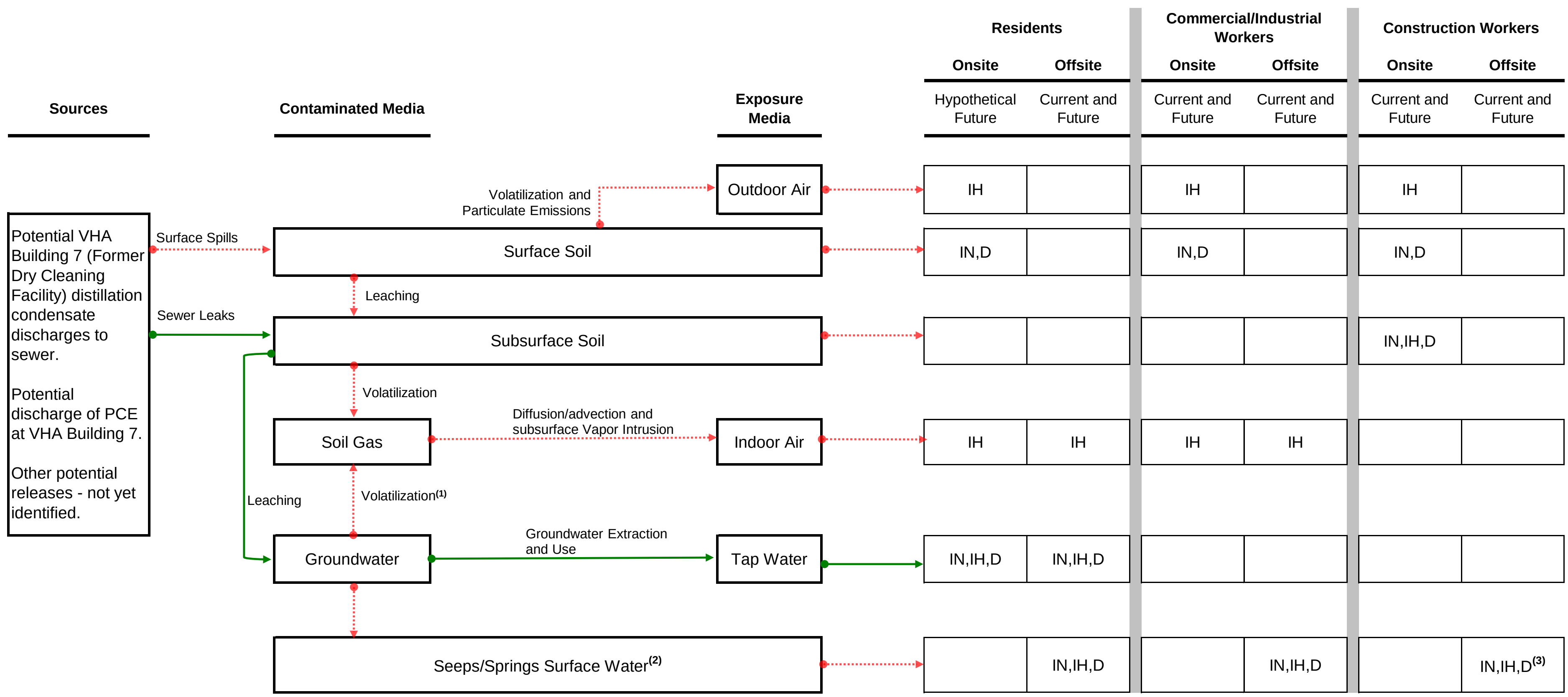
< 1 µg/L = less than 1 microgram per liter
AOU = Accelerated Operable Unit

FIGURE 5-4
PROPOSED SURFACE WATER SAMPLING LOCATIONS
OU-2 REMEDIAL INVESTIGATION WORK PLAN
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

EA Engineering, Science, and Technology, Inc., PBC (EA). 2016. 700 South 1600 East PCE Plume AOU-1 East Side Springs 2016 Groundwater, Surface Water, and Soil Sampling Technical Memorandum. Prepared for VASLCHCS. Final. September.

File Path: R:\ENBG\00_Proj\V\VA-SLC_665353\MapFiles\OU2_Remedial_Investigation_Work_Plan\December2017\Proposed_Surface_Water_Sampling_Locations.mxd jquan 12/28/2017 3:35:41 PM

ch2m.



Potentially Complete Transport Pathway

Insufficient current information to assess pathway

IN	Ingestion
IH	Inhalation
D	Dermal
Blank	Incomplete

Notes

AOU = Accelerated Operable Unit

OU = Operable Unit

PCE = tetrachloroethene

(1) Volatilization from groundwater would not be a significant pathway in areas of deep groundwater

(2) Only seep and springs outside of AOU-1 (if any) will be considered in the OU-2 RI Risk Assessment

(3) Includes potential exposures to nears-surface groundwater during excavation

Figure 5-5

Conceptual Site Exposure Model

OU-2 Remedial Investigation Work Plan

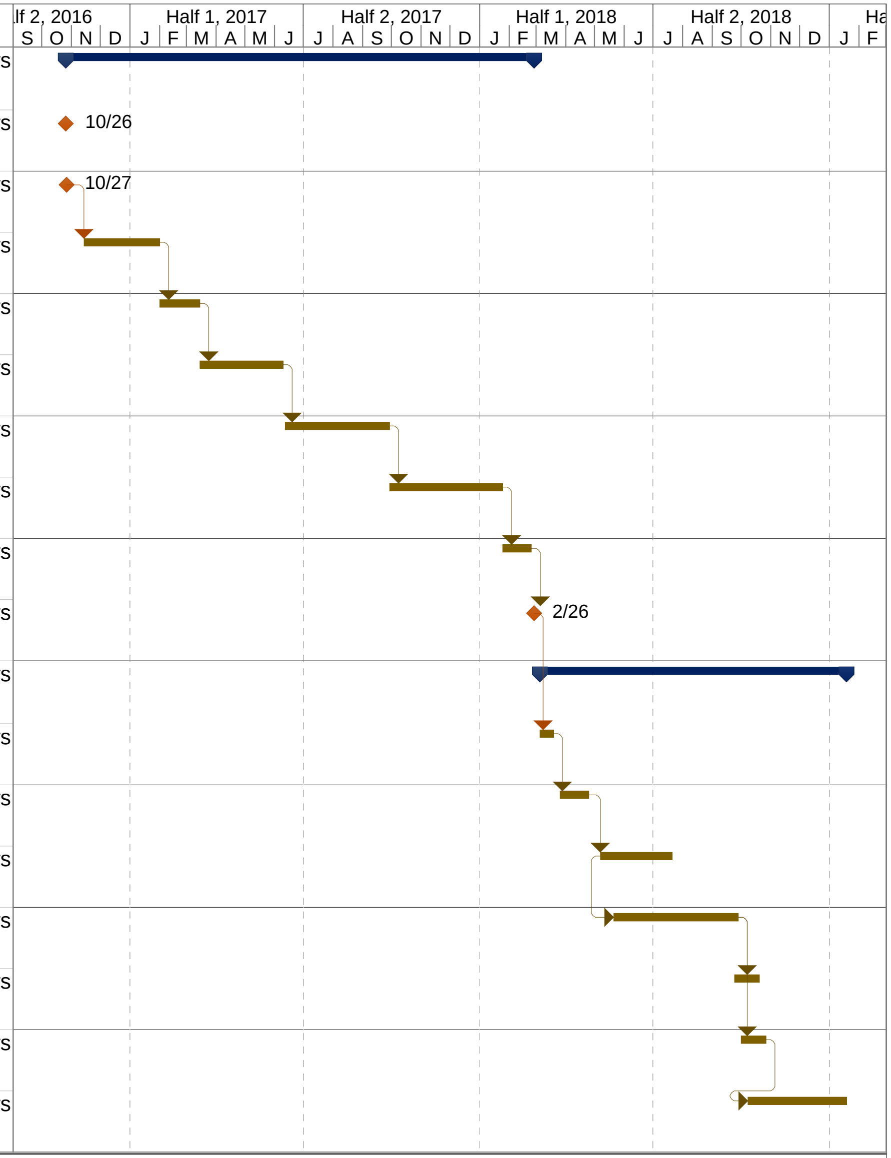
700 South 1600 East PCE Plume

Salt Lake City, Utah

Schedule

The proposed schedule for the RI field activities and deliverables is summarized on Figure 6-1.

ID	Task Name	Duration
1	**RI Work Plan**	489 days
2	Scoping Meeting - Internal	0 days
3	Scoping Meeting - Regulator	0 days
4	Pre-draft	79 days
5	USACE/VHA Review	42 days
6	RTC, Back Check, Produce Draft	87 days
7	EPA/UDEQ Review	109 days
8	RTC and Produce Draft Final	118 days
9	EPA/UDEQ Review/Acceptance	30 days
10	OU-2 RIWP is Finalized	0 days
11	**RI Field Investigation**	320 days
12	Mobilize (utility locate, IDW storage setup, etc.)	14 days
13	Soil Gas Sampling (up to 115 locations with an average of 4 locations sampled per day	30 days
14	Shallow GW Wells (up to 18 wells (7 pairs and 4 individual wells), 3 working days per well on average	75 days
15	Deep GW Wells (up to 6 wells, 15 working days per well on average	130 days
16	Slug and Pump Tests (up to 16 slug tests at 1/day and 2 pump tests at 2 days per test)	26 days
17	Geophysical, Geotech and Flow Logging (assumed)	26 days
18	Data Summary Report	103 days



Project: VA Schedule 2017 01 09
Date: Wed 1/24/18

Task — Milestone — Summary

Figure 6-1
Schedule for Field Activities and Deliverables
OU-2 Remedial Investigation Work Plan
700 South 1600 East PCE Plume
Salt Lake City, Utah

References

Arizona Department of Environmental Quality. 2011. Soil Vapor Sampling Guidance. Accessed January 30, 2017. http://legacy.azdeq.gov/environ/waste/download/svsg.pdf. May 19.

Beacon. 2001. EMFLUX Passive Soil-Gas Survey; Building 515, University of Utah, Salt Lake City, Utah.

Bowen Collins. 2004. *PCE Well Contamination Evaluation.* Technical Memorandum prepared for Salt Lake City Department of Public Utilities. June.

CH2M HILL, Inc. (CH2M). 2017. *2017 Vapor Intrusion Investigation Field Data Report, Accelerated Operable Unit 1, 700 South 1600 East PCE Plume, Salt Lake City, Utah*. September.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2017a. *Conceptual Site Model Update for the 700 South 1600 East PCE Plume AOU-1: East Side Springs, Salt Lake City, Utah.* February.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2017b. *700 South 1600 East PCE Plume, AOU-1: East Side Springs, 2016 Groundwater Data Validation Report*. Final. May.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2017c. *700 South 1600 East PCE Plume, AOU-1: East Side Springs, 2016 Surface Water and Stormwater Data Validation Report.* Final. May.

First Environment. 2015. *Remedial Investigation Work Plan AOU-1: East Side Springs 700 South 1600 East PCE Plume, Salt Lake City, Utah.* Final. July.

IHI Environmental. 2005. Soil Sampling Oversight Report, Sanitary Sewer Line, VASLCHCS Salt Lake City, Utah.

IHI Environmental. 2007. Soil Gas Investigation Report, Sanitary Sewer Lateral VASLCHCS Building 7 to Sunnyside Avenue, Salt Lake City, Utah.

MWH Americas, Inc. (MWH). 2012. *Final Hydrogeological and Groundwater Model Summary Report for: Culinary Water Supply Protection at Salt Lake City's Drinking Water Well #18 (also referred to as the 500 South Well).* Prepared for Salt Lake City Department of Public Utilities. July.

Thiros, S.A., L.M. Bexfield, D.W. Anning, and J.M. Huntington, eds. 2010. Conceptual understanding and groundwater quality of selected basin-fill aquifers in the Southwestern United States. U.S. Geological Professional Paper 1781.

URS Operating Services. 2012. *Trip Report, East Side Springs, Salt Lake City, Utah*. January.

U.S. Environmental Protection Agency (EPA). 1997a. *Soil Screening Guidance.*

U.S. Environmental Protection Agency (EPA). 1997b. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* EPA 540-R-97-006.

U.S. Environmental Protection Agency (EPA). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives.*

U.S. Environmental Protection Agency (EPA). 2012. Hazard Ranking System Documentation Record for 700 South 1600 East PCE Plume. EPA ID No. UTD981548985.

U.S. Environmental Protection Agency (EPA). 2014. 700 South 1600 East PCE Plume. Superfund Site. Accessed December 16, 2016. http://www2.epa.gov/region8/700-south-1600-east-pce-plume.

U.S. Environmental Protection Agency (EPA). 2017a. Vapor Intrusion Screening Levels. Vapor Intrusion. https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-levels-visls.

U.S. Environmental Protection Agency (EPA). 2017b. Regional Screening Levels (RSLs) – User's Guide. Risk Assessment. Accessed December 22, 2017. https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide-november-2017.

Utah Department of Environmental Quality (UDEQ). 2000. *Mount Olivet Cemetery Plume Analytical Results Report.* Division of Environmental Response and Remediation.

Utah Department of Environmental Quality (UDEQ). 2011. *Preliminary Assessment – East Side Springs, Salt Lake County, Utah*. Division of Environmental Response and Remediation.

Utah Department of Environmental Quality (UDEQ). 2012. *East Side Springs, Salt Lake County, Utah Site Investigation Analytical Results Report, UTN000802825.* Division of Environmental Response and Remediation).

Appendix A
Sampling and Analysis Plan

Appendix A.1
Field Sampling Plan

FINAL

Field Sampling Plan
OU-2 Remedial Investigation (Phase 1)
700 South 1600 East PCE Plume
Salt Lake City, Utah

Contract No. W912DQ-15-D-3014 Task Order 0005

Prepared for

U.S. Army Corps of Engineers

Kansas City District
601 East 12th Street
CENWK-PM-ES
Kansas City, MO 64106-2824

Department of Veterans Affairs

Veterans Health Administration Salt Lake City Health Care System
500 Foothill Drive
Salt Lake City, UT 84148

February 2018

ch2m

CH2M HILL, Inc.
4246 South Riverboat Road
Suite 210
Taylorsville, Utah 84123

STATEMENT OF TECHNICAL REVIEW

OU-2 Remedial Investigation for 700 South 1600 East PCE Plume, Salt Lake City, UT

Final Field Sampling Plan

The CH2M HILL, Inc. team has completed the technical review of the submittal of the Final Field Sampling Plan. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Contractor Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, using justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with the law and existing U.S. Army Corps of Engineers policy.

Technical Reviewer	Signature	Date of Review
Gary Colgan		1/23/2018
	Signature	Date

Quality Control System Manager or Project Manager	
David Waite	
	2/19/2018
Signature	Date

Independent Technical Reviewer	
Peter Lawson	
	01/05/2018
Signature	Date

Contents

Section Page

Appendix

Tables

Figures

Acronyms and Abbreviations

AOU	Accelerated Operable Unit
bgs	below ground surface
COC	chain-of-custody
DCE	dichloroethene
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
ESS	East Side Springs
FSP	field sampling plan
GC/MS	gas chromatography/mass spectrometer
HAPSITE	HAPSITE Smart Plus
HSS	headspace sampling system
ID	identification
IDW	investigative-derived waste
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
ORP	oxidation-reduction potential
OU	operable unit
PCE	tetrachloroethene
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RI	remedial investigation
RIWP	remedial investigation work plan
SC	specific conductance
SOP	standard operating procedure
SVOC	semivolatile organic compound
TCE	trichloroethene
UDEQ	Utah Department of Environmental Quality
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
VA	Department of Veterans Affairs
VHA	Veterans Health Administration
VISL	vapor intrusion screening level
VOC	volatile organic compound
ZIST	Zone Isolation Sampling Technology

Objectives

The objective of this field sampling plan (FSP) is to describe field and laboratory activities associated with Phase 1 of the Operable Unit 2 (OU-2) remedial investigation (RI) of the 700 South 1600 East tetrachloroethene (PCE) Plume Superfund Site in Salt Lake City, Utah (site). The FSP and the quality assurance project plan (QAPP) are companion documents to the RI Work Plan (RIWP), which presents the objectives of the RI and provides additional background information on the site.

The field investigation work for Phase 1 of the RI includes monitoring wells installation, aquifer testing on new and existing monitoring wells, geotechnical sample collection and testing, geophysical logging on selected monitoring wells, groundwater monitoring of new and existing monitoring wells, surface water sampling, soil gas surveys, and potential subsurface soil sampling. Phase 1 RI field activities will provide additional data that will be used to more thoroughly define the hydrostratigraphy and hydrogeologic characteristics of the site, assess the nature and extent of groundwater PCE contamination, and identify the need for future phases of field work.

Site Background

This section provides a brief description of the physical and hydrological setting of the site. The RIWP and the *Conceptual Site Model Update for the 700 South 1600 East PCE Plume AOU-1: East Side Springs, Salt Lake City, Utah* (EA, 2017a) provide additional information on the regulatory history of the site in addition to a detailed discussion of the geology, lithology, and hydrology of the site.

2.1 Site Description

The site is in the eastern portion of the Salt Lake Valley in the northwestern part of the State of Utah. The Salt Lake Valley alluvial basin is bounded to the east by the Wasatch Mountains, a north to northwest trending mountain range formed by uplift along the Wasatch Fault. Surface and groundwater in the valley ultimately drain to the Great Salt Lake, a terminal salt water lake that forms the northern boundary of the Salt Lake Valley. To the west and south, the valley is bounded by the Oquirrh and the Traverse Mountains, respectively. Altitudes in the valley range from approximately 5,200 feet at the foot of the Wasatch Mountains to approximately 4,200 feet at the Great Salt Lake (Thiros, 2010).

The site is southwest of the University of Utah campus near the intersection of 700 South and 1600 East in Salt Lake City, Utah. Some major streets in the vicinity of the 700 South and 1600 East PCE plume (site) include 500 South to the north, Michigan Avenue to the south, 1100 East to the west, and Foothill Drive to the east. The Mount Olivet Cemetery, East High School, and University of Utah athletics facilities, in addition to residential neighborhoods, are in the vicinity of the 700 South and 1600 East PCE plume. Surface water features in the vicinity of the 700 South and 1600 East PCE plume include Mount Olivet Reservoir, Red Butte Creek, Liberty Park Pond, and multiple seeps and springs. The East Side Springs (ESS) area, where groundwater surfaces along the Wasatch Fault, is in the southwest portion of the site. Groundwater resources in the site area include three irrigation wells (Fountain of Ute, University of Utah Well #1, and Mount Olivet well), a presently offline drinking water production well (SLC-18), and six monitoring wells installed during previous investigations of the PCE plume at the site (EPA-MW-01S, EPA-MW-01D, EPA-MW-02, EPA-MW-04, EPA-MW-05R, and EPA-MW-06).

In the eastern portion of the Salt Lake Valley, groundwater moves from primary recharge areas at the Wasatch Mountain front southwest to discharge to the Jordan River and ultimately the Great Salt Lake (EA, 2017a). Previous reports indicate local groundwater flow in the vicinity of the Department of Veterans Affairs (VA) Medical Center moves northwest to west-northwest. However, interpretations of local groundwater flow rely on a limited dataset and may be influenced by surveying errors (UDEQ, 2000; EA, 2017a). Any surveying errors will be corrected during the Phase 1 RI work. In addition, pumping from the University of Utah Well #1 may contribute to distortion in the upper potentiometric contours (EA, 2017a). Shallow groundwater within the ESS area flows to the southwest.

2.1.1 Source Area Identification

Although the VA Medical Center Building 7 has been identified as the likely source of the PCE plume, additional investigation is required to (1) definitively trace the PCE plume back to this location, (2) identify or eliminate other potential primary sources, and (3) determine if secondary sources downgradient of the primary source may be contributing to PCE and/or trichloroethene (TCE) contamination at the site. This data gap will be in part addressed through soil gas surveys conducted in the vicinity of the VA Medical Center and the Sunnyside Avenue sewer line in Phase 1 of the RI. In addition, groundwater and surface water sampling results obtained in Phase 1 of the RI may be used to address this data gap.

2.1.2 Characterization of Site Geology, Hydrostratigraphy, and Hydrogeology

Understanding local groundwater flow is essential to characterizing this site. Site characterization will be addressed by installing and instrumenting additional groundwater monitoring wells and the testing and sampling of existing monitoring wells. Site geology will be characterized through borehole logs, detailed lithology descriptions recorded during the installation of new monitoring wells, and geotechnical and geophysical measurements. The hydrogeology and hydrostratigraphy of the site will be characterized through the installation of multilevel monitoring wells, geophysical measurements, aquifer testing on new and existing monitoring wells, the installation and monitoring of pressure transducers to monitor long-term fluctuations in water levels, and collection of groundwater samples and field parameter data from new and existing monitoring wells. More information about these various investigation techniques is included in Section 5. Data collected during Phase 1 will be used to develop a groundwater flow and transport plume model. After the new monitoring wells have been installed, a groundwater flow and transport model QAPP will be developed for regulatory review and comment.

2.1.3 Identification of Potential Exposure Points

Potential exposure points for the site include exposure to groundwater through irrigation and drinking water, contact with contaminated surface water in residential areas and storm drains, and contact with contaminated soil-gas through vapor intrusion. Vapor intrusion and direct contact of surface water are addressed in the RI for Accelerated Operable Unit 1 (AOU-1). OU-2 will focus on exposures through groundwater. Groundwater data will be essential to identifying the potential risk associated with exposure through irrigation and drinking water. Surface water, shallow groundwater, shallow soil, and soil-gas data will provide additional information on the potential human health risks at the site. Ecological risks within AOU-1 will be addressed through the ecological risk screening for AOU-1, which will be presented in the AOU-1 RI report. Ecological risk screening for OU-2 will be evaluated in Phase 2 of the OU-2 RI, as described in Section 5.3.5 of the RIWP.

Rationale for Sample Locations and Laboratory Analyses

3.1 Monitoring Well Installation

Monitoring well installation and development details are discussed in detail in Section 5.1. The rationale for the proposed monitoring well locations and construction details are discussed is the following subsection.

3.1.1 Shallow Monitoring Wells

Shallow monitoring wells will be installed in the ESS area and in a transect generally along 1400 East.

Six shallow groundwater monitoring well pairs will be installed in the vicinity of the ESS area (MW-12S/D, MW-13S/D, MW-14S/D, MW-15S/D, MW-16S/D, and MW-17S/D), one shallow groundwater monitoring well pair will be installed near the intersection of Sunnyside Avenue and 1400 East (MW-20S/D), and four single shallow groundwater monitoring wells (MW-18, MW-19, MW-21, and MW-22) will be installed along 1400 East (1400 East transect) (Table 3-1, Figure 3-1). Shallow monitoring well pairs will consist of a clustered shallow and deeper well drilled within a radius of 5 to 10 feet (Figure 3-2). As mentioned in the RIWP, many of these monitoring wells are proposed to be screened in multiple intervals to provide additional data for vertical delineation of the plume, and to better characterize the complex hydrogeology at the site. For each monitoring well pair, the upper monitoring well would consist of a 10-foot well screen across the water table, and the well screen for the lower well in the pair would begin approximately 40 feet below the bottom of the upper monitoring well and also consist of a 10-foot well screen. In the ESS area, the total depth of the upper well in each monitoring well pair is estimated to range from approximately 15 to 45 feet below ground surface (bgs). The total depth of the lower well in each monitoring well pair would range from approximately 65 to 95 feet bgs. Along the 1400 East transect, the bottom of the well screens in the monitoring well pair are estimated to be up to 100 and 150 feet bgs, respectively, and the total depths of the single monitoring wells are expected to be up to approximately 100 feet bgs. Monitoring well depths may be increased in coordination with Veterans Health Administration (VHA) and U.S. Army Corps of Engineers (USACE) depending on field observations (for example, depth to groundwater) and drill rig capabilities.

The primary objectives of the shallow groundwater monitoring wells are to (1) evaluate the relationship between volatile organic compounds (VOCs) measured in the ESS area and VOCs measured in the U.S. Environmental Protection Agency (EPA) monitoring wells on and near VHA property, (2) evaluate the impact of the fault planes on groundwater flow and plume migration, and (3) help identify the width and leading edge of the plume. The location and monitoring well construction details are summarized below and in Table 3-1. The proposed location and construction details may change in response to field conditions.

The paired shallow monitoring wells MW-12S/D, MW-13S/D, MW-14S/D, MW-15S/D, MW-16S/D, and MW-17S/D will be located across the estimated area of shallow PCE contamination in the ESS area (Figure 3-1; see Figure 3-6 for shallow PCE concentrations), which forms a southwest trending transect across the west fault spur.

The clustered shallow monitoring well at Sunnyside Avenue and 1400 East (MW-20S/D) is located in-line with the preliminarily defined groundwater flow path connecting PCE observed at EPA-MW-01S/D and the ESS PCE hotspot (Figures 3-1 and 3-6).

The remaining four 1400 East transect shallow monitoring wells are planned as individual 2-inch monitoring wells. The screen interval (10 to 20 feet) will likely be set at between a depth of approximately 90 to 100 feet bgs; however, the actual screened intervals will be determined based on the water level and lithology. Combined with the transect cluster well, these five monitoring wells form a perpendicular transect across the preliminarily defined shallow groundwater flow direction (Figures 3-1 and 3-6). The 1400 East transect crosses the mapped fault trace of the eastern spur, thus field reconnaissance before drilling will attempt to establish drilling locations at consistent surface elevations.

3.1.2 Deep Monitoring Wells

It should be noted that the existing EPA 1998 monitoring wells, with the exception of EPA-MW-01D, are screened in the upper portion of the saturated zone, ranging in depths from 130 to 224 feet bgs (Table 3-3 includes existing screen intervals). The proposed deep monitoring wells will extend to depths greater than these monitoring wells, thus screening potential multiple zones to better assess the extent of impact within the plume identified by the EPA 1998 monitoring wells.

Six deep monitoring wells (MW-03R, MW-07, MW-08, MW-09, MW-10, and MW-11) will be installed across the site to a maximum depth of 500 feet bgs (Figure 3-1). The proposed deep monitoring wells will be constructed in several ways and screened in multiple intervals to optimize collection of hydrogeologic data and assess the vertical extent of PCE contamination in the site. Push-ahead groundwater sampling will be used to vertically-delineate groundwater VOC concentrations during drilling, thus helping refine target horizons for well construction. The well construction details and locations are described below and in Table 3-1. **Construction details and total depth from well to well may change according to field conditions** (for example, results of push-ahead groundwater sampling, water level, and lithology based on field logging and natural gamma logging). For all monitoring wells, the boring logs and natural gamma logging will be used to ensure that well screens are not placed across hydrostratigraphic units (across aquitards), if any are present.

Selected deep monitoring wells are planned to be constructed as Zone Isolation Sampling Technology (ZIST) wells. The ZIST wells allow for:

- Characterization of groundwater contamination within thin hydrostratigraphic units (for example, a perched water lens)
- Monitoring of more vertical intervals within a single borehole, because the well casings for ZIST wells are narrower than 2-inch or larger well screens

The narrow diameter of the ZIST well casings (7/8-inch to 1.25-inch) will not allow for geophysical testing in these wells. However, the benefits provided by these ZIST wells, including improved vertical delineation of site contaminants and the ability to target specific zones of interest, far outweigh the loss of geophysical tests in these locations. Natural gamma will still be performed, through the drill casing, for all ZIST well locations.

Monitoring well MW-03R will be installed near the former location of EPA-MW-03, a monitoring well installed by EPA, which was abandoned during construction of the ice arena at the Salt Lake City Sports Complex. One potential monitoring well configuration for MW-03R includes one ZIST well and one 5-inch monitoring well installed within the same boring. The ZIST screen will be placed in the interval between approximately 190 and 210 feet bgs to allow a direct comparison to historical data from EPA-MW-03, which was screened in a shallow zone from 190 to 210 feet bgs. The 5-inch monitoring well will consist of a 20-foot-long screened interval below 210 feet bgs based on field observation and readings.

MW-07 will be installed in the vicinity of the Mount Olivet Cemetery Well. One potential monitoring well configuration for MW-07 includes four ZIST multilevel wells with up to two screens placed in the upper 200 feet of the well and two screens placed below 200 feet bgs (Figure 3-3). MW-07 is intended to provide information about the vertical extent of PCE in this area at four vertical intervals. The Mount Olivet irrigation well is screened in four discrete intervals, spanning a total of 288 feet from the top of the first well screen to the bottom of the last well screen (EA, 2017a). Multilevel ZIST intervals will be labeled with a letter suffix to differentiate sample zones. For instance, the four planned ZIST intervals for MW-07 will be labeled from shallow to deep: MW-07a, MW-07b, MW-07c, and MW-07d.

MW-08 will be installed near the southwestern corner of Mount Olivet Cemetery. One potential monitoring well configuration for MW-08 includes two nested 2-inch monitoring wells (Figure 3-4). One 10- to 20-foot-long screen will be placed in the upper 200 feet of the boring and one 10- to 20-foot-long screen will be placed below 200 feet bgs. The primary objective of this monitoring well is to characterize groundwater flow and PCE transport across the eastern fault spur, and complement the 1400 East transect (Figure 3-1).

MW-09 will be installed southeast, upgradient, of the former drinking water-supply well SLC-18, in an area between Building 7 at the VA Medical Center and SLC-18. Historically elevated concentrations of PCE have been measured at SLC-18, with higher concentrations measured in the upper half of the screened interval (260 to 470 feet bgs) (MWH, 2012). The objective at this location is to characterize lithology and current PCE concentrations in this area. Construction at MW-09 is planned as one 5-inch monitoring well with a 20-foot-long screen interval placed below 200 feet bgs (Figure 3-5).

MW-10 will be installed at the southern end of Sunnyside Park along Sunnyside Avenue. One potential monitoring well configuration for MW-10 includes two nested 2-inch wells with 20-foot-long screened intervals between approximately 250 and 350 feet bgs and 400 and 500 feet bgs (Figure 3-4). This monitoring well completes the southern boundary of the Guardsman Way transect, and will help define the lateral extent of the PCE plume.

MW-11 will be located on the University of Utah property, cross-gradient of VHA property and upgradient of SLC-18 (Figure 3-1). One potential monitoring well configuration for MW-11 includes two nested 2-inch monitoring wells with 20-foot-long screened intervals located between approximately 250 and 350 and 400 and 500 feet bgs (Figure 3-4). Data collected from MW-11 will help establish the groundwater potentiometric surface as well as providing a northern boundary for the Guardsman Way transect for nature and extent.

3.2 Subsurface Geotechnical Soil Sampling Associated with Monitoring Well Installation

Geotechnical samples will be collected from soil cores collected during installation of shallow and deep monitoring wells. The sample locations, frequency, and requested analyses are discussed in the following subsections and summarized in Table 3-2. Subsurface chemical soil samples that may be collected during the soil gas screening program are discussed in Section 3.5.

Table 3-1. Summary of Proposed Monitoring Wells
Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

Label	Approximate Location	Possible Well Type	Possible Screened Intervals[b] (depths in feet bgs)	Comments
Deep Monitoring Wells				
MW-03R	Western Boundary of VHA Property, Adjacent to Valdez Drive	One ZIST and one 5-inch well	ZIST screen in upper 200 feet; 20-foot long 5-inch screen below 200 feet	Lithology and soil cores will be logged to 500 feet bgs
MW-07	Southeastern corner of Mount Olivet Cemetery	ZIST multilevel wells	Up to two screens in upper 200 feet; two screens below 200 feet	Lithology and soil cores will be logged to 500 feet bgs
MW-08	Southwestern corner of Mount Olivet Cemetery	Nested 2-inch wells	One screen in upper 200 feet; one 20-foot screen below 200 feet	Ground surface at MW-08 is approximately 50 feet lower than Mount Olivet Well. Maximum well depth is 500 feet bgs
MW-09	Southeast (upgradient) of SLC-18	5-inch well	One 20-foot screen below 200 feet	Lithology and soil cores will be logged to 500 feet bgs
MW-10	Sunnyside Avenue, east of Guardsman Way	Nested 2-inch wells	One 20-foot screen in upper 200 feet; one 20-foot screen below 200 feet	Maximum well depth is 500 feet bgs
MW-11	University of Utah property	Nested 2-inch wells	One 20-foot screen between 250 and 350 feet; one 20-foot screen between 400 and 500 feet	Maximum well depth is 500 feet bgs
Shallow Monitoring Wells				
MW-12S/D[a]	South of 800 South, along 100 East	Clustered 2-inch wells	35–45 and 85–95	Screened intervals will be determined based on water levels and lithology
MW-13S/D[a]	North of 900 South at the southwest corner of East High School	Clustered 2-inch wells	25–35 and 75–85	
MW-14S/D[a]	South of 900 South at the cul-de-sac on Alpine Place	Clustered 2-inch wells	5–15 and 55–65	
MW-15S/D[a]	Intersection of Belmont Avenue and McClelland Street	Clustered 2-inch wells	35–45 and 85–95	
MW-16S/D[a]	Corner of 800 South and Elizabeth Street	Clustered 2-inch wells	10–20 and 60–70	
MW-17S/D[a]	West of 1300 East at the bend of Gilmer Drive	Clustered 2-inch wells	10–20 and 60–70	
MW-18	Along 1400 East, south of MW-08 and Mount Olivet Cemetery, crossing Sunnyside Avenue, and continuing south	2-inch well	90–100	Screened intervals will be determined based on water levels and lithology.
MW-19		2-inch well	90–100	
MW-20S/D[a]		Clustered 2-inch wells	90–100 and 140–150	
MW-21		2-inch well	90–100	
MW-22		2-inch well	90–100	

[a] Shallow monitoring wells labeled S/D are clustered 2-inch wells drilled approximately 5 to 10 feet apart.
[b] Screen intervals and length will be determined based on water levels, lithology, push-ahead groundwater sampling, and site conditions encountered during drilling.

Table 3-2. Target Analyte List and Estimated Number of Samples
Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

Sample Type	Method Group	Analysis	Method	Frequency: Deep Monitoring Wells (Subsurface Soil and Groundwater Samples)	Frequency: Shallow Monitoring Wells (Subsurface Soil and Groundwater Samples)	Estimated Number of Samples[a]	Number of QA/QC Samples[b]	Comments
Subsurface Soil[f]	Laboratory Organic Carbon Analyses	Fraction Organic Carbon	ASTM D2974	Two to three samples per lithologic unit, collected from multiple boreholes[c]	Two to three samples per lithologic unit, collected from multiple boreholes[c]	12–18 (total for site)	2	QA/QC samples will consist of field duplicates only.
	Laboratory Mineralogical Analyses[d]	Magnetic Susceptibility	Microbial Insights Method	To be determined[e]	To be determined[e]	6–10 (total for site)	1	QA/QC samples will consist of field duplicates only.
	Laboratory Physical Properties Tests[g]	Sieve	ASTM D6913	Two to three samples per lithologic unit, collected from multiple boreholes[c]	Two to three samples per lithologic unit, collected from multiple boreholes[c]	12–18 (total for site)	NA	
		Dry Bulk Density	ASTM D2937	One sample per lithologic unit, collected from multiple boreholes[c]	One sample per lithologic unit, collected from multiple boreholes[c]	4–8 (total for site)	NA	Samples will be collected at the same time as vertical permeability.
		Hydrometer	ASTM D422a	Two to three samples per lithologic unit, collected from multiple boreholes[c]	Two to three samples per lithologic unit, collected from multiple boreholes[c]	12–18 (total for site)	NA	
		USCS Soil Classification/ Atterberg Limits/ Gradation	ASTM D2487/ ASTM D4318/ ASTM D1140	Two to three samples per lithologic unit, collected from multiple boreholes[c]	Two to three samples per lithologic unit, collected from multiple boreholes[c]	12–18 (total for site)	NA	
		Vertical Permeability	ASTM D2434	One per lithologic unit, collected from multiple boreholes[c]	One per lithologic unit, collected from multiple boreholes[c]	4–8 (total for site)	NA	For selected samples only from finer-grained layers.
		Moisture Content	ASTM D2216	One per 20 feet in upper 200 feet of 2 boreholes; up to 4 samples in remaining boreholes	NA	20–36 (total for site)	NA	Samples will be selected for submittal at the discretion of the site geologist.
Groundwater[h]	Laboratory Chemical Analyses (Contaminants)	PCE, TCE, and cis-1,2-DCE	HAPSITE method	One push-ahead approximately every 20 feet (starting at water table (approximately 120 feet bgs) to total depth for each boring	NA	114 (total for site)	16	
		VOCs	SW8260C	1 in 10 push-ahead samples	NA	12 (total for site)	4	

Table 3-2. Target Analyte List and Estimated Number of Samples

Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

				Frequency				
Sample Type	**Method Group**	**Analysis**	**Method**	**Deep Monitoring Wells (Subsurface Soil and Groundwater Samples)**	**Shallow Monitoring Wells (Subsurface Soil and Groundwater Samples)**	**Estimated Number of Samples[a]**	**Number of QA/QC Samples[b]**	**Comments**
Groundwater[h] *(continued)*	Laboratory Chemical Analyses (Contaminants) *(continued)*			One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	Trip blanks will be submitted at a frequency of 1 per cooler of VOCs.
		SVOCs	SW8270D	One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	
		Unfiltered - Total Metals	SW6010C/7470A	One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	
		Pesticides	SW8081B	One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	
	Laboratory Chemical Analyses (General Water Quality and Natural Attenuation Parameters)	Stable Isotopes of Hydrogen and Oxygen	Isotope Ratio Mass Spectrometry	One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	4	QA/QC samples will consist of field duplicates only.
		Total Organic Carbon	SW9060	One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	
		Total Dissolved Solids	SM2540C	One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	
		Chloride	E300.0	One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	
		Sulfate		One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	
		Nitrate/Nitrite		One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	
		Alkalinity	SM2320B	One sample per screen interval per well (new and existing monitoring wells) per round of sampling		37	8	39
	Field parameters	pH, DO, ORP, SC, Temperature, Turbidity	NA: field meter	NA		NA	NA	Field parameters will be measured prior to collecting samples at each monitoring well.

Table 3-2. Target Analyte List and Estimated Number of Samples
Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

Sample Type	Method Group	Analysis	Method	Frequency: Deep Monitoring Wells (Subsurface Soil and Groundwater Samples)	Frequency: Shallow Monitoring Wells (Subsurface Soil and Groundwater Samples)	Estimated Number of Samples[a]	Number of QA/QC Samples[b]	Comments
Surface Water[i]	Laboratory Chemical Analyses (Contaminants)	VOCs	SW8260C	One sample per sample location per round of sampling		8	3	Trip blanks will be submitted at a frequency of 1 per cooler of VOCs.
		SVOCs	SW8270D	One sample per sample location per round of sampling		8	3	
		Unfiltered – Total Metals	SW6010C/7470A	One sample per sample location per round of sampling		8	3	
		Pesticides	SW8081B	One sample per sample location per round of sampling		8	3	
	Laboratory Chemical Analyses (General Water Quality and Natural Attenuation Parameters)	Stable Isotopes of Hydrogen and Oxygen	Isotope Ratio Mass Spectrometry	One sample per sample location per round of sampling		8	1	QA/QC samples will consist of field duplicates only.
		Total Organic Carbon	SW9060	One sample per sample location per round of sampling		8	3	
		Total Dissolved Solids	SM2540C	One sample per sample location per round of sampling		8	3	
		Chloride	E300.0	One sample per sample location per round of sampling		8	3	
		Sulfate		One sample per sample location per round of sampling		8	3	
		Nitrate/Nitrite		One sample per sample location per round of sampling		8	3	
		Alkalinity	SM2320B	One sample per sample location per round of sampling		8	3	
	Field parameters	pH, DO, ORP, SC, Temperature, Turbidity	NA: field meter	NA		NA	NA	Field parameters will be measured prior to collecting surface water samples.
Soil Gas[j]	HAPSITE Portable GC/MS	PCE, TCE, and cis-1,2-DCE	HAPSITE method	One sample per sample location		71	NA	Initial number of soil gas samples; more may be collected based on HAPSITE data for initial samples.
	Laboratory Analyses	VOCs	TO-15	One sample per 10 sample locations		8	NA	Samples will be submitted for verification of HAPSITE results.

Table 3-2. Target Analyte List and Estimated Number of Samples
Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

				Frequency				
Sample Type	**Method Group**	**Analysis**	**Method**	**Deep Monitoring Wells (Subsurface Soil and Groundwater Samples)**	**Shallow Monitoring Wells (Subsurface Soil and Groundwater Samples)**	**Estimated Number of Samples[a]**	**Number of QA/QC Samples[b]**	**Comments**
Subsurface Soil (based on soil gas results)[k]	Laboratory Analyses	VOCs	Method 8260	NA		NA	NA	Quantify soil contamination in areas identified to have elevated VOCs in soil gas.

[a] Estimated number of soil samples may change in response to conditions encountered during drilling (for example, the number of lithologic units encountered). The estimated number of groundwater and surface water samples listed is per sampling round. After the initial sampling round, additional sampling rounds will be conducted quarterly for at least 4 quarters.
[b] QA/QC sample frequency is summarized in Table 3-4. Trip blanks are not included in total.
[c] The same lithologic units may be observed in multiple boreholes; as such, sampling frequency for these soil samples refers to the identification and sampling of unique lithologic units instead of individual boreholes. This could include multiple samples from one boring location and none from another. Additionally, samples may be collected and held for submittal until the remaining boring and geotechnical sample collection activities are complete to best use the analysis to meet project goals. The estimated numbers of samples provided in Table 3-2 are the total expected to be collected across the project site to assess and potentially correlate various observed lithologic units.
[d] Mineralogical analyses samples will be selected with a preference to align with monitoring well screen intervals.
[e] Samples will be collected approximately every 50 feet of depth per boring. A total of 6 to 10 samples will be selected for submittal.
[f] Samples will be collected during the installation of new monitoring wells.
[g] QC samples will not be submitted for laboratory physical properties tests.
[h] One sample will be collected per screened interval per sample location during baseline and quarterly groundwater monitoring (Table 3-3 shows sample locations).
[i] One sample will be collected per surface water sampling location. Surface water sampling will be conducted in conjunction with groundwater sampling.
[j] Sample locations are spaced approximately every 30 feet in the selected sample areas; Figure 3-7 shows sample locations.
[k] Soil gas-related subsurface soil samples will only be collected if the soil gas HAPSITE results indicate a 10-times exceedance to the residential VISL.

Notes:
DCE = dichloroethene
DO = dissolved oxygen
GC/MS = gas chromatography/mass spectrometer
HAPSITE = HAPSITE Smart Plus
NA = not applicable
ORP = oxidation-reduction potential
QA/QC = quality assurance/quality control
SC = specific conductivity
SVOC = semivolatile organic compound
USCS = Unified Soil Classification System
VISL = vapor intrusion screening level

3.2.1 Sample Locations and Frequency

Subsurface geotechnical soil samples will be collected from the six deep monitoring wells (MW-03R, MW-07, MW-08, MW-09, MW-10, and MW-11) and the eleven shallow monitoring wells (seven clustered monitoring wells and four individual 2-inch monitoring wells). The monitoring well locations and construction details are discussed in Section 3.1 and in Table 3-1. Subsurface sample frequencies are summarized in Table 3-2. The frequency of geotechnical sample collection will be based on the number of lithological units encountered, not the number of monitoring wells that are drilled. The same lithologic unit may be observed in multiple boreholes. As such, frequency refers to the identification of distinct lithologic units instead of individual boreholes. This could include multiple samples from one boring location and none from another. In addition, samples may be collected and held for submittal until the remaining boring and geotechnical sample collection activities are complete to best use the analysis to meet project goals. The estimated numbers of samples provided in Table 3-2 are the total expected to be collected across the project site to assess and potentially correlate various observed lithologic units.

3.2.2 Number of Samples

The total number of geotechnical samples collected will be determined based on the total depth drilled during deep and shallow monitoring well installation and the number of distinct water bearing (lithologic) zones encountered. The sample frequencies are summarized in Table 3-2. Quality assurance/quality control (QA/QC) samples for select soil sample test methods will consist of field duplicates, as outlined in Table 3-2.

3.2.3 Geotechnical Laboratory Analyses

Subsurface geotechnical soils samples will be submitted for the following analyses (summarized in Table 3-2):

- Fraction of Organic Carbon (ASTM D2974)
- Laboratory mineralogical analysis pertinent to assessment of abiotic PCE degradation (magnetic susceptibility)
- Laboratory physical properties:
  - Sieve (ASTM D6913)
  - Dry bulk density (ASTM D2937)
  - Hydrometer (ASTM D422a)
  - Unified Soil Classification System (USCS) soil classification/Atterberg limits/gradation (ASTM D2487/ASTM D4318/ASTM D1140)
  - Vertical permeability (ASTM D2434)
  - Moisture content (ASTM D2216)

3.3 Groundwater Sampling

Groundwater samples will be collected from new and existing monitoring wells at the site as described below. Table 3-3 includes a summary of groundwater sample locations.

3.3.1 Sample Locations and Frequency

In addition to the new monitoring wells to be installed, groundwater sample locations will include the five existing monitoring well locations (EPA-MW-01S/D, EPA-MW-02, EPA-MW-04, EPA-MW-05R, EPA-MW-06). An initial groundwater sampling event will be conducted after the completion of monitoring well installation and development. Additional sampling rounds, after the initial sampling round, will be conducted quarterly for at least four quarters. The frequency of future groundwater sampling will be assessed after the quarterly sampling has concluded. If a groundwater sampling location becomes temporarily inaccessible, the location will be sampled as soon as the site is again accessible. If a site becomes permanently inaccessible, discussion about abandonment and sample relocation will occur among VHA/USACE, EPA, and Utah Department of Environmental Quality (UDEQ).

Table 3-3. Summary of Groundwater Sampling Locations
Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

	Location ID	Well Screen Interval(s)[a] (feet bgs)	Latitude	Longitude	Comments
Existing Monitoring Wells	EPA-MW-01S/D	184–224 364–404	40.754157	-111.845086	
	EPA-MW-02	175.5–202.5	40.754099	-111.843134	
	EPA-MW-04	143–173	40.752133	-111.843739	
	EPA-MW-05R	186–221	40.755969	-111.839180	EPA-MW-05R replaced EPA-MW-05 in 2016
	EPA-MW-06	100–130	40.751363	-111.840428	
Proposed Deep Monitoring Wells[b]	MW-03R	One screen in upper 200 feet; one screen below 200 feet	--	--	MW-03R will replace EPA-MW-03
	MW-07	Up to two screens in upper 200 feet; two screens below 200 feet	--	--	
	MW-08	One screen in upper 200 feet; one screen below 200 feet	--	--	
	MW-09	One screen below 200 feet	--	--	
	MW-10	One screen above 200 feet; one screen below 200 feet	--	--	
	MW-11	One screen between 250 and 350 feet; one screen between 400 and 500 feet	--	--	
Proposed Shallow Monitoring Wells[a,b]	MW-12S/D	35–45 and 85–95	--	--	
	MW-13S/D	25–35 and 75–85	--	--	
	MW-14S/D	5–15 and 55–65	--	--	
	MW-15S/D	35–45 and 85–95	--	--	
	MW-16S/D	10–20 and 60–70	--	--	
	MW-17S/D	10–20 and 60–70	--	--	
	MW-18	90–100	--	--	
	MW-19	90–100	--	--	
	MW-20S/D	90–100 140–150	--	--	
	MW-21	90–100	--	--	
	MW-22	90–100	--	--	

[a] Screen intervals may change based on water level, lithology and site conditions encountered during drilling.
[b] Table 3-1 shows proposed monitoring well locations.

Notes:
ID = identification

3.3.2 Push-Ahead and Quality Control Groundwater Samples

During deep monitoring well drilling, push-ahead groundwater samples will be collected approximately every 20 feet, starting at the water table, for vertical profiling of PCE, TCE, and cis-1,2- dichloroethene (DCE). The push-ahead groundwater samples will be analyzed onsite using the HAPSITE Smart Plus (HAPSITE) for the selected VOCs (Section 5.1.6). Following the HAPSITE analysis, push-ahead groundwater samples may also be submitted for confirmation laboratory analysis for VOCs by Method 8260 at a frequency of 1 in 10 samples.

After construction and development, newly installed monitoring wells will be sampled (Table 3-2 and Sections 5.2.3, 5.2.4, and 5.2.5). QA/QC samples will be collected at the frequencies summarized in Table 3-4 and outlined in Section 5.12.

Table 3-4. Field Quality Assurance/Quality Control Sample Frequency
Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

QA/QC Sample Type	Frequency
Field Duplicate	One per 10 normal samples
Matrix Spike	One per 20 normal samples
Matrix Spike Duplicate	One per 20 normal samples
Trip Blank	One per cooler (VOC groundwater samples only)
Equipment Blanks	After each decontamination of any non-dedicated sampling equipment

3.3.3 Laboratory Analyses

Groundwater samples collected during Phase 1 of the RI (Table 3-2) will be submitted for the following analyses:

- Contaminant analyses (VOCs, semivolatile organic compounds, total metals, and pesticides)
- General water quality and natural attenuation parameters (stable isotopes of hydrogen and oxygen, total organic carbon, total dissolved solids, chloride, sulfate, nitrate/nitrite, and alkalinity)
- Water quality field parameters (pH, oxidation-reduction potential [ORP], dissolved oxygen [DO], specific conductance [SC], temperature, and turbidity)

These analyses will provide information on the subsurface conditions that will be used to assess the extent of PCE contamination at the site and develop the conceptual site model. After the first four rounds of groundwater sampling are complete, the analytical parameters will be refined with regulatory input.

3.4 Surface Water Sampling

Surface water samples will be collected in conjunction with groundwater sampling events as described in the following subsections. Table 3-5 and Figure 3-6 provide a summary of surface water sampling locations.

3.4.1 Sample Locations and Frequency

Surface water samples will be collected from five locations that were sampled previously in the ESS area and three locations along Red Butte Creek (Figure 3-6).

Four of the five ESS locations (SW-06, SW-33, SW-35, and SW-39) were selected because of high PCE concentrations measured in the 2016 sampling event relative to other surface water sample locations (EA, 2016, 2017b). A fifth location (SW-48) was selected based on an EPA comment requesting samples from Benson Spring. Two selected locations (SW-33 and SW-35) are seeps; one location (SW-06) is a spring-fed sump; one location (SW-48) is Benson Spring; and one location (SW-39) is a stormwater sampling location receiving water from Smith Spring (EA, 2016).

Table 3-5. Summary of Surface Water Sampling Locations
Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

Location ID	Location Description	Location Type	Approximate Latitude	Approximate Longitude	Comments
SW-06[a]	Adjacent to 900 South between 1100 and 1200 East	Spring-fed sump	40.74959	-111.85759	
SW-33[a]	South of 900 South, adjacent to Gilmer Drive	Seep	40.74822	-111.85694	
SW-35[a]	South of 800 South between 1100 East and 1200 East	Seep	40.75143	-111.85881	
SW-39[a]	South of 900 South, adjacent to Alpine Place	Mitigated Spring Water	40.74932	-111.85779	
SW-47[a]	Red Butte Creek west of 1300 East	Creek	40.74509	-111.85524	Upstream sample location
SW-48[a]	East of Elizabeth Street, between 700 South and 800 South	Spring	40.753228	-111.857745	Benson Spring
SW-51[b]	Red Butte Creek east of 1100 East	Creek	40.74501	-111.85812	Downstream of SW-47
SW-52[b]	Red Butte Creek west of 1100 East	Creek	40.74504	-111.86002	Downstream of SW-51

[a] Previous sample location (last sampled in 2016)
[b] New sample location

Notes:
ID = identification

The three Red Butte Creek locations (SW-47, SW-51, and SW-52) are along a stretch of Red Butte Creek between 1300 East and McClelland Avenue. In this area, Red Butte Creek is located above-ground and is believed to be a gaining stream, based on the presence of Bowen Spring at the eastern (upstream) sampling location (EA, 2016).

Surface water sampling events will be conducted in conjunction with groundwater sampling. The frequency of additional surface water sampling will be assessed after the first four quarterly sampling events have concluded. If a surface water sampling site becomes temporarily inaccessible, the location will be sampled as soon as the site is accessible. If a site becomes permanently inaccessible, discussion about abandonment and sample relocation will occur among VHA/USACE, EPA, and UDEQ.

3.4.2 Number of Samples

One sample will be collected per surface water sample location during each sampling event. QA/QC will be collected at the frequencies summarized in Table 3-4 and Section 5.12.

3.4.3 Laboratory Analyses

Surface water samples collected during Phase 1 of the RI will be submitted for the following analyses:

- Contaminant analyses (VOCs, semivolatile organic compounds, total metals, and pesticides)
- General water quality and natural attenuation parameters (stable isotopes of hydrogen and oxygen, total organic carbon, total dissolved solids, chloride, sulfate, nitrate/nitrite, and alkalinity)
- Water quality field parameters (pH, ORP, DO, SC, temperature, and turbidity)

These analyses will be used to assess the lateral and downgradient extent of PCE contamination and to support the evaluation of groundwater flow paths and potential for natural attenuation. The analyte list will be refined with regulatory input following the completion of four rounds of quarterly sampling.

3.5 Soil Gas Surveys

Soil gas surveys will be conducted in the vicinity of the VA Medical Center and the Sunnyside Avenue sewer line. Figure 3-7 provides a summary of soil gas survey sample locations.

3.5.1 Sample Locations, Frequency, and Number of Samples

Soil gas surveys will be conducted in three locations: outside VA Medical Center Building 7, along the sewer line from Building 7 to Sunnyside Avenue, and along a short portion of Foothill Drive in front of the VA Medical Center (Figure 3-7) where PCE was detected in a soil gas sample during a previous investigation. The soil gas survey around Building 7 and the sewer line will provide data regarding a potential PCE source on VHA property. The previous 2007 soil gas activities in the area of Building 7 and the sewer line only collected samples at a maximum of 1 foot in depth (IHI Environmental, 2007) and was not adequate to assess potential source areas. The soil gas samples on the north side of the VHA property are intended to investigate an isolated area where a single soil gas sample in 2012 detected a trace amount of PCE in soil gas (URS Operating Services, 2012).

Soil gas samples along the sewer and Building 7 will initially be collected at a spacing of approximately 30 feet and at a depth of up to 15 feet bgs, with the depth of the sample at least 1 foot below the estimated depth of sewer invert. Samples on the north side of the VHA campus will be collected at 15 feet bgs. There is a total of approximately 71 initial samples (Table 3-2). The soil gas sample locations shown on Figure 3-7 are the set of initial sample locations. Depending on the results of the soil gas screening (Section 3.5.2), additional samples may be collected to infill between the sample locations along the alignment of the sewer or Building 7 perimeter. Additional samples may also be collected by stepping out, in a perpendicular direction to the alignment of the sewer or perimeter of Building 7, to collect additional samples to further define the lateral extent of any elevated soil gas areas. A total of up to 115 soil gas sample locations (including the initial and step-out locations) are anticipated, though a lesser number of locations may be sampled based on the analytical results.

3.5.2 Sample Analysis

Soil gas samples will be analyzed with the HAPSITE for the following VOCs: PCE, TCE, and cis-1,2-DCE. The HAPSITE data for these three analytes will be compared to threshold levels (Table 5-2 and Section 5.2.1 of the RIWP) to assess if additional locations should be sampled near the location with the elevated reading. Ten percent of the total number of samples collected will be submitted to the laboratory for EPA Method TO-15 analysis as a verification for the HAPSITE results (Table 3-2).

3.6 Subsurface Soil Sampling Associated with Soil Gas Surveys

Soil sampling related to soil gas will be performed if a soil gas concentration at a given location exceeds 10 times the residential soil gas screening level (the EPA vapor intrusion screening level [VISL] for soil gas [$VISL_{sg}$]) or associated data.

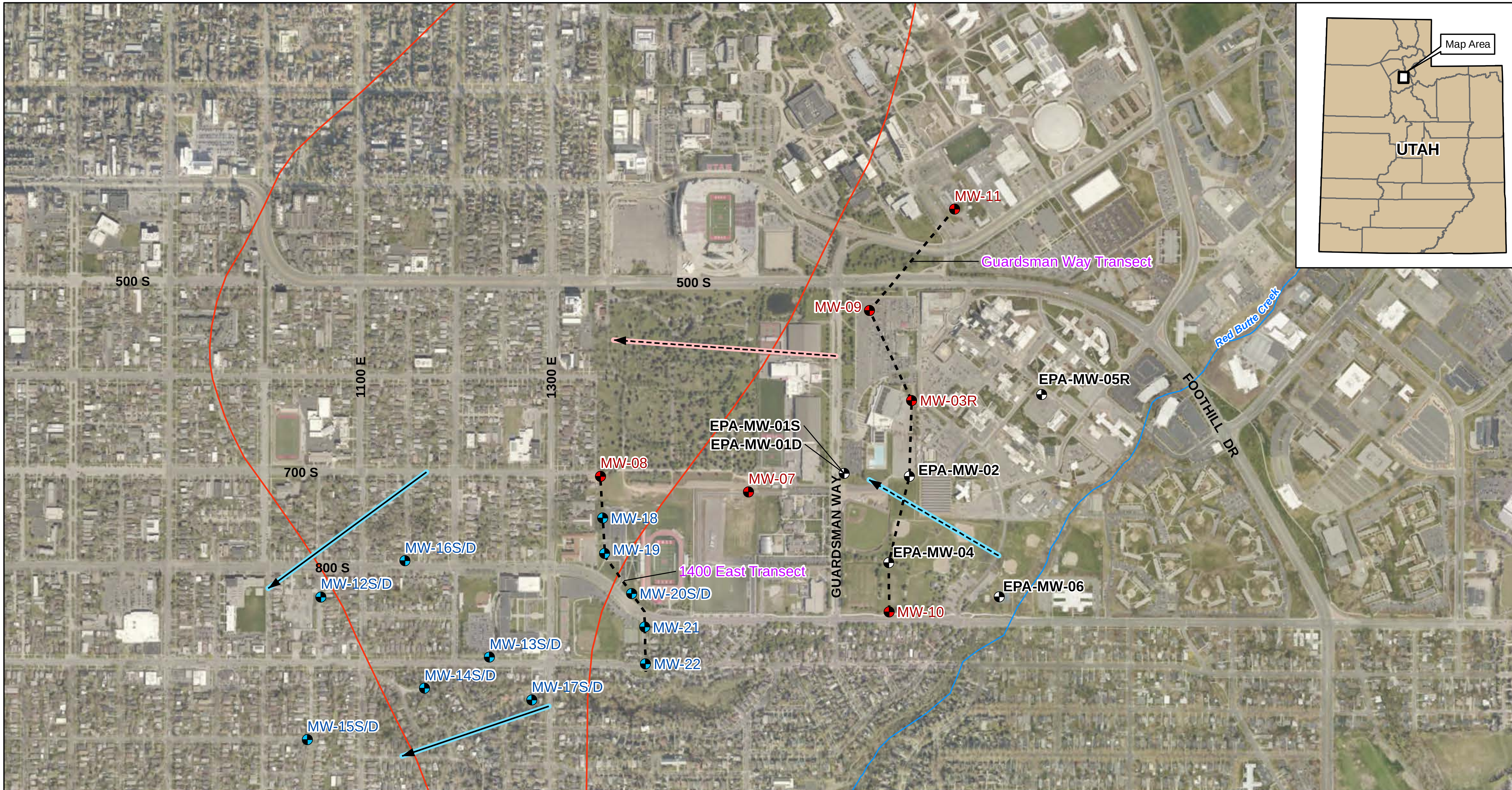
3.6.1 Sample Locations, Frequency, and Number of Samples

Sample locations will be determined in the field based on the results of the HAPSITE soil gas screening. The frequency and number of samples is dependent on the results of the soil gas survey.

The depth and location of the soil sample correlative to an exceeding soil gas measurement will be determined in the field. It is expected that the correlative soil sample will be collected below the depth of the soil gas measurement.

3.6.2 Sample Analysis

Soil samples will be collected using EnCore disposable samplers via direct-push technology for EPA Method 8260 VOC analysis.



Legend

- Existing Monitoring Well
- Red Butte Creek
- Fault Line
- Proposed Transect Line
- Proposed Deep Monitoring Well
- Proposed Shallow Monitoring Well
- East Side Springs Area Groundwater Flow Direction (1)
- Shallower Groundwater Flow Direction (2)
- Deeper Groundwater Flow Direction (2)

Notes
- Proposed well locations are approximate and may change according to site conditions and access agreements.
- Proposed shallow monitoring wells labeled S/D are clustered shallow/deep wells.
- Monitoring well IDs will be numbered sequentially in order of installation
(1) Shallow groundwater flow direction within AOU-1 determined from water level data collected from 2/22/2016 and 3/8/2016 (EA, 2016)
(2) The shallower and deeper groundwater flow directions are based on data and uncertainties presented in the Conceptual Site Model (EA, 2017a).

EA Engineering, Science, and Technology, Inc., PBC (EA). 2016. 700 South 1600 East PCE Plume AOU-1 East Side Springs 2016 Groundwater, Surface Water, and Soil Sampling Technical Memorandum. Prepared for VASLCHCS. Final. September.
EA. 2017a. Conceptual Site Model Update for the 700 South 1600 East PCE Plume AOU-1: East Side Springs, Salt Lake City, Utah. February.

N / W / E / S

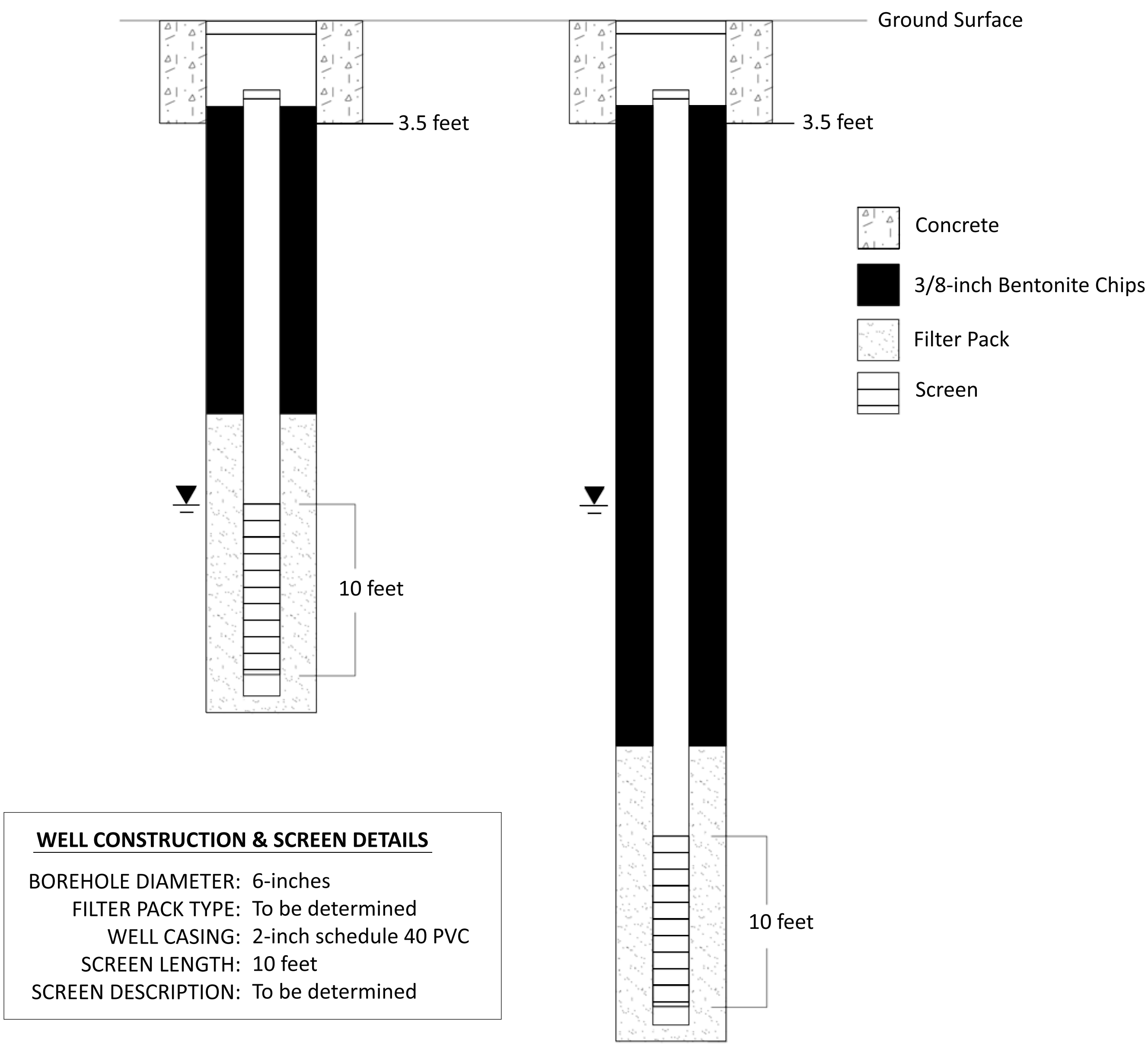
0 400 800
Feet
1 inch = 800 feet

FIGURE 3-1
PHASE I MONITORING WELL INSTALLATION AND GROUNDWATER SAMPLING LOCATIONS
FIELD SAMPLING PLAN
OU-2 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

File Path: R:\ENBG\00_Proj\V\VA-SLC_665353\MapFiles\Field_Sampling_Plan\2017_Dec\PhaseI_MW_Well_Installation_GW_Sampling_Locations_20171221.mxd jquan 2/22/2018 12:30:58 PM

ch2m

Well Construction Diagram

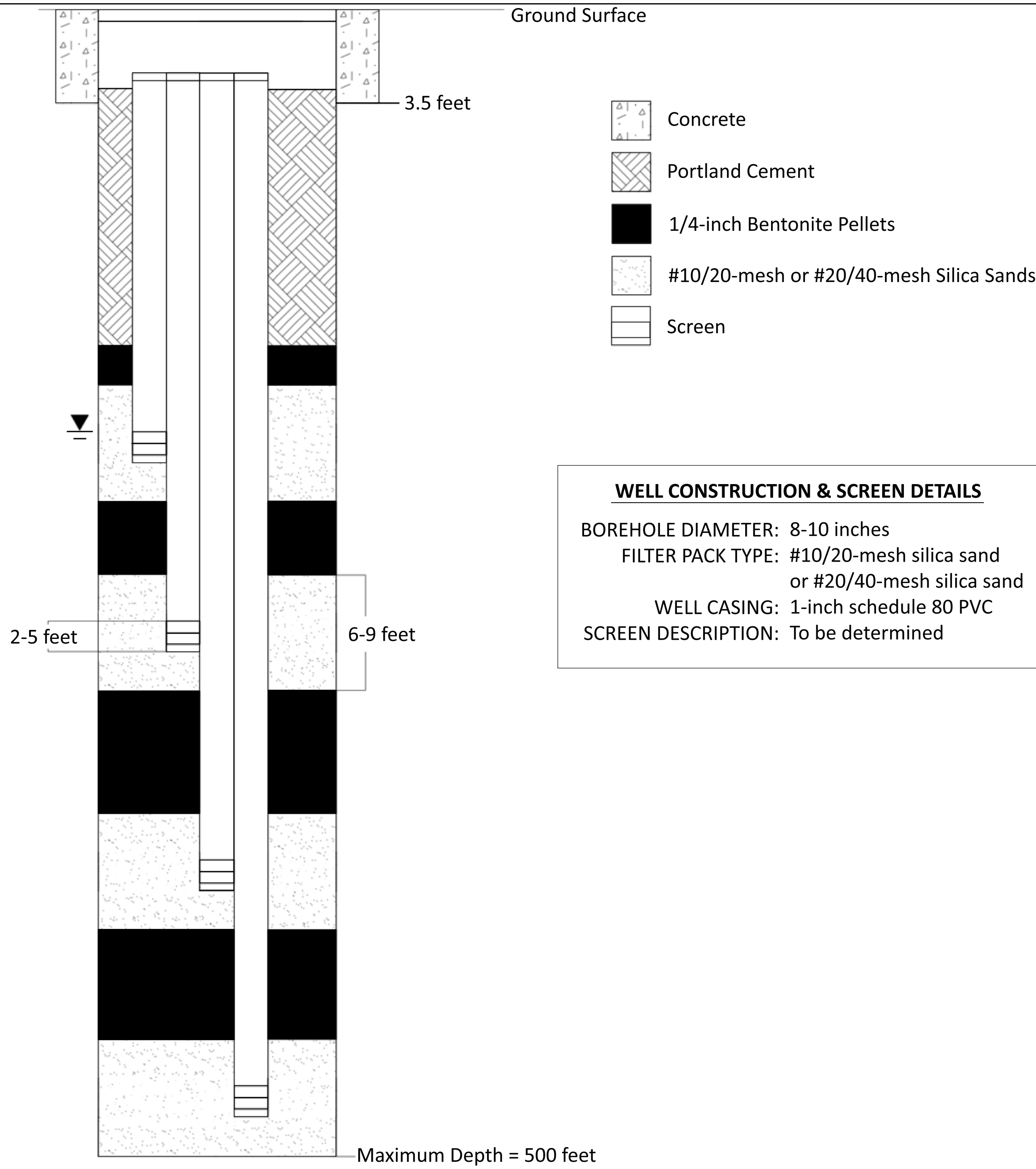


Notes:
PVC = polyvinyl chloride
Well diagram is not to scale.
All depths are reported as depth in feet below ground surface.
Screen intervals will be determined based on water level and lithology.
Individual shallow wells will be constructed similar to the deep well shown in the diagram.
Well construction will be consistent with Utah Administrative Code R655-4-15: “Monitor Well Construction Standards”

FIGURE 3-2
TYPICAL CLUSTERED SHALLOW MONITORING WELL CONSTRUCTION
FIELD SAMPLING PLAN
OU-2 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

ch2m

Well Construction Diagram



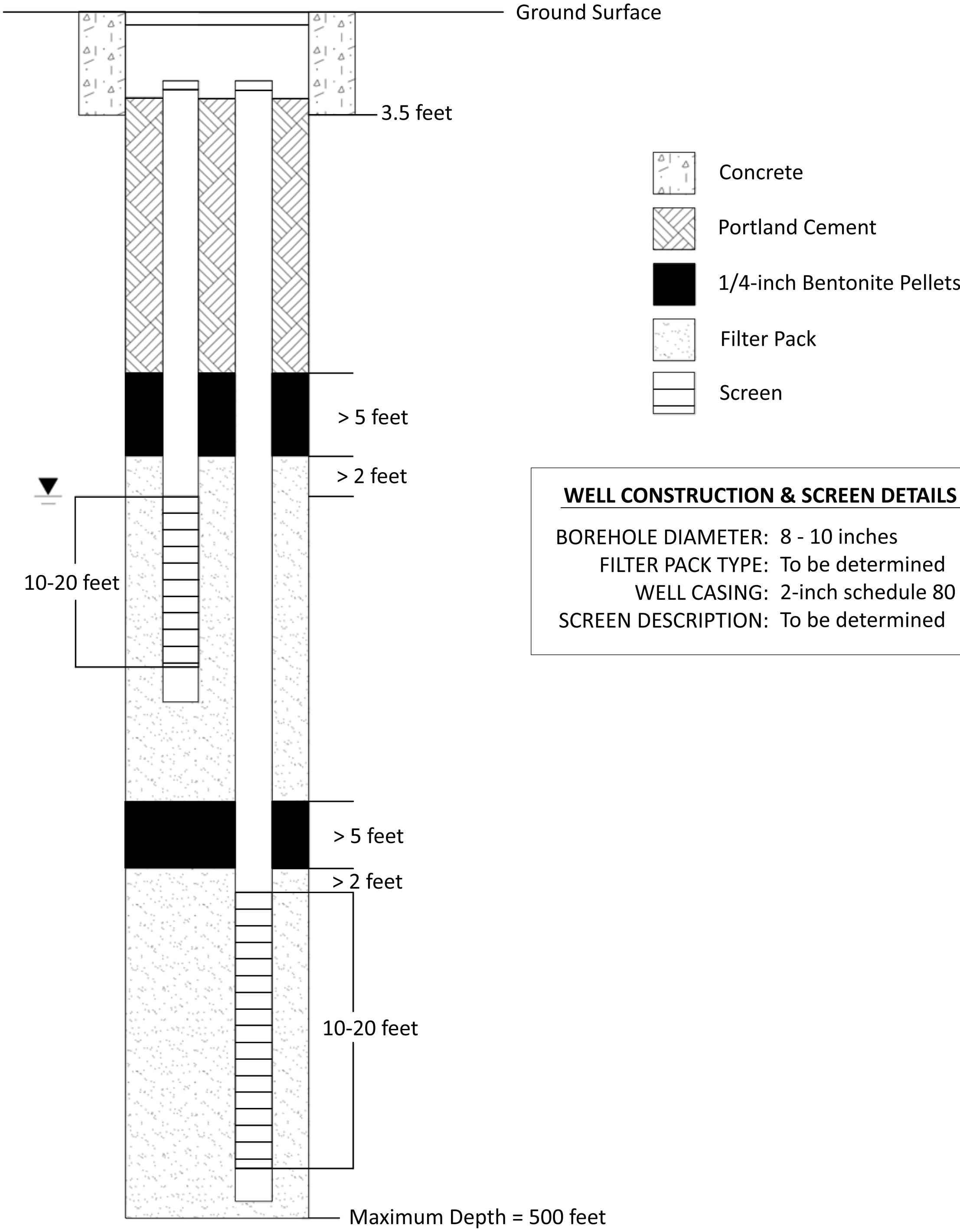
WELL CONSTRUCTION & SCREEN DETAILS

BOREHOLE DIAMETER:	8-10 inches
FILTER PACK TYPE:	#10/20-mesh silica sand or #20/40-mesh silica sand
WELL CASING:	1-inch schedule 80 PVC
SCREEN DESCRIPTION:	To be determined

Notes:
PVC = polyvinyl chloride
ZIST = Zone Isolation Sampling Technology
Well diagram is not to scale.
All depths are reported as depth in feet below ground surface.
Screen depths will be determined based on field observations and drilling conditions.

FIGURE 3-3
TYPICAL MULTI-LEVEL ZIST DEEP MONITORING WELL CONSTRUCTION
FIELD SAMPLING PLAN
OU-2 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

Well Construction Diagram



WELL CONSTRUCTION & SCREEN DETAILS

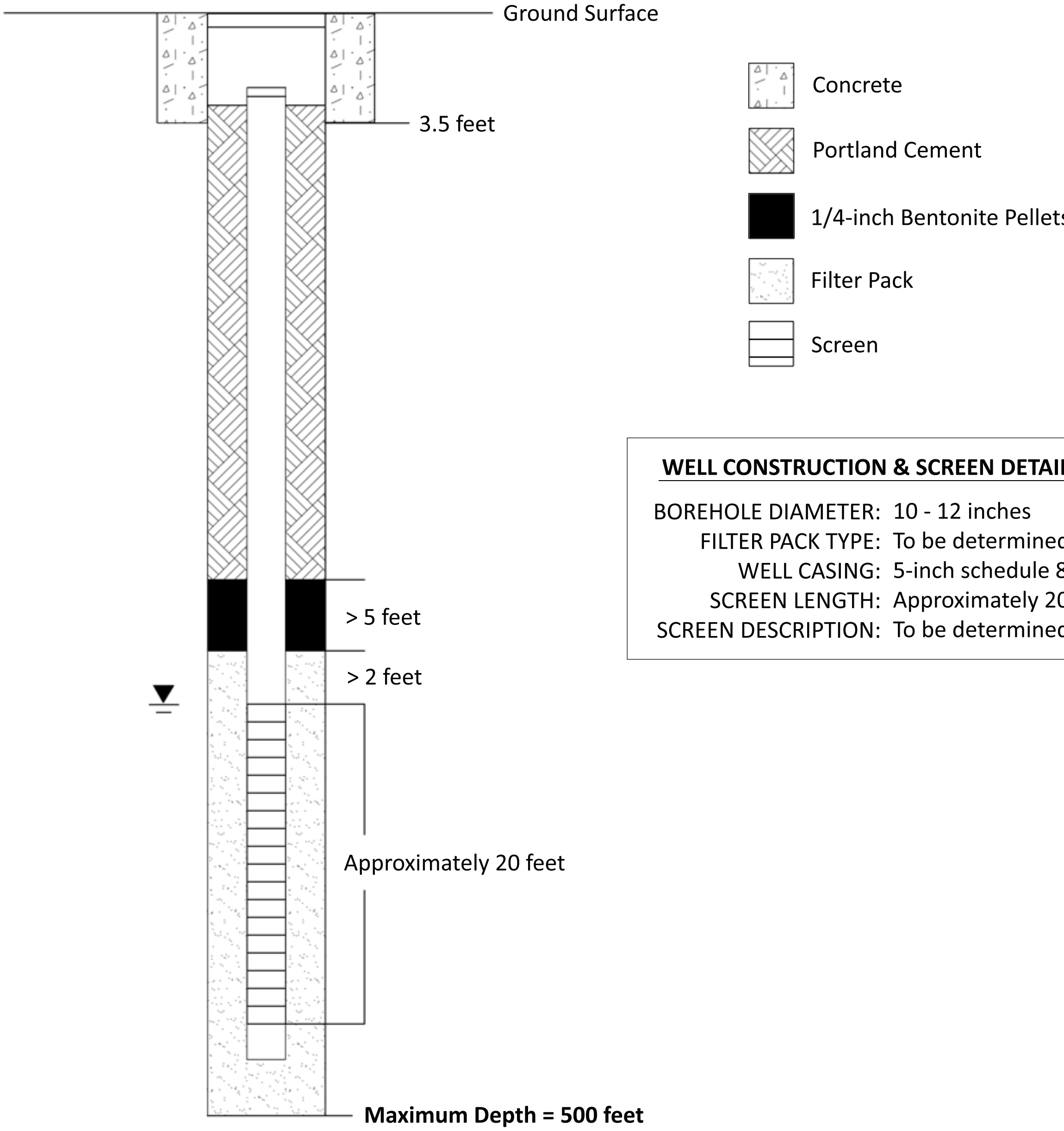
BOREHOLE DIAMETER: 8 - 10 inches
FILTER PACK TYPE: To be determined
WELL CASING: 2-inch schedule 80 PVC
SCREEN DESCRIPTION: To be determined

Notes:
PVC = polyvinyl chloride
Well diagram is not to scale.
All depths are reported as depth in feet below ground surface.
Screen intervals are approximate.
Well construction will be consistent with Utah Administrative Code R655-4-15: "Monitor Well Construction Standards"

FIGURE 3-4
TYPICAL NESTED DEEP MONITORING WELL CONSTRUCTION
FIELD SAMPLING PLAN
OU-2 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

ch2m

Well Construction Diagram



WELL CONSTRUCTION & SCREEN DETAILS

BOREHOLE DIAMETER:	10 - 12 inches
FILTER PACK TYPE:	To be determined
WELL CASING:	5-inch schedule 80 PVC
SCREEN LENGTH:	Approximately 20 feet
SCREEN DESCRIPTION:	To be determined

Notes:
PVC = polyvinyl chloride
Well diagram is not to scale.
All depths are reported as depth in feet below ground surface.
Screen intervals will be determined based on water level and lithology.
Well construction will be consistent with Utah Administrative Code R655-4-15: “Monitor Well Construction Standards”

FIGURE 3-5
TYPICAL 5-INCH MONITORING WELL CONSTRUCTION
FIELD SAMPLING PLAN
OU-2 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

Legend

- Landmark
- Proposed Surface Water Sampling Location (1)
- Shallow Groundwater Flow Direction (2)
- PCE Contour Line (µg/L) for Groundwater (3)
- Red Butte Creek
- Fault Line

Notes:
1) Proposed surface water sample locations are approximate and may change according to site conditions and access agreements. Proposed surface water sampling is contingent upon results of groundwater sampling along proposed 1400 East Transect.
(2) Shallow groundwater flow direction within AOU-1 determined from water level data collected from 2/22/2016 and 3/8/2016 (EA, 2016).
(3) PCE contours in shallow groundwater within AOU-1 are based on samples collected from 2/22/2016 and 3/8/2016 (EA, 2016).

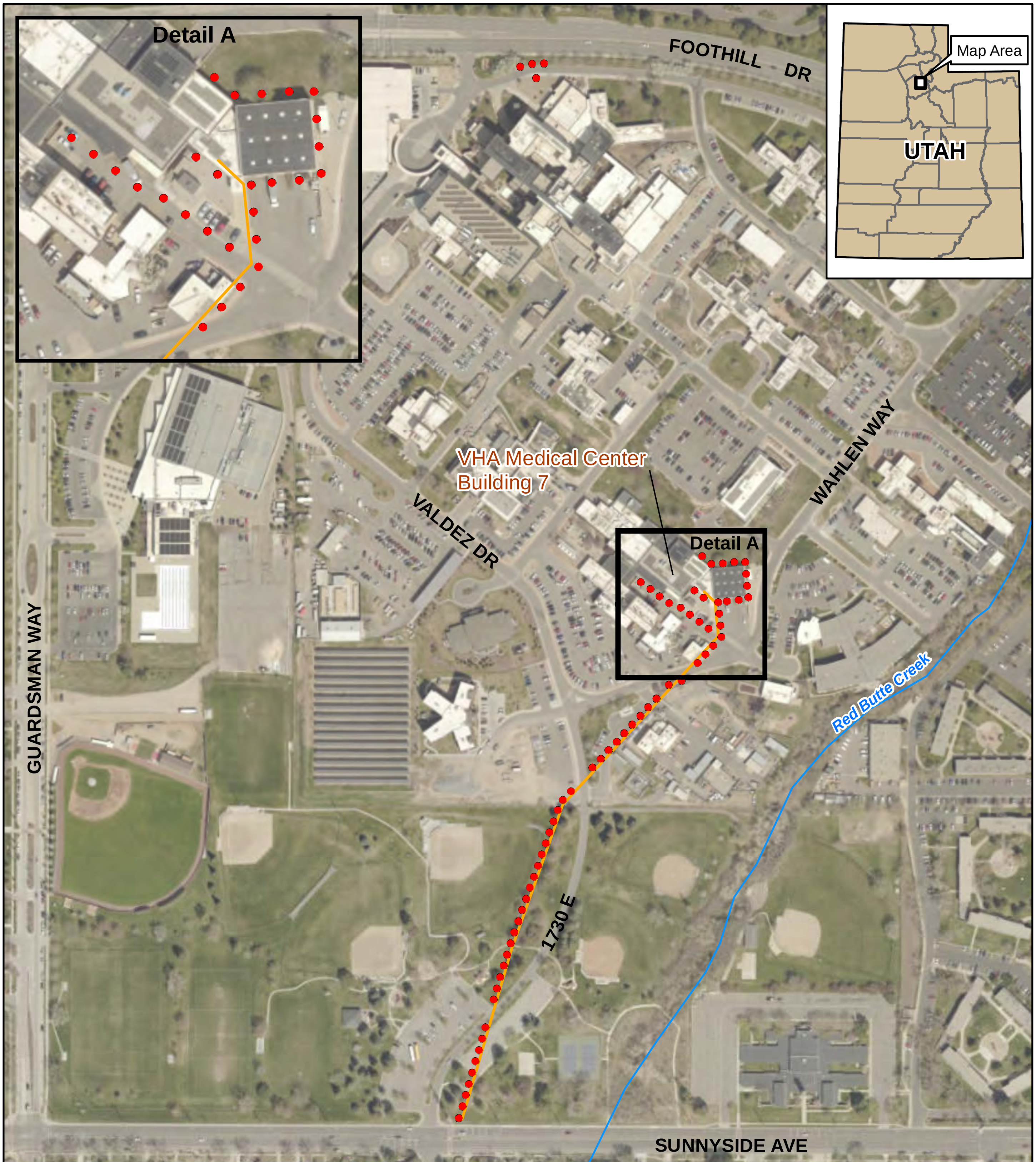
< 1 µg/L = less than 1 microgram per liter
AOU = Accelerated Operable Unit

EA Engineering, Science, and Technology, Inc., PBC (EA). 2016. 700 South 1600 East PCE Plume AOU-1 East Side Springs 2016 Groundwater, Surface Water, and Soil Sampling Technical Memorandum. Prepared for VASLCHCS. Final. September.

FIGURE 3-6
PROPOSED SURFACE WATER SAMPLING LOCATIONS
FIELD SAMPLING PLAN
OU-2 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

File Path: R:\ENBG\00_Proj\V\VA-SLC_665353\MapFiles\Field_Sampling_Plan\2017_Dec\Proposed_Surface_Water_Sampling_Locations.mxd jquan 12/28/2017 3:44:19 PM

ch2m.



Legend

- Initial Soil Gas Sampling Location
- Sewer Line
- Red Butte Creek

Notes:
- Proposed soil gas sampling locations are approximate and may change based on site conditions. The initial set of sampling locations are shown. Additional locations may be sampled based on results from the initial locations.

0 350
Feet
1 inch = 350 feet

FIGURE 3-7
INITIAL SOIL GAS SAMPLING LOCATIONS
FIELD SAMPLING PLAN
OU-2 REMEDIAL INVESTIGATION
700 SOUTH 1600 EAST PCE PLUME
SALT LAKE CITY, UTAH

ch2m

SECTION 4

Request for Analyses

Table 4-1 summarizes the requests for analyses for groundwater, surface water, and soil sampling that will occur during the OU-2 RI field activities. Sections 2 and 3 of the QAPP provide summaries of the analytical parameters, target reporting limits, and the regulatory goals for the samples.

Table 4-1. Requests for Analyses
Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

Medium	Description	Number of Locations	Onsite or Offsite Analysis?	Analytical Parameters/ Test Methods	Comments
Groundwater	Push-ahead sampling at new monitoring wells	Six new deep wells	Onsite	HAPSITE (PCE, TCE, and cis-1,2-DCE)	After four quarters of sampling, samples collected during subsequent, ongoing monitoring events may be submitted for a reduced set of analyses that will be determined with regulatory input based on the results of previous sampling events. Field QC samples are summarized in Table 3-4 and Section 5.12
			Offsite	TO-15 (full-scan)	
	Monitoring wells	Six existing EPA wells; six new deep wells (most multilevel); 11 newly installed shallow wells (7 pairs and 4 individual wells)	Onsite	See Table 3-2	
Surface Water	Seeps, springs, and Red Butte Creek	Eight locations	Offsite	See Table 3-2	After four quarters of sampling, samples during subsequent, ongoing monitoring events may be submitted for a reduced set of analyses that will be refined with regulatory input based on previous results. Field QC samples are described in Table 3-4 and Section 5.12
Subsurface Soil	Boreholes for new monitoring wells	Six new deep wells; 11 newly installed shallow wells	Offsite	Geotechnical analyses – see Table 3-2	
	Soil gas survey locations	Selected locations, based on soil gas data		VOCs (8260)	Refer to Section 3.6
Soil Gas	Soil gas survey locations	71 initial locations; additional locations as needed	Onsite	HAPSITE (PCE, TCE, and cis-1,2-DCE)	
			Offsite	TO-15 (full-scan)	Ten percent of soil gas samples

Field Methods and Procedures

This section provides information on the methods and procedures used in the RI for OU-2. The field investigation for Phase 1 of the RI will include the following key activities:

- Monitoring well installation and development
- Geotechnical sample collection and testing
- Geophysical and flow logging
- Groundwater sample collection
- Aquifer testing
- Soil gas survey
- Subsurface soil collection (if necessary based on results of soil gas sampling)
- Equipment calibration
- Decontamination
- Investigative-derived waste (IDW) management
- Sample management procedures and documentation
- Quality control sampling

5.1 Monitoring Well Installation

5.1.1 Borehole Utility Clearance

Before commencing drilling, boring locations will be marked in white paint and cleared by Utah Blue Stakes and a private utility locater. All utilities within a 20-foot radius of each location will be demarcated to allow for minor location adjustments to be made in the field. Hand augering to a minimum of 5 feet bgs will be performed at each location before drilling to further avoid potential utility strikes.

5.1.2 Borehole Drilling

Rotosonic drilling technology will be used for borehole drilling, core recovery, and monitoring well installation. Experience using Rotosonic drilling technology in unconsolidated sediments, such as in the Lake Bonneville sediment deposits (particularly cobbles, gravels, and sands of Provo Formation) beneath Hill Air Force Base (Feth, 1966), which are anticipated to be similar to gravels in the site area, has demonstrated that continuous core can be recovered, and that original sedimentary structures can be preserved in the core barrel. This benefit of Rotosonic drilling permits complete lithologic logging of the borehole, including small-scale features such as interbedded sediments and geochemical alteration. In addition, Rotosonic drilling often does not require the addition of water or drilling fluids to advance the drill bit, thus permitting downhole sampling during the drilling process. For boreholes less than 100 feet deep bgs, a smaller track-mounted remote-controlled Rotosonic drill rig (mini-Sonic) will likely be used. However, for boreholes approaching 500 feet deep bgs, a larger truck-mounted Rotosonic drill rig will be required. Borehole sizes may range between 6-inch to 12-inch diameter.

5.1.3 Borehole Logging

Continuous Rotosonic cores will be collected and bagged for the length of the boring. Borings will be continuously logged in the field following the USCS. Soil cores will be screened with a photoionization detector and results will be recorded on the boring log. Core samples from at least one boring for shallow monitoring well installation and one boring for deep monitoring well installation will be preserved in core boxes and stored on VHA property at a location selected by VHA. The USCS establishes the minimum standards for information that should be recorded in the field to adequately characterize recovered soil cores. (standard operating procedure [SOP] B.4, Appendix B of the RIWP, contains additional information on application of the USCS classification system to borehole logging for this project). Additional information of particular importance to be included in the logs includes the following:

- Observations of moisture content throughout the core (qualitative)
- Depths of free/perched water encountered
- Depth to bedrock (if encountered)
- Core recovery per run

In addition to producing written boring logs, complete photo logs of the core will be produced. To create the photo log, soil cores will be laid out on a portable table, depths will be referenced on temporary placards, and a photo of a section of the core will be taken. To maintain a useful level of detail in the photos, soil cores are typically photographed in 2-foot sections.

Following completion of the boring, the onsite geologist will also record the following information:

- The total depth of the borehole from ground surface
- The height of the water column (if present) in the borehole
- The number of water bearing zones encountered (if more than one)
- Sampling depths (if applicable)

5.1.4 Geotechnical Testing

Soil samples will be collected for geotechnical testing. The sample frequencies and test methods are summarized in Table 3-2. The geotechnical tests to be performed include the following:

- Fraction organic carbon (ASTM Method D2974)
- Laboratory mineralogical analysis (magnetic susceptibility by Microbial Insights Laboratory method)
- Sieve analysis (ASTM Method D6913)
- Dry bulk soil density (ASTM Method D2937)
- Hydrometer (ASTM Method D422a)
- USCS soil classification/Atterberg limits/gradation (ASTM Method D2487/D4318/D1140)
- Vertical permeability (ASTM Method D2434) (from select samples from finer-grained lenses)
- Moisture content (ASTM Method D2216)

The Atterberg Limit, vertical permeability, dry bulk soil density, sieve analysis, and hydrometer tests will provide basic lithologic data to identify hydrostratigraphic units for the conceptual site model. The fraction of organic carbon is a key parameter that will help account for the effect of adsorption, which affects the rate of contaminant migration for contaminants like PCE that sorb to organic matter in soil. Laboratory mineralogical analyses will be used to assess whether abiotic natural attenuation processes may be occurring at the site. Undisturbed soil samples will be collected with a Shelby Tube to perform permeability testing.

5.1.5 Geophysical Logging

Natural gamma and nuclear magnetic resonance geophysical logging may be used to complement borehole lithology descriptions, identify potential water-bearing units, and, in some cases, facilitate monitoring well design. Natural gamma geophysical logging can be performed while steel drill casing is in the borehole, thus facilitating well design. Nuclear magnetic resonance geophysical logging cannot be performed through steel drill casing, but can be used in 2-inch and larger polyvinyl chloride (PVC) monitoring wells.

Geophysical logging will be performed either by the VHA using geophysical logging equipment, or a subcontractor (for example, Colog and Century Wireline). Geophysical logging procedures are described in SOP B.5, Appendix B of the RIWP.

5.1.6 Push-Ahead Groundwater Sampling

Push-ahead groundwater sampling (SOP B.4 of Appendix B of the RIWP) will be conducted during the drilling process of deep monitoring wells to provide data that will be used to assess the maximum depth of PCE contamination and help choose zones to screen. Deep monitoring wells will be drilled to below the zone of PCE contamination above the maximum contaminant level, to a maximum depth of approximately 500 feet bgs. If PCE is detected above the maximum contaminant level level at 500 feet bgs in any monitoring well locations, USACE and VHA will discuss contract/budget implications for drilling deeper.

Push-ahead groundwater sampling will be collected every 20 feet starting from the water table to total depth. Groundwater sample screening will consist of a field screening measurement using the Inficon HAPSITE, a portable gas chromatography/mass spectrometer (GC/MS) equipped with a headspace sampling system (HSS). After collection, groundwater screening samples will be transported to Building 9, Room 111 on VHA property for analysis as soon as possible on the day of sample collection. To collect a screening measurement, the groundwater sample will be loaded into a glass vial and placed into the HSS oven. The HSS operates by heating the sample to a preselected temperature and flushing the vial headspace with a VOC-free carrier gas (ultra-pure nitrogen) after equilibrium has been established. The headspace is then drawn into and analyzed by the HAPSITE. HAPSITE operation with respect to VOCs in water is discussed in further detail in SOP B.18 in Appendix B of the RIWP, and the HAPSITE ER/Smart PLUS Training - Headspace Sampling System Presentation (INFICON, 2010).

Push-ahead groundwater sampling results will be used for well design purposes, and the screening-level data will be reported in the data summary report. The push-ahead groundwater sampling results will not be validated, but HAPSITE calibration and quality control protocols (SOP B.18 in Appendix B of the RIWP) will be used throughout the investigation.

Following the HAPSITE analysis, push-ahead groundwater samples will be submitted for confirmation laboratory analysis at a frequency of 1 in 10 samples (Table 3-2).

5.1.7 Monitoring Well Installation and Construction

Construction will proceed after the successful drilling of each borehole. Appropriate filter pack and screen slot size will be generally chosen using methods described in Driscoll (1986). Schematics of typical monitoring well construction types are shown on Figures 3-2, 3-3, 3-4, and 3-5. During installation of the deep monitoring wells, the onsite geologist will ensure that (1) the monitoring well casing is suspended and slowly lowered into the borehole through the casing, and (2) all well casing and screen sections are inspected for defects (and replaced as needed). In addition, the geologist will monitor the filter pack, bentonite seal, and neat Portland cement grout installation to ensure the appropriate depths are attained, and to maintain at least 2 feet of well completion materials inside the drill casing during emplacement to prevent caving.

Final well design will be determined in the field based on borehole lithology, and identification of water-bearing zones, and field screening-level data. However, likely well design types include the following:

1. Shallow "clustered," 2-inch-diameter Schedule 40 PVC monitoring wells installed in 6-inch-diameter boreholes (Section 5.1.7.5)
2. Multiple deep 7/8-inch-diameter in-line ZIST-type monitoring wells installed in 8- to 10-inch-diameter boreholes (Section 5.1.7.6)
3. Two deep nested 2-inch-diameter Schedule 80 PVC monitoring wells installed in 8- to 10-inch-diameter boreholes (Section 5.1.7.7)
4. Single deep 5-inch-diameter Schedule 80 PVC monitoring wells installed in 10- to 12-inch-diameter boreholes (Section 5.1.7.8)
5. One 7/8-inch-diameter in-line ZIST-type monitoring well and one 5-inch-diameter Schedule 80 PVC monitoring well installed in a 10- to 12-inch-diameter borehole (Section 5.1.7.9)

5.1.7.1 Well Casing and Screen

For each monitoring well, the casing and screen with the end cap attached will be slowly lowered into the borehole through the center of the casing and must be hung to prevent any excessive curvature of the well casing. The well screen and casing will be constructed section by section as the lowering process continues. All well casing and screen sections will be inspected by the onsite geologist for defects when the materials arrive onsite, and during the installation process. Any identified defective material will be removed from the area to avoid accidental use. Centralizers will be used, where applicable, to ensure the casing string is positioned in the center of the borehole.

5.1.7.2 Filter Pack

At least one representative sample of filter pack material will be sampled and tested for grain-size distribution to assure compliance with the RIWP. Filter-pack emplacement will be continuously monitored with a weighted measuring tape, accurate to the nearest 0.1 foot, to determine when the filter pack reaches the desired height. After the intended filter pack thickness has been attained, the filter pack will be allowed to settle for at least 20 minutes, after which the depth of the top of the filter pack can be verified. More sand will be added as necessary until it is a minimum of 2 feet above the top of the well screen. When the filter pack is being installed in a temporarily cased borehole, the temporary casing will only be pulled out 1 to 2 feet at a time to prevent caving. At least 2 feet of filter-pack sand will be maintained inside the drill casing at all times during filter-pack emplacement (continuous emplacement).

5.1.7.3 Bentonite Seal

After the desired filter pack thickness is attained, a bentonite seal will be emplaced to seal the borehole. A minimum thickness of 5 feet of bentonite is required above the filter pack. The bentonite will be placed on top of the sand filter pack as the casing is slowly removed, and will be hydrated at regular intervals if above the water table. In the case of multiple monitoring wells inside a borehole, bentonite will be used to fill the interstitial space between the respective screen intervals.

5.1.7.4 Neat Portland Cement Grout

For the deep monitoring wells, neat Portland cement grout will be used to seal the remainder of the annulus (above the upper bentonite seal) to approximately 3 feet bgs. The cement will be mixed in the proportion of approximately one 94-pound bag of Portland Type I/II cement to 7 gallons of water. The water used to mix the neat cement will be clean, with a total dissolved solids concentration of less than 1,000 parts per million. Once the slurry is mixed, it should remain workable for 15 to 30 minutes.

During this time, the slurry will be pumped to the top of the filter-pack through a tremmie pipe. Once in place, the grout slurry requires a minimum of 24 hours to strengthen. Additional grout will be added to the borehole until the grout is approximately 5 feet bgs using the previously described procedures.

5.1.7.5 Shallow Clustered 2-inch-diameter Monitoring Wells

The shallow clustered 2-inch-diameter monitoring wells will be built within 6-inch-diameter boreholes. These monitoring wells will generally be less than 50 feet bgs. The screen intervals will generally be approximately 10 feet long. Depending upon the lithologic observations, the filter pack material will either be #20/40 or #10/20 mesh silica sand, which will extend approximately 1 foot below and 2 feet above the screened interval. Depending on the lithology of the target screen interval, either 0.010- or 0.020-inch slot Schedule 40 PVC will be installed. The filter pack material will be selected based on the screen opening. Above the filter pack, ⅜-inch bentonite chips will be used to seal and backfill the remaining borehole. The bentonite chips will extend to approximately 3 feet bgs. Deeper monitoring wells, such as along the 1400 East transect, may be completed with a ¼-inch bentonite pellet (minimum 5 feet thick) and neat cement seal. The shallow clustered 2-inch-diameter monitoring wells will be completed with a flush-mount surface completion (Section 5.1.7.10).

5.1.7.6 Multiple Deep 7/8-inch-diameter in-line ZIST-type Monitoring Wells

One type of deep (maximum depth 500 feet bgs) well design consists of the installation of multiple ⅞-inch diameter in-line ZIST-type monitoring wells strung on 1-inch-diameter Schedule 80 PVC. For this design, there may be up to four monitoring well intervals. Either 0.010- or 0.020-inch slot Schedule 40 PVC will be installed for the screen intervals. The filter pack material for the ZIST-type monitoring wells will consist of either #10/20-mesh or #20/40-mesh silica sand extending at least 1 foot above and 1 foot below the screen interval. The screen and filter pack selection will be determined based upon the observed lithology of the selected screen interval. Between each filter pack interval, regardless of the annular space length, ¼-inch bentonite pellets will be installed. After the final 5-feet-thick bentonite seal, neat Portland Cement grout will extend to approximately 3 feet bgs. The ZIST-type monitoring wells will be completed with a flush-mount surface completion (Section 5.1.7.10).

5.1.7.7 Nested 2-inch-diameter Monitoring Wells

One type of deep (maximum depth of 500 feet bgs) monitoring well design consists of the installation of two 2-inch-diameter Schedule 80 PVC monitoring wells in the same borehole. Well design will be based upon observed lithology during drilling, but is anticipated to consist of the following:

- A deeper monitoring well with a 10- to 20-foot-long, 0.020-slot Schedule 80 PVC screen
- A shallower monitoring well with a 10- to 20-foot-long, 0.020-slot Schedule 80 PVC screen
- Filter pack material will consist of #10/20-mesh silica sand, which will extend approximately 3 feet below and at least 2 feet above the screened interval
- Between each filter pack interval, regardless of the annular space length, ¼-inch bentonite pellets will be installed. After the final 5-feet-thick bentonite seal, neat Portland cement grout will extend to approximately 3 feet bgs. The nested 2-inch-diameter monitoring wells may be completed with either a flush-mount or aboveground surface completion (Section 5.1.7.10).

5.1.7.8 Five-inch-diameter Monitoring Wells

One type of deep (maximum depth 500 feet bgs) well design consists of installing a single 5-inch-diameter Schedule 80 PVC monitoring well. Well design will be based upon observed geology, but is anticipated to consist of the following:

- 0.040-slot screen interval approximately 10 to 20 feet long
- The filter pack material will consist of #10/20, #12/20, or #8/16-mesh silica sand, which will extend at least 2 feet below and 2 feet above the screened interval
- Above the filter pack, a minimum of 5 feet of ¼-inch bentonite pellets will be installed to seal the borehole
- Above the bentonite seal, neat Portland cement grout will extend to approximately 3.5 feet bgs. These 5-inch-diameter monitoring wells will likely be completed as above-ground surface completions (Section 5.1.7.10)

5.1.7.9 Combined 7/8-inch-diameter ZIST-type Monitoring Well and 5-inch-diameter Monitoring Well

One type of deep (maximum depth 500 feet bgs) monitoring well will consist of one in-line ZIST type monitoring well and one 5-inch-diameter well in the same borehole. The ZIST screen intervals will be placed in the upper 200-feet of the borehole. The 5-inch diameter monitoring well is anticipated to have an approximately 10- to 20-foot screen placed below 200 feet bgs. Well construction details for the ZIST type monitoring well and the 5-inch diameter PVC monitoring well are described in Sections 5.1.7.6 and 5.1.7.8, respectively.

5.1.7.10 Monitoring Well Completions

A concrete seal will extend from the top of the grout seal, at approximately 3.5 feet bgs to the ground surface. The concrete seal will be finished at the surface as either (1) a concrete pad for an above-ground completion, or (2) as a concrete pad flush-mount surface completion. Flush well completions will be installed in areas of vehicular traffic.

Above-ground surface completions will consist of a steel casing enclosure and a concrete pad. The protective casing will be designed to accommodate a permanent sampling pump, if needed, and water level/transducer equipment. The protective casing will be approximately 10-inches in diameter and 5 feet in length, extending to a height of approximately 2.5 feet above and below the ground surface, and centered on a 2.5-feet by 2.5-feet by 6-inch concrete pad. The protective casing will have a cap that can be secured with a lock. Bollards will be installed around the aboveground surface completions.

Flush surface completions consist of a flush well vault enclosure and a concrete pad. The flush well vault will be centered on a 2.5-feet by 2.5-feet by 6-inch concrete pad. The concrete pad should be graded so that water does not pool on the wellhead and vault lid.

5.1.7.11 Final Monitoring Well Inspection

For the monitoring well to meet specifications after completion of monitoring well construction, a 4-inch-diameter bailer should pass freely through a 5-inch-diameter monitoring well. Likewise, a 1-inch-diameter bailer must pass freely through a 2-inch-diameter monitoring well. If the monitoring well inspection test fails and the monitoring well is deemed unusable, the drilling subcontractor may need to abandon and/or replace the monitoring well.

5.1.8 Monitoring Well Development

Monitoring well development is included in SOP B.4 in Appendix B of the RIWP. A few critical details are provided below.

The development of each monitoring well will be completed between 48 hours and 7 days after construction is completed. The monitoring well development process includes the following:

- The application of sufficient energy in a monitoring well to create groundwater flow (surging) in and out of the filter pack to release and draw fines into the monitoring well
- Bailing to remove fines that have been surged into the monitoring well
- Pumping to further remove fines from the filter pack and establish good connectivity between the formation and the monitoring well
- Development water will be discharged to a temporary storage tank to settle the fines. With appropriate permits and approvals, clear water will be discharged to the publicly owned treatment works or stored in 55-gallon drums in the IDW storage area for disposal by VHA
- A minimum of five borehole volumes of water plus the volume of potable water added during monitoring well construction or a minimum of two times the volume of potable water added during monitoring well construction, whichever is greater, must be removed

During monitoring well development by pumping, groundwater quality parameters (specific conductivity, temperature, turbidity, and pH) will be monitored. The parameters will be measured at the beginning of monitoring well development and, at minimum, after evacuation of each borehole volume. A minimum of six water quality parameter measurements will be made during monitoring well development using a calibrated water-quality meter. The parameters and variability for stabilization during development are as follows:

- Specific Conductivity = ±10 percent
- Temperature = ±1 degree Celsius
- Turbidity = <10 nephelometric turbidity units or stable within 10 percent
- pH = ±0.2 units

Approximately 1 liter of the last water withdrawn from the monitoring well during development will be collected in a clear container, labeled, and photographed to document the clarity of the water.

5.1.9 Installation of Pressure Transducers

Pressure transducers/data loggers will be installed in selected monitoring wells near the center of the screen interval after monitoring well development is complete. Pressure transducers will be emplaced to provide for continuous, long-term water level data in selected locations in both shallow and deep monitoring wells. The monitoring wells at which transducers will be placed will be selected following complete installation of the monitoring well network and in consultation among VHA/USACE, EPA, and UDEQ. The pressure transducers will be suspended in the monitoring wells via direct-read cables, which allow for data download at the wellhead. The direct-read cable will be securely attached to the wellhead so that the pressure transducers do not move or slip during deployment.

5.1.10 Monitoring Well Survey

All new and existing monitoring wells will have the ground surface and top of casing surveyed for horizontal location and vertical elevation, accurate to 0.1 foot horizontally and 0.01 foot vertically. A mark will be made on the northern side of the PVC casing upon completion of monitoring well installation activities and will be used as the location for all subsequent future water level measurements. The surveyor will provide data in the horizontal datum North American Datum 1983 State Plane Utah North FIPS 4301 (International Feet), and in the vertical datum North American Vertical Datum 1988.

5.2 Groundwater Sample Collection

Groundwater samples will be collected from new and existing monitoring wells following the completion of monitoring well installation and development. New monitoring wells will be allowed to equilibrate for a minimum of 14 working days after completion and development before samples are collected. Groundwater sampling techniques will be selected based on the monitoring well instrumentation and the field conditions. The following subsections describe groundwater sampling techniques including low-flow, standard purge, purge/sample on recovery, and ZIST sampling. SOPs for the following methods are also included in Appendix B of the RIWP.

5.2.1 Water Level Measurements

Water level will be measured before sampling using an electric water level meter. Pressure transducer data will be collected quarterly and concurrent with groundwater sampling events before purging and collecting groundwater samples.

5.2.2 Field Parameter Measurements

Field parameter measurements will be collected during each sampling event. Field parameters include water-quality parameters (pH, ORP, DO, SC, turbidity, and temperature), and water level measurements.

Water-quality parameters will be measured using a calibrated meter equipped with a flow-through cell, weighted screen, or sample cup. During low-flow sampling, water-quality parameters will be measured using the flow-through cell and recorded in approximately 5-minute intervals. Where the flow-through cell cannot be employed, water-quality parameters will be measured in situ using the weighted screen or by filling the sample cup. The measurement method will be recorded in the appropriate field form or in the field logbook. Field parameters will be recorded on a groundwater sampling form (Appendix A) or in a field logbook.

The field hydrogeologist will calibrate the equipment used to measure field parameters according to manufacturer specifications at the start of each day. Calibration data will be recorded on the groundwater sampling field form or in the field logbook along with the equipment model number. Calibration methods are outlined in SOP B.1, in Appendix B of the RIWP).

5.2.3 Low-Flow Groundwater Sampling

Monitoring wells equipped with dedicated bladder pumps will be sampled using the low-flow sampling method. This sampling technique uses a variable flow rate to minimize drawdown and stabilize the water level observed in the monitoring well during pumping. Samples are collected after the water-quality parameters (pH, ORP, DO, SC, turbidity, and temperature) have stabilized over 3 readings collected over 15 minutes, which indicates that the water being pumped is coming from a steady-state source.

The field hydrogeologist will set an initial flow rate of 0.2 to 0.5 liter per minute, adjusting the flow rate as necessary to minimize drawdown, ideally to less than 0.3 foot, and to achieve a stable flow rate. The field hydrogeologist will record the purge volume, water level, and water-quality parameters at 5-minute intervals during purging to assess when equilibrium has been reached. The stabilization parameters to determine equilibrium are listed in the SOPs provided in Appendix B of the RIWP.

5.2.4 Low-Yield Monitoring Well Groundwater Sampling

When low-yield monitoring wells cannot be sampled using the low-flow methods because of slow recharge rates, the well can be purged and sampled using a purge dry and sample upon recovery method. In this method, the monitoring well is pumped or bailed dry after measuring the initial water level of the monitoring well. Samples are collected after the monitoring well has recovered to 90 percent of the pre-purge water column thickness. If the monitoring well does not recover to 90 percent within a normal workday, the monitoring well will be allowed to recover overnight and be sampled the following morning. The procedures for sampling low-yield monitoring wells are outlined in SOP B.10 in Appendix B of the RIWP.

5.2.5 ZIST Groundwater Sampling

Multi-level ZIST pumps allow for the simultaneous purging and sampling of multiple zones per monitoring well. In employing this sample method, the field hydrogeologist will apply an inert gas to the gas-in line of the ZIST pump. A timer control unit is used to regulate the amount of applied pressure and set the recharge time. Once lift pressure has been reached, water will be returned through the sample-return line. The field hydrogeologist will collect samples after completing one purge cycle (evacuating one well volume from the riser pipe) and priming the system to prevent the water/gas interface in the gas-in line to reach the pump during sampling. This sampling method is discussed in detail in SOP B.11 in Appendix B of the RIWP.

5.3 Surface Water Sample Collection

Surface water samples will be collected from the sample locations shown on Figure 3-6 and summarized in Table 3-5. SOP B.19 (in Appendix B in the RIWP) describes the sample methods that will be used to collect surface water samples.

5.3.1 Field Parameter Measurements

Field parameter measurements will be collected from each sample location during each sampling event. Surface water field parameters include pH, ORP, DO, SC, turbidity, and temperature. Field parameters will be collected using a calibrated water-quality meter equipped with a weighted screen. Prior to collecting samples, the water quality meter will be lowered into the water such that the water-quality probes are fully submerged. After allowing the meter to equilibrate, the measurements will be recorded in the appropriate field form or in the field logbook. Appendix A includes the surface water sampling form.

The water-quality meter will be calibrated by the field geologist at the start of each day. The meter will be calibrated according to manufacturer specifications and the calibration data recorded on the surface water sampling form or in the field logbook. Calibration methods are described in SOP B.1 in Appendix B of the RIWP).

5.3.2 Sample Collection

Surface water samples will be collected using the procedures outlined in SOP B.19 (in Appendix B of the RIWP). Field personnel will sample downstream to upstream to avoid cross-contamination. If possible, all sample containers will be filled directly from the source; a decontaminated stainless steel or glass beaker may be used if the sample container cannot be filled directly.

5.4 Aquifer Testing

Two types of aquifer testing are planned for the site: slug tests and pumping tests. The primary objective of this testing is to characterize the hydraulic properties governing groundwater flow through the subsurface. The following subsections discuss locations planned for testing, field methods, and analytical methods.

5.4.1 Slug Testing

Slug testing is generally appropriate for testing in which monitoring wells are shallow and of small diameter where testing with a pump is impractical. The method involves inserting or withdrawing a known volume (slug) into the monitoring well and recording the response of water levels over time. The transmissivity and horizontal hydraulic conductivity can be estimated from this displacement and water level response.

5.4.1.1 Slug Testing Locations and Rationale

Slug testing may be conducted in nested, clustered and individual monitoring wells (Table 3-1) to supplement aquifer tests conducted in 5-inch diameter monitoring wells. The 2-inch-diameter monitoring wells are most suitable for slug testing. The monitoring wells selected for slug testing will be determined after installation of the monitoring well network, as described in Section 5.2.4.1 of the RIWP. Slug test locations will be selected to target each identified hydrostratigraphic unit and provide geographic distribution across the site. Slug tests in approximately 12 to 16 monitoring wells are anticipated.

5.4.1.2 Field Methods

Performance of slug testing at each location will consist of static water level measurement, pressure/water level recording with a pressure transducer, and slug emplacement/withdrawal. The static water level will be measured with an electric water level indicator before emplacing downhole equipment (the slug and the pressure transducer). A pressure transducer and data logger will be lowered into the water column and set up to log water levels. Manual water levels will be measured after emplacing the transducer to ensure stabilization after deployment of the transducer, and data will be recorded in the slug testing field form included in Appendix A. Upon stabilization, a slug consisting of 1-inch to 1.5-inch outside diameter PVC pipe filled with clean silica sand will be emplaced into the water column as quickly as practical to initiate a falling head test. After equilibration, consisting of water levels change less than 0.01 foot per 10 minutes, the slug will be withdrawn from the water column to initiate a rising head test. At least one cycle of falling and rising head testing will be performed at each location. All equipment placed into the monitoring well will be decontaminated upon retrieval from the monitoring well. The methods summarized here are consistent with guidance for slug testing issued by the U.S. Geological Survey (2010) and EPA (1994). The aquifer testing SOP (SOP B.7 in Appendix B of the RIWP) includes additional details for executing slug tests.

5.4.1.3 Analytical Methods

Data from the slug tests will be analyzed using an appropriate analytical method (for example, the Hvorslev [1951] or Bower and Rice [1980] methods) within analytical software, such as AQTESOLV.

5.4.2 8-Hour Aquifer Tests

Eight-hour aquifer tests involve discharging groundwater from the test well and measuring water level responses in the tested well and surrounding observation wells. Hydraulic properties are quantified from these data, including transmissivity and horizontal hydraulic conductivity, storativity, and vertical hydraulic conductivity across aquitards, if possible. Other information potentially available from these tests are insights into aquifer type (unconfined, confined, or leaky confined) and whether recharge or no-flow boundaries are present near the test locations. VOC samples may be collected at regular intervals during pumping tests to determine whether concentrations increase as a result of pumping.

5.4.2.1 Testing Locations and Rationale

Pumping tests are planned for new deep monitoring well locations constructed with a 5-inch-diameter screen and casing that will allow for passage of a submersible pump at least 3 inches in diameter. The monitoring wells selected for pumping tests, including observation wells, will be determined after installation of the monitoring well network, as described in Section 5.2.4.2 of the RIWP. Additional testing may occur upon future phases of monitoring well installation.

The field components of conducting a pumping test include groundwater discharge, discharge measurement, and water level response measurement. The field methods summarized here are consistent with EPA guidance.

Discharge and Discharge Measurement Methods

In preparation for constant rate aquifer testing, an attempt will be made to conduct step testing during development of each monitoring well to be tested, depending upon the maximum yield of each monitoring well. If possible, step testing will be done at approximately 20, 40, 60, and 80 percent of the maximum sustainable pumping rate of each monitoring well (rate may be pump limited), based upon specific capacity estimates during well development and the length of the water column. This planned strategy may be pump limited; if such a strategy is pump limited, the step testing will be done at approximately 20, 40, 60, and 80 percent of the pump capacity. This step testing would consist of discharging at three to four different discharge rates (for example, at rates of approximately 10, 20, 30, and 40 gallons per minute) and monitoring water levels with an electric water level indicator and a pressure transducer. Termination of testing at one step and transition to the next step will occur when drawdown stabilizes. If drawdown does not stabilize, a field decision will be made about whether to continue or terminate the step test. Step testing data would provide information about the well efficiency to allow for correction of drawdown data for well losses if needed and would inform decisions about pumping rates to be used for subsequent constant rate aquifer testing.

The constant rate aquifer test will proceed upon conclusion of step testing (if performed), and a background water level data collection period of at least several days (see Water Level Monitoring Methods below). Upon start of the test, the discharge rate will be brought up to the target rate as quickly as possible. Discharge from each tested monitoring well will be from an electrical submersible pump equipped with a check valve and deployed to near the bottom of the well screen, but at least 2 feet from the bottom of the monitoring well. Pumped groundwater will be conveyed through straight sections of at least 2-inch-diameter PVC or steel pipe plumbed to the inlet and outlet of an in-line digital flowmeter with a gate valve and a sampling port several feet downstream of the meter. A junction and valve will also be plumbed to the discharge line downstream of the meter to allow for periodic bucket tests of flow rate, in which the rate at which a known-volume container fills. Discharge measurement will be taken as frequently as practical during the first hour of testing and recorded in the field form included as Appendix A.

Pumped groundwater will be discharged to a sanitary sewer manhole (pending permission from Salt Lake City Public Utilities) or will be routed to an existing holding pond for slower release to the sewer. Pumping will proceed for approximately 8 hours, after which the pump will be shut down and water level recovery data will be monitored (see Water Level Monitoring Methods below).

Water Level Monitoring Methods

Water levels will be monitored with both pressure transducers/data loggers and with electric water level indicators. Deployment of pressure transducers and measurement of initial static water levels will occur at all testing and observation wells before any pumping during development and aquifer testing and according to SOP B.6 (in Appendix B of the RIWP). Field schedule allowing, unstressed water level data will be collected with the pressure transducers for at least several days between development/step testing and constant rate aquifer testing. Data from this unstressed monitoring period will allow for equilibration after development and will help to identify whether there are any background trends to the water level data for which corrections of the testing data may be needed. After the background monitoring period, a round of manual water level measurements will be taken immediately before starting constant rate aquifer testing.

Meteorological Monitoring Methods

In addition to water level data, meteorological data will be collected to correct water level responses for non-pumping influences. A barometric pressure logger will be deployed concurrent with background water level measurements, to correct water level data for changes in response to atmospheric pressure fluctuation. Precipitation data will be obtained from existing sources (for example, the University of Utah Weather Station) to support assessment of the influence of precipitation upon water level data.

After pumping starts, manual water level measurements will be collected as frequently as practical from the pumping well for the first 15 minutes and compared with the transducer readings to ensure the transducer data are accurate. Manual water level measurements will be taken approximately hourly from each observation well to provide backup for data collected with the pressure transducers. The pressure transducers will be left in-place at all monitoring wells to record water level recovery data after pumping ends. The recovery data will be monitoring until water levels rebound to at least 90 percent of pre-pumping levels or 1 week has elapsed since the end of pumping, and a final round of manual water level measurements will be taken before retrieving the pressure transducers from the monitoring wells. All equipment placed downhole will be decontaminated after retrieval.

5.4.2.2 Data Evaluation Methods

Data from the pumping tests will be reduced and pre-processed to make any needed corrections. Following pre-processing, the data will be analyzed using an appropriate analytical method within an aquifer testing analysis software (such as AQTESOLV) considering the conceptual model of the aquifer at the testing site and drawdown response. Data may also be analyzed using the software Multi-Layered Unsteady State for analysis of multi-layered, or stratified, aquifer response.

5.5 Soil Gas Surveys

5.5.1 Sample Collection

Initial soil gas surveys will focus on three areas: outside the VA Medical Center Building 7, along the sewer line extending from Building 7 to Sunnyside Avenue, and along a short portion of Foothill Drive in front of the VA Medical Center (Figure 3-7). Initial soil gas sampling points have been selected approximately every 30 feet in the selected sample areas. Additional soil gas sample points will be selected based on the HAPSITE results from the initial set of data.

Soil gas samples will be collected with a direct push drill rig, using temporary GeoProbe post run tubing soil vapor probes extended to approximately 15 feet bgs (SOP B.14 in Appendix B of the RIWP*)*. A soil gas sampling field form is included in Appendix A. SOP B.14 (Appendix B of the RIWP) describes the procedures for installing and leak testing both types of probes as well as collecting soil gas samples. Two types of soil gas samples will be collected:

- Samples collected in Tedlar bags using a lung-box. These samples will be collected for field analysis
- Samples collected for laboratory analysis in individually-certified clean, 1-liter SUMMA canisters

The Tedlar bag samples will be analyzed with a calibrated field instrument HAPSITE portable GC/MS. The sample will be screened with a calibrated portable photoionization detector before analysis on the HAPSITE to help assess whether dilutions are necessary to bring VOC concentrations to within the HAPSITE calibration range. SUMMA canister samples will be analyzed by EPA Method TO-15 (full scan).

5.5.2 Sample Analysis

Soil gas samples will be analyzed for PCE, TCE, and cis-1,2-DCE using the HAPSITE portable GC/MS. HAPSITE operation and calibration is discussed in SOP B.17 (Appendix B of the RIWP). A subset of samples (10 percent of the total) will be submitted to the laboratory for TO-15 analysis (full scan) to validate the HAPSITE results and provide data for other VOCs.

5.6 Subsurface Soil Sampling Associated with Soil Gas Surveys

Soil sampling related to soil gas will be performed if a soil gas concentration at a given location exceeds 10 times the residential soil gas screening level (the EPA $VISL_{sg}$), as described in Section 3.6.

Soil samples will be collected for VOC analysis. The sample frequencies and test methods are summarized in Table 3-2. The VOC test to be performed includes the following:

- EPA Method 8260

5.7 Equipment Calibration

Field equipment requiring calibration (for example, water-quality meters) will be calibrated before the start of work of each sampling day according to the manufacturer's instructions. The calibration information (equipment serial number, date, time of calibration, standards used, readings before and after calibration) will be recorded on the appropriate field form and/or field logbook (SOP B.3 in Appendix B of the RIWP). If equipment drift or malfunction occurs during sampling, field personnel will stop and re-calibrate the instrument as necessary. Equipment that fails to calibrate will be removed from service and replaced with properly functioning equipment. Equipment calibration is discussed further in SOP B.1 (in Appendix B of the RIWP).

5.8 Decontamination

Decontamination of heavy equipment, groundwater sampling, water level meters, and other sampling or sampling preparation equipment will occur before and after each use to prevent cross contamination. Decontamination will consist of combinations of either steam cleaning or a detergent wash with water rinses, followed by repeated distilled water rinse. Personnel conducting decontamination procedures will wear gloves, steel toe boots, and safety glasses or chemical splash goggles at a minimum. Additional level D personal protective equipment (for example, Tyvek coveralls, face mask, and hard hat) may also be required depending on the field task. Decontamination equipment and materials will be containerized in accordance with the investigation-derive waste management procedures outlined in the IDW management plan. Field personnel will follow the decontamination procedures outlined below and in SOP B.2 for different types of equipment used during the field program.

- **Downhole Drilling Equipment:** Steam-clean all downhole equipment including drill casing, core barrels, and drill pipe before use on the project and between each drilling location.
- **Groundwater Sampling Equipment (example, water level indicator, flow-through cell, and water-quality meter):** Decontaminate as follows unless directed otherwise by manufacturer's instructions:
  - Spray and scrub with Alconox solution
  - Rinse with potable tap water
  - Rinse repeatedly (at least triple-rinse) with distilled water
  - Air dry
- **Submersible Pump and Non-dedicated Tubing:** If possible, new disposable discharge tubing should be used at each monitoring well. If submersible pumps are removed from monitoring wells for cleaning, the following procedure should be used:
  - Remove pump from monitoring well and place pump in clean bucket, making sure that tubing does not touch the ground
  - Pump 1 gallon of Alconox solution through the sampling pump
  - Rinse with 1 gallon of tap water
  - Rinse with 1 gallon of distilled water or triple rinse with potable water
  - Keep decontaminated pump in clean bucket or remove and wrap in clean plastic sheeting or a clean garbage bag

5.9 Investigation-Derived Waste Management

The disposal of investigation-derived waste is described in detail in the IDW management plan included as Appendix C of the RIWP.

5.10 Sample Containers and Preservation

Soil and groundwater samples will be collected and preserved as specified in the QAPP included as Appendix A.2 of the RIWP.

5.11 Field Documentation and Sample Management Procedures

The following subsections detail the field documentation and sample management procedures that will be implemented during field activities, including field documentation, sample labeling, and sample packaging and shipment.

5.11.1 Field Documentation

5.11.1.1 Field Logbooks

Field personnel will record all daily activities during monitoring well installation, geophysical and groundwater flow logging, groundwater sampling, surface water sampling, aquifer testing, and soil sampling events in bound and pre-numbered logbooks. The Field Team Leader will keep the master field logbook and will document field activities. Original field logbooks will be retained by the Field Team Leader. After field activities are complete, field logbook pages will be scanned and uploaded to Microsoft SharePoint, as discussed in Section 5.4.1 of the RIWP. Field documentation procedures are described in SOP B.3 in Appendix B in the RIWP.

5.11.1.2 Field Forms

Field forms for borehole logging, monitoring well construction, monitoring well development, groundwater sampling, and surface water sampling are included in Appendix A of the RIWP. Field data will be captured on hardcopy field forms, reviewed by the Project Manager, or designated project reviewer within 1 week of the field task completion, and scanned. Scanned field forms will be submitted to the VA, uploaded to the project file on Microsoft SharePoint, and included in technical memorandums/final reports that summarize field activities. Information captured in the appropriate field form does not need to be duplicated in the field logbook. However, the logbook should reference the field personnel and activities and any applicable field forms.

5.11.1.3 Photographs

Photographs may be taken in the field to document sampling locations, collected samples, and field conditions. Any photographs taken will be documented in a photographic log that will include the date, location, photographer's name, and the direction the photographer was facing. Selected photographs will be used in reports as deemed necessary or appropriate.

5.11.1.4 Chain-of-Custody Forms

Chain-of-custody (COC) procedures will document sample collection and possession. COC forms will be developed electronically and printed and will include the sample IDs, the date and time of sample collection, and the requested analyses. The sampling team members will fill out the hard copy with the date and time of sample collection in the field. All COC forms and custody seals will be signed by the designated sampling team member. Custody seals will be applied to coolers before shipment. A copy of all COC records will be retained. See the QAPP for additional information on COC procedures.

5.11.2 Sample Labeling

Pre-printed sample labels will be used by field team members and the time and date of sample collection filled out in the field. If pre-printed sample labels are not available, handwritten labels may be used. All sample labels will include, at a minimum, the following information:

- Sample name/number
- Time and date of sample collection
- Site name and location
- Project number
- Sample type and matrix
- Container
- Preservative
- Analysis method

The sample naming scheme is outlined in Table 5-1.

Table 5-1. Sample Identification System and Examples of Sample Designations
Field Sampling Plan, OU-2 Remedial Investigation (Phase 1), 700 South 1600 East PCE Plume, Salt Lake City, Utah

Group	Item	Example Code
1	General location	OU-2 = OU2-
2	Sampling Location	EPA-MW-01S = MW01S MW-07 = MW07 SW-06 = SW06 SG-01 = SG01
3	Sample media	SB = soil boring GW = groundwater IW = investigation-derived waste SW = surface water SG = soil gas
4	Date Code (MM-DD-YY)	10118-, 010218-, 010318-, etc.
5	Sample Depth, if multiple at one sampling location	Depth, in feet bgs = 100, 200, and 300 feet
6	QA/QC sample type, when applicable	Standard (non-QC) sample = blank Field duplicate = FD Matrix Spike = MS Matrix Spike Duplicate = MSD

Notes:
The sample numbers will be cross-referenced in the field logbook.

Examples are given below for each type of sample collection planned:

- Normal soil sample collected at 100 feet during boring for installation of monitoring well MW-09, collected on June 15, 2017 = OU2-MW09-SB061517-100
- Matrix spike (MS) QA/QC groundwater sample collected from ZIST well interval MW-07c on June 15, 2017 = OU2-MW07c-GW061517-MS (Section 3.1.2 includes the labeling convention for ZIST well intervals).
- IDW characterization sample collected from roll-off bin holding cuttings from drilling of MW-09, collected on June 15, 2017 = OU2-MW09-IW061517

Immediately following sample collection, the field hydrogeologist will close the filled sample container and apply the completed label.

5.11.3 Sample Packaging and Shipment

Sample packaging and shipment procedures are detailed in SOP B.13, in Appendix B of the RIWP. Samples will be stored on ice immediately after collection and during sample shipment. Sample coolers will be delivered or shipped overnight to the contracted laboratory.

5.12 Field Quality Assurance/Quality Control Sampling

For groundwater and surface water contaminant sampling and analysis, QA/QC samples will include field duplicates, blanks, and laboratory QA/QC samples. Field sampling personnel will collect QA/QC samples concurrent with, and using the same procedure as, the collection of the target environmental samples. QA/QC samples will not be collected or prepared in association with IDW sampling. Table 3-4 includes a summary of field QA/QC sample frequency.

For sampling and analysis of soil and general water quality, natural attenuation, and field parameters, QA/QC samples will consist only of the collection and analysis of field duplicates.

5.12.1 Field Duplicates

Field duplicates are independent samples collected as close as possible to the original sample, from the same source, and using the same sampling procedure and preservation methods. Field duplicates are used to document sampling precision. Sampling personnel will label and package field duplicates such that the laboratory cannot distinguish between samples and duplicates. Field duplicates will be collected at a frequency of 1 field duplicate per 10 standard (non-QC) samples.

5.12.2 Matrix Spike/Matrix Spike Duplicate Samples

MS/matrix spike duplicate (MS/MSD) samples are independent samples collected as close as possible to the original sample, using the same source, and using the same sampling procedure and preservation methods. MS/MSD samples are spiked in the laboratory at a known concentration to determine if the laboratory procedure is working within established control limits. MS/MSD samples will be collected at a frequency of 1 MS and 1 MSD sample per 20 standard (non-QC) samples.

5.12.3 Blank Samples

Blank samples are collected to verify that contamination is not introduced to samples during collection, handling, or shipping of the samples.

5.12.3.1 Trip Blanks

Trip blanks (blank water collected into pre-preserved volatile organic analyses vials) will be obtained from the contracted laboratory. One trip blank sample will be submitted for each cooler containing volatile organic analyses samples. Trip blanks will accompany the sample containers at all times before, during, and after sample collection. Trip blank samples will use the same preservation methods, packaging, and sealing procedures as used during the collection of standard (non-QC) samples.

5.12.3.2 Equipment Blanks

If any non-dedicated sampling equipment are used, field personnel will collect equipment blanks by collecting a sample of the rinsate after decontamination. Field personnel will use the same preservation methods, packaging, and sealing procedures as used during the collection of standard (non-QC) samples.

References

Bower, H. and R.C. Rice. 1980. "A Slug Test for Determining the Hydraulic Properties of Tight Formations." *Water Resources Research.* Vol 16, No. 1, p. 233-238.

Driscoll, F.G. 1986. *Groundwater and Wells* (2nd ed.), Johnson Filtration Systems, Inc. St. Paul, Minnesota, 1089p.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2016. *700 South 1600 East PCE Plume AOU-1: East Side Springs, 2016 Groundwater, Surface Water, and Soil Sampling Technical Memorandum*. Final. September.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2017a. *Conceptual Site Model Update for the 700 South 1600 East PCE Plume AOU-1: East Side Springs, Salt Lake City, Utah.* February.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2017b. *700 South 1600 East PCE Plume AOU-1: East Side Springs, 2016 Surface Water and Stormwater Data Validation Report.* Final. May.

Feth, J.H., et al. 1966. *Lake Bonneville: Geology and Hydrology of the Weber Delta District, Including Ogden, Utah.* Geological Survey Professional Paper 518, United States Geological Survey. 86p.

Hvorslev. 1951. *Time Lag and Soil Permeability in Ground Water Observations*, Bulletin No. 36, U.S. Army Corps of Engineers, p. 50.

INFICON. 2010. HAPSITE ER/Smart PLUS Training - Headspace Sampling System. Presentation.

IHI Environmental. 2007. *Soil Gas Investigation Report, Sanitary Sewer Lateral, VHASLCHCS Building 7 to Sunnyside Avenue, Salt Lake City, Utah*. December.

MWH Americas, Inc. (MWH). 2012. *Hydrogeological and Groundwater Model Summary Report for: Culinary Water Supply Protection Project at Salt Lake City's Drinking Water Well # 18 (Also Referred to as the 500 South Well).* Salt Lake City Department of Public Utilities. July.

Thiros, S.A. 2010. *Conceptual understanding and groundwater quality of the basin-fill aquifer in Salt Lake Valley, Utah,* in Thiros, S.A., Bexfield, L.M., Anning, D.W., and Huntington, J.M., eds., 2010, Conceptual understanding and groundwater quality of selected basin-fill aquifers in the Southwestern United States: U.S. Geological Survey Professional Paper 1781, p. 13-24.

U.S. Environmental Protection Agency (EPA). 1994. *Slug Tests*. SOP#:2046.

Utah Department of Environmental Quality (UDEQ). 2000. *Mount Olivet Cemetery Plume Analytical Results Report.* Division of Environmental Response and Remediation. Prepared by Neil B. Taylor.

U.S. Geological Survey (USGS). 2010. GWPD 17—*Conducting an Instantaneous Change in Head (Slug) Test with a Mechanical Slug and Submersible Pressure Transducer.* Version 2010.1. Accessed January 17, 2017. https://pubs.usgs.gov/tm/1a1/pdf/GWPD17.pdf.

URS Operating Services. 2012. *Trip Report, East Side Springs, Salt Lake City, Utah*. January.

Appendix A
Field Forms

Appendix A.1. Soil Boring Log

	PROJECT	BORING NUMBER SHEET OF
	BORING LOG	

PROJECT : LOCATION :
LATITUDE/LONGITUDE : DRILLING CONTRACTOR :
WEATHER CONDITIONS:
DRILLING METHOD AND EQUIPMENT:
WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	SAMPLE				STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION	COMMENTS	VISUAL (%)		
	INTERVAL (FT)	NUMBER AND TYPE	RECOVERY (IN)	MAX. PID READING (PPM)		SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY,	STRUCTURE, SORTING, ODOR DEPTH OF CASING, DRILLING RATE, TESTS, AND INSTRUMENTATION. PID (ppm): Breathing Zone Above Hole	GRAVEL	SAND	CLAY/SILT

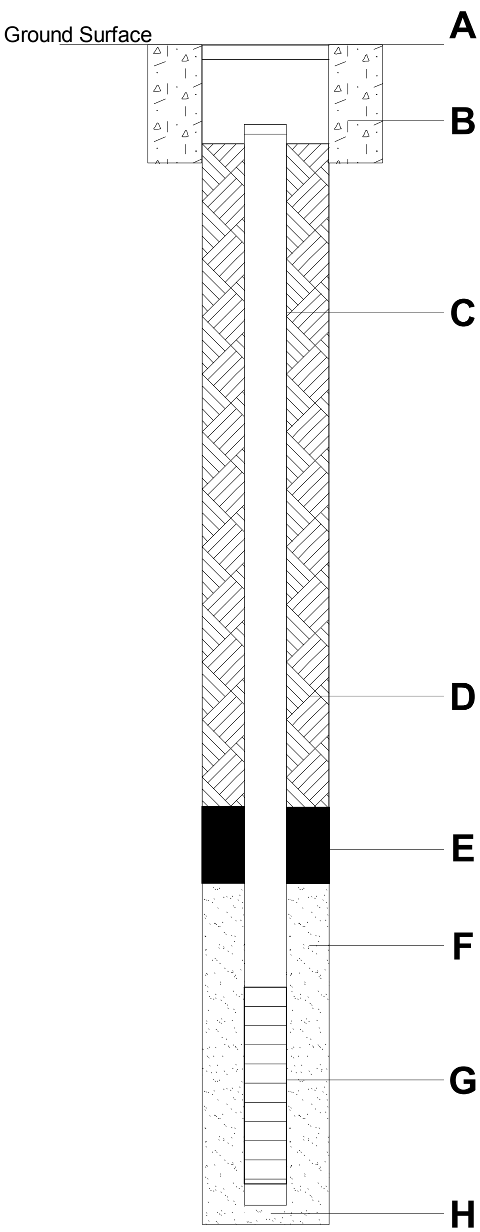
	PROJECT	BORING NUMBER SHEET OF

DEPTH BELOW SURFACE (FT)	SAMPLE: INTERVAL (FT)	SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (IN)	SAMPLE: MAX. PID READING (PPM)	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY,	COMMENTS: STRUCTURE, SORTING, ODOR DEPTH OF CASING, DRILLING RATE, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole	VISUAL (%): GRAVEL	VISUAL (%): SAND	VISUAL (%): CLAY/SILT

APPENDIX A.2. WELL CONSTRUCTION LOGS

MONITORING WELL CONSTRUCTION LOG: SINGLE WELL

GEOLOGIST:	DATE STARTED:	DATE COMPLETED:
WELL NO:	PROJECT:	SITE:
PROJECT NO:	CONSTRUCTED BY:	CITY:
NORTHING: EASTING:	GROUND SURFACE ELEVATION:	MEASURING POINT ELEVATION:



BORING DIAMETER: ____________

TOTAL DEPTH: ____________

(FEET BELOW GROUND SURFACE)

A. SURFACE COMPLETION

TYPE: ____________

SIZE: ____________

B. SURFACE SEAL

MATERIAL: ____________

INTERVAL: ____________

C. RISER PIPE

DIAMETER: ____________

TYPE: ____________

INTERVAL: ____________

D. GROUT

COMPOSITION: ____________

INTERVAL: ____________

E. SEAL

TYPE: ____________

INTERVAL: ____________

F. FILTER PACK

MATERIAL: ____________

INTERVAL: ____________

G. SCREEN

DIAMETER: ____________

TYPE: ____________

SLOT SIZE: ____________

INTERVAL: ____________

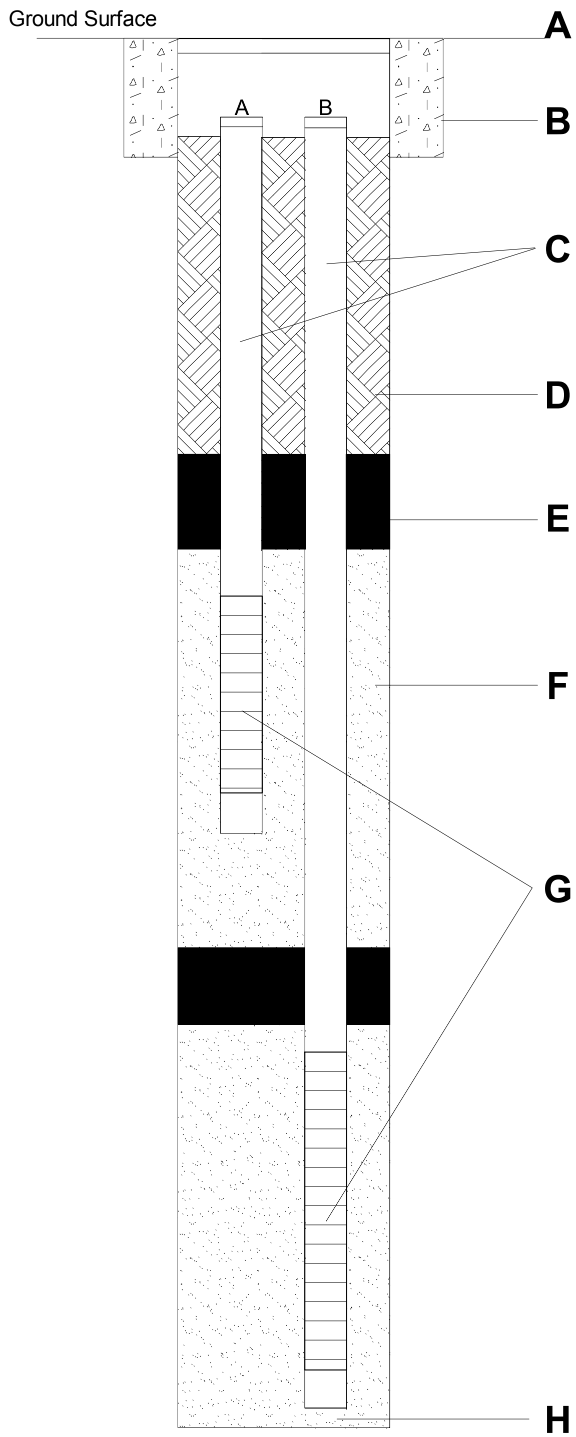
H. BACKFILL

MATERIAL: ____________

INTERVAL: ____________

MONITORING WELL CONSTRUCTION LOG: NESTED WELL

GEOLOGIST:	DATE STARTED:	DATE COMPLETED:
WELL NO:	PROJECT:	SITE:
PROJECT NO:	CONSTRUCTED BY:	CITY:
A. NORTHING: EASTING:	GROUND SURFACE ELEVATION:	A. MEASURING POINT ELEVATION:
B. NORTHING: EASTING:		B. MEASURING POINT ELEVATION:



BORING DIAMETER: ________

TOTAL DEPTH: ____________

(FEET BELOW GROUND SURFACE)

A. SURFACE COMPLETION

TYPE: ____________

SIZE: ____________

B. SURFACE SEAL

MATERIAL: ____________

INTERVAL: ____________

C. RISER PIPE

DIAMETER: A. ____________ B. ____________

TYPE: A. ____________ B. ____________

INTERVAL: A. ____________ B. ____________

D. GROUT

COMPOSITION: ____________

INTERVAL: ____________

E. SEAL

TYPE: ____________

INTERVAL: A. ____________ B. ____________

F. FILTER PACK

MATERIAL: A. ____________ B. ____________

INTERVAL: A. ____________ B. ____________

G. SCREEN

DIAMETER: A. ____________ B. ____________

TYPE: A. ____________ B. ____________

SLOT SIZE: A. ____________ B. ____________

INTERVAL: A. ____________ B. ____________

H. BACKFILL

MATERIAL: ____________

INTERVAL: ____________

MONITORING WELL CONSTRUCTION LOG: ZIST WELL

GEOLOGIST: | DATE STARTED: | DATE COMPLETED:

WELL NO: | PROJECT: | SITE:

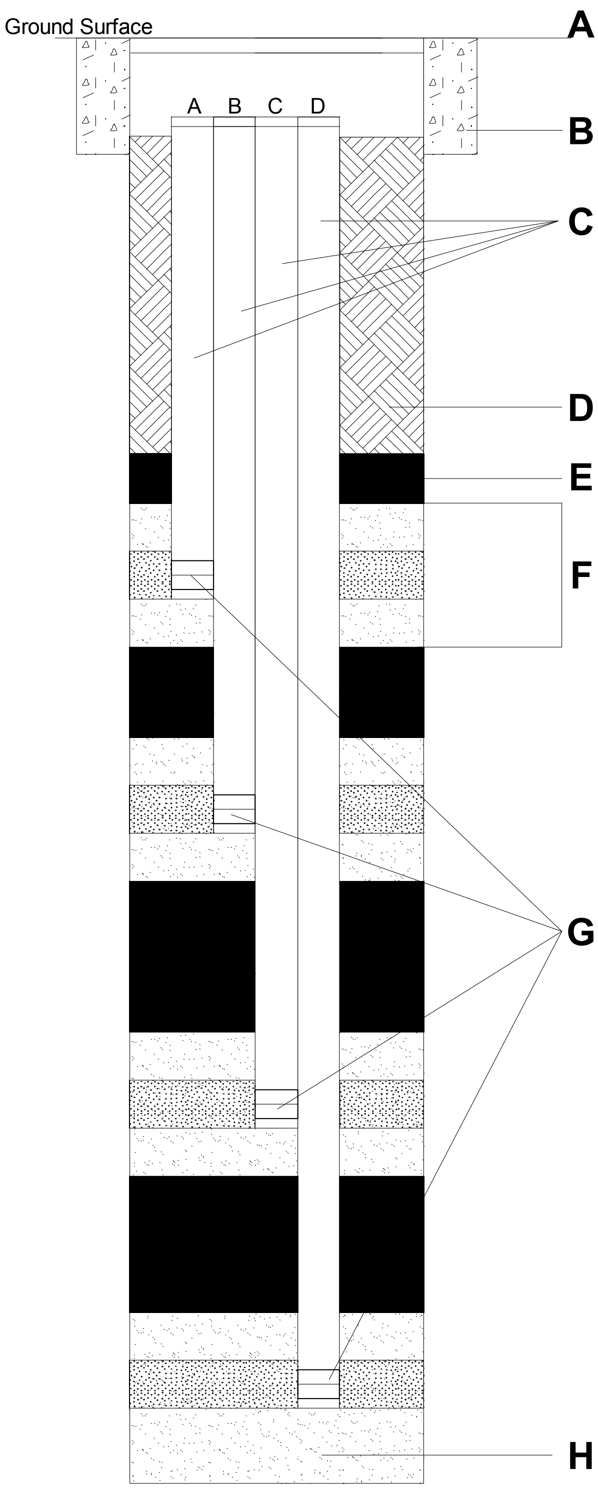
PROJECT NO: | CONSTRUCTED BY: | CITY:

A. NORTHING: ______ EASTING: ______ GROUND SURFACE ELEVATION: ______ A. MEASURING POINT ELEVATION: ______

B. NORTHING: ______ EASTING: ______ B. MEASURING POINT ELEVATION: ______

C. NORTHING: ______ EASTING: ______ C. MEASURING POINT ELEVATION: ______

D. NORTHING: ______ EASTING: ______ D. MEASURING POINT ELEVATION: ______



BORING DIAMETER: ______

TOTAL DEPTH: ______

(FEET BELOW GROUND SURFACE)

A. SURFACE COMPLETION

TYPE: ______

SIZE: ______

B. SURFACE SEAL

MATERIAL: ______

INTERVAL: ______

C. RISER PIPE

DIAMETER: A. ______ C. ______ B. ______ D. ______

TYPE: A. ______ C. ______ B. ______ D. ______

INTERVAL: A. ______ C. ______ B. ______ D. ______

D. GROUT

COMPOSITION: ______

INTERVAL: ______

E. SEAL

TYPE: ______

INTERVAL: A. ______ C. ______ B. ______ D. ______

F. FILTER PACK

MATERIAL/INTERVAL: A. ______ C. ______

MATERIAL/INTERVAL: B. ______ D. ______

G. ZIST WELL

DIAMETER: A. ______ C. ______ B. ______ D. ______

TYPE: A. ______ C. ______ B. ______ D. ______

SLOT SIZE: A. ______ C. ______ B. ______ D. ______

INTERVAL: A. ______ C. ______ B. ______ D. ______

H. BACKFILL

MATERIAL: ______

INTERVAL: ______

Appendix A.3. Well Development Log

Monitoring Point: ______ Date: ______ Sampler: ______

Weather: ______ Visitors: ______

Boring Dia. ______ Casing Dia. ______ DTW: ______ TD: ______ Pump Intake Depth: ______ Pump Top Depth: ______

Purge/Sampling Method: ______ Vial pH: ______ Depth to Water @Sampling: ______

Calculated Purge Volume[1] ______ (Water added during construction (gal)) **x 2** = ______ (Purge Volume (gal) (0.0))
(Method 1)

[1] = Calculate the purge volume using both methods. Purge the well to whichever volume is greater.

Calculated Purge Volume[1] (Method 2): Casing and Annular Volume **[(** ______ TD (ft) **-** ______ DTW (ft) **) x (** ______ CF **+** ______ BF **)] +** Vol. Above Filter Pack **(** ______ Casing Leng. (ft) **x** ______ CF **) =** ______ **x 5 +** ______ (Water added during construction (gal)) **=** ______ (Purge Volume (gal) (0.0))

Casing Volume Factors (gal/ft): 2"= 0.17; 4"=0.66; 5"=0.95 Borehole Factor Vols. (Cas.Dia/Bor.Dia.)(in): 2/8"= 0.71 gal/ft; 4/10"= 0.98 gal/ft; 4/12"= 1.18 gal/ft; 5"/12"= 1.38 gal/ft

Site Safety: ______ PPE Disposal: ______ Disposition of Purge Water: ______ 90% Recharge Level: ______ ft

Time	Purge Vol specify ml or gal	Temp (C) (0.0)	pH (0.0)	Specific Cond. (mS/cm) (0.000)	Turbidity (NTU) (0.0)	GW Level (ft below MP)	Comments (Color/Odor)

Time	Purge Vol specify ml or gal	Temp (C) (0.0)	pH (0.0)	Specific Cond. (mS/cm) (0.000)	Turbidity (NTU) (0.0)	GW Level (ft below MP)	Comments (Color/Odor)
Field parameters stable?		Y N	Y N	Y N	Y N	Total Purge Volume (mL or gallons) =	

Flow-through Cell Calibration Meter: ______

Parameter	Calibration	Check	Date	Time	Calibration Standards	Initial Reading	Final Reading	Calibration within Specifications
pH								
Turbidity								
Spec Cond								

General Notes: ______

Appendix A.4. Groundwater Sampling and Water Quality Meter Calibration Log

Operable Unit: ____________ Monitoring Point: __________________________ Date: ______________________ Sampler: ____

Weather: ____ Visitors: ____

Boring Dia. ____________ Casing Dia. ____________ DTW: ______________ TD: _______________ Pump Intake Depth: ________________ Pump Top Depth: ____________________

Purge/Sampling Method: ____ Vial pH: __________ Depth to Water @Sampling: ____

Low Flow:
Calculated Purge Volume

_______ (Tubing Leng. (ft)) X _______ (Tubing Dia. Factor) + _______ (Pump Volume) X 2 = _______ (Purge Volume (ml)) = _______ (Rounded Purge Volume (Rounded up to nearest 100 ml))

Tubing Diameter Factors: 3/8"= 13 ml/ft 1/2"= 20 ml/ft

Standard Method:
Calculated Purge Volume

Casing Volume Above Screen: [_______ (TD (ft)) - _______ (DTW (ft)) = _______ (Water Column (ft)) - _______ (Scr. Leng. (ft)) = _______ (Casing Leng.) X _______ (Casing Factor) X 3 = _______ (Casing Vol.)] + Screen Volume: (_______ (Scr. Leng. (ft)) X _______ (Scr. Factor)) = _______ (Purge Volume (gal) (0.0))

Casing Volume Factors (gal/ft): 2"= 0.17; 4"=0.66; 5"=0.95 Screen Interval Volume Factors (Cas.Dia/Bor.Dia.)(in): 2/8"= 2.15 gal/ft; 4/10"= 2.93 gal/ft; 4/12"= 4.55 gal/ft; 5"/10"=2.54 gal/ft

Site Safety: PPE Disposal: Disposition of Purge Water: 90% Recharge Level: ft Sampling Flow Rate ≤ 100 ml/min?

Time	Purge Vol specify ml or gal	Temp (C) (0.0)	pH (0.0)	Specific Cond. (mS/cm) (0.000)	Turbidity (NTU) (0.0)	DO (mg/l) (0.0)	ORP (mV) (0.0)	Chloride (YSI) (mg/l) (0.00)	Ammonia (YSI) (mg/l) (0.000)	Nitrate (YSI) (mg/l) (0.000)	GW Level (ft below MP)	Comments (Color/Odor)	Other Parameters
													Sulfide (mg/l) (0.00)
													Sulfate (mg/l) (0.00)
													DO (mg/l) (0.00)
													Total Iron (Fe) (mg/l) (0.00)
													Ferrous Iron (Fe+2) (mg/l) (0.00)
													Purge Flow Rate (ml (0) or gal per min (0.0))

Time	Purge Vol specify ml or gal	Temp (C) (0.0)	pH (0.0)	Specific Cond. (mS/cm) (0.000)	Turbidity (NTU) (0.0)	DO (mg/l) (0.0)	ORP (mV) (0.0)	Chloride (YSI) (mg/l) (0.00)	Ammonia (YSI) (mg/l) (0.000)	Nitrate (YSI) (mg/l) (0.000)	GW Level (ft below MP)	Comments (Color/Odor)	Other Parameters
Field parameters stable?		Y N	Y N	Y N	Y N	Y N	Y N						

	Sample ID	Time	Date	Analysis	Number of Bottles
Normal					
Duplicate					
MS/SD					
Trip Blank					
Equipment Blank					

Flow-through Cell Calibration Meter: ____________________

Parameter	Calibration	Check	Date	Time	Calibration Standards	Initial Reading	Final Reading	Calibration within Specifications
pH								
Turbidity								
ORP								
Spec Cond								
DO								
Ammonia								
Chloride								
Nitrate								

General Notes: ____________________

Well Condition:

Appendix A.5. Monitoring Well Condition Log

Monitoring Well Condition

Monitoring Point: ____________ Date/time: ____________ Sampler: ____________

Completion: (check all that apply; if "other" is circled provide explanation)

- ☐ Concerte Pad (circle all that apply) Very Good Good Fair Poor Comments:
- ☐ Above Ground-(circle one) Square Round Other: ____________
- ☐ Flush-mount- (circle one) Round Steel Augustyn, Square steel bolt on, Bolt on Iron, Round bolt on (4", 6", 8", 10", 12"), other: ____________
- ☐ Completion(circle) Locked, Unlocked, Not lockable, Comments: ____________
- ☐ Completion Paint Condition- (circle one) Very good, Good, Fair, Needs repaint, Not painted, comments: ____________
- ☐ Completion Bollard Condition- (circle) Intact, Damaged, Removed, Undersized (less than 4" diameter), N/A, Repair necessary ____________
- ☐ Monitoring Point ID Tag - (circle) intact, legible, attached, missing ____________

PVC Casing (circle) Good Fair Poor Comments ____________

- ☐ Repair Necessary
  - ☐ Completion Leakage
  - ☐ Bolts Stripped
  - ☐ Rubber seal; comments ____________
  - ☐ Other: ____________
  - ☐ Missing or broken lid (circle one)
  - ☐ lid stuck; comments:

Pump:

- ☐ Pump type-(circle one) Bladder, Electric, Peristaltic, other: ____________
- ☐ Repair Necessary-(circle one) Stuck, Broken, other: ____________

Maintenance Performed (date and description):

Maintenance Immediate Actions:

Maintenance Recommendations/comments:

Slug Test Data Form

Page __ of __

FIGURE 1. Slug Test Data Form

DATE: ______________________________

SITE ID: ______________________________ SLUG VOLUME (ft^3): ____________________

LOCATION ID: ______________________ LOGGER: ______________________________

TEST METHOD: __ SLUG INJECTION __ SLUG WITHDRAWAL

COMMENTS: ____

____

____

Time Beginning of Test #1 __________ Time Beginning of Test #2 _______________

Time End of Test #1 __________ Time End of Test #2 ________________

ELAPSED TIME (MIN)	DEPTH TO WATER (FT)	ELAPSED TIME (MIN)	DEPTH TO WATER (FT)

Appendix A.7. Hydrologic Testing Log

Well Location ID:

Systems Check

Transducer Clock Synchronized?
Transducer zeroed to atmospheric conditions?
Sufficient memory available?
Sufficient battery power?
Depth calibration applied and correct?
Log file name consistent?
Transducer Serial Number:

Transducer Make and Model:
Auto Start Time: *Yes / No* Specified Time:
Recording Interval:
Reference Level: Submergence / Surface Elevation / Depth to Water
Pumping Well ID:
Type of Pump:
Pumping Well Start (Date/Time)
Pumping Well Stop (Date/Time)

	Date	Local Standard Time	Depth to Water (ft bTOC) [WLI]	Transducer Installation Depth (ft bTOC)	File Name	Installation notes, site conditions, changes to TOC survey elevation
Setup						

	Date	Local Standard Time	Depth to Water (ft bTOC) [WLI]	Depth to Water (ft bTOC) [Datalogger]	Specific Conductivity (µS/cm)	Temperature (deg.C)	Pumping Rate (gpm)	Logger	Comments
Testing									

Well Location ID:

	Date	Local Standard Time	Depth to Water (ft bTOC) [WLI]	Depth to Water (ft bTOC) [Datalogger]	Specific Conductivity (µS/cm)	Temperature (deg.C)	Pumping Rate (gpm)	Logger	Comments
Testing									

Appendix A.8. PID Monitoring and Calibration Log

PID DAILY SITE MONITORING REPORT

Page 1 of ___

Project:	Date:
Task Name:	Subcontractor(s):
Description of Activities:	Description of Potential Contaminant(s) and Source:

1. Monitoring Instrumentation

Instrumentation Description: Instrument ID Number:	Calibration gas and lot number: Time & Date Calibrated: Calibration Results:

2. Site Monitoring Results

Time(s)	Monitoring Location (note distance from source, upwind/downwind, etc.)	Sample Type (source, breathing zone, area, etc.)	Instrument Reading (Units)	Comments or list name and company of person if reading is a Breathing Zone sample,*

Review

Sampler:	Signature:	Date:

*IF RESULTS ARE BREATHING ZONE RESULTS, SEND THIS COMPLETED FORM TO YOUR HEALTH AND SAFETY MANAGER.

DAILY SITE MONITORING REPORT

Page ___ of ___

3. Site Monitoring Results

Time(s)	Monitoring Location (note distance from source, upwind/downwind, etc.)	Sample Type (source, breathing zone, area, etc.)	Instrument Reading (Units)	Comments or list name and company of person if reading is a Breathing Zone sample,*

Review

Sampler:	Signature:	Date:

Appendix A.9 Surface Water Sampling and Water Quality Meter Calibration Log

Monitoring Location: ____________________ **Date:** __________ **Sampler** ____________________

Weather: ____________________ **Sample Method:** ____________________

Direct collect, decanter, rinse

Coordinates: ____________________

Time	Temp (C) (0.0)	pH (0.0)	Specific Cond. (mS/cm) (0.000)	Turbidity (NTU) (0.0)	DO (mg/L) (0.0)	ORP (mV) (0.0)	Comments (Color/Odor)

	Sample ID	Time	Date	Analysis
Normal				
Duplicate				
MS/SD				
Trip Blank				
Equipment Black				

Calibration **Meter:**

Parameter	Calibration	Check	Date	Time	Calibration Standard	Initial Reading	Final Reading	Calibration within Specifications
pH								
Turbidity								
ORP								
Spec. Cond								
DO								

General Notes:

Appendix A.10. Soil Gas Installation and Sampling Log

Sheet ___ of ___

Vapor Intrusion Best Practices
Exterior Soil Gas Probe Installation and Sampling Log

Project Info

Project Name: .... **Project # :** ....

Sampler Name: .... **Date:** ....

Site

Identification: ....

Address: ....

Site Information:

Describe ground cover ....

Depth to groundwater (feet below ground surface) ....

Describe vadose zone soil type(s) ....

Was a soil boring log completed? .... Was a probe diagram completed? ....

Soil Gas Probe Installation, Purging, Leak Checking, & Sampling Log

Sample location/Probe ID (describe and show in diagram)		
Sample Identification (field ID)		
Probe Installation	Date and time	
	Depth of hole drilled (feet below ground surface)	
	Bottom of probe screen (feet below ground surface)	
	Length of probe screen (inches)	
	Width of probe screen (inches)	
	Dead volume - including screen, sand pack, and tubing (mL)	
Manifold Leak Check	Leak check (sampling manifold) - Pass/No Pass	
Probe Purge	Purge rate (mL/min)	
	Purge start time	
	Purge vacuum (" Hg)	
	Purge completion time	
Helium Leak Check*	Helium concentration in shroud (% or ppmv helium)	
	Leak check (% or ppmv helium)	

* The soil gas probe passes the helium leak check if the detected helium concentration is less than 1,000 ppm (0.1%). Do NOT collect a soil gas sample if the probe fails the helium leak test.

		Calibration	**Field Result**
Field Analysis (optional) and Calibration	GEM2000 - O2 (%)		
	GEM2000 - CO2 (%)		
	GEM2000 - CH4 (%)		
	PID - Total VOCs (ppmv)		
	Start Date and Time		
	Completion Date and Time		
Equipment Info	Canister ID		
	Flow controller ID		
	Pressure gauge ID (optional)		
Sample Collection	Start Date and Time		
	Sampling rate or period (mL/min or hours)		
	Initial canister pressure ("Hg)		
	Sampling vacuum ("Hg)		
	Completion Date and Time		
	Final canister pressure (" Hg)		

Weather conditions during sampling: ....

Observations and Comments: ....

REV. 10/20/14

Vapor Intrusion Best Practices
Soil Gas Field Sampling Log

Sheet ___ of ___

Diagram - Outline of Site & Location of Soil Gas Probes

N

Note:
Show the location of each soil gas probe and indicate distances from significant features at the site.

Other observations and comments: ____________________

REV. 11/15/11

Appendix A.2
Quality Assurance Project Plan

The Quality Assurance Project Plan will be submitted under separate cover.

Appendix B
Standard Operating Procedures

Contents

Section Page

Section Page

Section Page

SOP B.1 Equipment Calibration

1.0 Purpose and Scope

This standard operating procedure (SOP) provides a general guideline for the calibration of field equipment. Field personnel should consult equipment manuals for specific calibration procedures. Field equipment should be calibrated at the start of every work day and re-calibrated if equipment drift is observed.

2.0 Equipment and Materials

- Field equipment for calibration (for example, water quality meter)
- Calibration cup for water quality meters
- Disposable gloves
- Paper towels
- Spray or squeeze bottle with distilled or deionized water
- Calibration standards (Section 3)
- Field form or field logbook

3.0 Procedures

3.1 Water Level Meters

Water level meters typically do not require calibration. The proper operation of a water level meter can be checked as follows:

1. Ensure the thumb screws are tight. If an “on/off” switch is present set the switch to the “on” position.
2. Submerse the electrode in tap water. The action should complete the circuit and activate the buzzer.
3. Some meters may have a sensitivity knob for cascading water. If the buzzer does not sound, ensure the sensitivity knob is not set to the lowest sensitivity position and immerse the probe again.
4. If the buzzer is not activated, replace the battery. Check the battery operation by depressing the “test” or “change mode” button while the probe is not immersed in water.

3.2 Water Quality Meters

Water quality meters (YSI 6-Series) generally include probes for the measurement of temperature, conductivity, dissolved oxygen (DO), pH, oxidation-reduction potential (ORP), and turbidity. The types of probes present depend on the type of water quality meter. The equipment manual should be consulted for the specific calibration and maintenance procedures for each type of probe. The equipment manual is included as an attachment to this SOP. The following steps should be followed in conjunction with the equipment manual for the calibration of the meter.

3.2.1 Temperature Calibration

Temperature probes generally cannot be calibrated and should not require calibration. To check the accuracy of the temperature reading, the temperature probe can be compared to a thermometer or other known reference in a water bath. If the temperature sensor is not reading accurately, ensure the probe is clean and free of debris.

3.2.2 pH Calibration

A three-point pH calibration should be used for the calibration of the pH electrode. Consult the equipment manual for specific calibration procedures in addition to the following steps:

1. Rinse and dry the electrode and the calibration cup prior to calibration. Any rinse water present on the probes or in the calibration cup may dilute the calibration standards.
2. Fill the calibration cup with pH 7.00 solution. Ensure the probe is fully immersed.
3. Monitor the pH readings on the data logger. Allow 1 minute for temperature stabilization and sufficient additional time for the readings to stabilize. Press “calibrate.”
4. Follow steps two and three with pH buffers 4.00 and 10.00. Rinse and dry the electrode and calibration cup in between calibration standards.

If pH readings fail to stabilize, gently clean the electrode with distilled water. The bulb should not be mechanically cleaned; the bulb can break and abrasion can lead to permanent damage. If an air bubble is observed in the electrode tip, the meter can be carefully shaken to dislodge the air bubble.

3.2.3 Specific Conductivity Calibration

Conductivity probes can be calibrated for conductivity, specific conductance, salinity, and total dissolved solids. Unless otherwise noted the probe should be calibrated for specific conductance. The equipment manual should be consulted for specific procedures in addition to the following general steps:

1. Rinse and dry the probe and the calibration cup prior to calibration. If possible, rinse the conductivity sensor with a small amount of calibration standard that can be discarded. Note that conductivity calibration standards are sensitive to dilution.
2. Fill the calibration cup with the conductivity standard (typically a 1.413 milliSiemens per centimeter standard is used). Ensure the probe is fully immersed.
3. Gently rotate the meter/probes to remove any bubbles from the conductivity cell.
4. Allow 1 minute for temperature stabilization and sufficient additional time for the reading to stabilize. Press “calibrate.”

3.2.4 Dissolved Oxygen Calibration

A rapid pulse DO probe or an optical DO probe may be present depending on the meter type. A one-point saturated air calibration is used for both probe types. The following general steps should be followed in addition to the specific procedures outlined in the equipment manual.

1. Rinse and dry the DO probe and the calibration cup prior to calibration.
2. Place approximately ⅛-inch of water in the bottom of the calibration cup.
3. Place the probe into the calibration cup, ensuring that the DO and temperature probes are not in contact with water.
4. Engage only one or two threads of the calibration cup to allow the DO probe to be vented to the atmosphere.

5. If the probe is an optical DO probe, select ODOsat%. When prompted, enter the barometric pressure in millimeters Hg. The barometric pressure may be provided by the meter, depending on meter type.
6. Wait at least 5 minutes for the air in the calibration cup to become water saturated and the temperature to equilibrate (consult the equipment manual for the specific time required for equilibration).
7. Press "calibrate" once the reading has stabilized.

If a rapid pulse oxygen probe is being used and the readings fail to stabilize, the electrolyte solution and membrane may need to be replaced. Consult the equipment manual for maintenance procedures.

3.2.5 Turbidity Calibration

A two-point calibration should be conducted for the calibration of turbidity probes. Follow the general steps provided below in addition to specific procedures provided by the equipment manual.

1. Rinse and dry the turbidity probe and the calibration cup prior to calibration.
2. Select a two-point calibration.
3. Fill the calibration cup with the 0 Nephelometric Turbidity Unit (NTU) standard. Distilled water may be used if a 0 NTU standard is not provided.
4. Insert the probe into the calibration cup, ensuring the tip of the turbidity probe is immersed in the calibration standard.
5. Depending on the probe type, the probe may be cleaned during calibration. Activate the wiper by selecting "clean optics" if the option is present on the screen.
6. Allow sufficient time for readings to stabilize.
7. Press "calibrate."
8. Follow steps three through seven for the second calibration standard. Ensure the calibration cup and probe are clean and dry before switching calibration standards.

3.2.6 Oxidation-Reduction Potential Calibration

The following general steps should be followed for the ORP calibration in addition to the specific procedures provided by the calibration manual.

1. Prepare the ZoBell ORP/Redox standard solution according to the instructions on the container. Once mixed the solution may be used for up to 6 months.
2. Consult the temperature chart to find the corresponding ORP calibration value.
3. Rinse and dry the ORP probe and the calibration cup prior to calibration.
4. Pour the prepared ZoBell solution into the calibration cup.
5. Insert the probe into the calibration cup. Ensure the probe is fully immersed in the ORP solution. Depending on the available volume of solution, the meter may need to be set at an angle to immerse the probe.
6. Select the ORP calibration and enter the ORP calibration value when prompted.
7. Allow sufficient time for the readings to stabilize.
8. Press "calibrate."

Once the calibration procedures are complete, rinse the probes and calibration cup to remove any traces of calibration standards. The probes should be stored in the calibration cup with a small amount of distilled water to keep the sensors moist.

3.3 Photoionization Detectors

Photoionization detectors (PIDs) are used for field screening of site contaminants. The values recorded by the detector represent a total volatile organic concentration of the gases present at a site. The following limitations should be noted prior to the calibration and operation of the instrument. Consult the equipment manual for additional specifications and specific calibration procedures.

- PIDs do not detect methane and cannot be used as an indicator for combustible gases or oxygen deficiency.
- PIDs do not detect compounds with ionization potentials that exceed the energy level of the instruments bulb.
- Response may change when gases are mixed.
- Other voltage sources such as power lines may interfere with the measurements.
- Readings can only be reported relative to the calibration standard used.
- Response is affected by high humidity. During cold weather, condensation may form on the ultraviolet (UV) light source window, resulting in erroneous results.
- Total concentrations are relative to the calibration gas used. Therefore, specific contaminant concentrations cannot be identified.
- Over the 0 to 2,000 parts per million range, response is linear to the calibration gas. Greater concentrations may be displayed at a higher or lower level than the true value.
- Wind speeds greater than 3 miles per hour may affect fan speed and readings, depending on the position of the probe relative to wind direction.

Calibrations and standards vary depending on the equipment model. The following procedures should be followed in addition to the specific procedures outlined in the equipment manual.

1. Turn on the instrument and connect the sampling hose to a Tedlar bag filled with calibration gas or to a regulator to calibrate. The calibration gas should not be used beyond the date indicated on the canister.
2. Ensure the final calibration value matches or approximates the concentration listed on the calibration gas canister.
3. If the value does not match or approximate the calibrated concentration, the instrument should be recalibrated and/or repaired.

Consult the equipment manual for maintenance and troubleshooting procedures. The condition of the bulb and battery should be checked on a regular basis. The UV light source window and ionization chamber should be cleaned regularly. The filters should be checked and cleaned regularly and care taken to prevent solids and liquids from being drawn into the instrument.

4.0 Documentation and Field Forms

The following information should be noted on the appropriate field form and/or field logbook:

- Date and time of calibration
- Instrument model and serial number
- Personnel conducting calibration
- Calibration standards
- Readings before and after calibration (if applicable)
- Any maintenance or troubleshooting procedures conducted
- Any re-calibration procedures conducted in response to equipment drift or malfunction

SOP B.1 Attachment
YSI 6-Series Multiparameter Water Quality Sondes

YSI incorporated

6-Series

Multiparameter
Water Quality Sondes

User Manual

6-Series:

6600 V2
6600EDS V2
6920 V2
6820 V2
600 OMS V2
600XL
600XLM
600LS
600R
600QS

SAFETY NOTES

TECHNICAL SUPPORT AND WARRANTY INFORMATION

Contact information for technical support and warranty information on YSI's Environmental Monitoring Systems products can be found in **Section 9, Warranty and Service Information**.

COMPLIANCE

When using the YSI 6-Series sondes in a European Community (CE) country, please be aware that electromagnetic compatibility (EMC) performance issues may occur under certain conditions, such as when the sonde is exposed to certain radio frequency fields.

If you are concerned with these issues, consult the Declaration of Conformity that was enclosed with your instrument. Specific conditions where temporary sensor problems may occur are listed in this document.

The Declaration of Conformity for your instrument can be found in Appendix H, EMC Performance. A similar document for YSI Model 650 is located at the end of Section 3, 650 MDS.

SPECIFICATIONS

For general specifications for all YSI Environmental Monitoring Systems products included in this manual, please see **Appendix O, Specifications**.

GENERAL SAFETY CONSIDERATIONS

For Health and Safety issues concerning the use of the calibration solutions with the sondes, please see **Appendix A, Health and Safety**.

NOTICE

Information contained in this manual is subject to change without notice. Effort has been made to make the information contained in this manual complete, accurate, and current. YSI shall not be held responsible for errors or omissions in this operations manual.

WARNING:
When caring for your sonde, remember that the sonde is sealed at the factory, and there is never a need to gain access to the interior circuitry of the sonde. In fact, if you attempt to disassemble the sonde, you would void the manufacturer's warranty.

TABLE OF CONTENTS

SECTION 1 INTRODUCTION

1.1 ABOUT YSI INCORPORATED

From a three-man partnership in the basement of the Antioch College science building in 1948, YSI has grown into a commercial enterprise designing and manufacturing precision measurement sensors and control instruments for users around the world. Although our range of products is broad, we focus on three major markets: water testing and monitoring, health care, and bioprocessing.

In the 1950s, Hardy Trolander and David Case made the first practical electronic thermometer using a thermistor. This equipment was developed to supply Dr. Leland Clark with a highly sensitive and precise temperature sensor for the original heart-lung machine. The collaboration with Dr. Clark has been critical to the success of the company. In the 1960s, YSI refined a Clark invention, the membrane covered polarographic electrode, and commercialized oxygen sensors and meters which revolutionized the way dissolved oxygen was measured in wastewater treatment plants and environmental water. Today, geologists, biologists, environmental enforcement personnel, officials of water utilities and fish farmers recognize us as the leader in dissolved oxygen measurement.

In the 1970s, YSI again worked with Clark to commercialize one of his many inventions, the enzyme membrane. This development resulted in the first practical use of a biosensor, in the form of a membrane based on immobilized glucose oxidase, to measure blood sugar accurately and rapidly. In the next few years, this technology was extended to other enzymes, including lactate oxidase, for applications in biotechnology, health care, and sports medicine.

In the early 1990s, YSI launched a line of multi-parameter water monitoring systems to address the emerging need to measure non-point source pollution. Today we have thousands of instruments in the field that operate with the push of a button, store data in memory, and communicate with computers. These instruments (described in this manual) are ideal for profiling and monitoring water conditions in industrial and wastewater effluents, lakes, rivers, wetlands, estuaries, coastal waters, and monitoring wells. If the instrument has ‘on board’ battery power, it can be left unattended for weeks at a time with measurement parameters sampled at the user’s setup interval and data securely saved in the unit's internal memory. The fast responses of YSI’s sensors make the systems ideal for vertical profiling, and the small size of some our sondes allows them to fit down 2-inch diameter monitoring wells. All of YSI’s multi-parameter systems feature either the YSI-patented Rapid Pulse Dissolved Oxygen Sensor, which exhibits low-stirring dependence and provides accurate results without an expensive, bulky, and power-intensive stirrer or an ROX optical dissolved oxygen sensor which exhibits no flow dependence and is extremely stable in long-term deployments.

YSI has established a worldwide network of selling partners in over 50 countries that includes laboratory supply dealers, manufacturers' representatives, and YSI’s sales force. A subsidiary, YSI UK, distributes products in the United Kingdom, a sales office in Hong Kong supports YSI’s distribution partners in Asia Pacific, and YSI Japan supports distribution partners in Japan.

Through an employee stock ownership plan (ESOP), every employee is one of the owners. In 1994, the ESOP Association named YSI the ESOP Company of the Year. YSI is proud of its products and are committed to meeting or exceeding customers' expectations.

1.2 HOW TO USE THIS MANUAL

The manual is organized to let you quickly understand and operate the YSI 6-Series environmental monitoring systems. However, it cannot be stressed too strongly that informed and safe operation is more than just knowing which buttons to push. An understanding of the principles of operation, calibration techniques, and system setup is necessary to obtain accurate and meaningful results. Thorough reading and understanding of this manual is essential to proper operation.

Because of the many features, configurations and applications of these versatile products, some sections of this manual may not apply to the specific system you have purchased.

If you have any questions about this product or its application, please contact YSI's Technical Support Group or authorized dealer for assistance. See **Section 9, Warranty and Service Information** for contact information.

1.3 UNPACKING AND INSPECTION

Inspect the outside of the shipping box for damage. If any damage is detected, contact your shipping carrier immediately. Remove the equipment from the shipping box. Some parts or supplies are loose in the shipping box so check the packing material carefully. Check off all of the items on the packing list and inspect all of the assemblies and components for damage.

If any parts are damaged or missing, contact your YSI representative immediately. If you purchased the equipment directly from YSI, or if you do not know from which YSI representative your equipment was purchased, refer to **Section 8, Warranty and Service Information** for contact information.

SECTION 2 SONDES

2.1 GETTING STARTED

The 6-Series Environmental Monitoring Systems from YSI are multi-parameter, water quality measurement, and data collection systems. They are intended for use in research, assessment, and regulatory compliance applications. Section 2 concentrates on sondes and how to operate them during different applications. A sonde is a torpedo-shaped water quality monitoring device that is placed in the water to gather water quality data. Sondes may have multiple probes. Each probe may have one or more sensors that read water quality data.

The following list contains parameters that your sonde may measure. See **Appendix O, Specifications** for the specific parameters of each sonde.

- Rapid Pulse Polarographic Dissolved Oxygen
- ROX Optical Dissolved Oxygen
- Conductivity
- Specific Conductance
- Salinity
- Total Dissolved Solids
- Resistivity
- Temperature
- pH
- ORP
- Depth
- Level
- Flow
- Turbidity
- Chlorophyll
- Rhodamine WT
- Phycocyanin-Containing Blue-green Algae
- Phycoerythrin-Containing Blue-green Algae
- Nitrate-N
- Ammonia-N
- Ammonium-N
- Chloride

This section is designed to quickly familiarize you with the hardware and software components of the sondes and their accessories. You will then proceed to probe installations, cable connections, software installation and finally basic communication with your Sonde. Diagrams, menu flow charts and basic written instructions will guide you through basic hardware and software setup.

2.2 CONNECTING YOUR SONDE

There are a number of ways in which you may connect the sondes to various computers, data collection devices and VT-100 terminal emulators. To utilize the configuration that will work best for your application, make sure that you have all of the components that are necessary. The following list and diagrams (Figures 1-4) are a few possible configurations.

- Sonde to Lab Computer (recommended for initial setup)
- Sonde to Data Collection Platform
- Sonde to Portable Computer
- Sonde to YSI 650 MDS Display/Logger

Figure 1

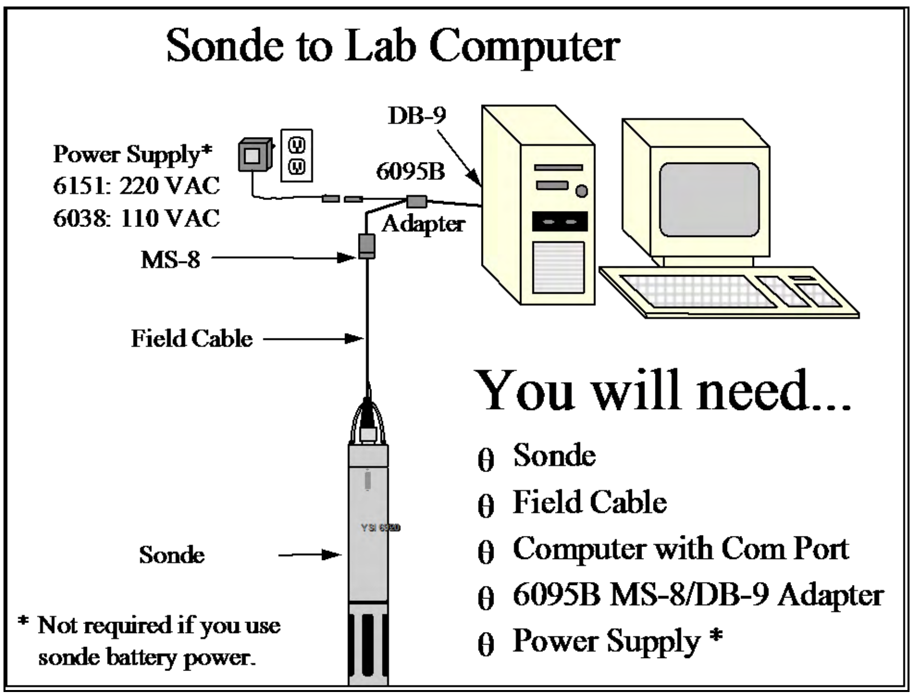


Figure 2

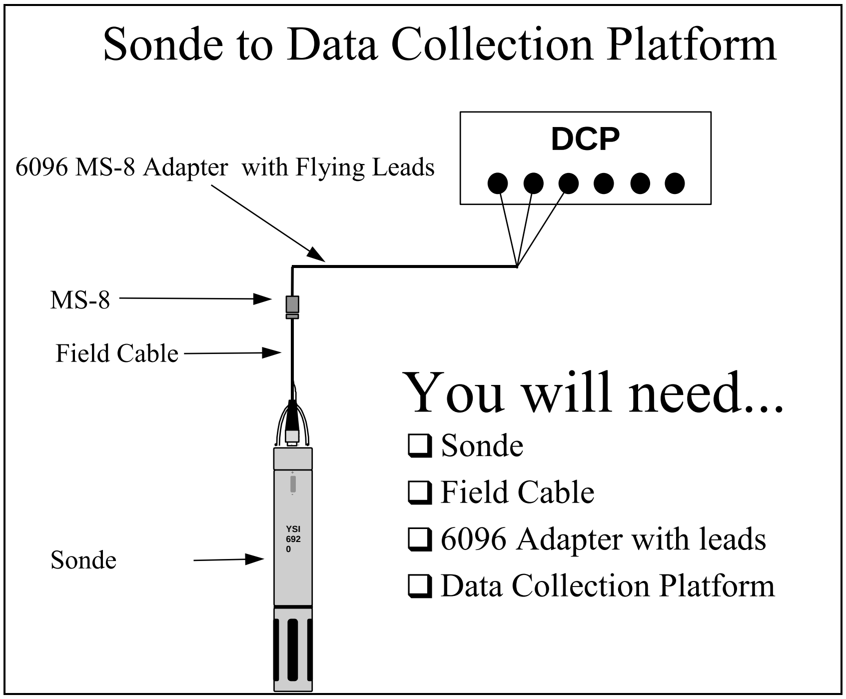


Figure 3

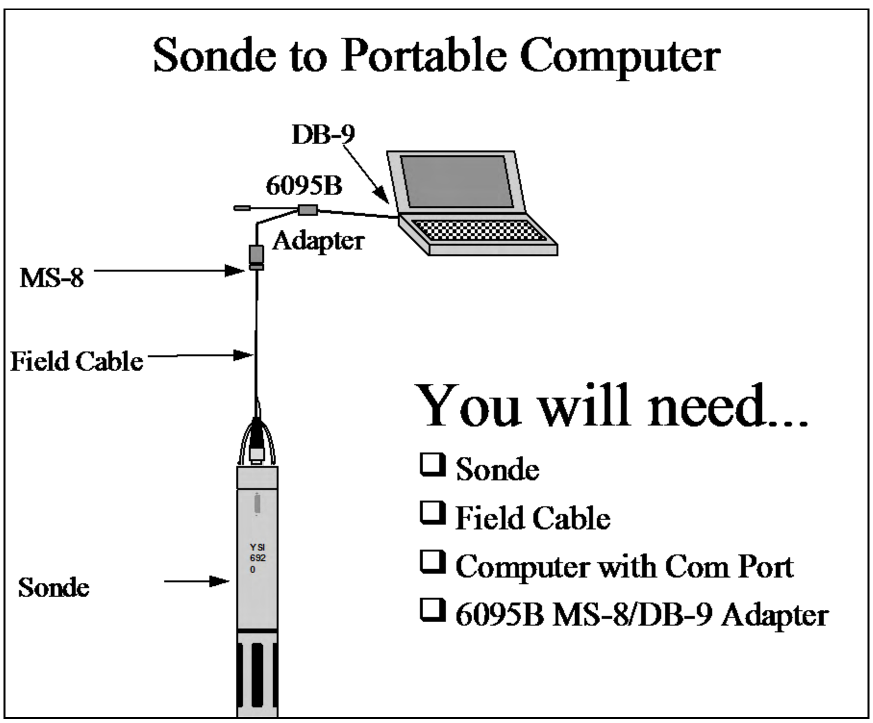
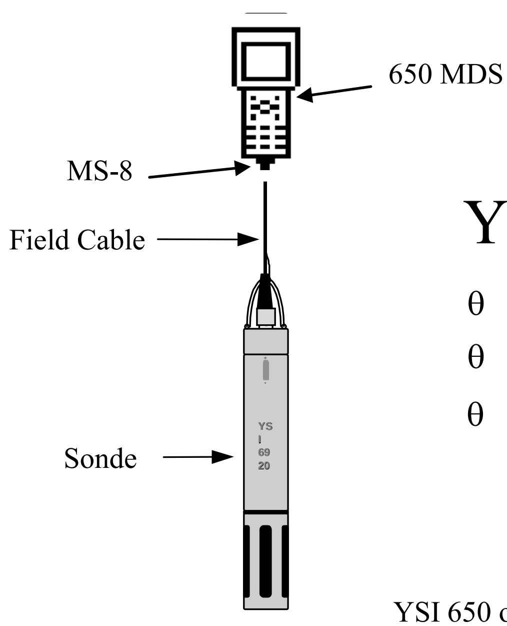


Figure 4

Sonde to 650 Display/Logger



You will need...

- θ Sonde
- θ Field Cable
- θ 650 MDS Display/Logger

YSI 650 operates on C-cells or rechargeable batteries.

2.3 PREPARING THE SONDE FOR USE

To prepare the sonde for calibration and operation, you need to install probes (sensors) into the connectors on the sonde bulkhead. In addition to probe installation, you need to install a new membrane on the YSI 6562 DO Probe if you are using this item. It is recommended that you install the DO membrane before installing the probe onto the bulkhead. For membrane changes in the future, you may be able to perform this operation without removing the DO probe. This will largely depend on whether the other installed probes interfere with your ability to install a membrane. The next step is providing power for the sondes, through batteries or line power, and then connecting a field cable. The four steps necessary for getting your sonde ready for use are listed below.

Step 1 Installing the Dissolved Oxygen Membrane – Section 2.3.1
Step 2 Installing the Probes – Section 2.3.2
Step 3 Supplying Power – Section 2.3.3
Step 4 Connecting a Field Cable – Section 2.3.4

2.3.1 STEP 1 - INSTALLING THE DISSOLVED OXYGEN MEMBRANE

Note: If you are using a ROX Optical DO sensor for your applications, please skip to Section 2.3.2 at this time.

The 6562 Rapid Pulse Polarographic DO probe is shipped with a protective dry membrane on the sensor tip held in place by an O-ring. Remove the O-ring and membrane. Handle the probe with care. It is very important not to scratch or contaminate the sensor tip. See **Section 2.10.2, Probe Care and Maintenance**, for information on how often the membrane should be replaced.

Unpack the YSI 6562 DO Probe Kit and follow the instructions below.

Open the membrane kit and prepare the electrolyte solution. Dissolve the KCl in the dropper bottle by filling it to the neck with deionized or distilled water and shaking until the solids are fully dissolved. After the KCl is dissolved, wait a few minutes until the solution is free of bubbles.

Figure 5

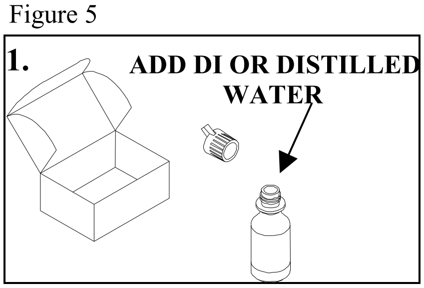
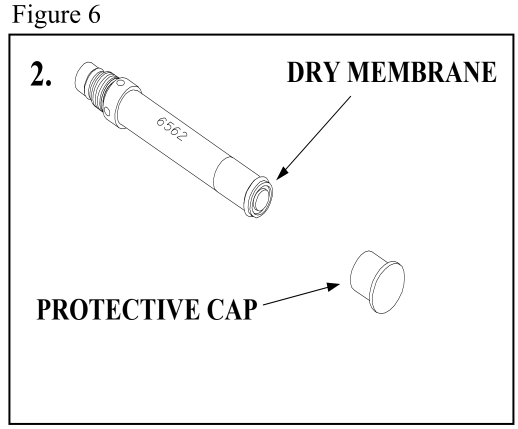


Figure 6



The DO membrane can be installed with the DO probe either free or installed in the sonde. Both methods are described in detail below. **CAUTION: If you install the membrane with the probe not installed in the sonde, be sure that the protective cap is installed on the probe end away from the sensor face to ensure that the connector is not contaminated with electrolyte.**

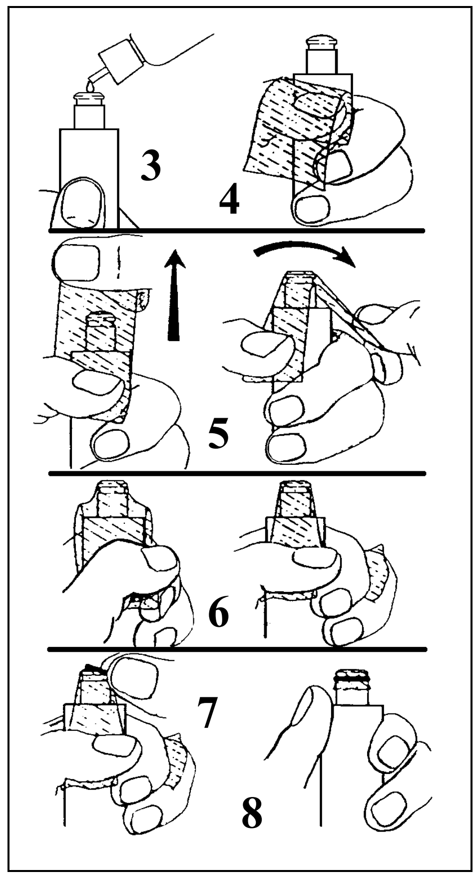
DO MEMBRANE INSTALLATION WITH THE PROBE NOT INSTALLED IN THE SONDE

Remove the protective cap and the dry membrane from the YSI 6562 Dissolved Oxygen probe.

Make sure that the protective cap is installed on the connector end of the probe. Do not allow the electrolyte solution to wet the probe‟s connector and O-ring seal areas. This solution is extremely corrosive to the connector and is difficult to remove.

Before using any electrolyte, wrap a clean, dry paper towel around the capped probe to catch any spilled electrolyte. Hold the probe in a vertical position and apply a few drops of KCl solution to the tip. The fluid should completely fill the small moat around the electrodes and form a meniscus on the tip of the sensor. Be sure no air bubbles are stuck to the face of the sensor. If necessary, shake off the electrolyte and start over.

Figure 7



Secure a membrane between your left thumb and the probe body. Always handle the membrane with care, touching it only at the ends.

With the thumb and forefinger of your right hand, grasp the free end of the membrane. With one continuous motion, gently stretch it up, over, and down the other side of the sensor. The membrane should conform to the face of the sensor.

Secure the end of the membrane under the forefinger of your left hand.

Roll the O-ring over the end of the probe, being careful not to touch the membrane surface with your fingers. There should be no wrinkles or trapped air bubbles. Small wrinkles may be removed by lightly tugging on the edges of the membrane. If bubbles are present, remove the membrane and repeat steps 3-8.

Trim off any excess membrane with a sharp knife or scissors. Rinse off any excess KCl solution, but be careful not to get any water in the connector.

If you are concerned that electrolyte may have dripped onto the O-ring seal area, probe connector, or bulkhead connectors, rub the area clean with paper towels wetted with Deionized water and then dry the affected area with a final dry towel, compressed air blasts, or rinse with fresh alcohol.

NOTE: You may find it more convenient to mount the probe vertically in a vise with rubber jaws while applying the electrolyte and membrane to the sensor tip.

DO MEMBRANE INSTALLATION WITH THE PROBE INSTALLED IN THE SONDE

Secure the sonde in a vertical position using a vise or a clamp and ring stand such that the sensors are upright. Remove the probe guard from the sonde.

Remove the old DO membrane and clean the probe tip with water and lens cleaning tissue. Make sure to remove any debris or deposits from the O-ring groove.

Using the dropper bottle of electrolyte supplied, place electrolyte on the DO probe tip until a high meniscus is formed as shown in Figure 8 below.

Figure 8

Figure 9

Hold the membrane so that all four corners are supported, but do not stretch the membrane laterally.

Position the membrane over the probe, keeping it parallel to the probe face as shown in Figure 9 above.

Using one continuous downward motion, stretch the membrane over the probe face as shown. See Figure 10 below. Do not hesitate to stretch the membrane.

Figure 10

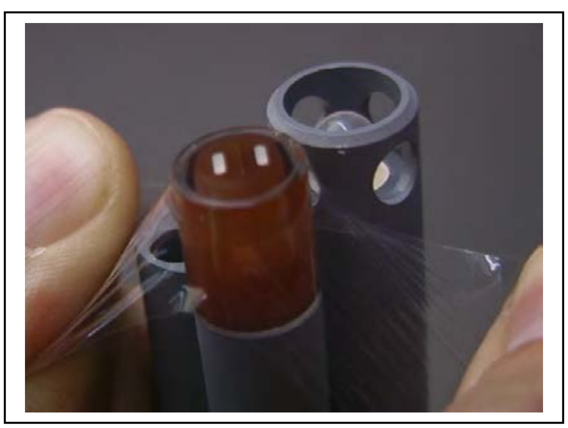


Figure 11

Install a new O-ring by placing one side of the O-ring in the groove and rolling into place across the membrane and into the groove on the opposite side of the probe face. Avoid touching the probe face with your fingers. Once the O-ring is in position, squeeze it every 90 degrees to equalize the tension. See Figure 11 above. DO **NOT** USE GREASE OR LUBICANT OF ANY KIND ON THE O-RING.

Using a hobby knife or a scalpel, trim the excess Teflon from the membrane, making your cut about 1/8 inch below the O-ring as shown in Figure 12 below. A razor blade can be used for the cut if no knife or scalpel is available.

Figure 12

Figure 13

If the installation has been done properly, the finished product should have no bubbles, wrinkles, or tears as shown in Figure 13 above.

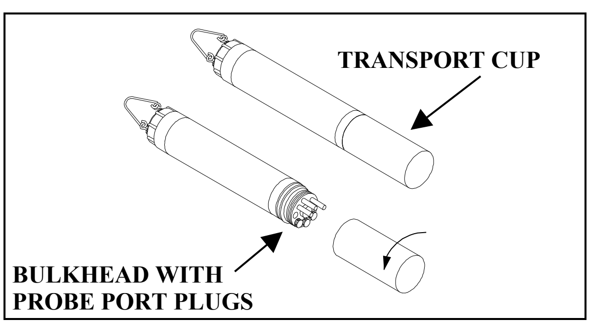
NOTE: Observe the following cautions to assure that your membrane installation is proper:

- Secure the sonde tightly so that it will not move during membrane installation.
- Wash hands before installation and do not allow finger oils or O-ring lubricant to touch the probe face or the membrane.
- Use caution when replacing the probe guard that you do not touch the membrane. If you suspect that the membrane has been damaged, replace it immediately.

2.3.2 STEP 2 - INSTALLING THE PROBES

Remove the calibration cup from your sonde by hand as shown in Figure 14, to expose the bulkhead.

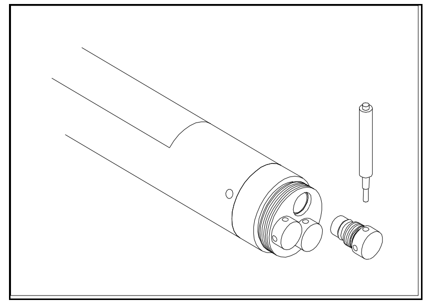
Figure 14



REMOVING THE PORT PLUGS

Using the long extended end of the probe installation tool supplied in the YSI 6570 Maintenance Kit, remove the port plugs. Save all the port plugs for possible future use.

Figure 15



There are a variety of probe options for the sondes. Figures 15, 16 and 17 illustrate the uses of the common tool for port plug removal.
Note that this tool will also be used to install the various probes.

If the tool is misplaced or lost, you may use 7/64" and 9/64" hex keys as substitutes.

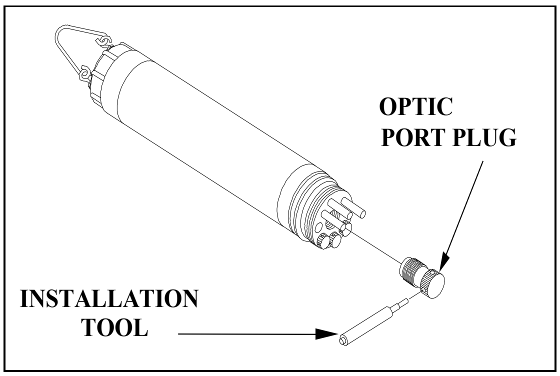


Figure 16

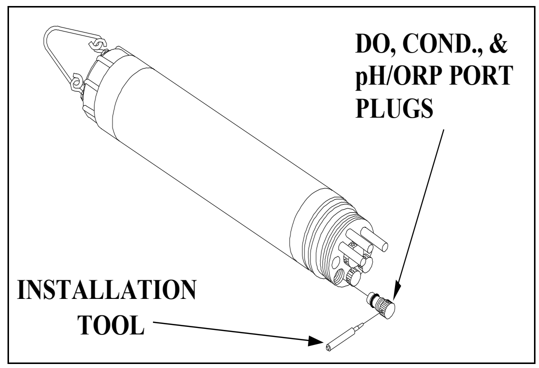
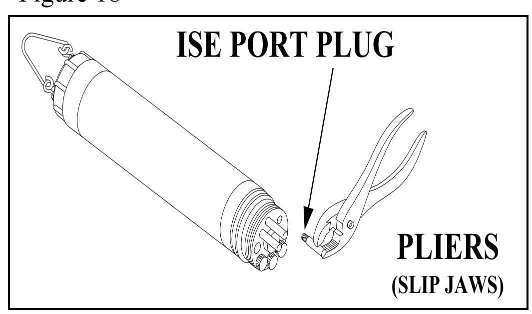


Figure 17

NOTE: You may need pliers to remove the ISE port plugs, but do not use pliers to tighten the ISE probes. Hand-tighten only.

Now refer to Figures 19-24 to find the probe locations in your sonde.

Figure 18

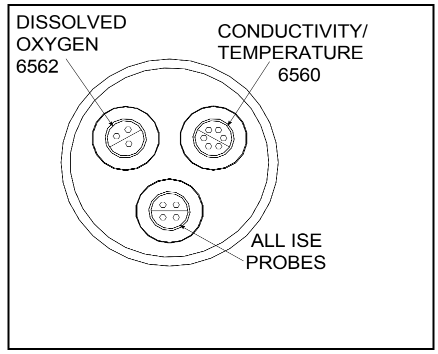


600XL & 600XLM SONDE BULKHEAD

3 Port Sonde: 1 Rapid Pulse DO, 1 Conductivity/Temperature, and 1 pH/ORP

- 6562 Dissolved oxygen probe = 3-pin connector
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 pH probe = 4 pin connector
- 6565 Combo pH/ORP probe = 4 pin connector

Figure 19

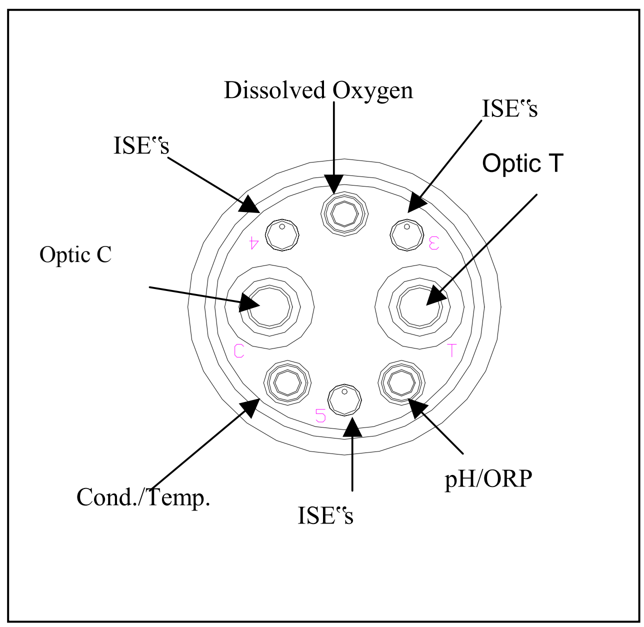


6600V2-2 SONDE BULKHEAD

8 Port Sonde: 1 Rapid Pulse DO, 1 Conductivity/Temperature, 2 Optical, 3 ISE, 1 pH/ORP

- 6562 Dissolved oxygen probe = 3-pin connector
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 or 6561FG pH probe = 4 pin connector
- 6565 or 6565FG pH/ORP probe = 4 pin connector
- 6566 Fouling Resistant pH/ORP probe = 4 pin connector
- 6882 Chloride Probe = leaf spring connector
- 6883 Ammonium Probe = leaf spring connector
- 6884 Nitrate Probe = leaf spring connector
- 6026 Turbidity Probe, Wiping = 8 pin connector
- 6136 Turbidity Probe, Wiping = 8 pin connector
- 6025 Chlorophyll Probe, Wiping = 8 pin connector
- 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- 6150 Optical Dissolved oxygen probe = 8 pin connector
- 6131 PC-Blue-green Algae probe = 8 pin connector
- 6132 PE-Blue-green Algae probe = 8 pin connector

Figure 20A

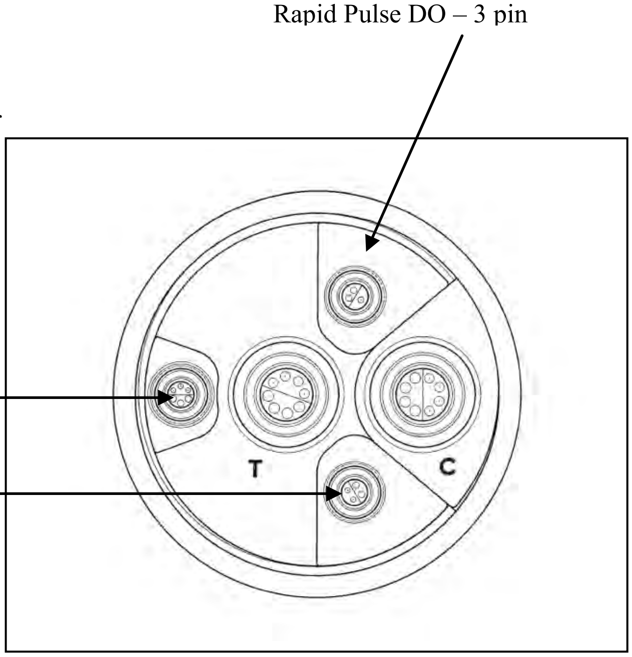


6600EDS V2-2 SONDE BULKHEAD

5 Port Sonde: 1 Rapid Pulse DO, 1 Conductivity/Temperature, 2 Optical, 1 pH/ORP

Figure 20B

- 6562 Dissolved oxygen probe = 3-pin connector
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 or 6561FG pH probe = 4 pin connector
- 6565 or 6565FG pH/ORP probe = 4 pin connector
- 6566 Fouling Resistant pH/ORP probe = 4 pin connector
- 6026 Turbidity Probe, Wiping = 8 pin connector
- 6136 Turbidity Probe, Wiping = 8 pin connector
- 6025 Chlorophyll Probe, Wiping = 8 pin connector
- 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- 6150 Optical Dissolved oxygen probe = 8 pin connector
- 6131 PC-Blue-green Algae probe = 8 pin connector
- 6132 PE-Blue-green Algae probe = 8 pin connector

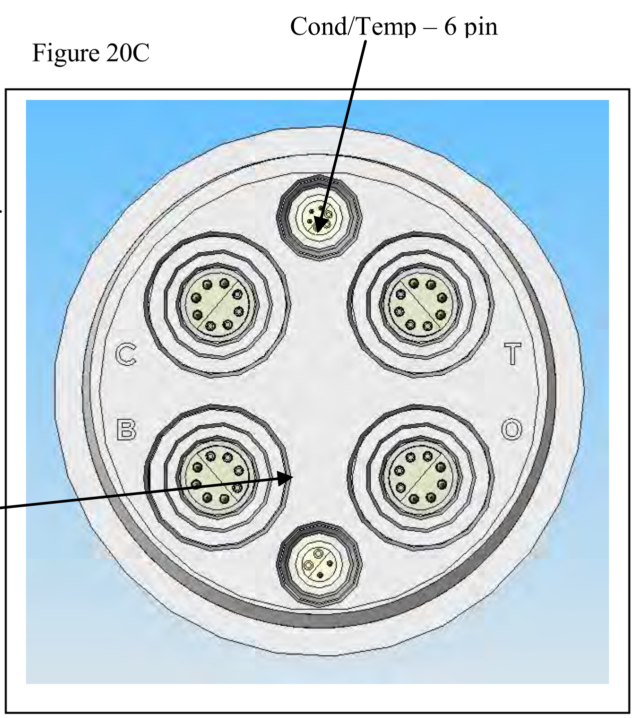


6600V2-4 SONDE BULKHEAD

6 Port Sonde: 1 Conductivity/Temperature, 4 Optical, 1 pH/ORP

Figure 20C

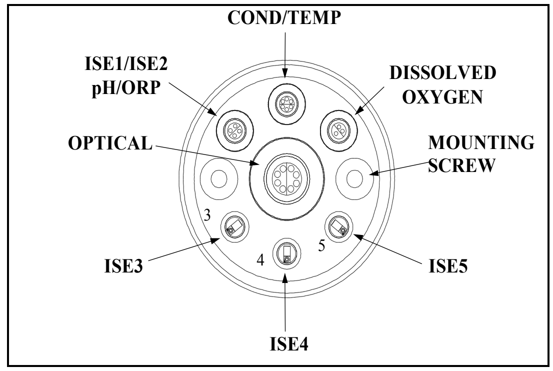
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 or 6561FG pH probe = 4 pin connector
- 6565 or 6565FG pH/ORP probe = 4 pin connector
- 6566 Fouling Resistant pH/ORP probe = 4 pin connector
- 6026 Turbidity Probe, Wiping = 8 pin connector
- 6136 Turbidity Probe, Wiping = 8 pin connector
- 6025 Chlorophyll Probe, Wiping = 8 pin connector
- 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- 6150 Optical Dissolved oxygen probe = 8 pin connector
- 6131 PC-Blue-green Algae probe = 8 pin connector
- 6132 PE-Blue-green Algae probe = 8 pin connector



6820V2-1 & 6920V2-1 SONDE BULKHEADS

7 Port Sonde: 1 Rapid Pulse DO, 1 Conductivity/Temperature, 1 Optical, 1 pH/ORP, 3 ISE

Figure 21A

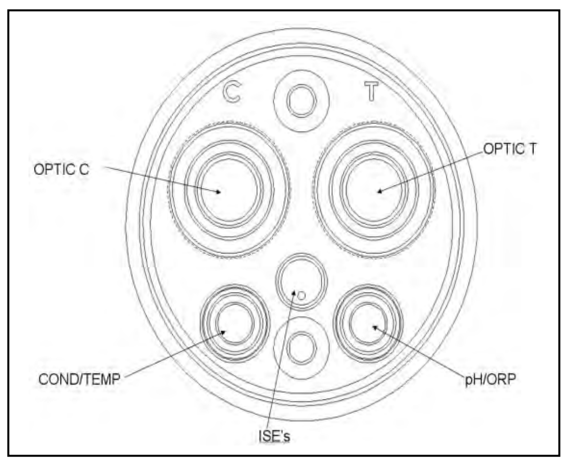


- 6562 Dissolved oxygen probe = 3-pin connector
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 or 6561FG pH probe = 4 pin connector
- 6565 or 6565FG pH/ORP probe = 4 pin connector
- 6566 Fouling Resistant pH/ORP probe = 4 pin connector
- 6882 Chloride Probe = leaf spring connector
- 6883 Ammonium Probe = leaf spring connector
- 6884 Nitrate Probe = leaf spring connector
- 6026 Turbidity Probe, Wiping = 8 pin connector
- 6136 Turbidity Probe, Wiping = 8 pin connector
- 6025 Chlorophyll Probe, Wiping = 8 pin connector
- 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- 6150 Optical Dissolved oxygen probe = 8 pin connector
- 6131 PC-Blue-green Algae probe = 8 pin connector
- 6132 PE-Blue-green Algae probe = 8 pin connector

6820V2-2 & 6920V2-2 SONDE BULKHEADS

5 Port Sonde: 1 Conductivity/Temperature, 2 Optical, 1 pH/ORP, 1 ISE

Figure 21B

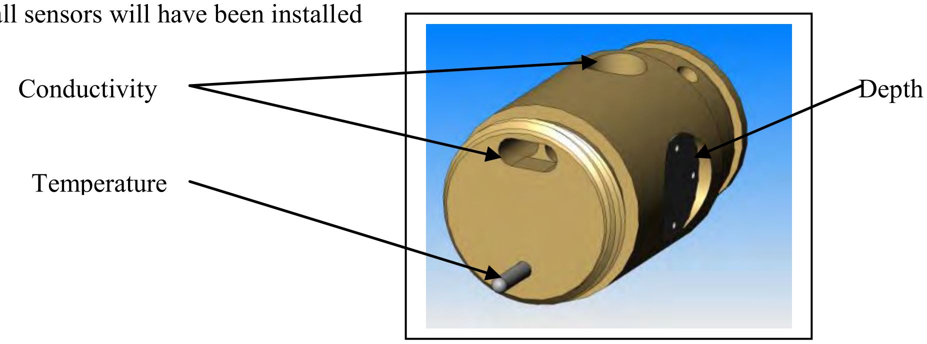


- 6560 Conductivity/Temperature = 6-pin connector
- 6561 or 6561FG pH probe = 4 pin connector
- 6565 or 6565FG pH/ORP probe = 4 pin connector
- 6566 Fouling Resistant pH/ORP probe = 4 pin connector
- 6882 Chloride Probe = leaf spring connector
- 6883 Ammonium Probe = leaf spring connector
- 6884 Nitrate Probe = leaf spring connector
- 6026 Turbidity Probe, Wiping = 8 pin connector
- 6136 Turbidity Probe, Wiping = 8 pin connector
- 6025 Chlorophyll Probe, Wiping = 8 pin connector
- 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- 6150 Optical Dissolved oxygen probe = 8 pin connector
- 6131 PC-Blue-green Algae probe = 8 pin connector
- 6132 PE-Blue-green Algae probe = 8 pin connector

600LS BULKHEAD

Figure 21C

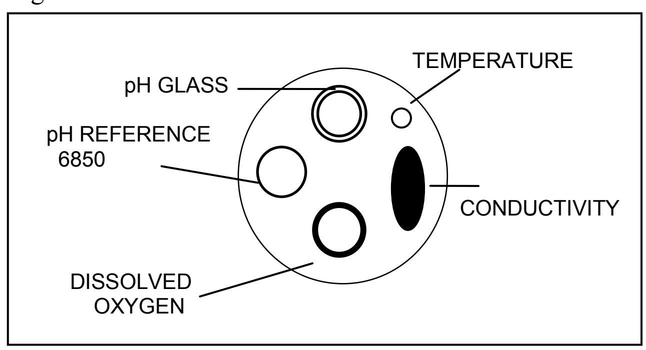
If are working with a 600LS, all sensors will have been installed at the factory.



600R BULKHEAD

Figure 22

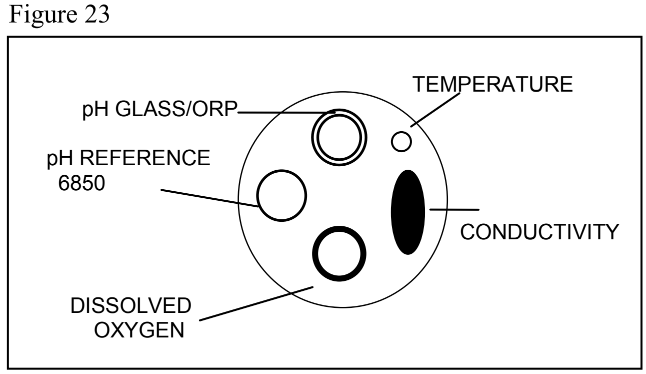
If are working with a 600R sonde, your instrument will arrive with the probes installed.



600QS BULKHEAD

Figure 23

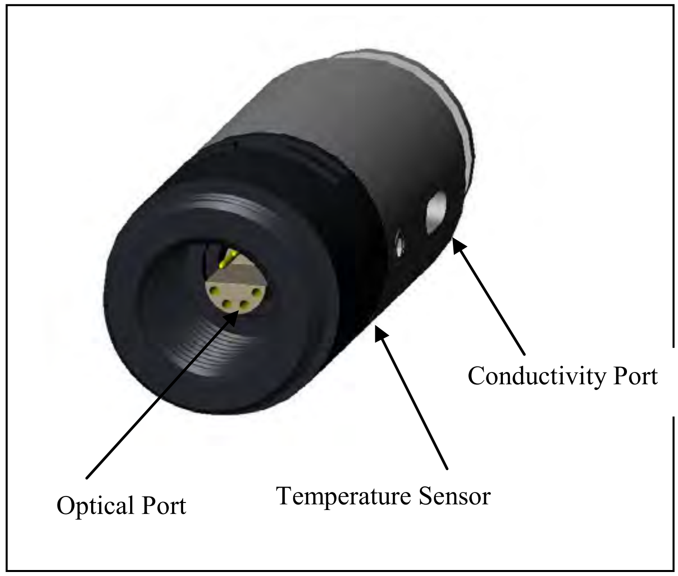
If are working with a 600QS sonde, your instrument will arrive with the probes installed.



600 OMS V2-1 BULKHEAD

The conductivity sensor (module/port) for the 600 OMS V2-1 is factory installed. Optical probes (turbidity, chlorophyll, rhodamine WT, ROX optical DO, BGA-PC, and BGA-PE) are threaded into the optical port on the bottom of the sonde by the user.

Figure 24

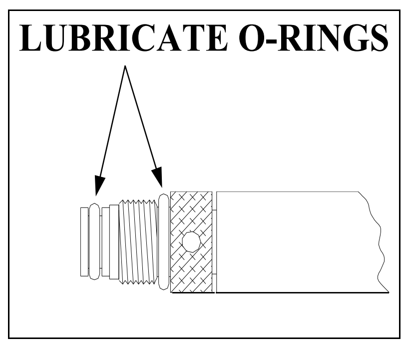


LUBRICATE O-RINGS

Apply a thin coat of O-ring lubricant, supplied in the YSI 6570 Maintenance Kit, to the O-rings on the connector side of each probe that is to be installed.

CAUTION: **Make sure that there are NO contaminants between the O-ring and the probe. Contaminants that are present under the O-ring may cause the O-ring to leak when the sonde is deployed.**

Figure 25

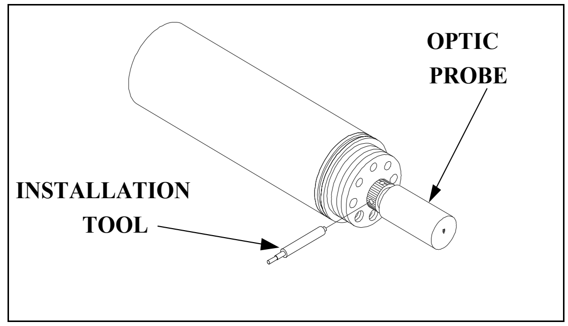


NOTE: Before installing any probe into the sonde bulkhead, be sure that the probe port is free of moisture. If there is moisture present, you may use a can of compressed air to blow out the remaining moisture.

INSTALLING THE TURBIDITY, CHLOROPHYLL, RHODAMINE WT , BGA-PHYCOCYANIN, BGA-PHYCOERYTHRIN, AND ROX OPTICAL DISSOLVED OXYGEN PROBES

If you are using any of optical probes listed, it is recommended that the optical sensors be installed first. If you are not installing one of these probes, do not remove the port plug, and go on to the next probe installation.

Figure 26



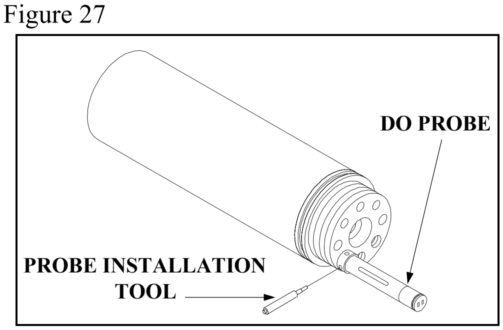
All optical probes, 6136 turbidity, 6025 chlorophyll, 6130 Rhodamine WT, 6131 Phycocyanin Blue-green algae, 6132 Phycoerythrin-Blue-green algae, and 6150 ROX Optical DO are installed in the same way. Install the probe into the center port, seating the pins of the two connectors before you begin to tighten. Tighten the probe nut to the bulkhead using the short extended end of the tool supplied with the probe. Do not over-tighten.

CAUTION: Be careful not to cross-thread the probe nut.

The YSI 6820V2-1 and 6920V2-1 sondes can accept a single turbidity, chlorophyll, Rhodamine WT, BGA-PC, BGA-PE, or ROX DO probe. The 6600V2-2, 6600EDS V2-2, 6820V2-2, and 6920V2-2 sondes can accept and utilize two of the six optical sensors at the same time. The two optical ports of these sondes are labeled “T” and “C” on the sonde bulkhead. Each port can accept any of the six sensors so be sure to remember which sensor was installed in which port so that you will later be able to set up the sonde software correctly. The 6600V2-4 sonde can accept and utilize four of the six optical sensors at the same time. The four optical ports of this sonde are labeled “T” , “C”, “B”, and “O” on the sonde bulkhead. Each port can accept any of the six sensors so be sure to remember which sensor was installed in which port so that you will later be able to set up the sonde software correctly.

INSTALLING THE 6562 RAPID PULSE DISSOLVED OXYGEN PROBE, CONDUCTIVITY/TEMP AND pH/ORP PROBES

Figure 27



Insert the probe into the correct port and gently rotate the probe until the two connectors align.

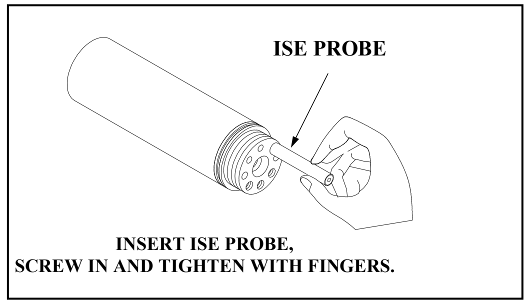
The probes have slip nuts that require a small probe installation tool to tighten the probe. With the connectors aligned, screw down the probe nut using the long extended end of the probe installation tool. Do not over-tighten.

CAUTION: Do not cross thread the probe nut.

INSTALLING THE ISE PROBES

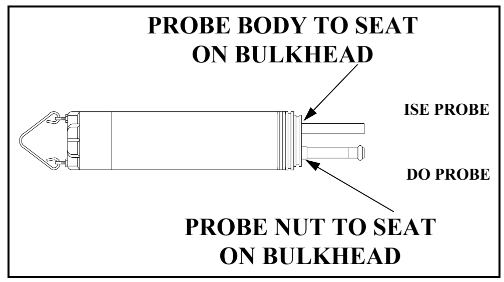
The Ammonium, Nitrate and Chloride ISE probes do not have slip nuts and should be installed without tools. Use only your fingers to tighten. Any ISE probe can be installed in any of the three ports labeled "3", "4", and "5" on the sonde bulkhead of the 6820V2-1, 6920V2-1, and 6600V2-2 sondes or the single ISE port on the 6820V2-2 and 6920V2-2 bulkheads. Be sure to remember which sensor was installed in which port so that you will later be able to set up the sonde software correctly.

Figure 28



IMPORTANT: Make sure that the probe nut or probe body of the ISE probes are seated directly on the sonde bulkhead. This will ensure that connector seals will not allow leakage.

Figure 29



INSTALLING THE PROBE GUARD

Included with each sonde is a probe guard. The probe guard protects the probes during calibration and measurement procedures. Once the probes are installed, install this guard by aligning it with the threads on the bulkhead and turn the guard clockwise until secure.

CAUTION: Be careful not to damage the Rapid Pulse DO membrane during installation of the probe guard.

Figure 30 shows the YSI 6820V2-1/6820V2-2/6920V2-1/6920V2-2 probe guard; the guard for the 6600V2-2/6600V2-4 is similar. The YSI 600R, 600QS, 600XL and 600XLM probe guards resemble Figure 31.

Figure 30

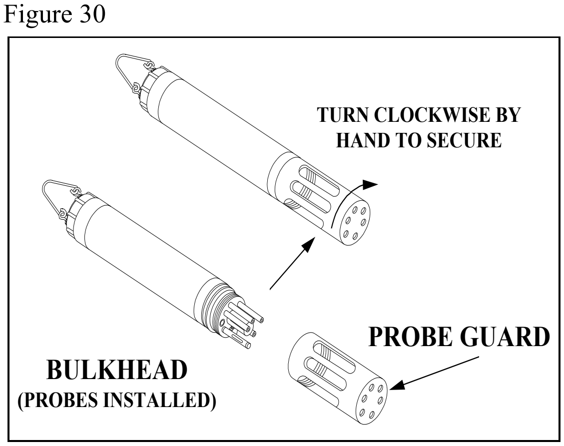
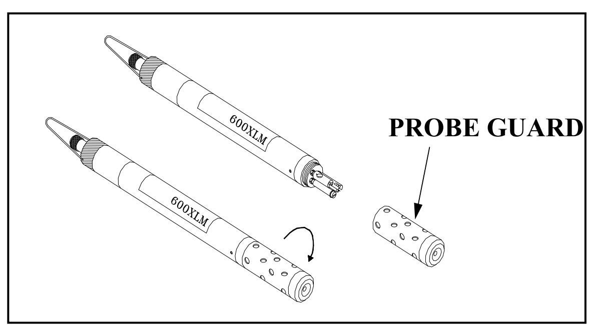


Figure 31



2.3.3 STEP 3 - POWER

Some type of external power supply is required to power the YSI 600R, 600QS, 600XL 6820V2-1, and the non-battery version of the 600 OMS V2-1sondes. The YSI 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, 6600V2-4, 600XLM, and battery version of the 600 OMS V2-1sondes have internal batteries or can run on external power.

If you have purchased a YSI 650 MDS display/logger, attaching your sonde to the display/logger will allow your sonde to be powered from the batteries or the external power of the display/logger. See **Section 3, Displays/Loggers,** for power options.

The battery-powered version of this instrument is powered by alkaline batteries, which the user must remove and dispose of when the batteries no longer power the instrument. Disposal requirements vary by country and region, and users are expected to understand and follow the battery disposal requirements for their specific locale.

The circuit board in this instrument contains a manganese dioxide lithium "coin cell" battery that must be in place for continuity of power to memory devices on the board. This battery is not user serviceable or replaceable. When appropriate, an authorized YSI service center will remove this battery and properly dispose of it, per service and repair policies.

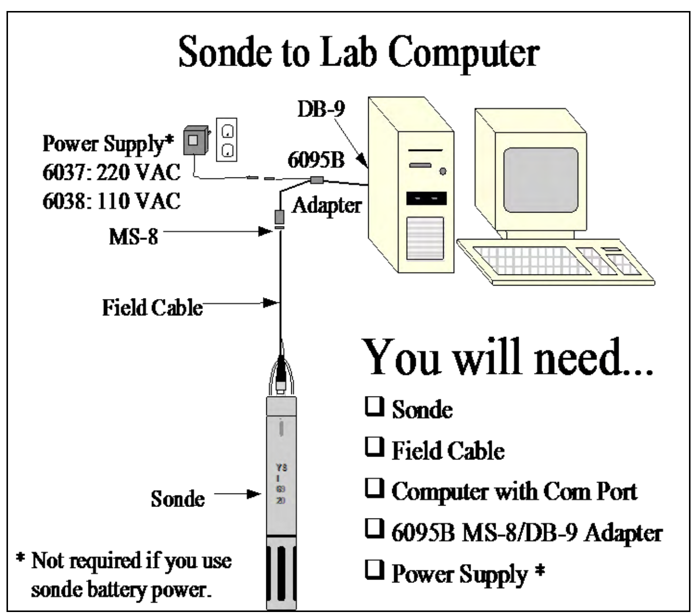
POWER FOR LAB CALIBRATION

A YSI 6038 (110 VAC) or 6651 (64-240 VAC) Power Supply is required for sondes without internal batteries when using them with a PC for calibration and setup. Sondes with internal batteries do not require a power supply, but using the sonde with a power supply in the lab is often convenient and extends battery life. Most adapters include a short pigtail for power that plugs into the power supply. After attaching the four-pin connector from the power supply to the pigtail, simply plug the power supply into the appropriate AC outlet.

See **Section 2.2, Connecting Your Sonde**, for specific information on cables, adapters and power supplies required for connecting your sonde to various devices.

The system configuration best suited for initial setup is shown in Figure 32.

Figure 32

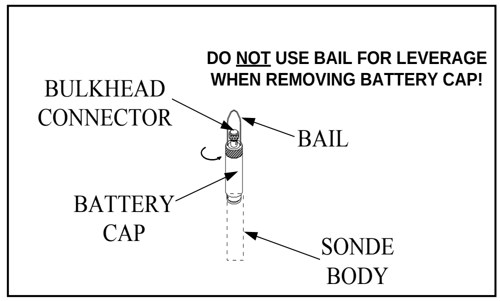


INSTALLING BATTERIES

The 600XLM, 6600V2-2, 6600EDS V2-2, 6600V2-4, 6920V2-1, 6920V2-2 and battery version of the 600 OMS V2-1are the sondes that use alkaline batteries for power. A set of batteries is supplied with each of these sondes. If you do not have one of these sonde model types, you may skip this section.

INSTALLING BATTERIES INTO THE YSI 600XLM OR 600 OMS V2-1 SONDES

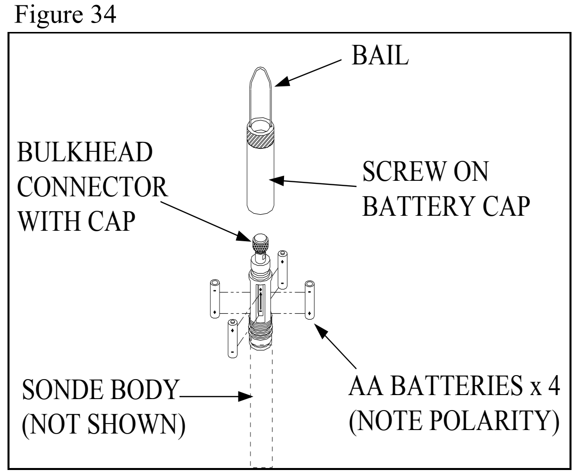
Figure 33



To install 4 AA-size alkaline batteries into the sonde, refer to the following directions and Figure 33.

Grasp the cylindrical battery cover and unscrew by hand. Then slide the battery lid up and over the bulkhead connector. Insert batteries, paying special attention to polarity. Labeling on the battery compartment posts describes the orientation. It is usually easiest to insert the negative end of battery first and then “pop” the positive terminal into place.

Figure 34



Check the O-ring and sealing surfaces for any contaminants that could interfere with the O-ring
seal of the battery chamber.

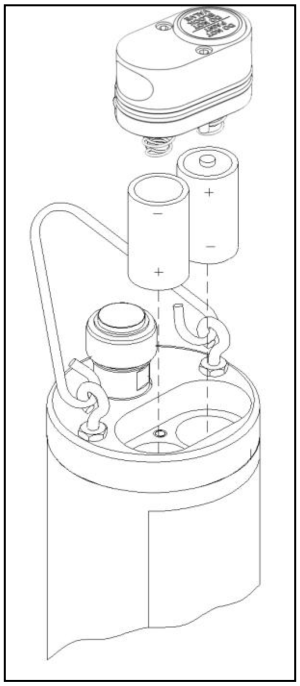
***CAUTION:* Make sure that there are NO contaminants between the O-ring and the sonde. Contaminants that are present under the O-ring may cause the O-ring to leak when the sonde is deployed.**

Lightly lubricate the o-ring on the outside of the battery cover. DO NOT lubricate the internal o-ring.

Return the battery lid and tighten by hand.
DO NOT OVER-TIGHTEN.

INSTALLING BATTERIES INTO THE YSI 6600V2-2, 6600EDS V2-2, AND 6600V2-4 SONDES

Figure 35



IMPORTANT SAFETY FEATURE: The 116003 battery lid for the 6600V2-2, 6600EDS V2-2, and 6600V2-4 is equipped with a safety pressure-release valve. The valve will vent off any pressure build up in the battery compartment from waste gas that could be created by battery failure, improperly marked or installed batteries, flooding, and dead or heavily discharged batteries. Pressure from the waste gas can deform the battery compartment and cause the sonde to shatter, projecting fragments from the sonde casing in all directions. People near a sonde that shatters could suffer serious puncture wounds and serious eye injuries. DO NOT defeat this safety feature by blocking the valve or painting over or in close proximity to the valve. DO NOT attempt to disassemble the safety valve.

Install 8 C-size alkaline batteries according to the following directions and Figure 35.

Using the 9/64" hex driver supplied with the 6600V2-2, 6600EDS V2-2 and 6600V2-4 loosen the battery lid screws.

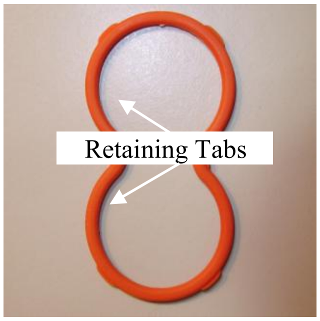
NOTE: The battery lid screws are captive. It is not necessary to remove them from the lid completely.

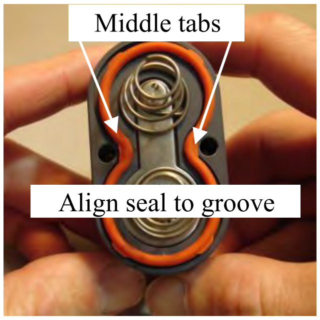
Remove the battery lid and install the batteries, as shown. If installing or replacing the batteries, test batteries for proper polarity and voltage and observe the correct polarity before installing the batteries into the battery chamber.

***CAUTION*: Be sure the orange O-ring is installed in the groove of the lid. The o-ring is designed with retention tabs to prevent it from falling out of the grove during installation. Check the O-ring and sealing surfaces for any contaminates which could interfere with the O-ring seal of the battery chamber. Remove any contaminates present. Also clean the protective O-rings which are located the side of the battery lid. Apply a small amount of grease to the threads of each screw to prevent binding. See the next section and Figures 35A through 35L for details on proper installation of the battery lid o-ring.**

The updated face seal for the 6600 sonde battery lid incorporates six retaining tabs to hold the face seal in the seal groove during installation, allowing consistent and effective sealing after battery replacement. In order for this feature to work properly, the retaining tabs must be correctly seated in the battery lid"s seal groove to prevent it from becoming dislodged during handling. If the seal is not installed correctly it can fall out of its groove during battery lid installation and then can be crushed during assembly. This may cause damage to the seal and cause battery compartment flooding when the sonde is deployed. The following procedure is a recommended method to properly retain the seal in its groove:

1. Place seal on the battery lid groove so that it follows the profile of the groove and is centered about the two middle retaining tabs.





Figures 35A and 35B

2. Press two of the outermost retaining tabs down into the groove. It should be clear that the retaining tabs have recessed into the groove along with the seal so that the tabs outermost edges are at or below the battery lid‟s mounting surface.

Figures 35C and 35D

3. Press the remaining two outermost retaining tabs into the groove and check to make sure the tabs have been recessed as before. Verify that the other two previously seated retaining tabs have not been forced from their position in the groove.

Figures 35E and 35F

4. Place your thumbs on the seal about a ¼" or so from the sides of the center retaining tab and press the seal down into the groove while sliding your thumbs towards each other. This stretches the seal to fit the profile of the groove allowing the center tab to be seated properly. You may need to use the tip of one of your thumbs to finish pressing the tab into place.

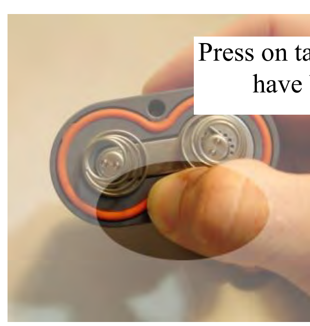
Figures 35G and 35H

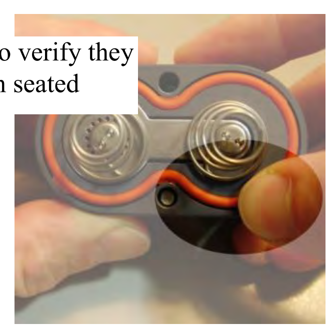
5. Press the remaining middle retaining tab into the groove as before and verify that none of the other retaining tabs have been forced from their positions in the groove during this part of the seal installation.

Figures 35I and 35J

6. To ensure that all the retaining tabs are properly seated in the seal groove you can apply pressure to the seal forcing it into the groove at the location of each tab. This will further seat each tab into the groove allowing it to capture the seal.

Figures 35K and 35L





CAUTION: **Before installing the battery lid, ensure that the pressure release valve is closed. If the pressure release valve is open, DO NOT install (see Figures 35M and 35N). The valve**

cannot be reset and the battery lid must be replaced before sonde deployment. Contact YSI Technical Support for instructions.

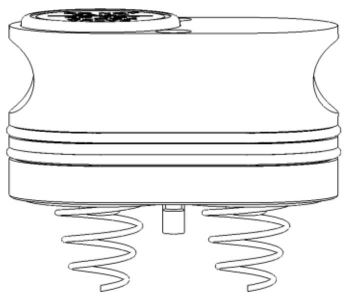


Figure 35M: Closed valve
OK to Deploy

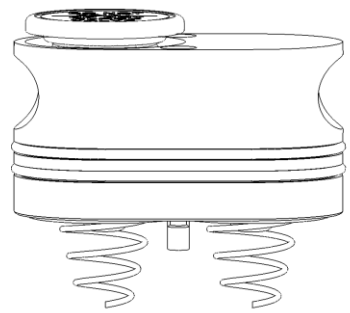


Figure 35N: Open valve
DO NOT Deploy

Lightly lubricate the o-rings on the outside of the battery cover. DO NOT lubricate the orange internal o-ring.

Return the battery lid and HAND tighten the screws with the hex driver until snug. *DO NOT OVER TIGHTEN.*

***CAUTION*: Over-tightening the screws may cause the battery compartment to flood. Do NOT use power tools to tighten the battery lid screws.**

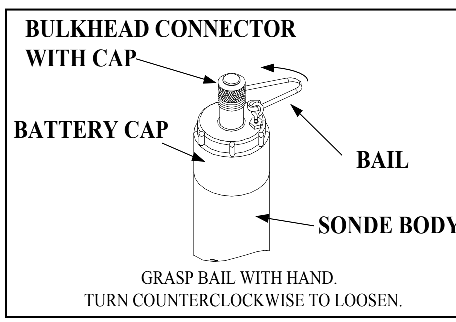
With the battery cover installed and secured, check the battery voltage in the sondes Status Menu. The voltage must be 12.0 volts or higher with new cells. A voltage less then 12.0 volts could indicate that a cell was installed upside down or that one of the cells is not at full strength.

***CAUTION: Remove Batteries When Not in Use.* As with any battery-powered instrumentation, batteries should be removed before short or long-term storage. Even with the new battery lid, batteries can leak, releasing toxic and corrosive battery acid and damaging equipment.**

INSTALLING BATTERIES IN THE 6920V2-1 AND 6920V2-2 SONDES

To install the 8 AA-size alkaline batteries into the sonde, refer to the following directions and Figures 36 and 37.

Figure 36



Position the bail so that it is perpendicular to the sonde and use it as a lever to unscrew the battery cap by hand. Then slide the battery lid up and over the bulkhead connector.

Insert batteries, paying special attention to polarity. Labeling on the top of the sonde body describes the orientation.

Check the O-rings and sealing surfaces for any contaminants that could interfere with the seal of the battery chamber.

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

Lightly lubricate the o-rings on the bottom of the threads and on the connector stem as shown in Figure 37.

Return the battery lid and tighten by hand. *DO NOT OVER-TIGHTEN.*

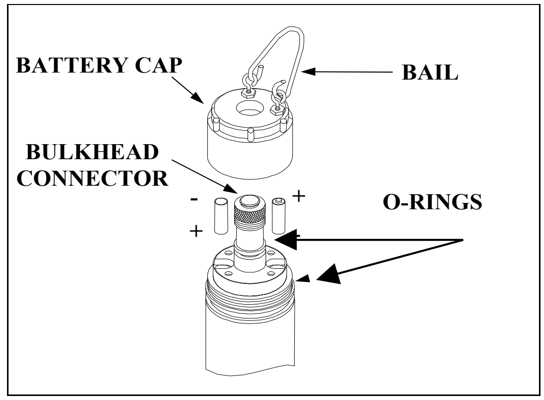


Figure 37

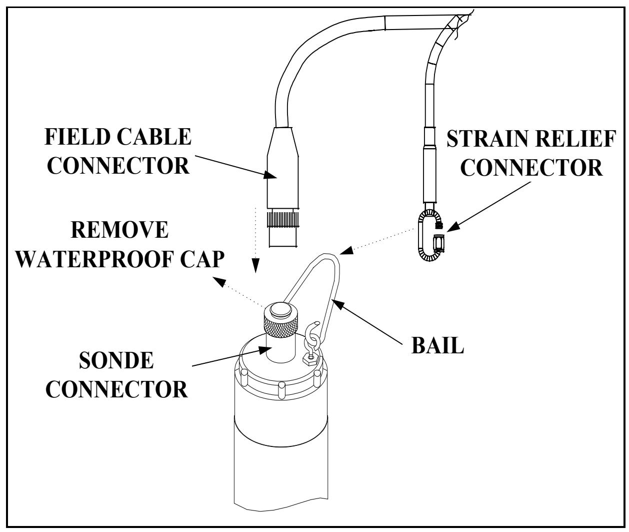
2.3.4 STEP 4 - CONNECTING A FIELD CABLE

All YSI 6600V2-2, 6600EDS V2-2, 6600V2-4, 6920V2-1, 6920V2-2, 6820V2-2, 600XLM, 600QS, and 600 OMS V2-1sondes have a sonde-mounted cable connector for attachment of the field cable. Some versions of the 600R, 600XL, and 6820V2-1 sondes also have this connector.

However, some versions of the YSI 600R, 600XL, and 6820V2-1sondes have permanently attached "integral" cables. If your sonde has a cable that is non-detachable, the next section will not be relevant.

To attach a field cable to the sonde connector, remove the waterproof cap from the sonde connector and set it aside for later reassembly during deployment or storage. Then connect your field cable to the sonde connector.

Figure 38



A built-in "key" will ensure proper pin alignment. Rotate the cable gently until the "key" engages and then tighten the connectors together by rotating clockwise. Attach the strain relief connector to the sonde bail. Rotate the strain relief connector nut to close the connector's opening.

For all of the sondes, the other end of the cable is a military-style 8-pin connector (MS-8). Through use of a YSI 6095B MS-8 to DB-9 adapter, the sonde may be connected to a computer for setup, calibration, real-time measurement, and uploading files.

This MS-8 connector also plugs directly into the 650 MDS display/logger. This instrument contains a microcomputer that allows it to be used in a similar manner to that of a terminal interface to a PC.

As an alternative to the field cable, you may use a YSI 6067B calibration cable for laboratory interaction with the sonde. In this case, simply plug the proper end of the cable into the sonde connector and attach the DB-9 connector of the cable to the Com port of your computer.

CAUTION: The 6067B cable is for laboratory use only -- it is not waterproof and should not be submersed!

Sondes that are equipped with level sensors use vented cables. See **Appendix G, Using Vented Level**, for detailed information.

2.4 ECOWATCH FOR WINDOWS -GETTING STARTED

This section will describe how to get started with EcoWatch for Windows, but detailed information is provided in **Section 4, EcoWatch for Windows**, or a convenient Windows Help section that is part of the software. It is recommended that you thoroughly read Section 4 or use the Help function for a comprehensive understanding of EcoWatch for Windows.

2.4.1 INSTALLING ECOWATCH FOR WINDOWS

EcoWatch for Windows software must be used with an IBM-compatible PC with a 386 (or better) processor. The computer should also have at least 4MB of RAM and Windows Version 3.1 or later.

Place the EcoWatch for Windows compact disk in your CD ROM drive. Select **Start**, then **Run** and type **d:\setup.exe** at the prompt. Press **Enter** or click on "**OK**" and the display will indicate that EcoWatch is proceeding with the setup routine. Simply follow the instructions on the screen as the installation proceeds.

2.4.2 RUNNING ECOWATCH FOR WINDOWS

To run EcoWatch for Windows, simply select the EcoWatch icon on your desktop or from the Windows Program Menu. For help with the EcoWatch program, see **Section 4, EcoWatch** or use the Help section of the software.

2.4.3 ECOWATCH FOR WINDOWS SETUP

To setup the EcoWatch software for use with a sonde, select the sonde icon  on the toolbar, and then the **proper** Com port to which your sonde is connected. If the default setting is correct, it does not need to be changed. Click "**OK**" to open a terminal window.

From the **Comm** Menu, select the **Settings** option to check the baud rate. The baud rate should be 9600. If it is not, select 9600 from the list and press **Enter**.

From the **Settings** Menu, select the **Font/Color** and **Background Color** options to choose a color scheme for the EcoWatch for Windows menus.

2.5 SONDE SOFTWARE SETUP

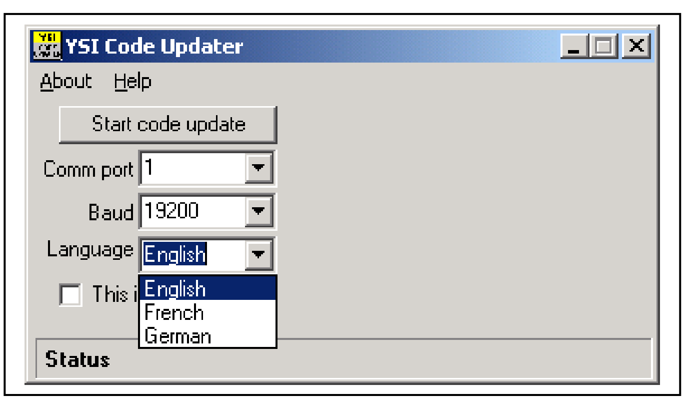
There are two sets of software at work in any YSI environmental monitoring system. One is resident in your PC and is called EcoWatch for Windows. The other software is resident in the sonde itself. In this section, you will first make sure that the language associated with your sonde software is appropriate to your application and change it if necessary. You will set up the sonde software using EcoWatch for Windows as the interface device between the sonde and your PC.

SETTING UP THE SONDE SOFTWARE LANGUAGE

The menus in the sonde software can be viewed in English, German, or French. However, the choice of language CANNOT be made from the sonde software itself. Rather the choice must be selected via a complete update of the software itself from the YSI Website as described below. Note that the menus in your sonde will be shown in English when you receive the instrument and, if this is your language of choice, no further action is required and you should skip to the next section. If you wish to change the language of your menus to German or French, use the following instructions.

Follow the step-by-step instructions below to change the language for the menus in your 6-series sonde:

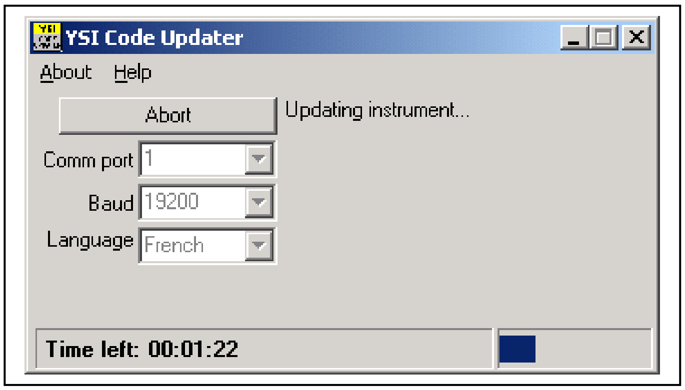
- Connect your sonde to the serial port of a PC with access to the Internet using the proper cable as described in the previous section of this manual.
- Make sure that the sonde is powered with either internal batteries or a suitable power supply.
- Access the YSI Environmental Software Downloads page at www.ysi.com/edownloads or go to main page at www.ysi.com and click on Support button in green bar.
- Log in, or if a first time user, fill out the registration form and wait for a login password via return E-mail.
- Click on the **Software** folder under the Software Downloads section.
- Inside the folder, click on the file *6-Series & 556MPS Code Updater, M-DD-YYYY* and save the file to a temporary directory on your computer.
- 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 Technical Support for advice.
- Run the YSI Code Updater software that you just installed on your computer. The following window will be displayed:



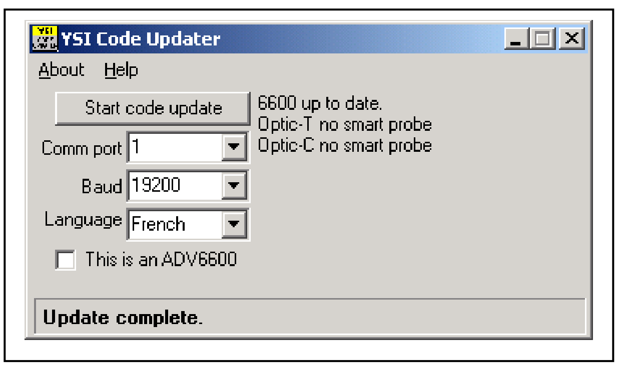
- Set the Comm port number to match the port to which you connected the sonde cable and make sure that the “This is an ADV6600” selection is NOT checked.

- **NEXT, SELECT THE LANGUAGE (ENGLISH, FRENCH, OR GERMAN) WHICH WILL BE USED IN YOUR SONDE MENUS.**

- Then click on the Start Code Update button. An indicator bar will show the progress of the upgrade as shown below.



- When the update is finished (indicated on the PC screen as shown below), close the YSI Code Updater window (on the PC) by clicking on the "X" in the upper right corner of the window.



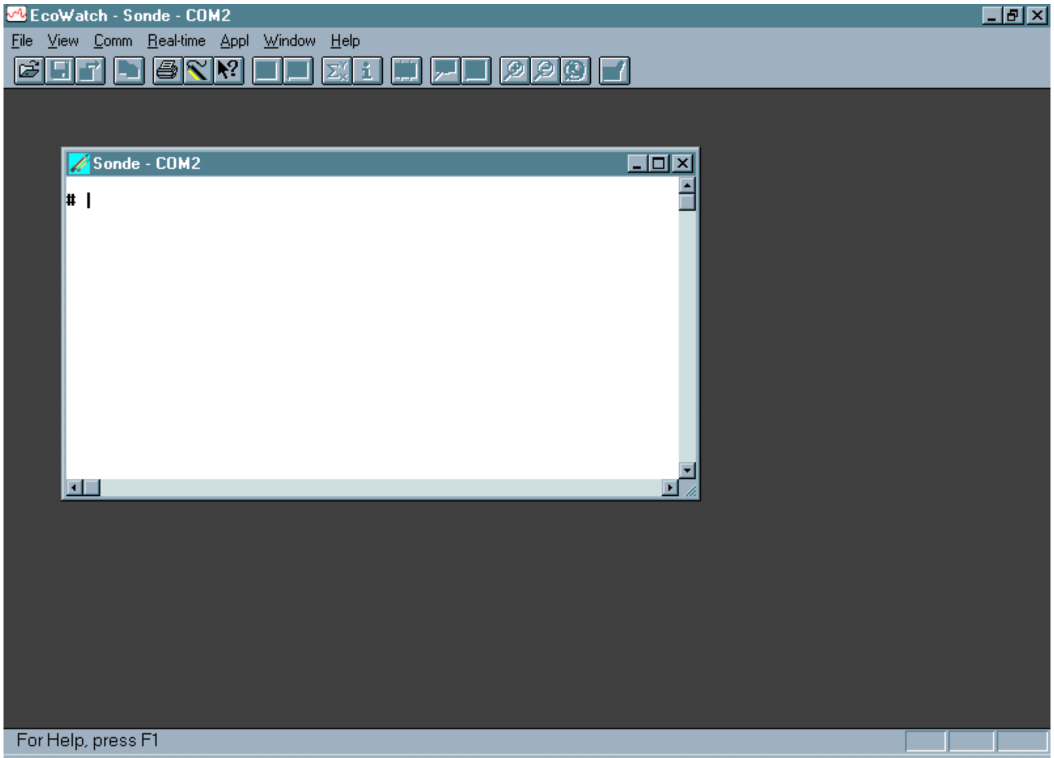
Your sonde menus will now appear in the language which you selected prior to running the updater. If you want to change the language associated with your sonde menu, you MUST rerun the YSI Code Updater and select the new language via this mechanism.

INTERFACING TO THE SONDE WITH ECOWATCH FOR WINDOWS

When you select **Sonde** from the EcoWatch for Windows menus, the PC-based software begins direct communication with the sonde-based software via standard VT100 terminal emulation.

In EcoWatch for Windows, select the sonde icon, . Then select the proper Com port and confirm by clicking **OK**. A window similar to that shown below will appear indicating connection to the sonde as shown in Figure 39. Type “**Menu**” after the # sign, press **Enter**, and the sonde Main menu will be displayed.

Figure 39



If your sonde has previously been used, the **Main menu** (rather than the **#** sign) may appear when communication is established. In this case simply proceed as described below. You will not be required to type "**Menu**".

If you are unable to establish interaction with the sonde, make sure that the cable is properly connected. If you are using external power, make certain that the YSI 6651 or 6038 power supply or other 12 vdc source is properly working. Recheck the setup of the Com port and other software parameters. Also refer to **Section 6, Troubleshooting**.

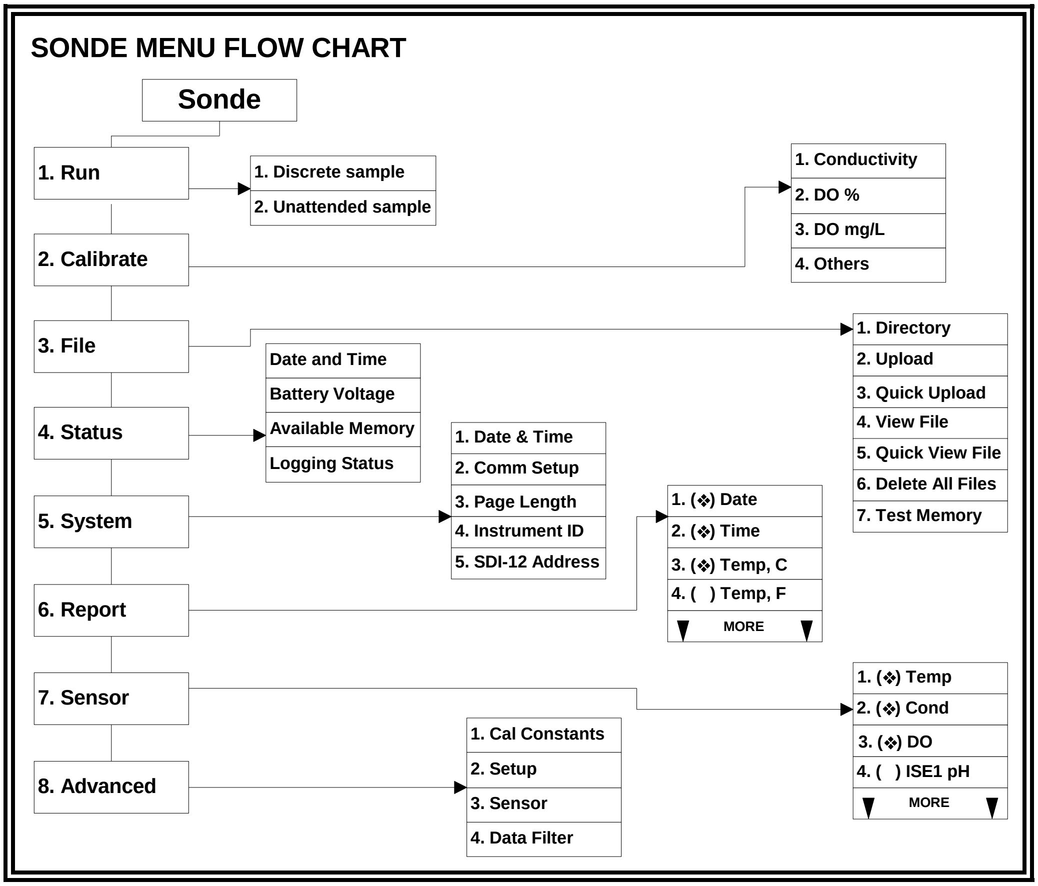
The sonde software is menu-driven. You select functions by typing their corresponding numbers. You do not need to press **Enter** after choosing a selection. Type the **0 or Esc** key to return to the previous menu.

Sonde Main Menu

```
------------------Main------------------
1-Run                    5-System
2-Calibrate              6-Report
3-File                   7-Sensor
4-Status                 8-Advanced

Select option (0 for previous menu):
```

Figure 40 - Sonde Menu Flow Chart



SYSTEM SETUP

At the Main menu, select **System**. The System Setup menu will be displayed.

System Setup Menu

```
1-Date & time
2-Comm setup
3-Page length=25
4-Instrument ID=YSI Sonde
5-Circuit board SN:00003001
6-GLP filename=00003001
7-SDI-12 address=0

Select option (0 for previous menu):
```

Select **1-Date & time**. An asterisk will appear next to each selection to confirm the entry. Press 4 and 5 to activate the date and time functions. Pay particular attention to the date format that you have chosen when entering date. You must use the 24-hour clock format for entering time. Option **4- ( ) 4 digit year** may be used so that the date will appear with either a two or four digit year display. If you do not enter the correct year format (8/30/**98** for 2-digit, 8/30/**1998** for 4 digit) your entry will be rejected.

```
-----------Date & time setup-----------
1-(*)m/d/y          4-( )4 digit year
2-( )d/m/y          5-Date=08/30/98
3-( )y/m/d          6-Time=11:12:30

Select option (0 for previous menu):
```

Select **4-Instrument ID** from the System setup menu to record the instrument ID number (usually the instrument serial number), and press **Enter**. A prompt will appear which will allow you to type in the serial number of your sonde. This will make sure that any data that is collected is associated with a particular sonde. Note that the selection **5-Circuit Board SN** shows the serial number of the PCB that is resident in your sonde (not the entire system as for Instrument ID). Unlike the **Instrument ID**, the user cannot change the **Circuit Board SN**. The **6-GLP filename** and **7-SDI-12 address** selections will be explained in Section 2.9.5

Press **Esc** or **0** to return to the **System setup** menu.

Then press **Esc** or **0** again to return to the **Main menu**.

```
------------------Main-----------------
1-Run               5-System
2-Calibrate         6-Report
3-File              7-Sensor
4-Status            8-Advanced

Select option (0 for previous menu):
```

ENABLING SENSORS

To activate the sensors that are in your sonde, select **Sensor** from the Sonde Main menu.

```
------------Sensors enabled------------
1-(*)Time
2-(*)Temperature
3-(*)Conductivity
4-(*)Dissolved Oxy
5-(*)ISE1 pH
6-(*)ISE2 Orp
7-(*)ISE3 NH4+
8-(*)ISE4 NO3-
9-( )ISE5 NONE
A-(*)Optic T Turbidity - 6136
B-(*)Optic C Chlorophyll

Select option (0 for previous menu):
```

Note that the exact appearance of this menu will vary depending upon the sensors that are available on your sonde. Enter the corresponding number to enable the sensors that are installed on your sonde. An asterisk indicates that the sensor is enabled.

When selecting any of the ISE or Optical ports, a submenu will appear. When this occurs, make a selection so that the sensor corresponds to the port in which the sensor is physically installed. Only ORP can be enabled as ISE2. Optic T, Optic C, Optic B, and Optic O generate a submenu on selection. Each optical port can have one of six probes (6136 Turbidity, 6025 Chlorophyll, 6130 Rhodamine WT, 6131 BGA-PC, 6132 BGA-PE, or 6150 ROX Optical DO) installed as indicated by the submenus.

NOTE CAREFULLY: It is NOT possible to simultaneously activate BOTH the 6562 Rapid Pulse polarographic dissolved oxygen sensor and the 6150 ROX Optical dissolved oxygen sensor. Activation of either sensor will automatically deactivate the other selection. Thus, users of 6600V2-2, 6600EDS V2-2, 6820V2-1, and 6920V2-1 sondes CANNOT measure oxygen with both types of sensors.

After all installed sensors have been enabled, press **Esc or 0** to return to the Main Menu.

ENABLING PARAMETERS

In order for a specific parameter to be displayed:

1. The sensor must first be enabled as described above.
2. That parameter must be activated in the Report Setup menu described below.

Select **Report** from the Main menu. A Report Setup menu similar to the one shown below will be displayed.

```
--------------Report setup-------------
1-(*)Date m/d/y     E-(*)Orp mV
2-(*)Time hh:mm:ss  F-(*)NH4+ N mg/L
3-(*)Temp C         G-( )NH4+ N mV
4-(*)SpCond mS/cm   H-( )NH3 N mg/L
5-( )Cond           I-(*)NO3- N mg/L
6-( )Resist         J-( )NO3- N mV
7-( )TDS            K-(*)Cl- mg/L
8-( )Sal ppt        L-( )Cl- mV
9-(*)DOsat %        M-(*)Turbid+ NTU
A-(*)DO mg/L        N-(*)Chl ug/L
B-( )DOchrg         O-(*)Chl RFU
C-(*)pH             P-(*)Battery volts
D-( )pH mV

Select option (0 for previous menu):
```

Note that the exact appearance of this menu will vary depending upon the sensors that are available and enabled on your sonde. The asterisks (*) that follow the numbers or letters indicate that the parameter will appear on all outputs and reports. To turn a parameter on or off, type the number or letter that corresponds to the parameter.

Note also that since a 6136 turbidity probe was selected in the Sensor menu above, the units of turbidity are presented as "turbid+ NTU". If a 6026 turbidity probe (which was offered by YSI up until 2002) had been selected, the units of turbidity would be presented as "turbid NTU". This designation is designed to differentiate the data from the two sensor types in later analysis.

For parameters with multiple unit options such as temperature, conductivity, specific conductance, resistivity and TDS, a submenu will appear as shown below for temperature, allowing selection of desired units for this parameter.

```
--------------Select units-------------
1-(*)NONE
2-( )Temp C
3-( )Temp F
4-( )Temp K

Select option (0 for previous menu): 2
```

After configuring your display with the desired parameters, press **Esc or 0** to return to the Main menu.

CHECKING ADVANCED SETTINGS

Select **Advanced** from the Main menu. The following menu will be displayed.

```
----------------Advanced--------------
1-Cal constants
2-Setup
3-Sensor
4-Data filter

Select option (0 for previous menu):
```

Select **Setup** from the Advanced menu.

```
-------------Advanced setup-----------
1-(*)VT100 emulation
2-( )Power up to Menu
3-( )Power up to Run
4-( )Comma radix
5-(*)Auto sleep RS232
6-(*)Auto sleep SDI12
7-( )Multi SDI12
8-( )Full SDI12

Select option (0 for previous menu): 0
```

Make sure that, other than **Auto sleep RS232**, all entries are activated or deactivated as shown above.

For sondes which will be used in sampling studies where the user is present and observes readings in real-time, **Auto sleep RS232** should usually be “off“. For sondes that will be used in unattended monitoring studies, **Auto sleep RS232** should usually be “on”. This is described in detail in **Section 2.9, Sonde Menu**. When this setup is verified, press **Esc** or **0** to return to the Advanced menu.

Select **3-Sensor** from the Advanced menu and make certain that the entries are identical to those shown below.

```
------------Advanced sensor-----------
1-TDS constant=0.65
2-Latitude=40
3-Altitude Ft=0
4-(*)Fixed probe
5-( )Moving probe
6-DO temp co %/C=1.1
7-DO warm up sec=40
8-( )Wait for DO
9-Wipes=1
A-Wipe int=5
B-SDI12-M/wipe=1
C-Turb temp co %/C=0.3
D-(*)Turb spike filter
E-Chl temp co %/C=0
F-( )Chl spike filter

Select option (0 for previous menu):
```

If you have a depth sensor installed, you can maintain the default settings of 40 and 0 for **2-Latitude and 3-Altitude**, respectively, without affecting your ability to learn the basic calibration and operation of the sonde. However, if you know the appropriate values for your location, change them. When this setup is verified, press **Esc** or **0** to return to the Advanced menu. For more information, see **Section 2.9.8, Advanced**.

The display under **3-Sensor** may be different from the one shown in the example above, depending on the sensors that are installed in your unit. For example, if you do not have a chlorophyll probe, the last two entries (which are relevant only to chlorophyll) will not appear.

When this setup is verified, press **Esc** or **0** to return to the Advanced menu. For a detailed explanation of the choices in the Advanced menu, see **Section 2.9.8, Advanced**. Press **Esc** or **0** to back up to the Main menu.

```
------------------Main------------------
1-Run                5-System
2-Calibrate          6-Report
3-File               7-Sensor
4-Status             8-Advanced

Select option (0 for previous menu):
```

The sonde software is now set up and ready to calibrate and run.

2.6 GETTING READY TO CALIBRATE

2.6.1 INTRODUCTION

HEALTH AND SAFETY

Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review health and safety information in **Appendix A** of this manual. Some calibration standard solutions may require special handling.

CONTAINERS NEEDED TO CALIBRATE A SONDE

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

Although not recommended except in unusual circumstances, instead of the calibration cup, you may use laboratory glassware to perform some of the calibrations. If you do not use a calibration cup that is designed for the sonde, you are cautioned to do the following:

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

CALIBRATION TIPS

1. If you use the Calibration Cup for calibration of either the Rapid Pulse Polarographic or ROX Optical DO sensors in water-saturated air, make certain to loosen the seal to allow pressure equilibration before calibration.

2. If you choose to calibrate your Rapid Pulse Polarographic or ROX Optical DO sensor in air-saturated water in a separate vessel, be sure to sparge the water with an aquarium pump and air-stone for at least 1 hour to assure that the water is truly saturated with air.

3. The key to successful calibration is to insure that the sensors are completely submersed when calibration values are entered. Use recommended volumes when performing calibrations.

4. For maximum accuracy, use a small amount of previously used calibration solution to pre-rinse the sonde. You may wish to save old calibration standards for this purpose.

5. Fill a bucket with ambient temperature water to rinse the sonde between calibration solutions or perform the calibration near a sink where the probes can be rinsed from the tap.

6. Have several clean, absorbent paper towels or cotton cloths available to dry the sonde between rinses and calibration solutions. Shake the excess rinse water off of the sonde, especially when the probe guard is installed. Dry off the outside of the sonde and probe guard. Making sure that the sonde is dry reduces carry-over contamination of calibrator solutions and increases the accuracy of the calibration.

7. Make certain that port plugs are installed in all ports where probes are not installed. It is extremely important to keep these electrical connectors dry.

USING THE CALIBRATION CUP

Follow these instructions to use the calibration cup for calibration procedures with all of the instruments except the 600R, 600QS, and 600 OMS V2-1. For these sondes, the over-the-guard bottle that comes with your sonde, must be used.

- ✓ Ensure that a gasket is installed in the gasket groove of the 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 of the bottom cap and tube.
- ✓ Remove the probe guard, if it is installed.
- ✓ Inspect the installed gasket on the sonde for obvious defects and if necessary, replace it with the extra gasket supplied.
- ✓ Screw the cup assembly into place on the threaded end of sonde and securely tighten. N**ote:** Do not over tighten as this could cause damage to the threaded portions of the bottom cap and tube.
- ✓ Sonde calibration can be accomplished with the sonde upright– i.e. the cable connector end of the sonde is oriented above the probe end, or inverted where the orientation is reversed. A separate clamp and stand, such as a ring stand, is required to support the sonde in the inverted position.
- ✓ When using the Calibration Cup for dissolved oxygen calibration in water-saturated air, make certain that the vessel is vented to the atmosphere by loosening the bottom cap or cup assembly, depending on orientation, and that approximately 1/8” of water is present in the cup.

NOTE CAREFULLY: If you are calibrating a 6136 turbidity sensor for use with a 6820V2-1 or 6920V2-1, you can use either the calibration cup supplied with your sonde or an optional extended length cup for the calibration. Please see the section below which describes the special calibration recommendations for this sensor.

RECOMMENDED VOLUMES OF CALIBRATION REAGENTS

The approximate volumes of the reagents are specified below for both the upright and inverted orientations. Note that the volume values are only estimates. The actual amount of calibrator solution required will depend on how many and what type of other probes are installed in you sonde bulkhead.

Table 1A 6820V2-1 and 6920V2-1 Sondes with Standard Calibration Cup*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	200ml	150ml
pH/ORP	125ml	175ml
ISE	125ml	175ml
All Optical Sensors	50ml	DO NOT CALIBRATE***

Table 1B 6820V2-1 and 6920V2-1 Sondes with Optional Extended Calibration Cup*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	320ml	150ml
pH/ORP	240ml	175ml
ISE	240ml	175ml
All Optical Sensors	225ml	DO NOT CALIBRATE***

Table 2 6820V2-2 and 6920V2-2 Sondes with Extended Calibration Cup*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	310ml	150ml
pH/ORP	200ml	150ml
ISE	200ml	150ml
All Optical Sensors	225 ml	DO NOT CALIBRATE***

Table 3 600XL and 600XLM Sondes

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	50ml	50ml
pH/ORP	25ml	50ml

Table 4 6600V2-2 Sonde with Short Calibration Cup and Long Cup in Parentheses*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	425ml (650ml)	250ml (250ml)
pH/ORP	300ml (500ml)	250ml (250ml))
ISE	300ml (500ml)	250ml (250ml)
All Optical Sensors	180ml (500ml)	DO NOT CALIBRATE***

Table 5 6600EDSV2-2 Sonde with Short Calibration Cup and Long Cup in Parentheses*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	275ml (520ml)	350ml (350ml)
pH/ORP	175ml (400ml)	350ml (350ml)
All Optical Sensors	225ml (420ml)	DO NOT CALIBRATE***

Table 6 6600V2-4 Sonde with Standard Long Calibration Cup****

Probe to Calibrate	Upright	Inverted
Conductivity	525ml	150ml
pH/ORP	500ml	150ml
All Optical Sensors	425ml	DO NOT CALIBRATE***

Table 7 600 OMS V2-1 Sonde* *

Probe to Calibrate	Upright	Inverted
Conductivity	375ml	N/A
Turbidity, Chlorophyll, Rhodamine WT	350ml	N/A

Table 8 600R and 600QS Sondes

Probe to Calibrate	Upright	Inverted
Conductivity	350ml	N/A
pH/ORP	120ml	N/A

* See section below for special instructions dealing with calibration of 6136 turbidity sensor.

** See section below for special instructions dealing with calibration of the conductivity sensor for the 600 OMS V2-1.

*** Optical Sensors CANNOT be calibrated with the sonde in the Upside-Down position because of interference from the meniscus of the calibration standard.

**** An extended length calibration cup is supplied with the 6600V2-4, 6600V2-2, and 6600EDSV2-2 to facilitate calibration of the 6136 turbidity sensor. This cup requires the use of larger volumes of other calibration solutions. Users may choose to purchase the shorter calibration cup sleeve for calibration of sensors other than the 6136 to reduce the volumes of calibrant. The shorter cal cup sleeve is YSI Item Number 066267 and can be obtained by contacting YSI Technical Support.

CALIBRATION OF THE 6136 TURBIDITY SENSOR

The 6136 can be calibrated using either the calibration cup supplied with the sonde or with an extended length calibration cup which can be purchased as an option for the 6820V2-1 and 6920V2-1. An extended cup is supplied as a standard item with the 6820V2-2, 6920V2-2, 6600V2-4, 6600V2-2, and 6600EDSV2-2 sondes. If you choose to calibrate with the short calibration cup, you also MUST first make certain that the vessel is equipped with a BLACK bottom. In addition, you should engage only ONE THREAD when screwing the calibration cup onto the sonde in order to keep the turbidity probe face as far as possible from the calibration cup bottom to avoid interference. Even with these techniques, there will still be a small interference from the bottom of the calibration cup that will cause your field turbidity readings to be approximately 0.5 NTU lower than the actual reading. This small error is usually only evident when the sonde is deployed in very clear water where the readings might appear as slightly negative values, e.g., a turbidity of 0.1 NTU would appear as –0.4 NTU.

Use of the extended length cup will require the use of significantly more standard solutions for 6820V2-1/ 6920V2-1 sondes (additional 180 mL) if calibration is done in the upright position. To minimize calibration solution volumes for sensors other than turbidity, users may wish to purchase the shorter calibration cup sleeve which is supplied as standard with the 6820V2-1 and 6920V2-1. The shorter cal cup sleeve for any 6600 is Item Number 066267, and the shorter cal cup sleeve for any 6820/6920 is Item Number 069286. These can be ordered from YSI Technical Support.

NOTE CAREFULLY: All optical sensors MUST be calibrated in the upright position no matter which type of calibration cup is employed. In the upside-down position, the meniscus of the standard causes a great deal of interference and this interference is likely to result in calibration errors and/or erroneous field readings.

CALIBRATION OF 600 OMS V2-1 CONDUCTIVITY SENSOR

In order to conserve calibration solution, the 600 OMS V2-1conductivity sensor should be calibrated with the optical probe removed and the optical port plug securely tightened. The volume of conductivity solution provided in Table 7 above reflects this special condition. In addition, it is recommended that the sonde be shaken vigorously after immersion in the conductivity reagent to assure that bubbles are expelled from the cell.

An instruction sheet dealing in greater detail with the special requirements for calibration of 600 OMS V2-1sensors is included with the sonde. Be sure to read the instructions carefully before using the sonde.

2.6.2 CALIBRATION PROCEDURES

The following calibration procedures are the most commonly used methods for the 6-series sensors. For detailed information on all calibration procedures, refer to **Section 2.9.2, Calibrate**.

To ensure more accurate results, you can rinse the calibration cup with water, and then rinse with a small amount of the calibration solution for the sensor that you are going to calibrate. Discard the rinse solution and add fresh calibrator solution. Use tables 1-8 to find the correct amount of calibrator solution.

1. Carefully immerse the probes into the solution and rotate the calibration cup to engage several threads. YSI recommends supporting the sonde with a ring stand and clamp to prevent the sonde from falling over.

2. With the proper cable, connect the sonde to a PC, access EcoWatch for Windows and proceed to the Main menu (for information on how to run EcoWatch for Windows software, see **Section 2.4.2, Running EcoWatch Software)**. From the sonde Main menu, select **2-Calibrate**.

```
---------------Calibrate--------------
1-Conductivity      6-ISE3 NH4+
2-Dissolved Oxy     7-ISE4 NO3-
3-Pressure-Abs      8-Optic T-Turbidity-6026
4-ISE1 pH           9-Optic C-Chlorophyll
5-ISE2 ORP

Select option (0 for previous menu):
```

3. Note that the exact appearance of this menu will vary depending upon the sensors that are available and enabled on your sonde. To select any of the parameters from the Calibrate menu, input the number that is next to the parameter. Once you have chosen a parameter, some of the parameters will have a number that appears in parentheses. These are the default values and will be used during calibration if you press **Enter** without inputting another value. Be sure not to accept default values unless you have assured that they are correct. If no default value appears, you must type a numerical value and press **Enter**.

4. After you input the calibration value, or accept the default, press **Enter**. A real-time display will appear on the screen. Carefully observe the stabilization of the readings of the parameter that is being calibrated. When the readings have been stable for approximately 30 seconds, press **Enter** to accept the calibration. The calibrated value is bolded on the example screen on the following page.

5. Press **Enter** to return to the Calibrate menu, and proceed to the next calibration.

CALIBRATION EXAMPLE

The example below for calibration of specific conductance, is designed to demonstrate the general calibration protocol for all parameters. From the Calibrate menu, press **1-Conductivity** and the following display will be shown.

```
------------Cond calibration-----------
1-SpCond
2-Cond
3-Salinity

Select option (0 for previous menu): 1
```

Select **1-SpCond** (the generally-recommended method for calibration of a conductivity sensor) and the following prompt will appear which calls for your numerical input of the specific conductance of your calibration solution.

```
Enter SpCond in mS/cm (10):
```

As noted above, the number in parentheses is the default value of this parameter and will be used in the calibration if *only* **Enter** is pressed without typing in another value. Similar prompts will be displayed during the calibration of all parameters, but for some sensors, such as pH, no default values are provided. In these cases, the user must input a numerical value and then press **Enter**.

After the correct calibration value for your solution is input and **Enter** is pressed, a real-time display similar to the following will then appear on the screen..

```
Date     Time      Temp SpCond   Cond   Sal DOsat     DO    Depth   pH   Battery
mm/dd/yy hh:mm:ss   C  mS/cm    mS/cm  ppt     %    mg/L    feet         volts
--------------------------------------------------------------------------------
To calibrate, press <Enter> when the readings are stable.

05/05/97 08:39:51 20.83 9.602 8.837   5.41  37.9   3.28  -0.252  7.06    10.2
```

Note that all parameters that have been enabled will appear - not just the one being calibrated at the moment. The user should carefully observe the stabilization of the readings of the parameter that is being calibrated and, when the readings are stable for approximately 30 seconds, press **Enter** to implement the calibration and the following message will appear.

```
Calibrated.  Press <Enter> to continue.
```

NOTE: If an ERROR message appears, begin the calibration procedure again. Be certain that the value you enter for the calibration standard is correct. Also see **Section 6, Troubleshooting** for more information on error messages.

CAUTION: Be certain to **immerse the entire sonde** in solution standards for calibration of all parameters. Most calibrations require readings not only from the sensor being calibrated but also from the temperature sensor.

Specific start-up calibration procedures for all sensors that commonly require calibration are provided in the following paragraphs of this section. Remember that these are basic protocols designed to get the user up and running with your 6-series sonde. A more-detailed discussion of sensor calibration can be found in Section 2.9.2.

CONDUCTIVITY

This procedure calibrates conductivity, specific conductance, salinity, and total dissolved solids.

Place the correct amount (see Tables 1-8) of 10 mS/cm conductivity standard (YSI 3163 is recommended) into a clean, dry or pre-rinsed calibration cup.

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 standard solutions with other solutions. Make certain that there are no salt deposits around the oxygen and pH/ORP probes, particularly if you are employing standards of low conductivity.

Carefully immerse the probe end of the sonde into the solution. Gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell. The probe must be completely immersed past its vent hole. Using the recommended volumes from the table in the previous subsection should insure that the vent hole is covered.

Allow at least one minute for temperature equilibration before proceeding.

From the Calibrate menu, select **Conductivity** to access the Conductivity calibration procedure and then **1-SpCond** to access the specific conductance calibration procedure. Enter the calibration value of the standard you are using (mS/cm at 25°C) and press **Enter**. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

Observe the readings under Specific Conductance or Conductivity and when they show 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 return to the Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

NOTE: The YSI conductivity system is very linear over its entire 0-100 mS/cm range. Therefore, it is usually not necessary to use calibration solutions other than the 10 mS/cm reagent recommended above for all environmental applications from low conductivity freshwater to seawater. YSI does offer the 3161 (1 mS/cm) and 3165 (100 mS/cm) conductivity standards for users who want to assure maximum accuracy at the high and low ends of the sensor range. Users of the 1 mS/cm standard should be particularly careful to avoid contamination of the reagent. In fact, because of contamination issues, YSI does not recommend using standards less than 1 mS/cm.

NOTE: For calibration of the 600 OMS V2-1conductivity sensor, the optical probe must be removed and the port plugged. See specific instructions in the application note supplied with the 600 OMS V2-1.

RAPID PULSE POLAROGRAPHIC DISSOLVED OXYGEN

Place approximately 3 mm (1/8 inch) of water in the bottom of the calibration cup. Place the probe end of the sonde into the cup. Make certain that the DO and temperature probes are not immersed in the water. Engage only 1 or 2 threads of the calibration cup to insure the DO probe is vented to the atmosphere. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.

Two calibration protocols are provided below for Rapid Pulse dissolved oxygen, one for sampling applications and one for long-term monitoring applications.

Sampling Applications

If your instrument will be used in sampling applications where the dissolved oxygen is “on” continuously during the study, deactivate “Autosleep RS232” as described in **Section 2.5, Sonde Software Setup**.

From the Calibrate menu, select **Dissolved Oxy**, then **1-DO %** to access the DO percent calibration procedure. Calibration of dissolved oxygen in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.

Enter the current barometric pressure in mm of Hg. (Inches of Hg x 25.4 = mm Hg).

Note: Laboratory barometer readings are usually “true” (uncorrected) values of air pressure and can be used “as is” for oxygen calibration. Weather service readings are usually not “true”, i.e., they are corrected to sea level, and therefore cannot be used until they are “uncorrected”. An approximate formula for this “uncorrection” (where the BP readings MUST be in mm Hg) is:

True BP = [Corrected BP] – [2.5 * (Local Altitude in feet above sea level/100)]

Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under DO%. When they show 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 return to the Calibrate menu.

Rinse the sonde in water and dry the sonde.

Monitoring Applications

If your instrument will be used in monitoring applications where data is being captured at a longer interval (e.g. 15 – 60 minutes) to internal sonde memory, a data collection platform or a computer, you need to activate "Autosleep RS232" as described in **Section 2.5, Sonde Software Setup**. Then follow the instructions detailed above for the Sampling Application calibration. With Autosleep active, the calibration will occur automatically with a display similar to that shown below.

```
================================================================
 Temp SpCond    Sal DOsat     DO   Depth    pH NH4+ N NO3- N Turbid
    C  mS/cm    ppt     %   mg/L    feet         mg/L   mg/L    NTU
----------------------------------------------------------------
Stabilizing: 38
```

After the warm-up time is complete, the readings just before and just after calibration are displayed. When you press **Enter**, the screen returns to the DO Calibration menu.

ROX OPTICAL DISSOLVED OXYGEN

Place the sensor either (a) into a calibration cup containing about 1/8 inch of water which is vented by loosening the threads or (b) into a container of water which is being continuously sparged with an aquarium pump and air stone. Wait approximately 10 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate.

Select **ODOsat %** and then **1-Point** to access the DO calibration procedure. Calibration of your Optical dissolved oxygen sensor in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.

Enter the current barometric pressure in **mm of Hg.** (Inches of Hg x 25.4 = mm Hg).

Note: Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for oxygen calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is:

True BP = [Corrected BP] – [2.5 * (Local Altitude in ft above sea level/100)]

Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under ODOsat %. When they show 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 return to the **Calibrate** menu.

The minor advantages and disadvantages of calibration in air-saturated water versus water-saturated air are outlined in **Appendix M, ROX Optical DO Sensor**

NOTE CAREFULLY: As opposed to the 6562 Rapid Pulse Polarographic DO sensor described above, there is no difference between the calibration routine for sensors which will be used for sampling or monitoring applications. Usually the Autosleep RS-232 feature in the **Advanced|Setup** menu will be activated for ROX calibrations, but there is no problem if it is not active.

Rinse the sonde in water and dry the sonde.

DEPTH AND LEVEL

For the depth and level calibration, make certain that the depth sensor module is in air and not immersed in any solution.

From the Calibrate menu, select **Pressure-Abs** (or **Pressure-Gage** if you have a vented level sensor) to access the depth calibration procedure. Input 0.00 or some known sensor offset in feet. Press **Enter** and monitor the stabilization of the depth readings with time. When no significant change occurs for approximately 30 seconds, press **Enter** to confirm the calibration. This zeros the sensor with regard to current barometric pressure. Then press **Enter** again to return to the Calibrate menu.

For best performance of depth measurements, users should ensure that the sonde‟s orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

pH 2-POINT

Using the correct amount of pH 7 buffer standard (see Tables 1-8) in a clean, dry or pre-rinsed calibration cup, carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

From the Calibrate menu, select **ISE1 pH** to access the pH calibration choices and then press **2- 2-Point**. Press **Enter** and input the value of the buffer at the prompt.

NOTE: The actual pH value of all buffers is somewhat variable with temperature and that the correct value from the bottle label for your calibration temperature should be entered for maximum accuracy. For example, the pH of YSI "pH 7 Buffer" is 7.00 at 25 C, but 7.02 at 20 C.

After entering the correct pH value of the buffer, press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press **Enter**. The display will indicate that the calibration is accepted.

After the pH 7 calibration is complete, press **Enter** again, as instructed on the screen, to continue. Rinse the sonde in water and dry the sonde before proceeding to the next step.

Using the correct amount (see Tables 1-8) of an additional pH buffer standard into a clean, dry or pre-rinsed calibration cup, carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Press **Enter** and input the correct value of the second buffer for your calibration temperature at the prompt. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press **Enter**. After the second calibration point is complete, press **Enter** again, as instructed on the screen, to return to the Calibrate menu.

Rinse the sonde in water and dry. Thoroughly rinse and dry the calibration containers for future use.

NOTE: The majority of environmental water of all types has a pH between 7 and 10. Therefore, unless you anticipate a pH of less than 7 for your application, YSI recommends a two point calibration using pH 7 and pH 10 buffers.

The next calibration instructions are only for the ISE sensors which are options for the 6820V2-1, 6800V2-2, 6600V2-2, 6920V2-1, and 6920V2-2 sondes. If you do not have one of these sondes, you may skip to the next section.

AMMONIUM (NH_4^+) , CHLORIDE CL^- AND NITRATE (NO_3^-) 3-POINT

WARNING: AMMONIUM AND NITRATE SENSORS CAN ONLY BE USED AT DEPTHS OF LESS THAN 50 FEET (15 METERS). USE OF THE SENSORS AT GREATER DEPTHS IS LIKELY TO PERMANENTLY DAMAGE THE SENSOR MEMBRANE.

The calibration procedures for ammonium, nitrate or chloride are similar to pH except for the reagents in the calibration solutions. Suggested values for calibrants are 1 and 100 mg/L of either ammonium-nitrogen (NH_4-N) or nitrate-nitrogen (NO_3-N). Suggested values for calibrants are 10 and 1000 mg/L of Chloride (Cl^-).

NOTE: The following procedure requires one portion of the high concentration calibrant and two portions of the low concentration calibrant. The high concentration solution and one of the low concentration solutions should be at ambient temperature. The other low concentration solution should be chilled to less than 10°C prior to beginning the procedure.

Place the proper amount of 100 mg/L standard (1000mg/l for chloride) into a clean, dry or pre-rinsed transport cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Select **Ammonium, Nitrate,** or **Chloride** to access the appropriate calibration choices. Then select **3-3-Point**. Press **Enter** and input the concentration value of the standard as requested. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under $NH4^+$, $NO3^-$, or Cl^- . When they show no significant change for approximately 30 seconds, press **Enter**.

After the first calibration point is complete, proceed as instructed on the screen, to continue. Rinse the sonde in water and dry the sonde prior to the next step.

Place the proper amount of 1 mg/L standard for Ammonium or Nitrate (10 mg/l for Chloride) into a clean, dry or pre-rinsed transport cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Press **Enter** and input the concentration value of the standard as requested.

Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under $NH4^+$, $NO3^-$, or Cl^-.and when they have show no significant change for approximately 30 seconds, press **Enter**.

After the second value calibration is complete, press **Enter** to continue. Place the proper amount of chilled 1 mg/L standard (10 mg/L for the chloride) into a clean, dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 5 minutes for temperature equilibration before proceeding.

Press **Enter** and input the concentration value of the standard as requested. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under $NH4^+$, $NO3^-$ or Cl^- and when they show no significant change for approximately 30 seconds, press **Enter**. After the third value calibration is complete, press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use.

CALIBRATION TIP: Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in these ISE probes (ammonium, nitrate and chloride probes). Therefore, when calibrating the pH probe, YSI recommends that you use one of the following methods to minimize errors in the subsequent readings:

- Calibrate pH first, immersing all of the probes in the pH buffers. After calibrating pH, place the probes in 100 mg/L nitrate or ammonium standard or 1000 mg/L chloride standard and monitor the reading. Usually, the reading starts low and may take as long as 30 minutes to reach a stable value. When it does, proceed with the calibration.

- When calibrating pH, remove ISE modules from the sonde bulkhead and plug the ports. After pH calibration is complete, replace the ISE sensors and proceed with their calibration with no stabilization delay.

TURBIDITY 2-POINT

Select **Optic X –Turbidity-6136** or **Optic X – Turbidity 6026** from the Calibrate Menu and then **2-2-Point**.

NOTE: Before calibrating your 6136 turbidity sensor, pay particular attention to the following cautions:

- To properly calibrate YSI turbidity sensors, you MUST use standards that have been prepared according to details in *Standard Methods for the Treatment of Water and Wastewater (Section 2130 B)*. Acceptable standards include (a) formazin prepared according to *Standard Methods*; (b) dilutions of 4000 NTU formazin concentrate purchased from Hach; (c) Hach StablCal™ standards in various NTU denominations; and (d) AMCO-AEPA standards prepared specifically for the 6026 and 6136 by either YSI or approved vendors who are listed on the YSI website (www.ysi.com). STANDARDS FROM OTHER VENDORS ARE **NOT** APPROVED FOR THE YSI TURBIDITY SYSTEM AND THEIR USE WILL LIKELY RESULT IN BOTH CALIBRATION ERRORS AND INCORRECT FIELD READINGS.

- For AMCO-AEPA standards, the value entered by the user during the calibration protocol is DIFFERENT depending on which YSI turbidity sensor (Legacy 6026 or Current 6136) is being calibrated. This reflects the empirically determined fact that 6026 and 6136 sensors that have been calibrated to the same value in the primary standard formazin, will have different responses in suspensions of the AEPA-AMCO beads. This effect is likely due to the larger optical cell volume of the 6136. Thus, for example, the label of the YSI 6073 turbidity standard bottle indicates that the value of the standard is **100 NTU when used for calibration of the 6026 sensor, but 126 NTU when used to calibrate the 6136.** Note that the phenomenon of a sensor-specific formazin/AEPA-AMCO ratio is well known for sensors other than the 6026 and 6136.

- When calibrating a 6136 turbidity sensor you MUST carefully follow the instructions found above in Section 2.6.1 to avoid interference from the bottom of the calibration cup. Failure to carry out the calibration properly can result in inaccurate readings, particularly water of very low turbidity.

- Before proceeding with the calibration, be certain that the probe compartment of the sonde has been cleaned and is free of debris. Solid particles from this source, particularly those carried over from past deployments, will contaminate the standards during your calibration protocol and cause either calibration errors and/or inaccurate field data.

- One standard must be 0 NTU, and this standard must be calibrated first.

To begin the calibration, place the correct amount (see Tables 1-8 above) of 0 NTU standard (clear deionized or distilled water) into the calibration cup provided with your sonde. Immerse the sonde in the water**.** Input the value 0 NTU at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen, to remove any bubbles. After stabilization is complete, press **Enter** to “confirm” the first calibration and then, as instructed, press **Enter** to continue.

Dry the sonde carefully and then place the sonde in the second turbidity standard (100 or 126 NTU is suggested) using the same container as for the 0 NTU standard. Input the correct turbidity value in NTU, press **Enter**, and view the stabilization of the values on the screen in real-time. As above, activate the wiper with the “3” key or manually rotate the sonde to remove bubbles. After the readings have stabilized, press **Enter** to confirm the calibration and then press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the turbidity sensor, see **Appendix E, Turbidity Measurements**.

CHLOROPHYLL 1-POINT

Select **Optic X -Chlorophyll** from the **Calibrate** Menu, **Chl µg/L** and then **1-1 point.**

NOTE: This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of chlorophyll concentration in µg/L, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to chlorophyll. However, the readings will reflect changes in chlorophyll from site to site, or over time at a single site.

To increase the accuracy of your chlorophyll measurements, follow the 2-point or 3-point calibration protocols outlined in **Section 2.9, Sonde Menu**.

Before making any field readings, carefully read **Section 5.14**, **Chlorophyll a**nd **Appendix I, Chlorophyll Measurements** that describe practical aspects of fluorescence measurements.

To begin the calibration, place the correct amount (see Tables 1-8 above) of clear deionized or distilled water into the YSI clear calibration cup provided. Immerse the sonde in the water**.** Input the value 0 µg/L at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen to remove any bubbles from the sensor. After stabilization is complete, press **Enter** to “confirm” the calibration and then, as instructed, press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the chlorophyll sensor, see **Section 5.14**, **Chlorophyll** and **Appendix I, Chlorophyll Measurements.**

BGA-PC 1-POINT

Select **Optic X BGA-PC -** from the **Calibrate** Menu, and then **1-1 point.**

NOTE: This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of phycocyanin-containing BGA in cells/mL, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to BGA-PC. However, the readings will reflect changes in BGA-PC from site to site, or over time at a single site.

To increase the accuracy of your BGA-PC measurements, follow the 2-point calibration protocols outlined in **Section 2.9, Sonde Menu**.

Before making any field readings, carefully read **Section 5.16, Principles of Operation** to better understand the practical aspects of BGA-PC fluorescence measurements.

To begin the calibration, place the correct amount (see Tables 1-8 above) of clear deionized or distilled water into the YSI clear calibration cup provided. Immerse the sonde in the water**.** Input the value 0 cells/mL at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen to remove any bubbles from the sensor. After stabilization is complete, press **Enter** to "confirm" the calibration and then, as instructed, press **Enter** to return to the Calibrate menu. Note that because the range of the BGA sensors in cells/mL is large, the readings may appear to be somewhat noisier during the calibration procedure than for other 6-series sensors. Variations of +/- 400 cells/mL for the zero point can be observed with a properly functioning sensor since this value is only 0.2% of the range.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the BGA-PC sensor, see **Section 5.16, Principles of Operation.**

Note that the 1-point calibration of the BGA-PC sensor in cells/mL will also zero the PC RFU (Relative Fluorescence Units) parameter which is in units of percent of the full scale of the sensor. Users may wish to activate PC RFU in the Report menu and simply use this parameter to determine BGA-PC events until a good correlation between the observed cells/mL value and the value determined from laboratory analysis has been established.

BGA-PE 1-POINT

Select **Optic X BGA-PE -** from the **Calibrate** Menu, and then **1-1 point.**

NOTE: This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of phycoerythrin-containing BGA in cells/mL, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to BGA-PE. However, the readings will reflect changes in BGA-PE from site to site, or over time at a single site.

To increase the accuracy of your BGA-PE measurements, follow the 2-point calibration protocols outlined in **Section 2.9, Sonde Menu**.

Before making any field readings, carefully read **Section 5.17, Principles of Operation** to better understand the practical aspects of BGA-PE fluorescence measurements.

To begin the calibration, place the correct amount (see Tables 1-8 above) of clear deionized or distilled water into the YSI clear calibration cup provided. Immerse the sonde in the water**.** Input the value 0 cells/mL at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen to remove any bubbles from the sensor. After stabilization is complete, press **Enter** to "confirm" the calibration and then, as instructed, press **Enter** to return to the Calibrate menu. Note that because the range of the BGA sensors in cells/mL is large, the readings may appear to be somewhat noisier during the calibration procedure than for other 6-series sensors. Variations of +/- 400 cells/mL for the zero point can be observed with a properly functioning sensor since this value is only 0.2% of the range.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the BGA-PE sensor, see **Section 5.17, Principles of Operation.**

Note that the 1-point calibration of the BGA-PE sensor in cells/mL will also zero the PE RFU (Relative Fluorescence Units) parameter which is in units of percent of the full scale of the sensor. Users may wish to activate PC RFU in the Report menu and simply use this parameter to determine BGA-PE events until a good correlation between the observed cells/mL value and the value determined from laboratory analysis has been established.

RHODAMINE WT 2-POINT

Select **Rhodamine** from the **Calibrate** Menu and then **2-2-Point**.

NOTE: One standard must be 0 ug/L in rhodamine WT, and this standard must be calibrated first.

To begin the calibration, place the correct amount (see Tables 1-8) of 0 standard (clear deionized or distilled water) into the calibration cup provided with your sonde and immerse the sonde in the water**.** Input the value 0 ug/L at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen, to remove any bubbles. After stabilization is complete, press **Enter** to "confirm" the first calibration and then, as instructed, press **Enter** to continue.

Dry the sonde carefully and then place the sonde in the second rhodamine WT standard (100 ug/L is recommended) using the same container as for the 0 ug/L standard. Input the correct rhodamine WT concentration in ug/L, press **Enter**, and view the stabilization of the values on the screen in real-time. As above, activate the wiper with the "3" key or manually rotate the sonde to remove bubbles. After the readings have stabilized, press **Enter** to confirm the calibration and then press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use.

2.7 TAKING READINGS

After you have (1) enabled the sensors, (2) set the report to show the parameters that you want to see, and (3) calibrated the sensors, you are now ready to take readings.

There are two basic approaches to sampling, discrete and unattended. Using discrete sampling, the sonde is connected via a communication cable to a PC or 650 MDS Display/Logger. The sampling frequency is likely to be rapid (seconds) in order to obtain a representative sampling as you move from site to site. Readings will probably be logged to several different files.

Unattended sampling is normally done with sondes that have internal batteries. The sampling frequency is likely to be longer (minutes or hours). A sonde is typically deployed for days or weeks at a time, and readings will be logged to a single file. The communication cable may be disconnected and internal battery power used to operate the sonde. Alternatively, the sonde may connect via SDI-12 communication to a data collection platform (DCP). Sondes without batteries need to be connected to an external power source for unattended sampling.

Select **1-Run** from the Main menu to begin taking readings or to set/verify the parameters required for a study. There are two options in the Run menu as shown below.

```
---------------Run setup---------------
1-Discrete sample   2-Unattended sample

Select option (0 for previous menu): 1
```

DISCRETE SAMPLING

Select **1-Discrete sample** from the Run menu. The Discrete sample menu will be displayed.

```
------------Discrete sample------------
1-Start sampling
2-Sample interval=4
3-File=
4-Site=
5-Open file

Select option (0 for previous menu):
```

Select **2-Sample Interval** to type a number that represents the number of seconds between samples. The maximum sample interval is 32767 seconds (9+ hours). The factory default sample interval is 4 seconds and works best for most discrete sampling applications. See Section 2.9.1 for more details.

Select **3-File** to enter a filename with a maximum of 8 characters. This is the file to which you will log readings.

If you started sampling without entering a filename, the default name NONAME1 will be assigned to your file. Whenever you press 1-LOG last sample or 2-LOG ON/OFF from the menu, NONAME1 will be opened during sampling. If this happens, and you want to restart the file with a different name, press **5-Close file** and rename the file.

Select **4-Site** to assign a site name with a maximum of 31 characters. This allows you to enter the name of the site where you are sampling.

When you select **5-Open File**, a file is opened and the number 5 changes to **Close File**. When you are finished logging data to the file, press **5-Close File** and number 5 changes back to **Open File**.

Now select **1-Start sampling** to start discrete sampling.

After the initial sampling time interval has passed, (e.g. 4 seconds in the example above), sequential lines of data will appear on the screen.

```
============================================================
 Temp    Sal DOsat     DO   Depth    pH NH4+ N NO3- N Turbid
    C    ppt     %   mg/L    feet         mg/L   mg/L    NTU
------------------------------------------------------------
*** 1-LOG last sample   2-LOG ON/OFF, 3-Clean optics ***
23.54   0.00  96.5   8.20   1.001  5.20  0.853  0.522    0.3
*** LOG is ON,  hit 2 to turn it OFF, 3-Clean optics ***
23.53   0.00  96.5   8.20   1.001  5.20  0.856  0.520    0.3
23.53   0.00  96.5   8.20   1.000  5.20  0.854  0.521    0.3
23.53   0.00  96.5   8.20   1.000  5.19  0.852  0.522    0.3
*** 1-LOG last sample   2-LOG ON/OFF, 3-Clean optics ***
23.53   0.00  96.5   8.20   1.000  5.19  0.852  0.522    0.3
Sample logged.
```

The following prompt will appear just below the screen header:
1-LOG last sample, 2-LOG ON/OFF, 3-Clean optics.

By entering **1–LOG last sample**, a single line of data can be logged to sonde memory and the following message will be displayed: **Sample logged.**

By entering **2-LOG ON/OFF**, a set of data can be logged to memory and the following message will be displayed: **LOG is ON, hit 2 to turn it OFF, 3-Clean optics.** Press **2** again to terminate logging.

By entering **3-Clean optics**, if your unit has an optical probe, the wiper will clean the optical surface**.** The **3-Clean optics** portion of the prompt will only appear if an optical probe was installed and enabled.

Select **Esc** or press **0** to exit discrete sampling.

UNATTENDED SAMPLING

Select **2-Unattended Sampling** from the Run menu. The Unattended sample menu will be displayed. Use the following example to understand the unattended sampling option.

> **Example:** You are going to deploy the sonde for 2 weeks, collecting a set of readings every 15 minutes. You start at 6:00 PM on July 17, 1996 and end the

sampling at 6:00 PM on July 31, 1996. The site is Clear Lake, near the spillway, and you want to log all of the readings to a single file CLRLAKE3.

```
------------Unattended setup-----------
1-Interval=00:15:00
2-Start date=07/17/96
3-Start time=18:00:00
4-Duration days=365
5-File=
6-Site=
7-Bat volts: 11.6
8-Bat life 25.1 days
9-Free mem 41.3 days
A-1st sample in 8.10 minutes
B-View params to log
C-Start logging
```

Follow the prompts on this screen to prepare your sonde for unattended deployment as described below:

To verify and/or correct the time and date enter **4-Status** or **5-System menu** from the Main menu. You may enter the correct date and time from either of these submenus.

- Select **1-Interval** and enter the desired time between samples (e.g. 15 minutes in the screen above). Use the 24-hour clock format to enter interval.

- Select **2-Start Date** and **3-Start Time** to set the time that data will begin to log to sonde memory. If you do not make any change to these entries, then the study will automatically begin at the next integral time interval, once you have pressed **C-Start logging**.

  Example: If the current time is 17:20:00 and your sample interval is 15 minutes, logging will automatically begin at 17:30:00.

It is better to start the study prior to taking the unit to the field so that you can confirm that readings are being saved to memory. If you should desire to start the instrument at the site at 6:00 PM as noted in the above example, change the Start Time to 18:00:00.

- Select **4-Duration** and set the length of the study in days. The default value is 365 days (which is longer than most deployments). In most cases, you will either want to stop the unattended study manually or allow the batteries to be expended. It is wise to set the duration to a value longer than the anticipated deployment. If you cannot retrieve the sonde at the expected time due to factors beyond your control such as weather or illness, data will continue to be acquired as long as battery power is present.

- Select **5-File** and enter a name of no more than 8 characters that will be used by your external computer to identify the study. Be sure to use ONLY alpha/numeric characters.

- Select **6-Site** and enter a site name of no more than 31 characters. This filename will appear in your sonde file directory, but will not be used to identify the file after transfer to your computer.

- Check **7-Battery** to make certain that the voltage is suitable for the length of the study that you are about to begin. No change can be made to this item via the software.

- ❑ Skip **B-View params to log** in this initial test study. This feature will be explained in detail in **Section 2.9, Sonde Menu**.

After making the above entries, the sonde software will automatically calculate the expected battery life, and the time it will take for the sonde memory to be filled. This information is displayed on the screen for your consideration as items 8, 9, and A. If the battery life or the free memory capacity will be exceeded sooner than the duration, you may want to make some changes to the entries. For example, you can free up memory in the sonde by uploading all existing data from the sonde memory to your PC and then deleting them out of the sonde (see 3-File from Main Menu). You may want to change the batteries for longer battery life. You can lengthen the sampling interval to extend both battery life and memory capacity.

Review the screen below, which now displays the entries made above and reflects your logging conditions.

```
------------Unattended setup-----------
1-Interval=00:15:00
2-Start date=07/17/96
3-Start time=18:00:00
4-Duration days=365
5-File=clrlake3
6-Site=Clear Lake at Spillway
7-Bat volts: 11.6
8-Bat life 25.1 days
9-Free mem 41.3 days
A-1st sample in 4.10 minutes
B-View params to log
C-Start logging
```

Once you press **C-Start logging**, a screen will appear to request confirmation.

```
-------------Start logging-------------
Are you sure?
1-Yes
2-No

Select option (0 for previous menu):
```

Select **1-Yes** and the screen will change.

```
----------------Logging----------------
1-Interval=00:15:00
2-Next at 07/17/96
3-Next at 18:00:00
4-Stop at 07/31/96
5-Stop at 18:00:00
6-File=clrlake3
7-Site=Clear Lake at Spillway
8-Bat volts: 11.7
9-Bat life 25.5 days
A-Free mem 41.3 days
B-Stop logging
C-Show Live Data

Select option (0 for previous menu):
```

The display now shows the next date and time for logging, and the stop date and time for the logging study. Most importantly, note that the "B" command now shows **B-Stop logging**, a confirmation that the logging has indeed been initiated.

The Unattended study will terminate when the duration you specified has expired or the batteries are expended. If you want to terminate sooner, simply select **2-Unattended** sample from the Run menu, then **B-Stop logging**. Select **1-yes** and return to the Unattended setup menu.

```
Stop logging?
1-Yes
2-No

Select option (0 for previous menu):
```

2.8 USING ECOWATCH TO CAPTURE, UPLOAD AND ANALYZE DATA

EcoWatch for Windows software is reporting and plotting software for use with the YSI 6-Series sondes. Instructions for installing this software were included in **Section 2.1, Getting Started**. This program can also be used to upload and view data logged to sonde memory during either discrete or unattended sampling.

CAPTURE

EcoWatch for Windows can be used to capture data in real-time to your PC‟s hard drive or to a floppy disk. To utilize this function, interface the sonde to your PC via a COM port, run EcoWatch for Windows, and follow the step by step instructions below.

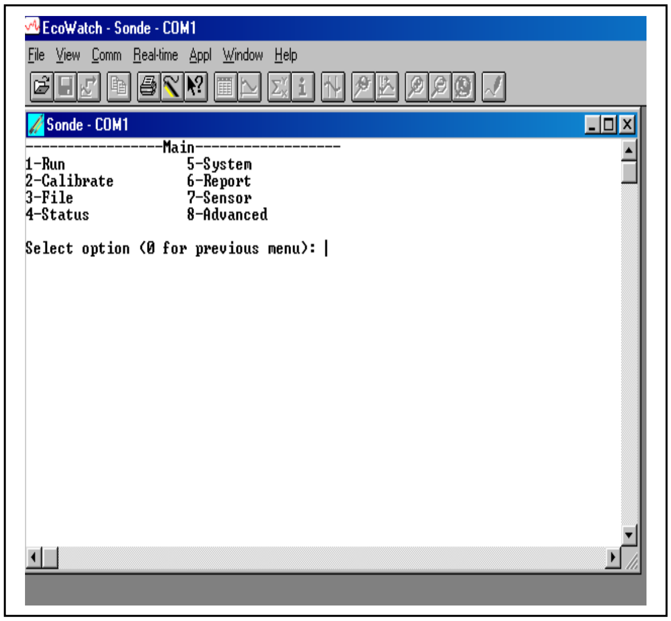
1. Click on the sonde icon , choose the proper Com port, and confirm.
2. From the **Main** sonde menu press **1-Run** and then **1-Discrete Sample**.
3. Make sure that the sample interval is set to the correct value. If it is not, change it to the correct value.
4. Close the terminal window by clicking on the **X** in the upper right hand corner. Do not close EcoWatch for Windows.
5. Open the **Real-Time** menu, click on **New** and select the location where you want to data transferred. Name the file, making sure that the name has extension **.RT**. The default location for the file is in the Data subdirectory of the ECOWWIN directory.
6. Click **OK**. After EcoWatch sets up the sonde for the study, data transfer will begin at the sample rate you selected. The data will be automatically plotted with autoscaling and saved as a .DAT file at your chosen selection.
7. To terminate the study, open the **Real-Time** menu, choose **Close**, and click **OK**.

UPLOAD DATA

If the sonde was deployed unattended (without a cable), clear debris and water from the bulkhead connector cap. Then remove the cap and connect the calibration cable (or field cable and adapter) from the sonde to your computer.

You may now retrieve data files using the following procedure. Remember these are files in the sonde directory, not files in the EcoWatch directory.

Run EcoWatch software on your PC and select the **Sonde** icon  from the menu bar. A terminal interface window (like that shown below) will appear. If a “#” prompt appears instead of the Main sonde menu, type “menu” at the prompt to generate the display as shown. Then press **3-File** to view data handling options.




```
-----------------File-----------------
-
1-Directory          4-View file
2-Upload             5-Quick view file
3-Quick Upload       6-Delete all files

Select option (0 for previous menu): 1
```

Select **1-Directory** to view all files currently stored in the sondes flash disk memory, the screen below shows 6 files. All data files (.dat extension) could be uploaded to EcoWatch for viewing or plotting, but you do not need to upload all files in the directory. The file with the .glp extension contains the calibration record of the sonde. It is fully described in Sections 2.9.2 and 2.9.3 below. Details of any of the studies can be obtained by pressing the number key associated with the file in the Directory.

```
 Filename    Samples
1-BRIDGE1.dat      19
2-BRIDGE2.dat      27
3-UPLAKE.dat       33
4-CLRLAKE2.dat    167
5-DWNLAKE2.dat     31
6-00003001.glp      3

Select option (0 for previous menu): 4
```

```
-------------File details--------
------
1-View file
2-File:CLRLAKE2.dat
3-Samples:    167
4-Bytes:   4421
5-First:08/23/2001
6-First:08:33:40
7-Last :08/23/2001
8-Last :09:04:20
9-Interval:00:00:10
A-Site:Clear Lake
```

Select **2-Upload** to view file lists in memory, and upload the data to PC-based software.

Prior to upload, a “**Time window**” display appears that will allow you to select portions of the logged data to upload. You may select **1-Proceed** to upload all logged data from the dates and times displayed.

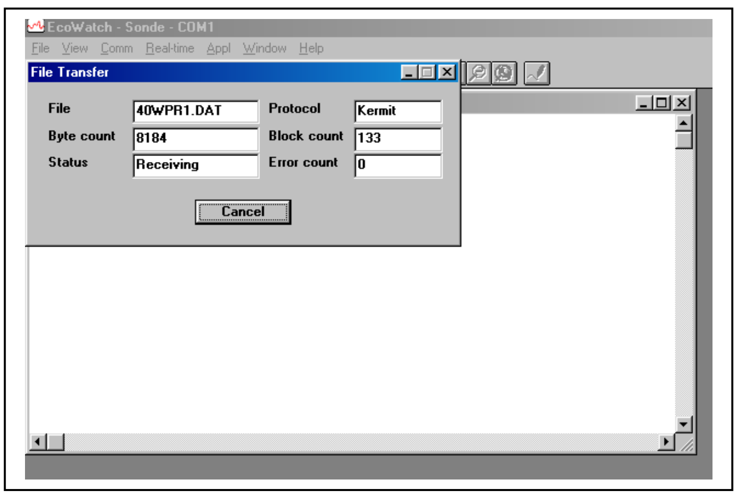
```
--------------Time window--------------
1-Proceed
2-Start date=08/14/96
3-Start time=18:00:00
4-Stop  date=08/28/96
5-Stop  time=11:00:00

Select option (0 for previous menu):
```

Select **1-Proceed**. Choose the appropriate file transfer protocol (in this example, PC6000) and a status box will show the progress of the upload. Verification of a successful transfer is indicated when all of the requested data have been transferred to the C:\ECOWIN\DATA subdirectory of your PC and automatically assigned a ".DAT" extension.

```
---------------File type---------------
1-PC6000
2-Comma & ' ' Delimited
3-ASCII Text

Select option (0 for previous menu):
```



Select **3-Quick Upload** to transfer the last logged file in its entirety to your computer. As noted above, the file will then be resident in the C:\ECOWIN\DATA subdirectory.

Select **4-View File** to examine the data in any file currently stored in the sondes flash disk memory. You will first view the same screen as viewed in the Directory menu. From this menu choose the file of interest, then, using the Time window menu, choose the dates and/or times of interest. If you choose dates or times that are not within the designated start and stop times, no data will be displayed.

You also may choose the entire file. You can use the **Space Bar** to stop and restart the scrolling at any time. Use the **Esc** key to stop the view.

Select **5-Quick view file** to view the last page of data from the last data file in flash disk memory. This feature is particularly useful to quickly review any recently acquired data so that system performance can be assessed.

Select **6-Delete** all files to ***IRREVERSIBLY*** remove all files (INCLUDING the .glp file that contains calibration information) from the sonde flash disk memory. It is critical not to use this option until all relevant data from sonde memory is transferred to your computer via one of the upload options. There is a verification screen that appears, so that pressing the number 6-key does not immediately delete all files.

NOTE: By choosing the Delete function **only** .dat and .glp files will be erased. Calibration data for all sensors installed and calibrated on the sonde will not be deleted.

REPORTING AND PLOTTING DATA WITH ECOWATCH

There are many features in EcoWatch related to viewing, plotting, manipulating and reporting data collected from a 6-Series sonde. EcoWatch includes a Windows Help section for convenient reference that describes all of the software‟s features. This section of the manual describes the most commonly used functions of the program and Section 4, **EcoWatch for Windows**, is a detailed manual for EcoWatch software.

For the purposes of describing and demonstrating EcoWatch plotting, reporting and data manipulation capabilities, we use the file SAMPLE.DAT available on the compact disk that was enclosed with your 6-series sonde. This file will be copied to your hard drive during EcoWatch installation and should be available to you for the instructions below.

When you are ready to move beyond the example SAMPLE.DAT file and analyze data collected from the sonde, locate and open the appropriate .DAT file from your data upload exercise. These data are normally found at C:\ECOWWIN\DATA\. An example filename is 1097CM01.DAT.

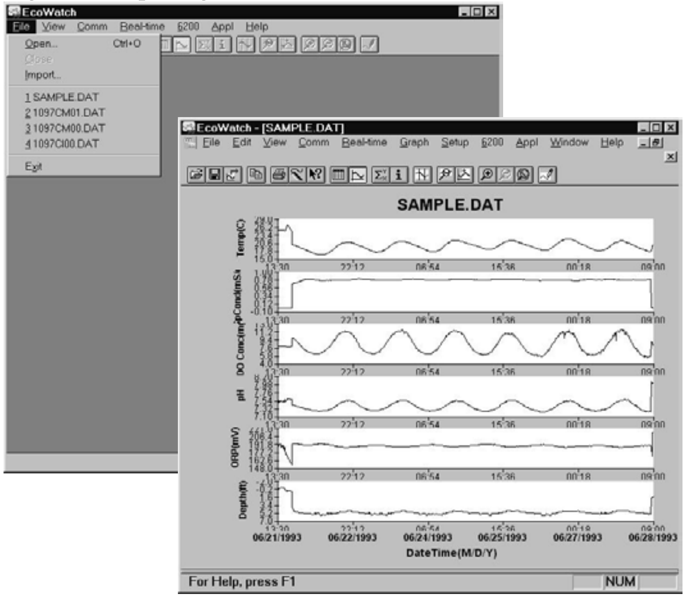
NOTE: In the instructions below that refer to clicking the mouse button, we always refer to the left mouse button unless otherwise specified.

OPENING A DATA FILE

If EcoWatch is not running, open the program by double clicking on the EcoWatch icon. Click on **File** to view a drop-down menu similar to the one shown in Figure 41. From this menu click on **Open**, then locate the drive and directory where SAMPLE.DAT (or your file of interest) resides. Alternatively, if you have been using EcoWatch during setup and checkout, you may be able to click on the file of your choice in the most recently opened files.

Once the SAMPLE.DAT file is open you should see a plot, Figure 41, which graphically represents seven days of sonde data for six different water quality parameters plotted as a function of date and time. Each set of data is autoscaled to allow you to see the minimum and maximum values for each parameter during the one-week study.

Figure 41 Opening a File



Some daily variations may be noticed in parameters such as dissolved oxygen, pH and temperature in this particular study. This is fairly typical in many natural bodies of water. Note also that conductivity is low at both ends of the graph. You may notice similar perturbations in some of the other readings as well. In this example, the sonde was not in the water for a short time at the beginning and end of the study. Not only can you see exactly when the sonde went in and out of the water, but the bottom graph shows the depth at which the sonde was deployed.

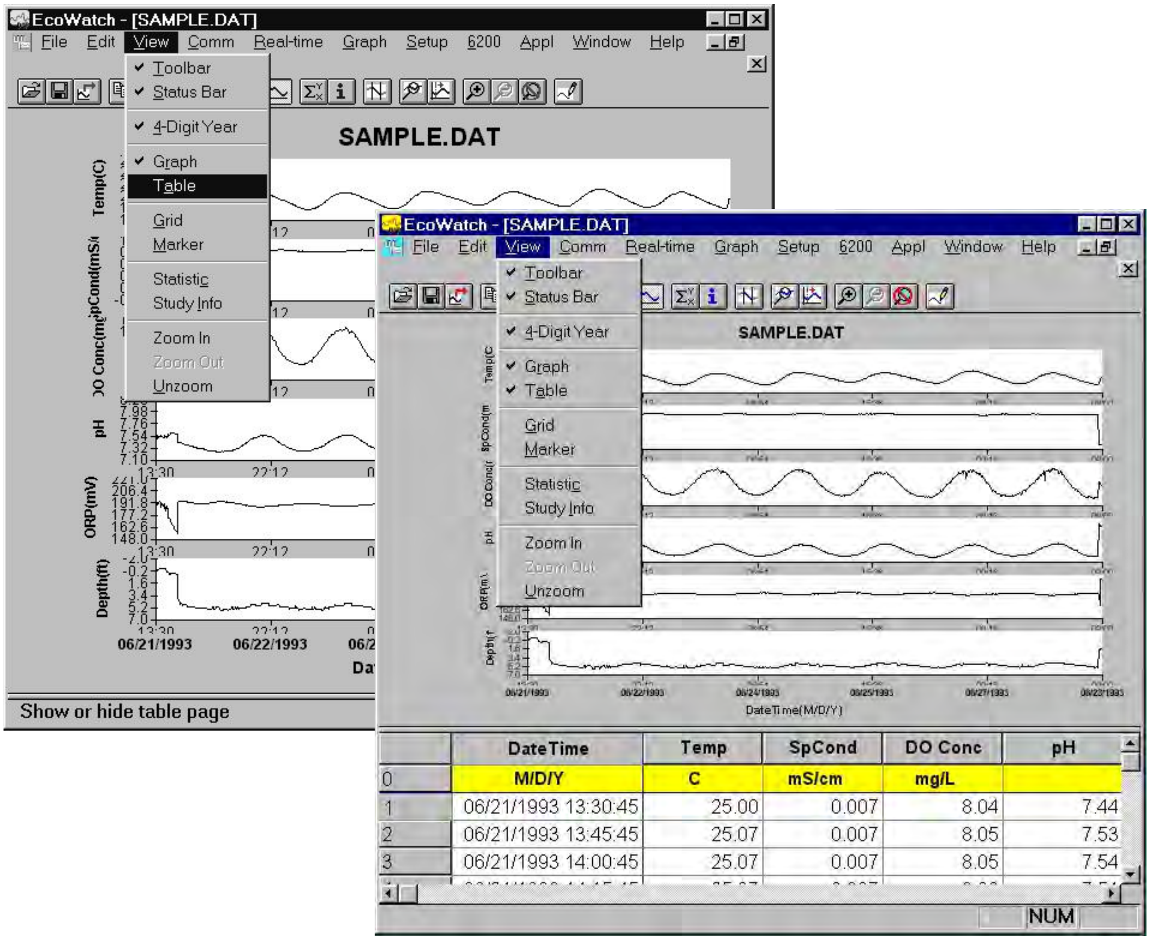
Notice also that you now see a new set of menu items in the top line. Some of these functions are specifically related to viewing and manipulating data. Next we will examine some of the viewing options.

VIEWING DATA

To look at some of the viewing options, click on **View** (Figure 42). Note that the Toolbar and Status Bar are turned on (check mark). In addition, the 4-Digit Year expression is checked. Also note that a check mark is just left of the Graph choice. When a check is next to Graph, all data are expressed graphically in the opening window.

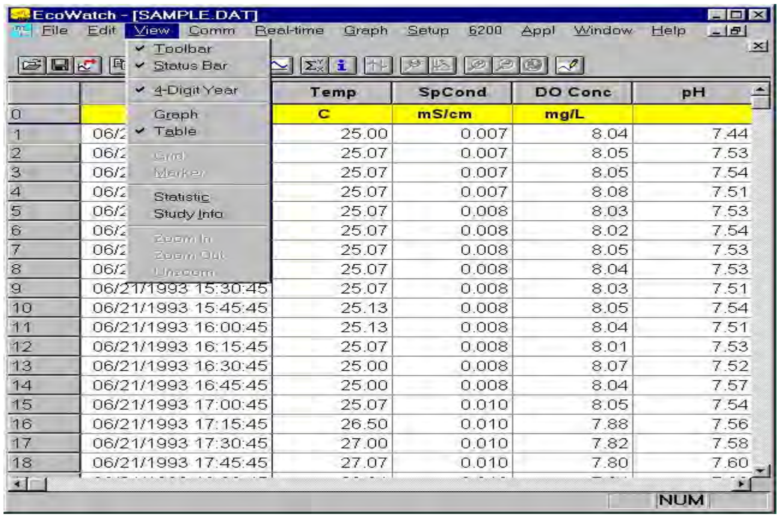
To show data in both graphical and data table format, highlight the Table menu item, then click or press **Enter**. The graphical portion of the window becomes compressed, and the data table becomes visible. If you then click on **View** again, both the Graph and Table items have check marks to their left, indicating that both functions are turned on. You may use your mouse to scroll up/down and left/right to view data.

Figure 42 Viewing Options



It may be somewhat awkward to scan the data table in this manner; therefore you have the option to turn off the graphical representation and allow the table to fill the window. See Figure 43. Notice now that when you click on **View**, the Graph item is no longer checked.

Figure 43 Viewing the Data in Table Format



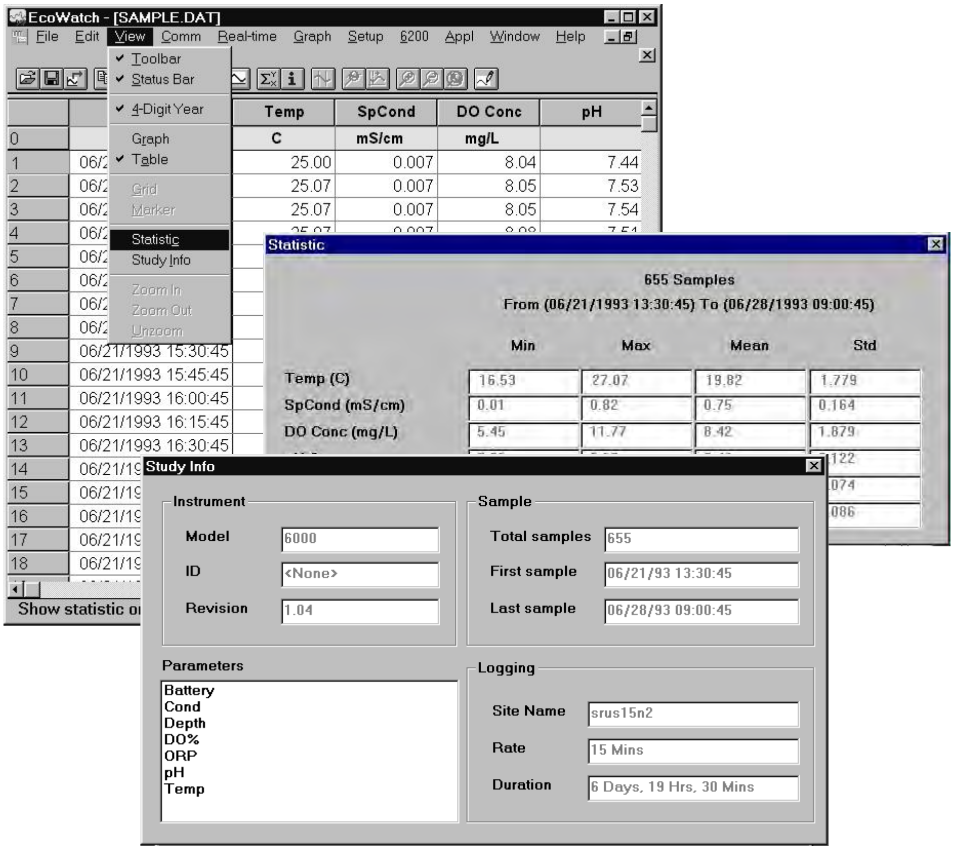
Viewing features such as Grid, Marker, Zoom In, Zoom Out and Unzoom are all available when you activate the **Graph** function. Give each a try as you practice and learn more about the many features of EcoWatch.

The **Statistics** and **Study** functions of EcoWatch are shown in Figure 44. Both provide overview information related to the study data. The **Statistics** function lists minimum, maximum, mean and standard deviation information for each parameter activated. The **Study** function provides useful information about the design of the study including sample interval, date/time, number of samples, sensor identification and parameters reported. The Statistics and Study windows may be activated over either graph or table presentations.

To view either of these windows, click on **View**, highlight the desired function and click again. The window opens on top of the table or graph, similar to what is shown in Figure 43. Only one of these windows may open at one time. To continue, you must close the Statistics or Study window to return to the graph or table and activate the top line menu again.

As before practice viewing the functions mentioned above to gain more familiarity with these features.

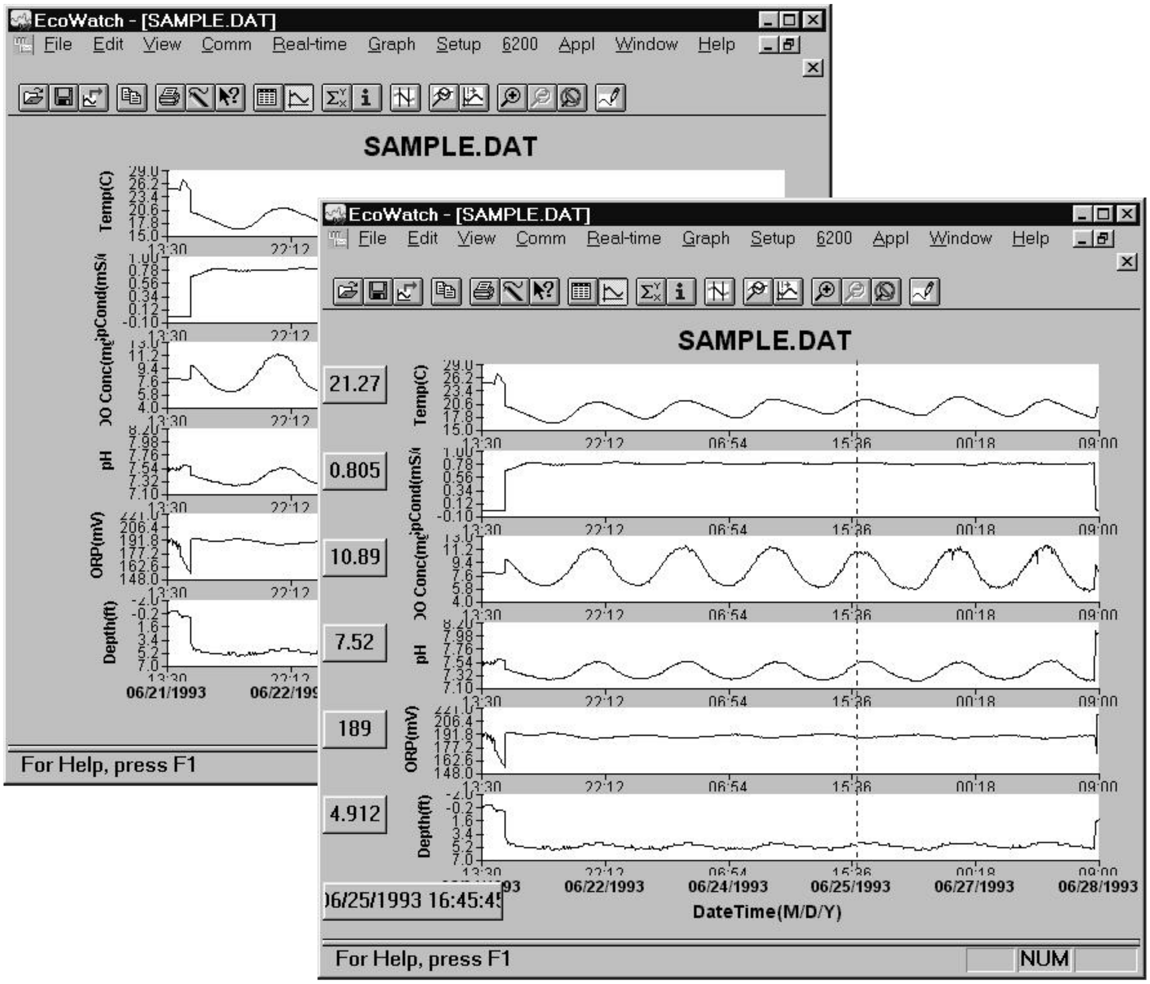
Figure 44 Statistics and Study Information



Next, with the Statistics and Study windows closed, return to the **View** menu, close **Table** and activate **Graph**.

Using the right mouse button, click at any point on the graph. A dotted vertical line appears along with specific data values in boxes to the left of the displayed graphs, as shown in Figure 45. You can hold down the right mouse button and move the mouse to scan the entire graph that is displayed in the window. The values in the boxes change as you move the mouse. This feature is very useful for quantifying specific data without the need to open the data table and scroll through what may be thousands of data points. Note also that the exact time and date change to let you know specifically when an event of interest occurred.

Figure 45 Viewing the Data with Right-Button Mouse Function

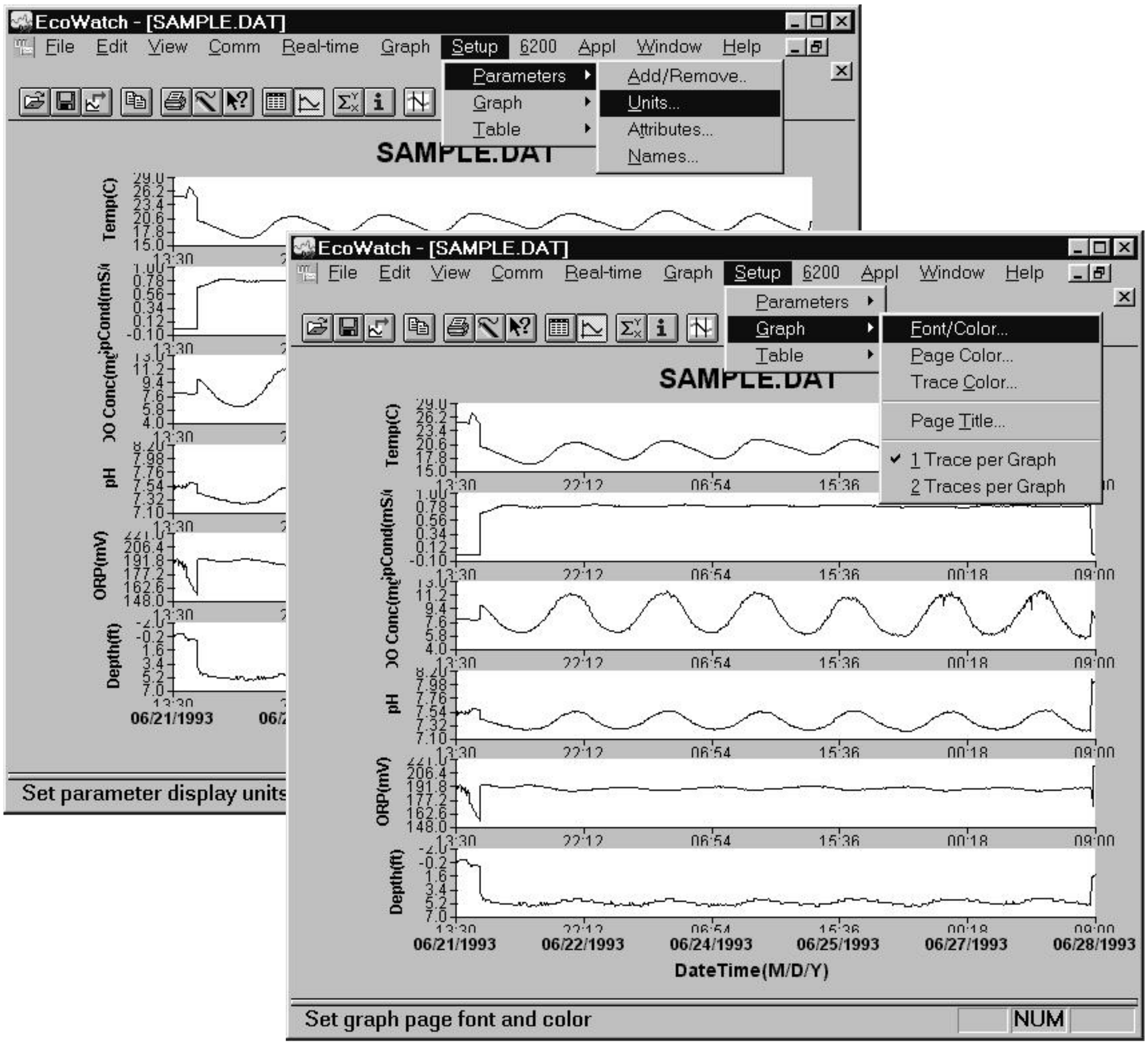


CHANGING DISPLAY FORMATS USING SETUP

Beyond selecting data viewing options such as table format or graphical format, you may also customize your data displays. For example, you may change the order in which parameters are viewed, you may add and delete parameters, you may change plot appearance using different interval times and different units, and you may change the x-axis if you prefer a parameter other than date or time.

The Top Line menu selection that allows you to select some of these parameter changes is **Setup**. Click on **Setup**, then **Parameters**. From here there are four submenus that allow you to Add/Remove parameters, change Units, change sample interval and/or x-axis (Attributes) and change the Names of the parameters you have assigned, as shown in Figure 46.

Figure 46 Changing the Appearance of a Graph or Table



If you are displaying the graph, you may change the appearance by changing font, font style, size and text color. You may also change page color, trace color and graph background color. You may assign a custom 2-line title for the graph, and finally, you may display 1 trace or 2 per set of axes. For display of table formatted results you may change font, font style, size and text color. In addition, you may change table color and highlight color.

The menu structure is easy to follow. Try some changes to gain familiarity with these **Setup** display options.

CHANGING DISPLAY FORMATS USING ‘GRAPH’ FUNCTION

The top line menu labeled **Graph**, as the name suggests, can be used to examine critical events within the graphical format. You may be able to more clearly understand an event by zooming in/out, centering an event of interest, and setting limits to focus in on a specific area of the graph. In addition to modifying along the x-axis, you may also manually scale the y-axis. This may allow you to discard a noise spike and obtain better resolution of events unrelated to the noise. Functions like Autoscale, Redraw and Cancel Limits are all used to "undo" some of the customization functions. Below in Figure 47 you see some of these functions.

One very commonly used function is **Limit Data Set**. If you choose this function by clicking on the highlighted item as shown below, you then use the mouse to move your cursor to the left limit of an area of interest, click once, then move the mouse to the right limit of interest and click again. The result will be a close up look at the specific area of the graph you have defined. Refer to Figure 47 and 48 below to see the results of this particular feature.

Figure 47 Selecting a Subset of Data within a Graph

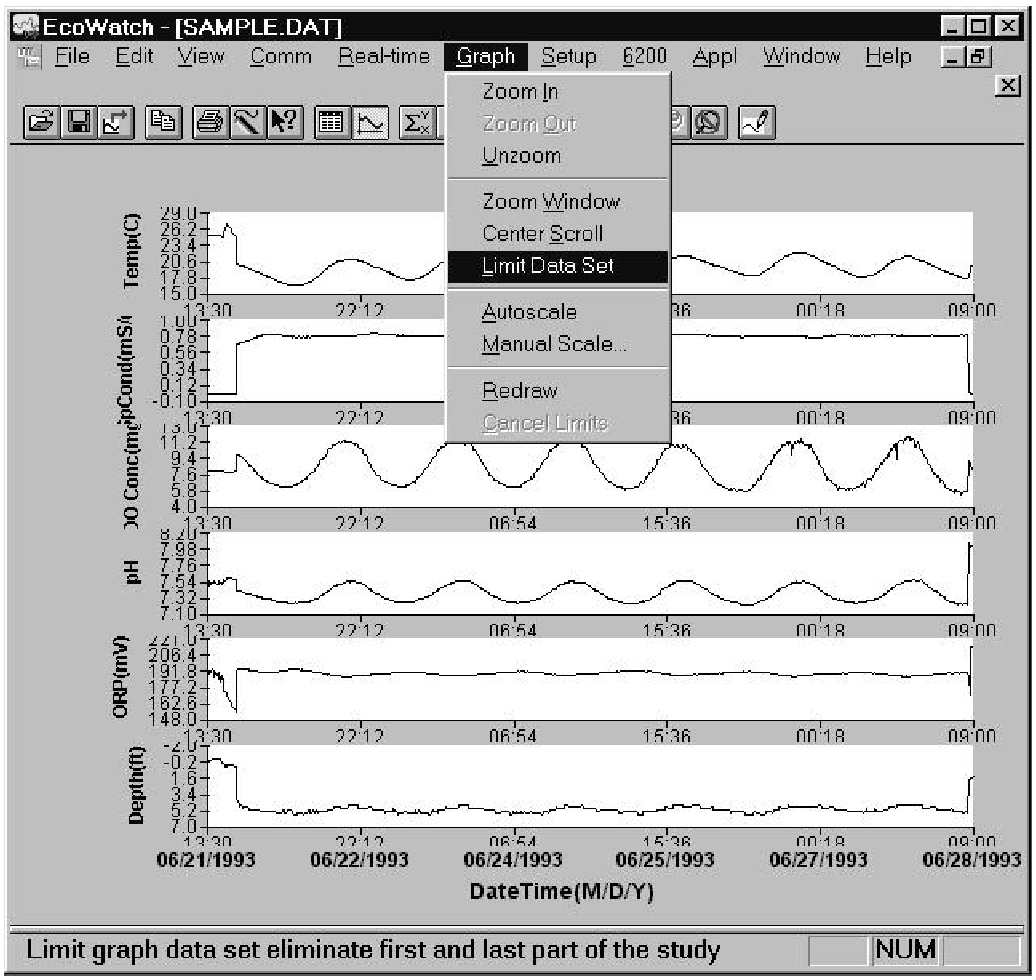
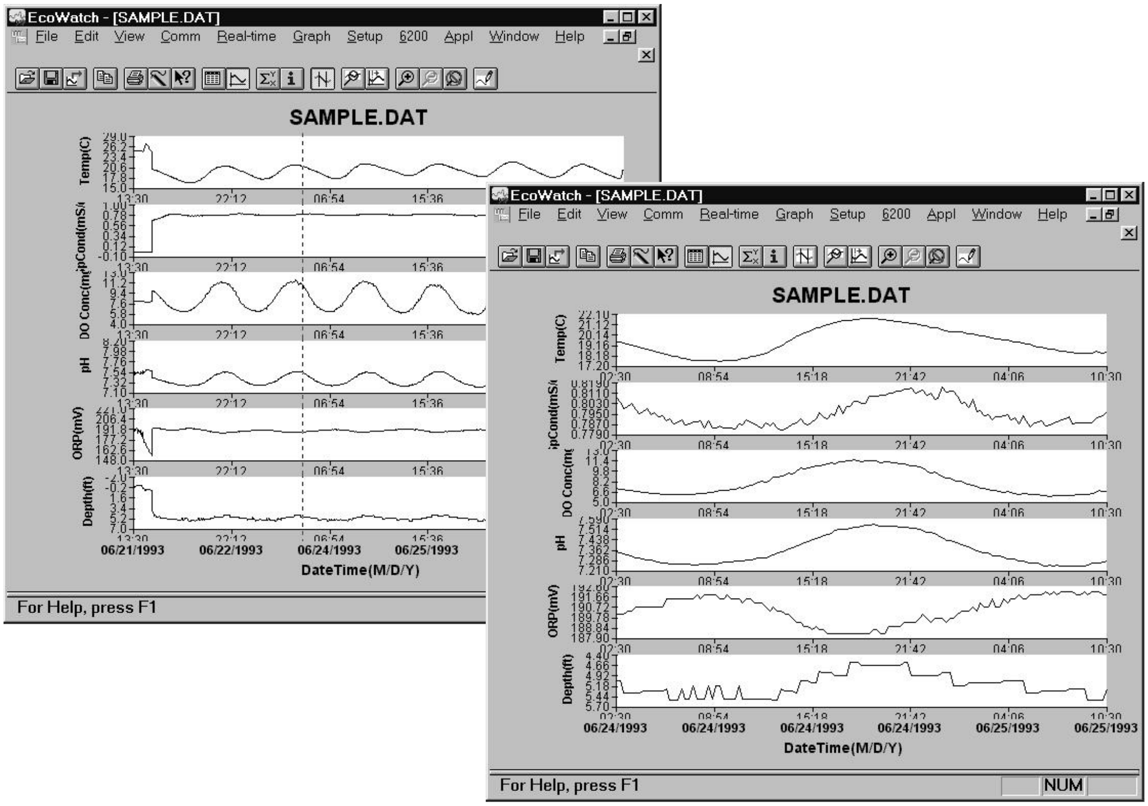


Figure 48 Using Limit Data Set to Display a Subset of Data

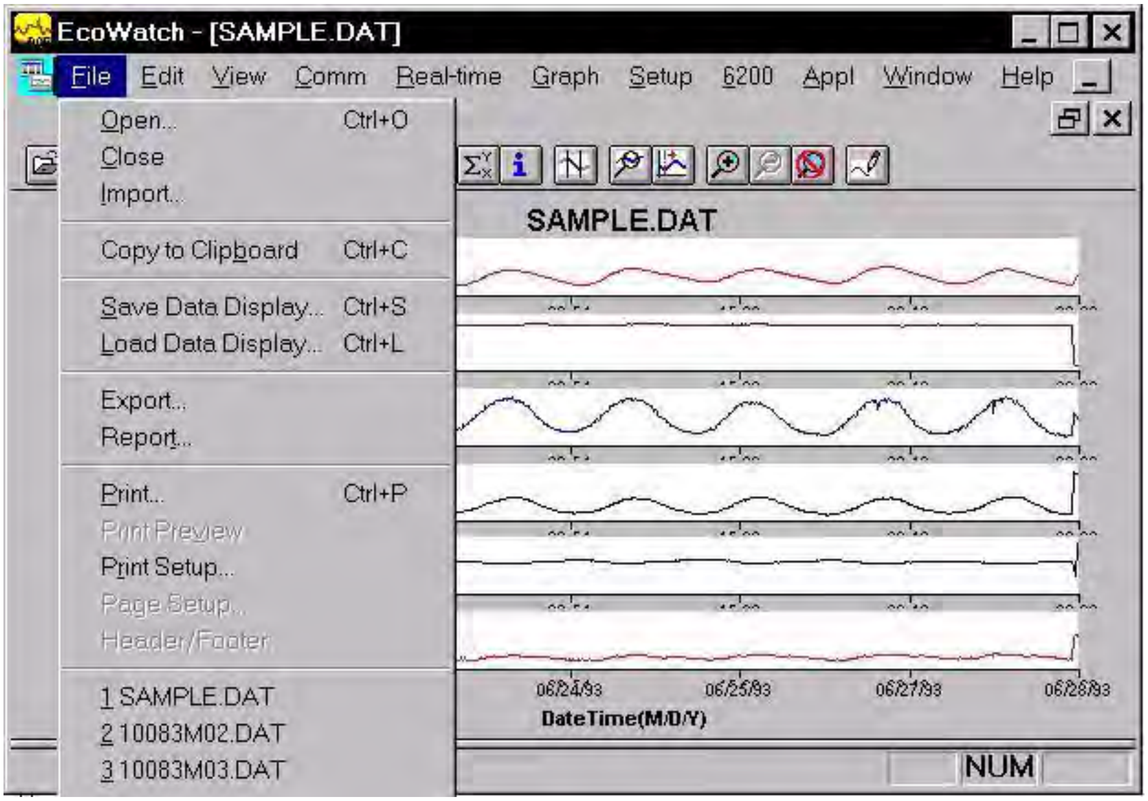


To return to the full set of data again, click on **Graph**, then **Cancel Limits**. If you desire a hard copy of any graph or table, or even a subset expression as shown above, you may use the **Edit, Copy** command to „copy‟ the graph in the active window to the "Clipboard". You can then „paste‟ this graph to the Windows application program of your choice. You may also be able to print graphs and tables as described in the next section.

SAVE, IMPORT, EXPORT AND PRINT COMMANDS

Under **File** function in the top line menu, you can save a particular presentation version of a data file and give the presentation a customized name. For example, you might want to call the expanded plot in Figure 48 "DIURNAL" using the **File|Save Data Display** command. This presentation will be saved with your data file and can be recalled in further by using the **File|Load Data Display** command. You can also export your custom data display as a spreadsheet compatible file (.CDF or .TXT) or print it to a compatible printer. You may also create a custom report format using **the File|Report** command. See Figure 49 for the **File** menu, which shows these commands. Use the Window‟s Help function to learn more about these features.

Figure 49 Saving, Exporting, Printing and Related Functions



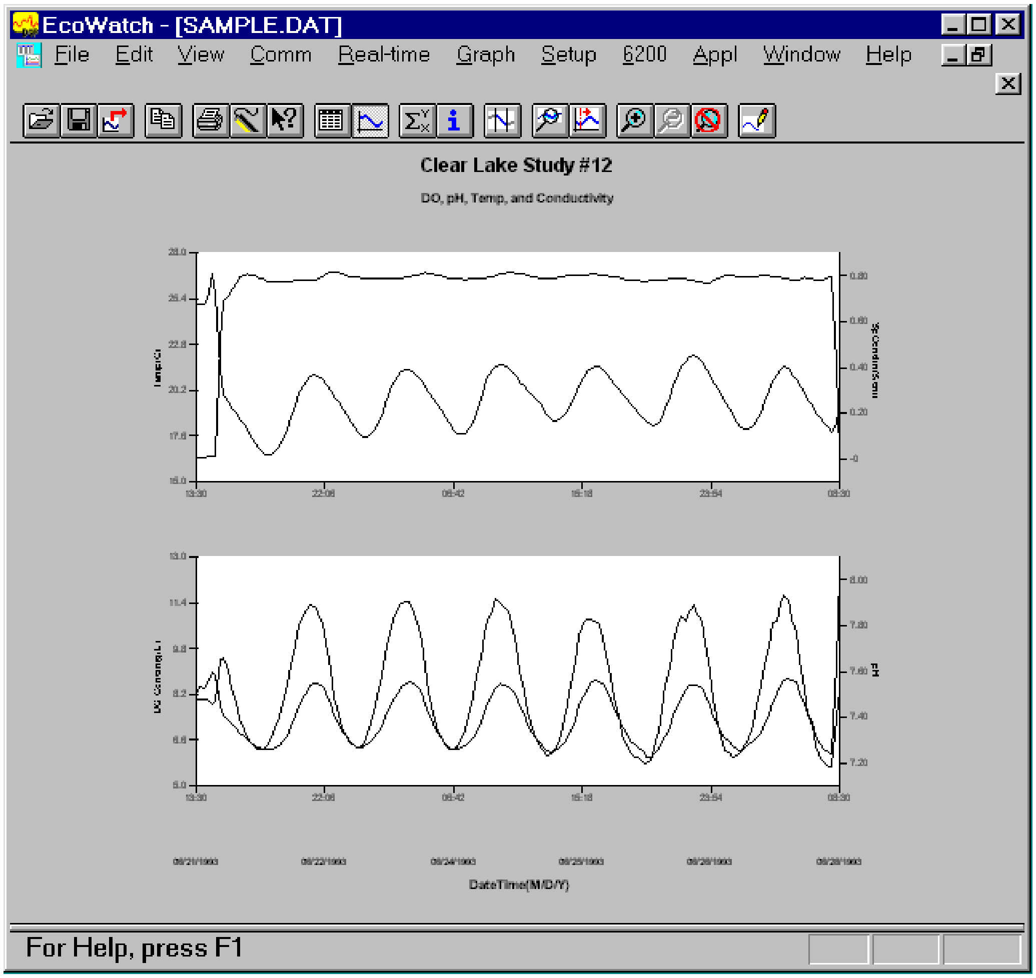
EXAMPLE OF CUSTOMIZING A SUBSET OF SAMPLE.DAT

To conclude this section we have used a few of the many tools available in EcoWatch to demonstrate how you might use this powerful plotting and reporting program to express study results. We encourage you to try some of the tools and learn more about EcoWatch by using the Window‟s Help function, which is available when the EcoWatch program is running.

Using SAMPLE.DAT we decided that some of the data were not of particular interest, so using top line menu item **Setup**, then Parameters, then **Add/Remove,** we removed ORP and Depth results from the data set. Note that we have not deleted this information from the file, but rather we are choosing not to display it. You can always return to this function and add original data back. Under the same **Parameters** function, we have selected **Attributes** and changed the Average Interval from the default **0** to **60**. Since data was collected every 15 minutes, the change to a 60 minute interval helps to smooth out the graph and average out any short term “noise” events.

Next, we again select **Setup**, then **Graph**. From the functions available, we first selected Title Page… and typed in a name (Clear Lake Study #2) and below that we typed the parameters that are shown in the graph. Just below **Title Page,** we clicked on **2 Traces per Graph**. This combines adjacent parameters which is sometimes useful in parameter and event evaluation. For example, in the second graph shown in Figure 50 below, you see that DO concentration and pH seem to track rather closely and change in a diurnal rhythm. In actuality, when DO levels drop in a natural body of water, CO_2 often builds up forming carbonic acid which leads to lower pH readings. DO rises again during the day due to photosynthesis, CO_2 then falls and pH increases again. The final plot after making these changes in shown in Figure 50.

Figure 50 Customizing a Graph from SAMPLE.DAT



Finally, we selected **File|Save Data Display** and gave the custom plot the name "4PARAM" to that the presentation can be immediately recalled in the future.

As you become more familiar with EcoWatch for Windows, the plotting, analysis and reporting functions can be accomplished easily and quickly. Practice with all of the functions and, again, do not forget to use Window's Help for more detail, or see Section 4, **EcoWatch for Windows**.

2.9 SONDE MENU

The functions of the sondes are accessible through the sonde menu. The sonde menu structure makes it simple and convenient to select functions. This section provides a description of the menus and their capabilities.

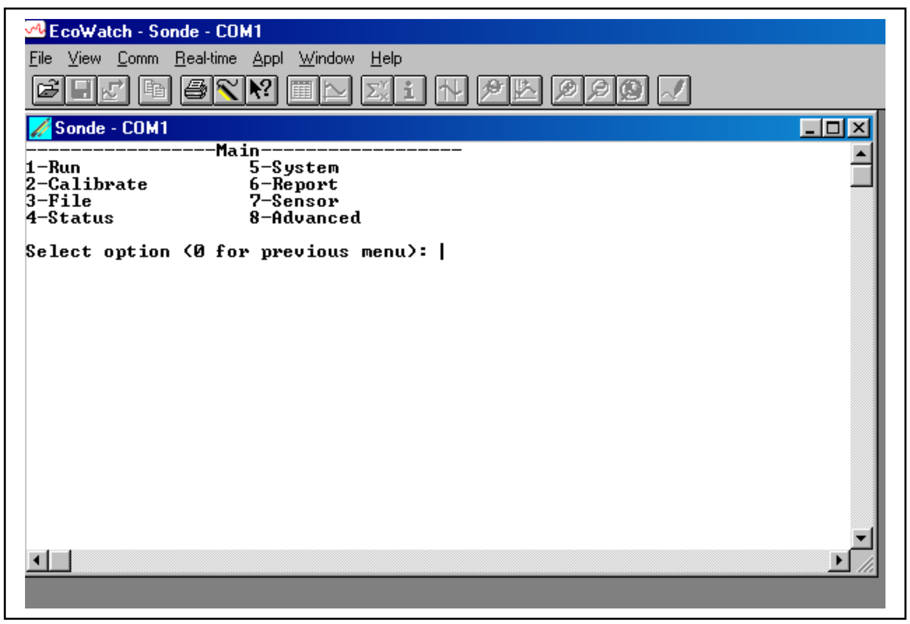
When moving between menus within the sonde software structure, use the **0** or **Esc** to back up to the previous menu. To exit menus and return to the sonde command line (the # sign), press **0 or Esc** until the question "**Exit menu (Y/N)?"** appears. Type **Y** and the command prompt ("#") will be shown. To return to the **Main** sonde menu, type **menu** and press **Enter.**

IMPORTANT MESSAGE!
WHAT IF THERE IS NO RESPONSE TO A KEYSTROKE?

To save power, the sondes will power down automatically if no interaction from the keyboard occurs for approximately 60 seconds. When the software is in this "sleep" mode, the first subsequent keystroke simply "wakes it up" and has no visible effect on the display. The next keystroke after the unit is "awakened" will be input to the software in the intended manner. Thus, if you press a key after the sonde has been inactive for some time and nothing seems to happen, press the key again.

To gain experience with the sonde menus, select the sonde icon in EcoWatch for Windows and press **Enter**. See Figure 40 above for the Sonde Menu Flow Chart.

In the following subsections you will learn about the functions of the various menu items and when to use them. The discussion of the menu and submenu functions is organized in numerical order, beginning with **Section 2.9.1 Run**



2.9.1 RUN

Select **1-Run** from the Main menu to begin taking readings or to set/verify the parameters required for a study. There are two options in the Run menu.

```
---------------Run setup---------------
1-Discrete sample
2-Unattended sample

Select option (0 for previous menu): 1
```

DISCRETE SAMPLING

Discrete sampling is usually used in short term, spot sampling applications when the user is present at the site and the unit is attached to a 650 MDS Display/Logger or laptop PC. It could be used in the vertical profiling of a lake or river where the user lowers the sonde incrementally into the water, and data acquired for a few minutes at each depth. In this section, you will learn how to use the sonde menu structure to open and close files, set the interval between samples, start the sampling operation, and log data to the internal memory of the sonde.

Select **1-Discrete sample** from the Run menu. The Discrete sample menu will be displayed.

```
------------Discrete sample------------
1-Start sampling
2-Sample interval=4
3-File=
4-Site=
5-Open file

Select option (0 for previous menu):
```

Select **1 – Start sampling** option to start discrete sampling. After the initial sampling time interval has passed (4 seconds in the screen above), sequential lines of data will appear on the screen.

```
======================================================================
    Date     Time   Temp SpCond    Sal  DO     Depth    pH   Turbid  Battery
mm/dd/yy hh:mm:ss     C  mS/cm    ppt  mg/L    feet          NTU   volts
------------------------------------------------------------------------------
*** 1-LOG last sample   2-LOG ON/OFF,  3-Clean optics***
05/05/97 10:04:40 21.57  0.009   0.00  7.73  -0.293  7.55        0.3    10.2
05/05/97 10:04:44 21.57  0.009   0.00  8.41  -0.300  7.55        0.3    10.3
*** LOG is ON,  hit 2 to turn it OFF,  3-Clean optics***
05/05/97 10:04:48 21.58  0.009   0.00  8.41  -0.302  7.55        0.3    10.3
05/05/97 10:04:52 21.58  0.009   0.00  8.40  -0.302  7.55        0.3    10.3
05/05/97 10:04:56 21.58  0.009   0.00  8.41  -0.303  7.55        0.3    10.2
05/05/97 10:05:00 21.58  0.009   0.00  8.42  -0.303  7.55        0.3    10.3
*** 1-LOG last sample   2-LOG ON/OFF ,  3-Clean optics***
05/05/97 10:05:04 21.58  0.009   0.00  8.44  -0.304  7.55        0.3    10.3
Sample logged.
05/05/97 10:05:08 21.58  0.009   0.00  8.45  -0.305  7.55        0.3    10.3
```

The following prompt will appear just below the screen header:
1-LOG last sample, 2-LOG ON/OFF, 3-Clean optics

- By entering **1–LOG last sample**, A single line of data can be logged to sonde memory and the following message will be displayed: **Sample logged.**

- By entering **2-LOG ON/OFF**, a set of data can be logged to memory and the following message will be displayed: **LOG is ON, hit 2 to turn it OFF, 3-Clean optics.** Press **2** again to terminate logging.

- By entering **3-Clean optics**, if your unit has an optical probe, the wiper will clean the optical surface**.** The **3-Clean optics** portion of the prompt will only appear if an optical probe was installed and enabled.

Select **Esc** or press **0** and return to the Discrete Sampling menu.

From the Discrete Sampling menu, select **2-Sample Interval** to type a number that represents the number of seconds between samples. The maximum sample interval is 32767 seconds (9+ hours). The factory default sample interval is 4 seconds and works best for most discrete sampling applications. The shortest possible sample interval for obtaining new DO readings is 4 seconds. If a smaller interval is selected, then the DO readings remain constant for the number of samples necessary to fill 4 seconds.

NOTE: If your have used your sonde with a 650 MDS data logger, the Sample Interval automatically be changed to 0.5 seconds.

Sampling Faster Than 0.5 Seconds

For special applications, your sonde is capable of faster sampling. The only limitation is a reduction of the number of sensors selected. To determine the maximum sampling frequency for your sensor setup, divide 36 by the number of enabled sensors in addition to the DO sensor.

Example:
If you enable any three sensors plus DO, divide 36 by 3 to obtain 12 samples/second (12 Hz) or 0.083 seconds between samples as the maximum sampling frequency. Remember that for sample intervals less than 4 seconds, DO readings are updated only every 4 seconds. Thus, at 12 Hz, the display will show 48 identical DO readings before a change occurs. Note also that at a faster sampling rate, consecutive readings are closer together, the threshold for any one sensor is less likely to be exceeded, and the data filter is less likely to disengage. For these applications you may want to adjust your threshold settings accordingly. See Section 2.9.8 for more information on the data filter.

Select **3-File** to enter a filename with a maximum of 8 characters. You will log readings to the filename that you enter.

If you started sampling without entering a filename, the default name NONAME1 will be assigned to your file. Whenever you press **1-LOG last sample** or **2-LOG ON/OFF** from the menu, NONAME1 will be opened during sampling. If this happens, and you want to restart the file with a different name, press **5-Close file** and rename the file.

Select **4-Site** to assign a site name with a maximum of 31 characters This allows you to enter the name of the site where you are sampling.

When you select **5-Open File**, a file is opened and the number 5 changes to **Close File**. When you are finished logging data to the file, press **5-Close File** and designation changes back to **Open File**. When you start logging the **Open File** designation changes automatically to **Close File**.

Now select **1-Start sampling** to start discrete sampling.

After the initial sampling time interval has passed, sequential lines of data will appear on the screen and you can log single or sequential data points and wipe the surface of your optical probe as described above.

UNATTENDED SAMPLING

This option is used for long-term deployment of the battery-powered sonde when the user is not present at the site. Prior to this selection, the sonde is usually attached to a computer in a laboratory and set up to automatically log data to sonde memory at a fairly long time interval (15-60 minutes). The unit is then taken to the field site and left for an extended time period (from 30 up to 150 days depending on the sensors used and the fouling conditions). When the study is complete, or the batteries are expended, the unit is brought back to the laboratory and the data file is uploaded to a computer. Quality assurance checks are performed prior to redeployment.

Select **2-Unattended Sampling** from the Run menu. The Unattended sample menu will be displayed. Use the following example to understand the unattended sampling option.

```
------------Unattended setup-----------
1-Interval=00:15:00
2-Start date=07/17/96
3-Start time=18:00:00
4-Duration days=14
5-File=clrlake3
6-Site=Clear Lake at Spillway
7-Bat volts: 9.1
8-Bat life 21.2 days
9-Free mem 18.9 days
A-1st sample in 8.10 minutes
B-View params to log
C-Start logging
```

Follow the prompts on this screen to prepare your sonde for unattended deployment as described below:

- Verify that the current time and date are correct to ensure that your unattended sampling study begins and ends when you desire. To verify correct the time and date, return to the Main menu and enter **4-Status** or **5-System**. You may enter the correct date and time from either of these submenus.

- Select **1-Interval** and enter the desired time between samples

- Select **2-Start Date** and **3-Start Time** to set the time that data will begin to log to sonde memory. . Use the 24-hour clock format to enter the time. If you do not make any change to these entries, then the study will automatically begin at the next integral time interval once you have pressed **C-Start logging**.

    Example: If the current time is 17:20:00 and your sample interval is 15 minutes, logging will automatically begin at 17:30:00.

It is better to start the study prior to taking the unit to the field so that you can confirm that readings are being saved to memory and carry out initial quality assurance. However, if your study demands that you start the instrument at the site at 6:00 PM, change the Start Time to 18:00:00.

- Select **4-Duration** and set the length of the study in days. The default value is 365 days (which is longer than most deployments). In most cases, you will either want to stop the unattended study manually or allow the batteries to be expended. It is wise to set the duration to a value longer than the anticipated deployment. If you cannot retrieve the sonde at the expected time due to factors beyond your control such as weather or illness, data will continue to be acquired as long as battery power is present.

- Select **5-File** and enter a name of no more than 8 characters that will be used by your external computer to identify the study. Be sure to use ONLY alpha/numeric characters.

- Select **6-Site** and enter a site name of no more than 31 characters. This filename will appear in your sonde file directory, but will not be used to identify the file after transfer to your computer.

- Check **7-Battery** to make certain that the voltage is suitable for the length of the study that you are about to begin. No change can be made to this item via the software. Note that no battery entry will appear for the 600R, 600QS, 600XL, and 6820V2-1 sondes.

- Select **B-View Parameters to log** to confirm that your sensor and report setups are configured correctly as described in Sections 2.9.6 and 2.9.7. An example screen is shown below.

```
-------------Params to log-------------
1-Temp C              6-Orp mV
2-Cond mS/cm          7-NH4+ N mg/L
3-DOsat %             8-NO3- N mg/L
4-DOchrg              9-Turbid NTU
5-pH                  A-Battery volts

Select option (0 for previous menu):
```

In some cases, the **View params to log** screen only identifies the raw parameters that are used in the calculation of the items that you have selected in the Report setup.

> **Example:** You have selected DO mg/L in the Report setup, but it does not appear under **View parameters to log** because it is calculated from DO saturation %,Temperature, and Conductivity. Likewise, although specific conductance is selected in the Report setup, it does not appear under **Parameters to log** because it is calculated from Conductivity and Temperature. In all but a few cases, the proper configuration of **Parameters to log** will be automatically set up as long as the sensor is enabled.

There are several items that must be activated in the Report setup so they will be available from the file after upload. These special parameters are: DO Chg, DOSat %Local, ODOsat %Local, pH mV, $NH4^{+}$ mV, $NO3^{-}$ mV, Cl^{-}mV, PAR1, PAR2, Chl RFU, BGA-PC RFU, and BGA-PE RFU. If you want to log any of these parameters to your data file, be certain that they are active in the Report setup before you begin the unattended study.

After making the above entries, the sonde software will automatically estimate the expected battery life, and the time it will take for the sonde memory to be filled. This information is displayed on the screen for your consideration. If the battery life or the free memory capacity will be exceeded sooner than the duration, you may want to make some changes to the sonde set-up or the batteries themselves. For example, you can free up memory in the sonde by uploading all existing files from the sonde memory to your PC and then deleting them from the sonde (see **3-File** from Main Menu). You may want to change the batteries for longer battery life. You can lengthen the sampling interval to extend both battery life and memory capacity.

The predicted battery life is an estimate only. The temperature of the site and the brand of batteries used can affect battery life. It is recommended to recover the sonde earlier than the predicted battery life, and to use new batteries for each deployment.

Once you press **C-Start logging**, the following screen will appear.

```
-------------Start logging-------------
Are you sure?
1-Yes
2-No

Select option (0 for previous menu):
```

Select **1-Yes** and the screen will change.

```
----------------Logging----------------
1-Interval=00:15:00
2-Next at 07/17/96
3-Next at 18:00:00
4-Stop at 07/31/96
5-Stop at 18:00:00
6-File=clrlake3
7-Site=Clear Lake at Spillway
8-Bat volts: 9.0
9-Bat life 21.2 days
A-Free mem 18.9 days
B-Stop logging
C-Show Live Data

Select option (0 for previous menu):
```

The display now shows the next date and time for logging and the stop date and time for the logging study. Most importantly, note that the bottom command now shows **B-Stop logging**, a confirmation that the logging has indeed been initiated.

If you select **C-Show Live Data** and leave the sonde attached to your PC, the data points will be shown on the screen as they are stored to internal memory.

The Unattended study will terminate when the duration you specified has expired or the batteries are expended. If you want to terminate sooner, simply select **2-Unattended** sample from the Run menu, then **B-Stop logging**. Select **1-Yes** and return to the Unattended setup menu.

```
Stop logging?
1-Yes
2-No

Select option (0 for previous menu):
```

2.9.2 CALIBRATE

All of the sonde sensors (except temperature) require periodic calibration to assure high performance. However, the calibration protocols for Rapid Pulse Polarographic dissolved oxygen are significantly different depending on whether the sonde is being set up for spot sampling or longer term unattended monitoring studies. This difference is user-selectable and is required primarily because the optimal performance of the Rapid Pulse dissolved oxygen sensor cannot be attained unless the control of this sensor varies from short term to long term applications.

For spot sampling it is best to pulse the sensor continuously during the **Run** mode to attain the most accurate results and optimize the response time. However, this continuous pulsing is not ideal for longer term logging studies in which the sonde data is captured to sonde memory or to a data collection platform at much less frequent intervals (e.g. 15 minutes). Continuous pulsing not only shortens the time between required probe maintenance, but consumes more power. With proper selection of the "Auto sleep" option (discussed in detail in **Section 2.9.8, Advanced Menu**), the user can configure the sonde software to either run continuously or "go to sleep" between samples to minimize Rapid Pulse DO probe wear and conserve power. The effect of this choice on the user interface relative to dissolved oxygen calibration is significant as described below:

- If "Auto sleep" is **deactivated**, the sonde runs continuously no matter what sample interval has been selected. Under these conditions, the user retains manual control of the dissolved oxygen calibration routine, viewing the stabilization of the readings in real time and confirming the calibration with keyboard entries.

- If "Auto sleep" is **activated**, the sonde will „warm up" the sensors for the period of time selected for the DO sensor. Under these conditions, the user loses manual control of the Rapid Pulse DO calibration routine. Rapid Pulse DO will <u>automatically</u> calibrate after the selected time for warm up of the DO sensor has expired. In this mode of calibration, you do not observe stabilization of the readings in real time, but instead will observe a countdown of the warm up period followed by a message indicating that the Rapid Pulse DO calibration is complete.

Only the calibration of Rapid Pulse dissolved oxygen is affected by whether "Autosleep" is on or off; the user retains manual control of the calibration of all other parameters regardless of the "Auto sleep" setting. Once a particular warm up time (in seconds) has been utilized in Rapid Pulse DO calibration, the length of that time should not be changed during a study. A new calibration should be performed whenever the value of the warm up time is altered.

Note that the ROX Optical DO sensor is not subject to the above issues relative to the activation of "Autosleep RS232" for the Rapid Pulse DO sensor. The ROX sensor calibrates in the same way as any other sensor such as conductivity, pH, or turbidity where the user manually confirms the calibration after the sensor readings have shown stability.

From the Main sonde menu select **2-Calibrate**. The Calibrate menu will be displayed. Only the enabled parameters will be available for calibration.

```
---------------Calibrate--------------
1-Conductivity      6-ISE3 NH4+
2-Dissolved Oxy     7-ISE4 NO3-
3-Pressure-Abs      8-ISE5 Cl-
4-ISE1 pH           9-Optic T-Turbidity 6136
5-ISE2 ORP          A-Optic C - Chlorophyll

Select option (0 for previous menu):
```

CONDUCTIVITY

Select **1-Conductivity** to calibrate the conductivity probe and a second menu will offer you the options of calibrating in specific conductance, conductivity, or salinity. Calibrating any one option automatically calibrates the other two. After selecting the option of choice (specific conductance is normally recommended), you will be asked to enter the value of the standard used during calibration. Be certain that the units are correct. After pressing **Enter**, you will be able to follow the stabilization of the readings and confirm the calibration when the readings are stable by pressing **Enter** as instructed on the screen. Then, as instructed, press **Enter** again to return to the Calibrate menu.

RAPID PULSE POLAROGRAPHIC DISSOLVED OXYGEN WITH AUTOSLEEP ON

If you intend to do Unattended Sampling, it is recommended that you turn Autosleep RS232 "on" in the Advanced|Setup menu and follow these instructions for DO calibration. If you intend to do Discrete Sampling, it is recommended that you turn Autosleep RS232 "off" and use the calibration instructions in the next section.

Select **2-Dissolved oxygen** to calibrate the oxygen probe. The submenu will offer you the option of calibrating in percent saturation or mg/L. After selecting the option of choice (percent saturation in water-saturated air is normally recommended), you will be prompted for the next step. Calibrating either of the choices will automatically calibrate the other.

For the percent saturation mode, be certain that the sensor has been thermally equilibrated in water-saturated air and that the sensor shows stable readings prior to beginning the calibration routine, particularly after a membrane change. <u>Note, however, that the sensor should be "off" for at least 5 minutes before initiating a calibration procedure with "Autosleep" active. If possible, it is ideal that the sensor be "off" for a time equal to the sample interval in the upcoming study.</u>

Remember, the Calibration Cup is designed to be air-tight and must be loosened if it is used as a calibration chamber. See **Section 2.6, Calibration** for more details. Follow the screen prompt and enter the local barometric pressure in mm Hg, (inches Hg x 25.4), press **Enter**, and the calibration will automatically occur after the warm-up time which has been selected by the user (default is 40 seconds). Then, as instructed, press **Enter** again to return to the Calibrate menu. Note that at calibration, the DOsat % (percent air saturation) value will reflect the barometer value that was entered. For example, if a barometric pressure of 720 mm is entered, the DOsat % value will change to 94.7 % (720/760 x 100).

Note that the parameter "DOsat %Local" is also available for users who prefer to set their percent air saturation value to 100%, no matter what barometer value is entered. The method of activating this parameter, its use, and its limitations are described in **Appendix J** of this manual. <u>The key factor to remember, however, is that no matter which convention (DOsat % or DOsat %Local) is selected, the mg/L value will not be affected.</u>

For the mg/L mode, calibration is carried out in a water sample which has a known concentration of dissolved oxygen, usually determined by Winkler titration. For this calibration procedure, the sensor should be immersed in the water. After thermal equilibration, enter the known mg/L value, press **Enter**, and the calibration procedure will be carried out automatically as for the percent saturation mode above.

RAPID PULSE DISSOLVED OXYGEN WITH AUTOSLEEP OFF

If you intend to do Discrete Sampling, it is recommended that you turn Autosleep "off" in the Advanced|Setup menu and follow these instructions for DO calibration. If you intend to do Unattended Sampling, it is recommended that you turn Autosleep "on" and using the calibration instructions in the preceding section.

Select the **Dissolved Oxygen** option from the **Calibrate** menu to calibrate the oxygen probe. The submenu will offer you the option of calibrating in percent saturation or mg/L. After selecting the option of choice (percent saturation in water-saturated air is normally recommended), you will be prompted for the next step. Calibrating either of the choices will automatically calibrate the other.

For the percent saturation mode, be certain that the sensor has been thermally equilibrated in water-saturated air and that the sensor has stabilized prior to beginning the calibration routine, particularly after a membrane change. Relieve pressure in the cup if necessary. Remember, the Calibration Cup is designed to be air-tight and must be loosened if used as a calibration chamber. Then follow the screen prompt and enter the local barometric pressure in mm Hg, (inches Hg x 25.4), press **Enter**, and monitor the stabilization of the DO readings. After no changes occur for approximately 30 seconds, press **Enter** to confirm the calibration. Then, as instructed, press Enter again to return to the **Calibrate** menu. Note that at calibration, the DOsat % (percent air saturation) value will reflect the barometer value that was entered. For example, if a barometric pressure of 720 mm is entered, the DOsat % value will change to 94.7 % (720/760 x 100).

Note that the parameter "DOsat %Local" is also available for users who prefer to set their percent air saturation value to 100%, no matter what barometer value is entered. The method of activating this parameter, its use, and its limitations are described in **Appendix J** of this manual. <u>The key factor to remember, however, is that no matter which convention (DOsat % or DOsat %Local) is selected, the mg/L value will not be affected.</u>

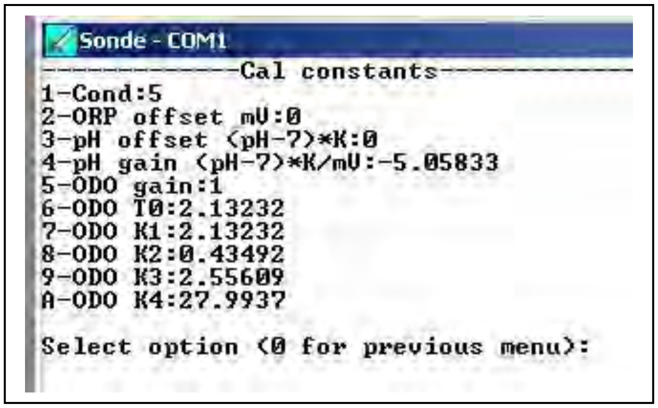
For the mg/L mode, calibration is carried out in a water sample which has a known concentration of dissolved oxygen, usually determined by a Winkler titration. For this calibration procedure, the sensor should be immersed in the water. After thermal equilibration, enter the known mg/L value, press **Enter**, and the calibration procedure will begin with similar viewing of stabilization and confirmation of calibration as for the percent saturation mode above.

NOTE: If you have resurfaced your DO sensor, we recommend running the probe continuously for 15-30 minutes or until good stability is realized. After only a membrane change (no resurfacing), run the probe continuously for 3-4 minutes or until good stability is realized.

ROX OPTICAL DISSOLVED OXYGEN

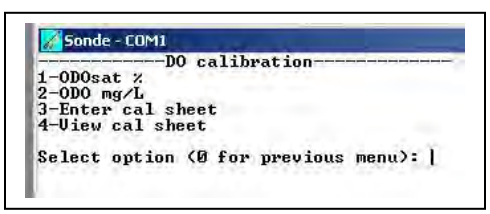
Understanding the Factory Calibration of the ROX Optical DO Sensor

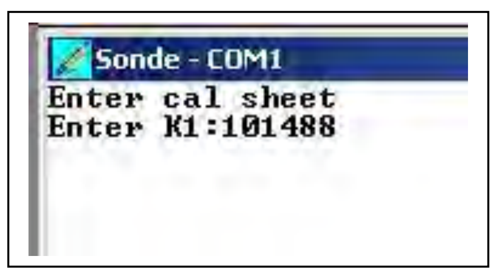
Unlike all other sensors for YSI 6-series sondes, the response of the ROX Optical DO sensor is not linear relative to the species being measured. This non-linearity requires that the sensor be factory-calibrated at a number of oxygen values and the data fit to a third-order regression. The three constants and the sensor value at zero dissolved oxygen which define this regression analysis are automatically stored in the sensor at the time of factory-calibration. It is important to note that these constants are a function of the sensor membrane installed on the 6150 probe and NOT a function of the probe, i.e., the constants reflect the characteristics of the sensor membrane and NOT the probe. When a 6150 probe is purchased from YSI, it already has a sensor membrane installed and the constants of that membrane are transferred automatically to the sonde PCB when the sensor is run for the first time. After transfer, the constants can be viewed by accessing the **Advanced|Cal Constants** menu as shown below – the regression constants are ODO K2-ODO K4 and the value at zero oxygen is K1 as shown below.

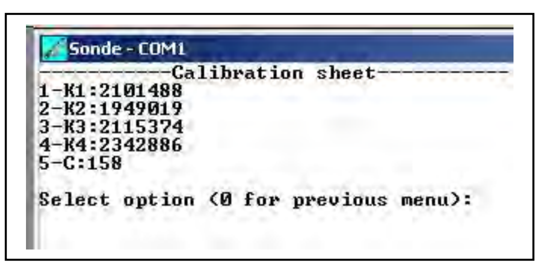


It should also be noted that the ROX sensor is characterized by two additional parameters – ODO Gain and Tzero. The ODO gain reflects the small change in the calibration which is carried out be the user in a 1-point calibration as described below. The Tzero value will always be the same as K1 until the user elects to perform a 2-point calibration as described below at which time it will change slightly to reflect the adjustment of the zero oxygen value.

You will also note that a different set of constants for your specific sensor membrane are supplied on the instruction sheet which came with your 6150 probe. These five constants (K1-K4 and C) have a different appearance than those shown in **Advanced|Cal Constants** because they are in coded form to allow error-free reentry by the user in the unlikely event that the regression constants in the probe are lost. The C constant is a check sum value associated with the values of K1-K4 and will prevent acceptance of the constants if typographical errors are made in their entry by the user. The coded constants must be entered in the **Calibrate|Optic X – Dissolved Oxy|Enter Cal Sheet** as shown below. The constants can also be viewed at any time by selecting **Calibrate|Optic X – Dissolved Oxy|View Cal Sheet.**







YSI recommends that your replace your sensor membrane after 1 year of use by purchasing the 6155 Optical DO Membrane Replacement Kit. This kit will be supplied with a new set of coded constants which characterize the new membrane and they MUST be entered via the **Calibrate|Optic X – Dissolved Oxy|Enter Cal Sheet** selection as show above. Once the new constants have been entered in coded form they will be transferred to the probe and will be visible in uncoded form in Advanced|Cal Constants.

See **Section 5.9, Principles of Operation** and **Appendix M, ROX Optical DO Sensor** for more information.

User Calibration of the ROX Optical DO Sensor

NOTE CAREFULLY: As opposed to the 6562 Rapid Pulse Polarographic DO sensor described above, there is no difference between the calibration routine for sensors which will be used for sampling or monitoring applications. Usually the Autosleep RS-232 feature in the **Advanced|Setup** menu will be activated for ROX calibrations, but there is no problem if it is not active.

Select the **Optic X-Dissolved Oxy** option from the **Calibrate** menu to calibrate the oxygen probe. The submenu will offer you the option of calibrating in either percent air-saturation (ODOsat %) or oxygen concentration (ODO mg/L) units. Calibrating either of the choices will automatically calibrate the other. After selecting the option of choice (ODOsat % in water-saturated air or air-saturated water is normally recommended), you will be prompted for the next step where you must elect to do either a 1-point or a 2-point calibration. Except under unusual circumstances as described below, you should select the 1-point option for the ROX Optical DO calibration.

Calibration Using Percent Air Saturation – 1-Point

NOTE: YSI recommends that you use this method for calibration of your 6150 Dissolved Oxygen Sensor to obtain the maximum accuracy under normal operating conditions.

Place the sensor either (a) into a calibration cup containing about 1/8 inch of water which is vented by loosening the threads or (b) into a container of water which is being continuously sparged with an aquarium pump and air stone. Wait approximately 10 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate.

Select **ODOsat %** and then **1-Point** to access the DO calibration procedure. Calibration of your Optical dissolved oxygen sensor in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.

Enter the current barometric pressure in **mm of Hg.** (Inches of Hg x 25.4 = mm Hg).

Note: Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for oxygen calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is:

True BP = [Corrected BP] – [2.5 * (Local Altitude in feet above sea level/100)]

Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under ODOsat %. When they show 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 return to the **Calibrate** menu.

The minor advantages and disadvantages of calibration in air-saturated water versus water-saturated air are outlined in **Appendix M, ROX Optical DO Sensor**

Calibration Using mg/L – 1-Point

Place the sensor in a container which contains oxygen of a known concentration of dissolved oxygen in mg/L AND THAT IS WITHIN +/- 10% of AIR SATURATION as determined by one of the following methods:

- Winkler titration
- Aerating the solution and assuming that it is saturated, or
- Measurement with another instrument.

CAUTION: Carrying out DO mg/L calibrations at values outside the range of +/- 10 % of air saturation is likely to compromise the quoted accuracy specification of the 6150 Optical DO Sensor.

Wait approximately 10 minutes before proceeding to allow the equilibration of the temperature and oxygen sensors.

Select **ODO mg/L** and then **1-Point** to access the mg/L calibration procedure. Calibration of your optical dissolved oxygen sensor using the DO mg/L procedure also results in calibration of the ODOsat % mode and vice versa.

Enter the known mg/L concentration and press **Enter**. The current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under ODO mg/L and, when they show 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 return to the **Calibrate** menu.

2-Point Calibrations

By selecting either **ODOsat %** and then **2-Point** or **ODO mg/L** and then **2-Point** from the appropriate menus, you will be able to calibrate your sonde at zero oxygen and in water-saturated air or air-saturated water (if you select **ODO%)** or at zero oxygen and a known concentration of oxygen within +/-10% of air-saturation (if you select **ODO mg/L).** These two-point calibrations should be done ONLY if you suspect that your 6150 Optical DO sensor is less accurate than you require at low oxygen values. The key to performing a 2-point calibration is to make certain that your zero oxygen medium (probably either nitrogen gas or an aqueous solution of sodium sulfite at a concentration of approximately 2 g/L) is truly oxygen-free as described in the tips below:

- If you use nitrogen gas for the zero point calibration, you should make certain that the vessel you use has a SMALL exit port to prevent back diffusion of air and that you have completely purged the vessel before confirming the calibration.

- If you use sodium sulfite solution for the zero point calibration, you should make up the solution at least 2 hours prior to use and keep it sealed in a bottle which does not allow diffusion of oxygen through the sides of the container. You should also transfer the sodium sulfite solution rapidly from its container to the sonde calibration cup, fill the cup as full as possible with solution to minimize head space, and seal the calibration cup to the sonde to prevent diffusion of air into the vessel.

To implement the 2-point calibrations, place the 6150 and the temperature sensor in a zero oxygen medium. Then select either **ODO%** and then **2-Point** or **ODO mg/L** and then **2-Point** from the **Calibrate|Optic T Dissolved Oxy** menu. For either calibration routine, you MUST ENTER ZERO at the first prompt asking for ODO in mg/L. Then view the readings in real time and when they are stable, press **Enter** to confirm the zero point calibration.

CAUTION: Be certain that you wait at least 10-12 minutes and until the readings are stable for at least 2 minutes before confirming the zero point calibration entry.

NOTE CAREFULLY: If you used sodium sulfite solution as your zero calibration medium, you MUST carefully remove all traces of the reagent from the probes prior to proceeding to the second point. YSI recommends that the second calibration point be in air-saturated water if you use sodium sulfite solution as your zero oxygen medium.

After confirming the zero point calibration, place the sensors in the medium containing a known oxygen pressure or concentration and wait at least 10 minutes for temperature equilibration. Then enter either the barometer reading in mm Hg (for **ODO% 2-Point** calibrations) or the actual concentration of oxygen which was probably determined from a Winkler titration (for **ODO mg/L 2-Point** calibrations). Press **Enter** and observe the readings in real time until they are stable. Then press **Enter** again to confirm the calibration. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the **Calibrate** menu.

CAUTION: Carrying out DO mg/L calibrations at values outside the range of +/- 10 % of air saturation for the second calibration point in the 2-Point routine is likely to compromise the quoted accuracy specification of the 6150 Optical DO Sensor.

NOTE CAREFULLY: It will normally not be necessary to perform 2-Point calibrations for the 6150 Optical DO Sensor and the procedure is not recommended unless (a) you are certain that the sensor does not meet your accuracy requirements at low DO levels and (b) you are operating under conditions where you are certain to be able to generate a medium which is truly oxygen free.

Note that the parameter "ODOsat %Local" is also available for users who prefer to set their percent air saturation value to 100%, no matter what barometer value is entered. The method of activating this parameter, its use, and its limitations are described in **Appendix J** of this manual. The key factor to remember, however, is that no matter which convention (ODOsat % or ODOsat %Local) is selected, the mg/L value will not be affected.

PRESSURE – ABS AND GAGE

Select **Pressure – Abs (non-vented) or Gage (vented)** to zero the depth sensor. The depth sensor is factory calibrated, but it is always necessary to zero the absolute sensor relative to the local barometric pressure. A minor correction is also sometimes necessary to set the Gage (vented) sensor output to exactly 0.000 feet or meters. The zeroing procedure should be carried out with the sonde in air for this initial calibration. Alternatively, you may set zero or an offset while the sonde is submersed for "relative depth" applications. After the depth option is selected, enter 0.00 (or other appropriate value in feet or meters depending on your Report setup) at the prompt, press **Enter** and monitor the stabilization of the depth readings. After no changes occur for approximately 30 seconds, press **Enter** to confirm the calibration. As instructed, press **Enter** again to return to the Calibrate menu.

Zeroing the depth sensor by the above protocol (entering 0.00 at the screen prompt) will result in a measurement of the distance between the water surface and the ports of the depth module. In order for the observed depth readings to reflect the distance between the water surface and the actual probe array, measure the length between the upper hole and the bottom of the sonde guard. Then, if you are concerned about this small difference, enter the measured difference (in feet or meters depending on your Report setup) at the screen prompt instead of 0.00.

For best performance of depth measurements, users should ensure that the sonde‟s orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

pH

When selecting **ISE1 pH**, you will be given the choice of 1-point, 2-point, or 3-point calibrations.

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. Immerse the sonde in a buffer of known pH value and press **Enter.** You will be prompted to type in the pH value of the solution.

NOTE: The actual pH value of all buffers is somewhat variable with temperature and that the correct value from the bottle label for your calibration temperature should be entered for maximum accuracy. For example, the pH of YSI "pH 7 Buffer" is 7.00 at 25 C, but 7.02 at 20 C.

After inputting the proper pH value for your calibration temperature, press **Enter** again, and the screen will display real-time readings that will allow you to determine when the pH and temperature readings have stabilized. Pressing **Enter** will confirm the calibration. Then, as instructed, press **Enter** again to return to the Calibrate menu. This calibration procedure adjusts only the pH offset and leaves the previously determined slope unaltered.

Select the **2-point** option to calibrate the pH probe using only two calibration standards. In this procedure, the pH sensor is calibrated using a pH 7 buffer and a pH 10 or pH 4 buffer depending on your environmental water. A two point calibration procedure (as opposed to a 3-point procedure) can save time if the pH of 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 appropriate. 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.

To begin the calibration, immerse the sonde in one of the buffers and enter the actual pH value depending on your calibration temperature. Press **Enter**, and the screen will display real-time readings that will allow you to determine when the pH sensor has stabilized. Pressing **Enter** will confirm the calibration. Following the instructions on the screen, place the sonde in the second pH buffer, input the pH value, press **Enter**, and view the stabilization of the values on the screen in real time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press **Enter** again to return to the Calibrate menu.

Select the **3-point** option to calibrate the pH probe 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 to complete the 3-point procedure.

ORP

Select **ISE2 ORP** to calibrate the ORP sensor. Immerse the sonde in a solution with a known oxidation reduction potential value (we recommend Zobell solution) and press **Enter.** You will be prompted to enter the ORP value of the solution. Press **Enter**, and monitor the stabilization of the ORP and temperature readings. After no changes occur for approximately 30 seconds, press **Enter** to confirm the calibration. Then, as instructed, press **Enter** again to return to the Calibrate menu.

AMMONIUM

When selecting **ISE3-NH4+,** you will be given the choice of 1-point, 2-point, or 3-point calibrations for your ammonium (NH_4^+) sensor.

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 doing a one point calibration. Immerse the sonde in any solution of known ammonium concentration and press **Enter.** You will be prompted to type in the NH_4^+ value (in mg/L of NH_4-N) of the solution you are using. Press **Enter** again, and the screen will display real-time readings that will allow you to determine when the $NH4^+$ readings have stabilized. Pressing **Enter** will confirm the calibration.

Select the **2-point** option to calibrate the NH_4^+ probe using only two calibration standards that are both at approximately the temperature of your environmental sample. In this procedure, the NH_4^+ sensor is usually calibrated using solutions that contain 1 and 100 mg/L of NH_4-N . Be certain that the calibration solution and sensor are thermally equilibrated prior to entering NH_4^+ values.

To begin the calibration immerse the sonde in the 1 mg/L standard, press **Enter**, input the NH_4-N value, and again press **Enter.** The screen will display real-time readings that will allow you to determine when the sensor has stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second NH_4^+ standard, press **Enter**, input the correct concentration value, again press **Enter**, and view the stabilization of the values on the screen in real time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the Calibrate menu.

Select the **3-point** option to calibrate the NH_4^+ probe using three calibration solutions, two at ambient temperature and one at a temperature significantly different from ambient. The 3-point calibration method should be used to assure maximum accuracy when the temperature 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 place the sonde in the additional solution to complete the 3-point procedure. Be certain that the calibration solution and sensor are thermally equilibrated prior to proceeding with the calibration. The recommended order of calibration standards is (1) 100 mg/L standard at ambient temperature, (2) 1 mg/L standard at ambient temperature, and (3) 1 mg/L standard at a different temperature (usually lower) than ambient. For best results, insure a temperature difference of at least 10 C° between the two 1 mg/L standards.

NOTE: YSI strongly recommends the use of the 3-point protocol to ensure the best possible performance from all ISE sensors (ammonium, nitrate, and chloride)

NITRATE

When selecting **ISE4 NO3**, you will be given the choice of 1-point, 2-point, or 3-point calibrations for your nitrate (NO_3^-) sensor. The procedure is identical to that for the ammonium sensor, except that the calibrant values are in mg/L of NO_3-N instead of NH_4-N.

NOTE: YSI strongly recommends the use of the 3-point protocol to ensure the best possible performance from all ISE sensors (ammonium, nitrate, and chloride)

CHLORIDE

When selecting **ISE5-CL-**, you will be given the choice of 1-point, 2-point, or 3-point calibrations for your chloride (Cl^-) sensor. The procedure is identical to that for the ammonium sensor, except that the calibrant values are in mg/L of Cl instead of NH_4-N. IMPORTANT: We recommend that the user employ standards for chloride that are 10 times greater than for ammonium and nitrate. Thus, the low calibration value should be 10 mg/L and the high calibration value should be 1000 mg/L Cl-. The difference is due to the fact that the effect of contamination of standards from inadvertent leakage of chloride ion from either the DO probe or the reference junction of the pH probe will be less significant at higher concentrations.

NOTE: YSI strongly recommends the use of the 3-point protocol to ensure the best possible performance from all ISE sensors (ammonium, nitrate, and chloride)

OPTIC TURBIDITY

NOTE: Before calibrating your 6026 or 6136 turbidity sensor, pay particular attention to the following cautions:

- To properly calibrate YSI turbidity sensors, you MUST use standards that have been prepared according to details in *Standard Methods for the Treatment of Water and Wastewater (Section 2130 B)*. Acceptable standards include (a) formazin prepared according to *Standard Methods*; (b) dilutions of 4000 NTU formazin concentrate purchased from Hach; (c) Hach StablCal™ standards in various NTU denominations; and (d) AMCO-AEPA standards prepared specifically for the 6026 and 6136 by either YSI or approved vendors who are listed on the YSI website (www.ysi.com). STANDARDS FROM OTHER VENDORS ARE **NOT** APPROVED FOR THE YSI TURBIDITY SYSTEM AND THEIR USE WILL LIKELY RESULT IN BOTH CALIBRATION ERRORS AND INCORRECT FIELD READINGS.

- For AMCO-AEPA standards, the value entered by the user during the calibration protocol is DIFFERENT depending on which sensor (6026 or 6136) is being calibrated. This reflects the empirically determined fact that 6026 and 6136 sensors that have been calibrated to the same value in the primary standard formazin, will have different responses in suspensions of the AEPA-AMCO beads. This effect is likely due to the larger optical cell volume of the 6136. Thus, for example, the label of the YSI 6073 turbidity standard bottle indicates that the value of the standard is **100 NTU when used for calibration of the 6026 sensor, but 126 NTU when used to calibrate the 6136.** Note that the phenomenon of a sensor-specific formazin/AEPA-AMCO ratio is well known for sensors other than the 6026 and 6136.

- The details below are relevant to the calibration of both turbidity sensors offered by YSI – 6026 and 6136. However, to calibrate a 6136 sensor, you should have Version 2.16 or later installed in your sonde.

- If you are calibrating a 6136 turbidity sensor you MUST use either a black bottomed calibration cup or laboratory glassware with the probe guard installed for the calibration. See Section 2.6.1 above for details. Failure to carry out the calibration properly can result in inaccurate readings, particularly water of very low turbidity.

- Before proceeding with the calibration, be certain that the probe compartment of the sonde has been cleaned and is free of debris. Solid particles from this source, particularly those carried over from past deployments, will contaminate the standards during your calibration protocol and cause either calibration errors and/or inaccurate field data.

When selecting **Optic X -6026-Turbidity (or 6136-Turbidity),** there will be a choice of 1-point, 2-point, or 3-point calibrations for your turbidity sensor.

The **1-point** option is normally used to zero the turbidity probe in 0 NTU standard. Place the sonde in clear water (deionized or distilled) with no suspended solids, and input 0 NTU at the screen prompt. Press **Enter** and the screen will display real-time readings that will allow you to determine when the turbidity readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the Calibrate menu.

Select the **2-point** option to calibrate the turbidity probe using only two calibration standards. In this case, one of the standards must be clear water (0 NTU) and the other should be in the range of known turbidity for the water to be monitored. For example, if the water to be evaluated is known to be low in turbidity, an appropriate choice of standards might be 0 and 10 NTU (6026) or 0 and 12.7 NTU (6136). However, for general purpose measurements an appropriate choice of standards is usually 0 and 100 NTU (6026) or 0 and 126 NTU (6136).

To begin the calibration, immerse the sonde in the 0 NTU standard, as instructed, and press **Enter.** It is mandatory that the 0 NTU standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second turbidity standard, input the correct turbidity value in NTU, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the Calibrate menu.

Select the **3-point** option for maximum accuracy over the entire range of 0 to 1000 NTU. As for the 2-point procedure, one of the standards must be 0 NTU. Because of the linearity characteristics of the sensors, we recommend that the other two standards have turbidity values of 100 and 1000 NTU. However, the user can select any values that are deemed appropriate. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sonde in the additional solution to complete the 3-point procedure.

For all turbidity calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration.

For further information related to setting up, calibrating and running turbidity measurements, refer to **Appendix E, Turbidity Measurements**.

OPTIC CHLOROPHYLL

When selecting **Optic X - Chlorophyll,** there will be a choice of zeroing the relative fluorescence unit parameter (**Chl RFU Zero**) or calibrating with actual chlorophyll standards (**µg/L 1-point, 2-point, or 3-point**).

If you have selected **Chl RFU** as a parameter in the **Report** menu, the sonde will report only relative values of fluorescence in the sample being measured. These values could then be converted into actual chlorophyll concentrations in µg/L by using a post-calibration procedure, after the chlorophyll content of grab-samples taken during a sampling or monitoring study has been analyzed in a laboratory. This determination can involve conducting the extractive analysis procedure described for chlorophyll in *Methods for the Examination of Water and Wastewater* or by carrying out an *in situ* measurement of chlorophyll using a commercial benchtop fluorometer.

The **Chl RFU Zero** option is used to zero the fluorescence probe in a medium that is chlorophyll-free. Place the sonde in clear water, and input 0 at the screen prompt. Press **Enter** and the screen will display real-time readings that will allow you to determine when the fluorescence readings have stabilized. Press

Enter after the readings have stabilized to confirm the calibration and zero the sensor. Then, press any key to return to the **Calibrate** menu.

If you select **Chl µg/L** in the initial calibration routine, there will be a choice of 1-point, 2-point, or 3-point options. The 1-point selection is normally used to zero the fluorescence probe in a medium that is chlorophyll-free. If you use this method, you will either choose to utilize the default sensitivity for chlorophyll in the sonde software or to update a previous multipoint calibration. Usually you will place the sonde in clear water, and input 0 µg/L at the screen prompt. After pressing **Enter** the screen will display real-time readings allowing you to determine when the chlorophyll readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the Calibrate menu.

Note: For the 2-point and 3-point calibrations described below, standards of known fluorescence are required. Two general types of standards can be used: (a) phytoplankton suspensions of known chlorophyll content, and (b) dye solutions whose fluorescence can be correlated to that of chlorophyll. The user is responsible for determining the chlorophyll content of phytoplankton suspensions, either by employing the extractive analysis procedure described in *Standard Methods for the Examination of Water and Wastewater,* or by analyzing the suspension *in situ* using a laboratory fluorometer. See **Section 5.14**, **Principles of Operation** and **Appendix I, Chlorophyll Measurements** of this manual for more information about chlorophyll standards.

Select the **2-point** option to calibrate the chlorophyll probe using only two calibration standards. In this case, one of the standards must be clear water (0 µg/L) and the other should be in the range of a known chlorophyll content of the water to be monitored. For example, if the water to be evaluated is known to be low in chlorophyll, an appropriate choice of standards might be 0 and 10 µg/L. However, for general-purpose measurements an appropriate choice of standards is usually approximately 100 µg/L.

To begin the calibration, immerse the sonde in the 0 µg/L standard, as instructed, and press **Enter.** It is mandatory that the 0 µg/L standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second chlorophyll standard, input the correct value in µg/L, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the **Calibrate** menu.

Select the **3-point** option for maximum accuracy over the entire range of 0 to 400 µg/L. As with the 2-point procedure, one of the standards must be 0 µg/L. The user can select any values for the second and third standards that are deemed appropriate. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sonde in the additional solution to complete the 3-point procedure.

For all chlorophyll calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration

CAUTION: To be assured of the accuracy for field measurements made with your chlorophyll sensor, you must either initially calibrate the sensor using a phytoplankton suspension of known chlorophyll content or post calibrate your sensor in a spreadsheet by comparing the fluorescence values obtained in field studies with those obtained by laboratory analysis for chlorophyll on grab samples collected during the field study. The use of chemical dye standards for "calibration" of the sensor may not result in accurate correlation between fluorescence and actual chlorophyll readings and is designed primarily to evaluate the sensor for drift. See **Section 5.14, Principles of Operation** and **Appendix I. Chlorophyll Measurements** for more information on the proper calibration of your chlorophyll sensor.

OPTIC BGA-PC

To calibrate your 6131 Blue-Green Algae-Phycocyanin (BGA-PC) sensor, select **BGA-PC cells/mL** in the initial calibration routine. There will be a choice of 1-point or 2-point options. The 1-point selection is normally used to zero the fluorescence probe in a medium that is BGA-free. If you use this method, you will either choose to utilize the default sensitivity for BGA-PC in the sonde software or to update a previous 2-point calibration. Usually you will place the sonde in clear water, and input 0 µg/L at the screen prompt. After pressing **Enter** the screen will display real-time readings allowing you to determine when the BGA-PC readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the **Calibrate** menu.

Note: For the 2-point calibration described below, a standard of known fluorescence is required. Two general types of standards can be used: (a) phytoplankton suspensions of known BGA-PC content, and (b) dye solutions whose fluorescence can be correlated to that of BGA-PC. The user is responsible for determining the BGA-PC content of algal suspensions by using standard cell counting techniques. See **Section 5.16**, **Principles of Operation** of this manual for more information about BGA-PC standards.

Select the **2-point** option to calibrate the BGA-PC probe using two calibration standards. In this case, one of the standards must be clear water (0 µg/L) and the other should be in the range of the suspected BGA-PC content at the environmental site.

To begin the calibration, immerse the sonde in the 0 cells/mL standard, as instructed, and press **Enter.** It is mandatory that the 0 cells/mL standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second BGA-PC standard, input the correct value in cells/mL, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the **Calibrate** menu.

For all BGA-PC calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration

CAUTION: To be assured of the accuracy for field measurements made with your BGA-PC sensor, you must either initially calibrate the sensor using an algal suspension of known BGA-PC content or post calibrate your sensor in a spreadsheet by comparing the fluorescence values obtained in field studies with those obtained by laboratory analysis for chlorophyll on grab samples collected during the field study. The use of chemical dye standards for “calibration” of the sensor may not result in accurate correlation between fluorescence and actual BGA-PC readings and is designed primarily to evaluate the sensor for drift. See **Section 5.16. Principles of Operation** for more information on the proper calibration of your BGA-PC sensor.

OPTIC BGA-PE

To calibrate your 6132 Blue-Green Algae-Phycoerythrin (BGA-PE) sensor, select **BGA-PE cells/mL** in the initial calibration routine. There will be a choice of 1-point or 2-point options. The 1-point selection is normally used to zero the fluorescence probe in a medium that is BGA-free. If you use this method, you will either choose to utilize the default sensitivity for BGA-PE in the sonde software or to update a previous 2-point calibration. Usually you will place the sonde in clear water, and input 0 µg/L at the screen prompt. After pressing **Enter** the screen will display real-time readings allowing you to determine when the BGA-PE readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the **Calibrate** menu.

Note: For the 2-point calibration described below, a standard of known fluorescence is required. Two general types of standards can be used: (a) phytoplankton suspensions of known BGA-PE content, and (b) dye solutions whose fluorescence can be correlated to that of BGA-PE. The user is responsible for determining the BGA-PC content of algal suspensions by using standard cell counting techniques. See **Section 5.17**, **Principles of Operation** of this manual for more information about BGA-PC standards.

Select the **2-point** option to calibrate the BGA-PE probe using two calibration standards. In this case, one of the standards must be clear water (0 cells/mL) and the other should be in the range of the suspected BGA-PC content at the environmental site.

To begin the calibration, immerse the sonde in the 0 µg/L standard, as instructed, and press **Enter.** It is mandatory that the 0 cells/mL standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second BGA-PC standard, input the correct value in cells/mL, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the **Calibrate** menu.

For all BGA-PE calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration

CAUTION: To be assured of the accuracy for field measurements made with your BGA-PE sensor, you must either initially calibrate the sensor using an algal suspension of known BGA-PE content or post calibrate your sensor in a spreadsheet by comparing the fluorescence values obtained in field studies with those obtained by laboratory analysis for chlorophyll on grab samples collected during the field study. The use of chemical dye standards for "calibration" of the sensor may not result in accurate correlation between fluorescence and actual BGA-PE readings and is designed primarily to evaluate the sensor for drift. See **Section 5.17. Principles of Operation** for more information on the proper calibration of your chlorophyll sensor.

OPTIC RHODAMINE WT

When selecting **Rhodamine,** there will be a choice of 1-point, 2-point, or 3-point calibrations for your rhodamine WT sensor.

The **1-point** option is normally used to zero the rhodamine probe in 0 ug/L standard. Place the sonde in clear water with no suspended solids, and input 0 ug/L at the screen prompt. Press **Enter** and the screen will display real-time readings that will allow you to determine when the rhodamine readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the Calibrate menu.

Select the **2-point** option to calibrate the rhodamine probe using only two calibration standards. In this case, one of the standards must be clear water (0 ug/L) and the other should be in the range of the predicted rhodamine concentration projected for the study. For general purpose measurements an appropriate choice of standards is usually 0 and 100 ug/L.

To begin the calibration, immerse the sonde in the 0 ug/L standard, as instructed, and press **Enter.** It is mandatory that the 0ug/L standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second rhodamine standard, input the correct rhodamine value in ug/L, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the Calibrate menu.

Select the **3-point** option for maximum accuracy over the entire range of 0 to 200 ug/L. As for the 2-point procedure, one of the standards must be 0 NTU. The procedure for this calibration is the same as for a 2-

point calibration, but the software will prompt you to place the sonde in the additional solution to complete the 3-point procedure.

For all rhodamine calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration.

REESTABILISHING DEFAULT CALIBRATION – "UNCAL" COMMAND

If, for any reason, you want to return to the factory default settings (slope and offset) for any parameter, follow the instructions below:

- Activate any calibration screen (1-point, 2-point, or 3-point) where a numerical entry is requested. In the example below, a 2-point turbidity calibration was selected.
- Instead of entering a numeric value, type the word "uncal" and press **Enter**.
- An "uncal" entry at any calibration prompt will reset both slope and offset for this parameter to the factory default settings.

```
-----Turbidity calibration--
1-1 point
2-2 point
3-3 point

Select option (0 for previous
menu): 2

Enter 1st Turbid NTU:uncal
```

NOTE: When using the 650 MDS as the sonde interface device, the "uncal" operation is performed by holding the **Enter** key down and then pressing the **Esc** key. See **Section 3** of this manual for more details.

CALIBRATION RECORD – THE GLP FILE

When any sensor is calibrated, 6-series sondes will automatically create a file in sonde memory that provides details of the calibration coefficients before and after the calibration. The file will have a .glp extension and will have the Circuit Board Serial # as the default filename. The file can be viewed by following the path File|Directory|View from the Main sonde menu.

```
-------------File details--------------
1-View file
2-File:00003001.glp
3-Samples:     39
4-Bytes:    790
```

```
------------------File-----------------
1-Directory      4-View file
2-Upload         5-Quick view file
3-Quick Upload   6-Delete all files


Select option (0 for previous menu): 1
```

```
Filename    Samples
1-BRIDGE1.dat      19
2-BRIDGE2.dat      27
3-UPLAKE.dat       33
4-CLRLAKE2.dat    167
5-DWNLAKE2.dat     31
6 - 00003001.glp   39
```

Pressing 1-View file will show the calibration record for the sonde. An example is shown below:

```
m/d/y hh:mm:ss      S/N                    Type    Value
08/23/2001 17:07:50 00003001    Conductivity gain 1.000000
08/23/2001 17:07:50 00003001              DO gain 1.000000
08/23/2001 17:07:50 00003001        DO local gain 1.000000
08/23/2001 17:07:50 00003001  pH gain (pH-7)*K/mV -5.05833
08/23/2001 17:07:50 00003001   pH offset (pH-7)*K 0.000000
08/23/2001 17:07:50 00003001        ORP offset mV 0.000000
08/23/2001 17:07:50 00003001         TDS constant 0.650000
08/23/2001 17:07:50 00003001          Turb Offset 0.000000
08/23/2001 17:07:50 00003001              Turb A1 500.0000
08/23/2001 17:07:50 00003001              Turb M1 500.0000
08/23/2001 17:07:50 00003001              Turb A2 1000.000
08/23/2001 17:07:50 00003001              Turb M2 1000.000
08/23/2001 17:07:50 00003001           Chl Offset 0.000000
08/23/2001 17:07:50 00003001               Chl A1 100.0000
08/23/2001 17:07:50 00003001               Chl M1 100.0000
08/23/2001 17:07:50 00003001               Chl A2 200.0000
08/23/2001 17:07:50 00003001               Chl M2 200.0000
08/23/2001 17:07:50 00003001         Fluor Offset 0.000000
08/23/2001 17:07:50 00003001              DO gain 1.103424
08/23/2001 17:07:50 00003001        DO local gain 1.000000
```

The data in the display shows a new sonde (Circuit Board # 00003001) which has just had its dissolved oxygen sensor calibrated. Note that the initial values for all parameters are the default settings. Only the last two entries (DO gain and DO local gain) have been affected by the calibration of the oxygen sensor. If the conductivity sensor is now calibrated, the new conductivity gain value is now automatically appended to the record as shown below:

```
m/d/y hh:mm:ss      S/N                    Type    Value
08/23/2001 17:07:50 00003001    Conductivity gain 1.000000
08/23/2001 17:07:50 00003001              DO gain 1.000000
08/23/2001 17:07:50 00003001        DO local gain 1.000000
08/23/2001 17:07:50 00003001  pH gain (pH-7)*K/mV -5.05833
08/23/2001 17:07:50 00003001   pH offset (pH-7)*K 0.000000
08/23/2001 17:07:50 00003001        ORP offset mV 0.000000
08/23/2001 17:07:50 00003001         TDS constant 0.650000
08/23/2001 17:07:50 00003001          Turb Offset 0.000000
08/23/2001 17:07:50 00003001              Turb A1 500.0000
08/23/2001 17:07:50 00003001              Turb M1 500.0000
08/23/2001 17:07:50 00003001              Turb A2 1000.000
08/23/2001 17:07:50 00003001              Turb M2 1000.000
08/23/2001 17:07:50 00003001           Chl Offset 0.000000
08/23/2001 17:07:50 00003001               Chl A1 100.0000
08/23/2001 17:07:50 00003001               Chl M1 100.0000
08/23/2001 17:07:50 00003001               Chl A2 200.0000
08/23/2001 17:07:50 00003001               Chl M2 200.0000
08/23/2001 17:07:50 00003001         Fluor Offset 0.000000
08/23/2001 17:07:50 00003001              DO gain 1.103424
08/23/2001 17:07:50 00003001        DO local gain 1.000000
08/23/2001 17:23:13 00003001    Conductivity gain 0.979114
```

Note that the default value of the conductivity "Value" is 1.00 in the .glp format shown above. This relative number is equivalent to a real cell constant of 5.00 which is provided in the **Advanced|Cal**

Constants and is described in Section 2.9.8. All other values in the .glp file are equivalent to those shown in the **Advanced|Cal Constants** menu.

CAUTION: Calibration records for all sensors will automatically be stored in the .glp file until the **Delete All Files** command is used from the **File** menu. However, if the Delete command is issued, all files, including the .glp (calibration record) file will be lost. Therefore, it is extremely important to remember to upload the .glp file to a PC or a 650 Display/Logger prior to deleting files from the sonde. See Section 2.9.3 for instructions on the upload and viewing of the .glp file.

2.9.3 FILE

Selections from the File menu allow the user to access data that has been stored in the sonde flash disk memory. Select **3-File** from the Main menu.

```
------------------File-----------------
1-Directory      4-View file
2-Upload         5-Quick view file
3-Quick Upload   6-Delete all files


Select option (0 for previous menu): 1
```

Select **1-Directory** to view all files currently stored in sonde flash disk memory. The screen below shows 5 files of varying sizes. To examine the details of each file, press the associated number (e.g., 4 for CLRLAKE2.dat) and an additional screen will be displayed as shown below that quantifies the time of the deployment, the sample interval, and the site where the sonde was used. In addition, the data in the file can be viewed by using the **1-View file** command

```
 Filename    Samples
1-BRIDGE1.dat      19
2-BRIDGE2.dat      27
3-UPLAKE.dat       33
4-CLRLAKE2.dat    167
5-DWNLAKE2.dat     31
6-00003001.glp      3

Select option (0 for previous menu): 4
```

```
-------------File details--------
------
1-View file
2-File:CLRLAKE2.dat
3-Samples:    167
4-Bytes:   4421
5-First:08/23/2001
6-First:08:33:40
7-Last :08/23/2001
8-Last :09:04:20
9-Interval:00:00:10
A-Site:Clear Lake
```

Select **2-Upload** to view file lists in memory (same as shown above) and then upload the data to a PC or to the YSI 650 MDS Display/Logger. The uploaded data can then be processed with YSI EcoWatch for Windows to allow data manipulation and to easily generate reports, plots, and statistics.

Three formats for file transfer are available: PC6000, Comma & Quote Delimited, and ASCII text.

- **PC6000** format will transfer the data so that it will be compatible with the EcoWatch for Windows (supplied with your sonde) software package. YSI recommends data transfer in this format since it is significantly more rapid than other transfer options. If this data is required in Comma & Quote Delimited and/or ASCII formats, the user can quickly generate data in these formats using the Export function in EcoWatch for Windows.

- **Comma & Quote Delimited** format is commonly used to generate files that can be imported into spreadsheet software in your PC, where you can perform custom data analysis. A comma is still the delimiter, but the radix is corrected to a period. In most cases you should set the Page Length to 0 before using this type of upload format. See the Windows Help section in EcoWatch for information on setting the page length.

- **ASCII Text** is another alternative to transferring data directly to your computer into spreadsheet or other PC-based software.

Prior to upload, a “Time window” display appears to allow you the option to select portions of the logged data to upload. You may select **1-Proceed** to upload all data logged from the dates and times shown.

```
--------------Time window--------------
1-Proceed
2-Start date=07/17/96
3-Start time=12:00:00
4-Stop  date=07/31/96
5-Stop  time=12:00:00

Select option (0 for previous menu):
```

Select **1-Proceed.** Choose the appropriate file transfer protocol. A status box will appear in the lower right quadrant of the screen. Verification of a successful transfer is indicated when all of the requested data are transferred.

```
---------------File type---------------
1-PC6000
2-Comma & ' ' Delimited
3-ASCII Text

Select option (0 for previous menu):
```

Press **0** or **Esc** to return to the File menu.

When you select the **3–Quick Upload** option, the same operation as **2-Upload** is performed, except that only the most recent flash disk file is uploaded and it is uploaded in its entirety. You still must choose the transfer format from the three options provided.

Select **4-View File** to examine the data in any file currently stored in sonde flash disk memory. You will first view the same screen as viewed in the Directory menu. From this menu choose the file of interest, then, using the Time window menu, choose the dates and/or times of interest. If you choose dates or times that are not within the designated start and stop times, no data will be displayed.

You may choose the entire file. Use the **Space Bar** to alternately stop and to resume scrolling. Use the **Esc** key to cancel the view.

Select the **5–Quick View File** option to view the last page of data from the last data file in sonde memory. This feature is particularly useful in quickly reviewing recently acquired data at field sites so that system performance can be assessed.

Select **6–Delete all files** to IRREVERSIBLY remove all files from the sonde memory (INCLUDING the .glp file that may contain valuable calibration data). It is critical not to use this option until all relevant data from sonde memory has been transferred to your computer via one of the upload options. There is a verification screen that appears, so that pressing the 6 key does not immediately delete all files at this point.

NOTE: By choosing the Delete function **only** .dat and .glp files will be erased. Calibration data for all sensors installed and calibrated on the sonde will not be deleted.

The management of the .glp calibration record file that is automatically stored in sonde memory and is described in Section 2.9.2 above is similar to that for data files. However, there are some differences in the upload procedure of which the user should be aware. When uploading a .glp file there will be a choice of three upload protocols as shown below:

```
---------------File type----------------
1-Binary
2-Comma & '' '' Delimited
3-ASCII Text

Select option (0 for previous menu):
```

The binary upload choice should ONLY be used when uploading the .glp file to a 650 Display/Logger; if the binary protocol is used in a direct upload to PC, a .glp file will indeed be transferred, but it will not be possible to open it using the current YSI software or any other text editor. Thus, during a direct transfer of the .glp file to your PC, either the CDF or ASCII formats should be used. The result will be the conversion of the file with a .glp extension in the sonde to one with a .txt extension which is now stored in the ECOWWIN\DATA subdirectory of your PC. For example, the file 00003001.glp in the sonde will become 00003001.txt on transfer to PC and the file will be in a format which can easily be viewed and edited using Notepad or other word processing software.

2.9.4 STATUS

Select **4-Status** from the Sonde Main menu to obtain general information about the sonde and its setup.

```
-----------------Status----------------
1-Version:3.01
2-Date=07/22/96
3-Time=09:04:28
4-Bat volts: 9.0
5-Bat life 21.2 days
6-Free bytes:129792
7-Logging:Inactive

Select option (0 for previous menu):
```

- **1-Version** identifies the specific version of sonde software loaded in the sonde. This number is especially useful if you are calling YSI Technical Support. It may also be useful to you if you are comparing 2 or more sondes purchased at different times.

- Select **2-Date and 3-Time** to display current date and time in 24-hour format. This is not a "live" display, but may be updated by pressing the 2 or 3 key again. This may be useful for viewing or setting real time. You may correct date or time from this submenu, by entering the corrected date or time as described in System setup. However, you cannot alter date format from this screen.

- In options **4, 5, and 6**, you can view battery voltage, battery life, and available free memory in your sonde to help you evaluate whether the current setup is appropriate to complete an active logging or to begin a study in which you have defined your logging parameters. If you press key 4, 5 or 6 before you exit this screen, it may change, since this triggers the Status screen to update information. Note that no battery information will appear for the 600R, 600QS, 600XL, 6820V2-1, and 600 OMS V2-1(nonbattery version) sondes.

- **7-Logging** provides one of two messages, active or inactive, indicating whether your sonde is in the unattended logging mode. This logging status indicator is not relevant to logging in the discrete mode, since there is no way to enter the Status screen without stopping discrete logging.

Press **0** or **Esc** to exit the Status screen and return to Main menu.

2.9.5 SYSTEM

Select **5-System** from the Sonde Main menu to set the date and time, customize the sonde communication protocol, adjust how information appears on the screen, and enter an instrument identification number and a GLP file designation.

```
1-Date & time
2-Comm setup
3-Page length=25
4-Instrument ID=YSI Sonde
5-Circuit board SN:00003001
6-GLP filename=00003001
7-SDI-12 address=0

Select option (0 for previous menu):
```

Select **Date & time.**

```
-----------Date & time setup-----------
1-(*)m/d/y          4-( )4 digit year
2-( )d/m/y          5-Date=08/11/98
3-( )y/m/d          6-Time=11:12:30

Select option (0 for previous menu):
```

Press **4** and **5** to activate the date and time functions. Pay particular attention to the date format that you have chosen when entering date. Use the 24-hour clock format for entering time. Option **4- ( ) 4 digit** year may be chosen to have the date appear with a two or four digit year.

Press **0** or **Esc** to return the System Setup menu.

Select **2-Comm setup** From the System Setup menu.

```
---------------Comm setup-------------
1-(*)Auto baud      5-( )2400 baud
2-( )300 baud       6-( )4800 baud
3-( )600 baud       7-(*)9600 baud
4-( )1200 baud

Select option (0 for previous menu): 0
```

The default is 9600, but you may change it to match your host communication interface protocol by typing in the corresponding number, 1 through 7. An asterisk confirms the selection. Auto baud may be selected along with any of the choices. The Auto baud option allows the sonde to recognize and adjust to the received characters and we recommend that it is activated.

NOTE: If you change the baud rate, exit the sonde interaction and immediately change the baud rate in EcoWatch for Windows, Comm Settings. If you do not adjust the baud rate in the PC software, the sonde will not be able to communicate with the computer or any display/logger and your system will appear to be "locked-up."

Select **3-Page length** from the System Setup menu and press **Enter**. This will allow you to control how many lines of data are sent to your display before a new header is shown. The smaller the page number, the fewer the lines of data will be transmitted to your display between headers. However, if you set the page length to zero (0), only the initial header will be displayed. In many cases, a page length of zero is the preferred configuration if you choose to upload your data in an ASCII or CDF format. See **Section 2.9.3, File Menu,** for more details.

NOTE: The header itself takes 4 lines. Therefore, if the page length is set to 25, there will be 21 lines of data and one header. Any page length less than 5 will result in no header being transmitted.

Select **4-Instrument ID** from the System setup menu to record the instrument ID number (usually the instrument serial number), and press **Enter**. A prompt will appear which will allow you to type in the serial number of your sonde. This will make sure that any data that is collected is associated with a particular sonde.

The **5-Circuit Board SN** entry shows the serial number of the PCB that is resident in your sonde (not the entire system as for Instrument ID). Unlike the **Instrument ID**, the user cannot change the **Circuit Board SN**.

Select **6-GLP filename** to enter a name for the file that is automatically generated and appended as you calibrate any of the sonde sensors. The default designation for the GLP file is the Circuit Board SN and this name can be retained if you wish. See section 2.9.3 for general information on the GLP file.

Select **7-SDI-12 address** from the System Setup menu to change the value. Input a number between 0 and 9 and then press **Enter** to confirm the selection. The SDI-12 default address is zero (0). This feature is fully described in **Section 7, Communication** and only utilized if the unit is to operate in a SDI-12 communication protocol network.

2.9.6 REPORT

The Report menu allows you to configure all reports displayed by the sonde software. You will be able to select which parameters and units of measure that are displayed during operation.

Select **6-Report** from the sonde Main menu. The following menu, or a similar menu, will be displayed. The parameters listed depend on both the sensors available and enabled on your sonde. Therefore your screen may not be identical to that shown below.

Select **Report** from the Main sonde menu to setup the report section. The Report Setup menu will be displayed.

```
-------------Report setup--------------
1-(*)Date            C-( )DOchrg
2-(*)Time hh:mm:ss   D-( )pH
3-(*)Temp C          E-( )pH mV
4-(*)SpCond uS/cm    F-(*)Orp mV
5-( )Cond            G-( )PAR1
6-( )Resist          H-( )PAR2
7-( )TDS             I-(*)Turbid+ NTU
8-( )Sal ppt         J-(*)Chl ug/L
9-(*)DOsat %         K-( )Chl RFU
A-(*)DOsat %Local    L-(*)Battery volts
B-( )DO mg/L

Select option (0 for previous menu):
```

The asterisks (*) that follow the numbers or letters indicate that the parameter will appear on all outputs and reports. To turn a parameter on or off type the number or letter, that corresponds to the parameter, after **Select option**. See **Appendix J** for instructions on activation of the parameter "DOsat %Local" and ODOsat %Local". The parameters "PAR1" and "PAR2" are associated with a special sonde equipped with a sensor for Photosynthetically Active Radiation (PAR) which can be purchased from the YSI Massachusetts. See **Section 9** of this manual for contact information and **Appendix K** for a brief description of the PAR system for potential users.

Note that the units of turbidity are automatically presented as "turbid NTU" if a 6026 sensor has been selected and "turbid+ NTU" if a 6136 sensor has been selected. The different designations are designed to differentiate the data from the two sensors types in later analysis.

For parameters with multiple unit options such as temperature, conductivity, specific conductance, resistivity and TDS, a submenu will appear as shown below, allowing selection of desired units for this parameter.

```
--------------Select units-------------
1-(*)NONE
2-( )Temp C
3-( )Temp F
4-( )Temp K

Select option (0 for previous menu): 2
```

After configuring your display with the desired parameters, press **Esc or 0** to return to the Main menu.

Even if all of the sensors are enabled, the measurements for those sensors will not appear on your display unless the parameter is selected in Report setup. In order for a specific parameter to show up on a report:

- The sensor must first be enabled (turned on).
- That parameter must be activated in the Report setup.

In the above example, if the appropriate sensors have been activated in the Sensor setup section, the following parameters will be displayed to the computer screen or captured to a computer or data collection platform when the sonde is sampling: Temperature in C, Specific Conductance in uS/cm, Dissolved

Oxygen in % air saturation, Dissolved Oxygen in mg/L, pH, ORP in millivolts, Turbidity in NTUs and Chlorophyll in ug/L. Date and time will also be displayed.

NOTE: Do not attempt to memorize or associate a number or letter with a particular parameter. The numbering scheme is dynamic and changes depending on the sensors which have been enabled.

The following list is a complete listing of the abbreviations utilized for the various parameters and units available in the Report setup menu.

Parameter	Description
Date	Day/Month/Year (format selectable)
Time	Hour:Minute:Second (24-hour clock format)
Temp C	Temperature in degrees Celsius
Temp F	Temperature in degrees Fahrenheit
Temp K	Temperature in degrees Kelvin
SpCond mS/cm	Specific Conductance in milliSiemens per centimeter
SpCond uS/cm	Specific Conductance in microSiemens per centimeter
Cond mS/cm	Conductivity in milliSiemens per centimeter
Cond uS/cm	Conductivity in microSiemens per centimeter
Resist MOhm*cm	Resistivity in MegaOhms * centimeter
Resist Kohm*cm	Resistivity in KiloOhms * centimeter
Resist Ohm*cm	Resistivity in Ohms * centimeter
TDS g/L	Total dissolved solids in grams per liter
TDS kg/L	Total dissolved solids in kilograms per liter
Sal ppt	Salinity in parts per thousand (set to local barometer at calibration)
DOsat %	Dissolved oxygen in % air saturation from Rapid Pulse Sensor
DOsat % Local	Dissolved oxygen in % air saturation (set to 100 % at calibration) from the Rapid Pulse sensor
DO mg/L	Dissolved oxygen in milligrams per liter from Rapid Pulse Sensor
DO chrg	Dissolved oxygen sensor charge from Rapid Pulse Sensor
ODOsat %	Dissolved oxygen in % air saturation from ROX Optical Sensor
ODOsat % Local	Dissolved oxygen in % air saturation (set to 100 % at calibration) from the ROX Optical Sensor
ODO mg/L	Dissolved oxygen in mg/L from ROX Optical Sensor
Press psia	Pressure in pounds per square inch absolute
Press psir	Pressure in pounds per square inch relative
Depth meters	Water column in meters
Depth feet	Water column in feet
pH	pH in standard units
pH mV	millivolts associated with the pH reading
Orp mV	Oxidation reduction potential value in millivolts
NH4+ N mg/L	Ammonium Nitrogen in milligrams/liter
NH4+ N mV	Ammonium Nitrogen in millivolt reading
NH3 N mg/L	Ammonia Nitrogen in milligrams/liter
NO3- N mg/L	Nitrate Nitrogen in milligrams/liter
NO3- N mV	Nitrate Nitrogen in millivolt reading
Cl- mg/L	Chloride in milligrams/liter
Cl- mV	Chloride in millivolt reading
Turbid NTU	Turbidity in nephelometric turbidity units from 6026 sensor
Turbid+ NTU	Turbidity in nephelometric turbidity units from 6136 sensor
Chl ug/L	Chlorophyll in micrograms/liter
Chl RFU	Relative fluorescence units for the chlorophyll sensor
BGA-PC cells/mL	Phycocyanin-Containing Blue-green Algae content in cells/mL
BGA-PC RFU	Relative fluorescence units for the BGA-PC sensor
BGA-PE cells/mL	Phycoerythrin-Containing Blue-green Algae content in cells/mL
BGA-PE RFU	Relative fluorescence units for the BGA-PE sensor
Rhod ug/L	Rhodamine WT in micrograms/liter

PAR1	Output from special photosynthetically active radiation sensor in mv or Photon Flux Density in umoles/sec/m2
PAR 2	Output from special photosynthetically active radiation sensor in mv or Photon Flux Density in umoles/sec/m2

2.9.7 SENSOR

The **Sensor** menu allows you to Enable or Disable (turn on or off) any available sensor and, in some cases, to select the port in which your sensor is installed.

From the Sonde Main menu select **7-Sensor** and the following display will appear.

```
------------Sensors enabled------------
1-(*)Time           7-( )ISE3 NONE
2-(*)Temperature    8-( )ISE4 NONE
3-(*)Conductivity   9-( )ISE5 NONE
4-(*)Dissolved Oxy  A-( )Optic T
5-(*)ISE1 pH        B-( )Optic C
6-(*)ISE2 Orp       C-(*)Battery

Select option (0 for previous menu):
```

Note that the exact appearance of this menu will vary depending upon the sensors available on your sonde.

When a particular sensor is active, an asterisk will appear in the parentheses associated with the selection. In this example the time, temperature, conductivity, dissolved oxygen, pH, ORP, and battery sensors are enabled. To disable a sensor, simply press the number of the active sensor or port, and the asterisk will disappear.

For the ISE and Optic selections, press the appropriate number, and then enable or disable the sensor using the submenu choices. Be certain that the appropriate sensor is “enabled” in the submenu according to the sonde bulkhead port in which it is physically installed. For example, if an ammonium sensor is placed in the port labeled “3” on the bulkhead, enable the sensor as ISE3 in the menu structure.

The following screen is the submenu selection structure for ISE3, ISE4 and ISE5.

```
--------------Select type--------------
1-( )ISE3 NH4+
2-( )ISE3 NO3-
3-( )ISE3 Cl-
4-( )ISE3 PAR1

Select option (0 for previous menu):
```

As noted above, the ISE3 PAR1 selection is used in a special instrument mated to a sensor for Photosynthetically Active Radiation that is available from Endeco/YSI. See **Section 9** for contact information and **Appendix K** for a brief description of the PAR system for potential users.

A submenu similar to that below will appear if any of the Optic options (T, C, B, or O) is chosen as a port for a particular optical sensor..

```
--------------Select type--------------
1-(*)Optic-T(or C,B,O) Turbidity-6026
2-( )Optic-T(or C,B,O) Turbidity-6136
2-( )Optic-T(or C,B,O) Chlorophyll
3-( )Optic-T(or C,B,O) Rhodamine

Select option (0 for previous menu):
```

Any available optical probe can be installed in any optical port on YSI 6-series sondes. If a single port is present (600 OMS V2-1, 6820V2-1, 6920V2-1), then the port will be designated “Optic T” in the software even though the port is not physically labeled with a “T” on the bulkhead. The two optical ports in the 6600V2-2, 6600EDS V2-2, 6820V2-1. and 6920V2-2 are labeled “Optic T” and “Optic C”, both in the software and on the bulkhead. Selection of either “Optic T” or “Optic C” in the software will produce submenus that allow the proper optical sensor to be selected. The four optical ports in the 6600V2-4 are labeled “Optic T”, “Optic C”, “Optic B”, and “Optic O”, both in the software and on the bulkhead. Selection of any of the options in the software will produce submenus that allow the proper optical sensor to be selected. Note, however, that only one probe of any type can be installed and activated in sondes with multiple optical ports. For example, it is not possible to use chlorophyll probes in both Optic T and Optic C ports of the 6600V2-2.

NOTE CAREFULLY: It is NOT possible to simultaneously activate BOTH the 6562 Rapid Pulse polarographic dissolved oxygen sensor and the 6150 ROX Optical dissolved oxygen sensor. Activation of either sensor will automatically deactivate the other selection. Thus, users of 6600V2-2, 6600EDS V2-2, 6820V2-1, and 6920V2-1 sondes CANNOT measure oxygen with both types of sensors.

NOTE: If you are using a previously purchased 6036 turbidity probe (discontinued on 1/1/02) with your sonde, select the “(*) Turbidity-6026” option in the above menu.

2.9.8 ADVANCED

From the Sonde Main menu select **8-Advanced** to display the sensor calibration constants, additional setup options, sensor coefficients and constants, and digital filtering options. The parameters listed depend on both the sensors installed and the sensors enabled, therefore your screen may not be identical to those shown below.

```
----------------Advanced--------------
1-Cal constants
2-Setup
3-Sensor
4-Data filter

Select option (0 for previous menu): 1
```

Select **1-Cal constants** to display the calibration constants, as shown in the following example. Note that values only appear for the enabled sensors.

```
-------------Cal constants-------------
1-Cond:5                 B-NO3 A:2.543
2-DO gain:1.3048         C-Cl J:99.5
3-mV offset:0            D-Cl S:-0.195
4-pH offset:0            E-Cl A:2.543
5-pH gain:-5.05833       F-Turb Offset:0
6-NH4 J:51.2             G-Turb A1:500
7-NH4 S:0.195            H-Turb M1:500
8-NH4 A:1.092            I-Turb A2:1000
9-NO3 J:99.5             J-Turb M2:1000
A-NO3 S:-0.195

Select option (0 for previous menu): 0
```

The following table provides the default value, operating range, and comments relative to the calibration constants. Error messages will appear during calibration if values are outside the indicated operating range unless the designation is "not checked".

Parameter	***Default***	***Operating range***	***Comments***
Cond:	5	4 to 6	Traditional cell constant
DO gain:	1	0.5 to 2.0	
ODO gain	1	0.75 to 1.40	
ODO Tzero	Same as K1	+/- 0.45 from K1	ODO value at zero oxygen after 2-point cal
ODO K1	N/A	N/A	ODO value at zero oxygen
ODO K2	N/A	N/A	ODO regression coefficient
ODO K3	N/A	N/A	ODO regression coefficient
ODO K4	N/A	N/A	ODO regression coefficient
Pres offset:			
if not vented	-14.7	-20.7 to -8.7	
if vented	0.0	-6 to 6	
mV offset:	0.0	-100 to 100	
pH offset:	0.0	-400 to 400	
pH gain:	-5.0583	-6.07 to -4.22	
NH4 J	51.2	Not checked	
NH4 S	0.195	0.15 to 0.217	
NH4 A	1.092	Not checked	
NO3 J	99.5	Not checked	
NO3 S	-0.195	-0.217 to -0.15	
NO3 A	2.543	Not checked	
Cl J	99.5	Not checked	
Cl S	-0.195	-0.217 to -0.15	
Cl A	2.543	Not checked	
Turb Offset	0	-10 to 10	
Turb A1	500	0.6 to 1.5	Range is ratio of M1 to A1
Turb M1	500		
Turb A2	1000	0.6 to 1.5	Range is ratio of (M2-M1) to (A2-A1)
Turb M2	1000		
Turb+ Offset	0	-10 to 20	
Turb+ A1	500	0.6 to 1.5	Range is ratio of M1 to A1
Turb+ M1	500		

Turb+ A2	1000	0.6 to 1.5	Range is ratio of (M2-M1) to (A2-A1)
Turb+ M2			
Chl Offset	0	-30 to 20	
Chl A1	500	0.6 to 1.5	Range is ratio of M1 to A1
Chl M1	500		
Chl A2	1000	0.6 to 1.5	Range is ratio of (M2-M1) to (A2-A1)
Chl M2	1000		
Chl RFU Offset	0	-0.1 to +0.1	
PC Offset	0	-5000 to 10000	
PC Gain	1	Not checked	
PC RFU Offset	0	Not checked	
PE Offset	0	-5000 to 15000	
PE Gain	1	Not checked	
PE RFU Offset	0	Not checked	
Rhod Offset	0	-10 to 10	
Rhod A1	500	0.6 to 1.5	Range ratio of M1 to A1
Rhod M1	500		
Rhod A2	1000	0.6 to 1.5	Range is ratio of (M2-M1) to (A2-A1)
Rhod M2	1000		

To reset a calibration cell constant, access the sonde Calibrate menu. Then select the sensor and type "UNCAL" instead of the value. This action will change the calibration constants of that sensor back to the factory default.

From the Advanced menu, select **2-Setup** to display miscellaneous options. Type the appropriate number to activate/deactivate any of the displayed features.

```
------------Advanced setup--------
1-(*)VT100 emulation
2-Start up:Normal
3-( )Comma radix
4-( )Auto sleep RS232
5-( )Auto sleep SDI12
6-( )Multi SDI12
7-( )Full SDI12
8-( )Sample and hold
```

1-(*)VT100 emulation. Activate this option for VT100 terminal emulation. This feature allows the sonde to send escape sequences to clear the screen which in turn results in an improved display. Usually this feature should be activated, but, if your terminal or terminal emulator shows odd characters at the beginning of each menu title, then turn this item off. With the feature off, the sonde will send several carriage returns and line feeds to 'clear' the display. The number of <cr>'s and <lf>'s is determined by the page length setting.

2- Start up. This option allows the user to select the mode of sonde operation when power is applied or a "reset" command is issued. After pressing the "2" key, the following options will be displayed.

```
------Start up:---------------
1-(*)Normal
2-( )Menu
3-( )Run
4-( )Menu Run
5-( )NMEA

Select option (0 for previous
menu):
```

Users should select the option for their application based on the descriptions below. Note, however, that the "Start up Normal" selection will be best for most applications.

1- ( ) Start up Normal. This selection is the factory default and should be used for most operations of the sonde. When power is applied or a "reset" command is issued, the sonde firmware will return the "#" prompt. The user should then type "menu" to access the sonde firmware functionality

2- ( ) Start up Menu. When this item is enabled, the sonde will go directly to menu mode when power is applied to the sonde. If the command line mode is not useful for your applications, then enabling this item will negate the need to type "Menu" and **Enter** at the # prompt to access the Main sonde menu. Activation of this item is NOT recommended except for special applications.

3-( ) Start up Run. When this item is enabled the sonde will start sampling and output data as soon as power is applied to the sonde. If you are using your sonde for Unattended sampling, do not activate this mode. Activation of this item is NOT recommended except for special applications.

4-( ) Start up Menu Run. When this item is enabled, the sonde will first enter the menu mode and then the run mode where it will start sampling. If you are using your sonde for Unattended sampling, do not activate this mode. Activation of this item is NOT recommended except for special applications.

5-( ) Start up NMEA. When this item is active, the sonde will start sampling and output data in a format which is compatible with devices which utilize the NMEA protocol. See **Appendix N - NMEA Applications** for additional details. Activation of this item is NOT recommended except for special applications.

3-( )Comma radix. When this item is enabled, the sonde will replace decimal points with commas when printing numbers. NOTE: Regardless of this setting, SDI-12 'D' commands will still respond using a decimal point.

4-(*)Auto sleep RS232. Activation of this feature enables a power savings system when communicating with the sonde in RS-232 mode. When enabled, power is only applied to the sensors during sampling or calibration. The most important aspect of this feature is its effect on the dissolved oxygen protocol as described in Section 2.9.2. For this reason, this feature should be activated for long term monitoring studies in the RS-232 communication mode and deactivated for sampling studies where the user is present and the sonde runs continuously. Even with Autosleep inactive, the sonde will "sleep" after one minute with no communications.

5-(*)Auto sleep SDI12. Activation of this feature enables the power savings system when communicating with the sonde in SDI-12 mode. This is basically the same as item 5 above except that it is used in communication via the SDI-12 interface. Also, the sonde will "sleep" in about 100 milliseconds in the absence of communication, rather that waiting one minute in the Auto sleep RS-232 mode.

6-( ) Multi SDI12. Modifies the SDI12 protocol as follows: (1) No SDI12 service request will be issued. (2) Break commands will not cause a measurement reading to be aborted. Normally, you should leave this feature "off".

7-( ) Full SDI12. Enabling this feature forces full SDI-12 specification in order to pass the NR Systems SDI-12 Verifier. Disabling this feature will allow the unit to be more fault tolerant and will save some power. We recommend that you leave this feature "off".

8-( ) Sample and Hold. This feature is designed to be activated ONLY for studies in which your sonde is attached to a YSI 6500 Process Monitor. When "Sample and Hold" is active, the 6500 display and the SCADA output of the 6500 becomes equivalent to the internal memory of the sonde while an Unattended study is running. In the Unattended mode, the sonde "sleeps" between periodic samples with the interval between samples defined by the user. This method of operation results the extension of both the sonde battery life (not important in 6500 applications) and the time between required sensor maintenance procedures (which is important to 6500 applications using Rapid Pulse DO). After activation of the feature another entry will appear automatically which will allow you to input your sample interval which defines how often data is transmitted to the 6500 display. This new sample interval will automatically become the sample interval for the **Run|Discrete sample** mode of operation and you will not be able to change the interval until **Sample and Hold** is deactivated. In addition, the interval in the Run|Unattended **sample** mode will also change to the Sample and Hold interval. In this case, however, you will be able to change the Unattended Sample interval, but with the caveat that the **Sample and Hold interval** will also change, i.e., the **Unattended sample interval** and the Sample and Hold interval MUST be synchronized and the software assures that this will be the case.

For DCP applications, when "Sample and Hold" is active, the routine which triggers optical wipers, the sensor warm-up pattern, and the acquisition of data will be controlled by the sonde rather than the DCP. If the Unattended mode of the sonde is inactive, the data will be stored in a memory buffer and then acquired by the DCP when the "D" command is issued. If the Unattended mode is active, then the data will be stored both in the memory buffer and sonde memory for acquisition by the DCP. Use of the "Sample and Hold" feature with a DCP is particularly useful if you are also logging a back-up file to internal sonde memory. In this case, the wiping and data acquisition sequence of the sonde will ONLY be triggered by the sonde itself rather than by BOTH the sonde and the DCP and this will result in significantly less power consumption from the DCP battery and/or power system.

NOTE CAREFULLY: When **Sample and Hold** is active, the sonde will behave as if it is in an **Unattended sample** mode EVEN IF AN UNATTENDED SAMPLE HAS NOT BEEN ACTIVATED. Therefore, to conserve batteries, you should always DEACTIVATE the **Sample and Hold** feature when your sonde is not attached to the 6500 Process Monitor.

Select **3-Sensor** to display and change user-configurable constants as shown in the following display. Type the appropriate number to change to these parameters. Note that the listed items depend on which sensors your have active in your sonde setup.

```
------------Advanced sensor-----------
1-TDS constant=0.65
2-Latitude=40
3-Altitude Ft=0
4-(*)Fixed probe
5-( )Moving probe
6-DO temp co %/C=1.1
7-DO warm up sec=40
8-(*)Wait for DO
9-Wipes=1
A-Wipe int=1
B-SDI12-M/wipe=1
C-Turb temp co %/C=0.3
D-(*)Turb spike filter
E-Chl temp co %/C=0


Select option (0 for previous menu):
```

NOTE: The number of items on this menu depends greatly on the sensors that are available and enabled on your sonde. Below we describe every possible item on this menu. Your sonde probably may not have every item described below.

To edit one of the following menu items choose the number or letter that corresponds to it.

TDS constant=0.65 This selection allows you to set the constant used to calculate TDS. TDS in g/L is calculated by multiplying this constant times the specific conductance in mS/cm. This item will only appear if the conductivity sensor is enabled in the "Sensors enabled" menu. See **Section 53, Principles of Operation** for more information on the TDS parameter.

Salinity=0 This selection allows you to input a manually-acquired value of salinity for calculating other parameters such as DO mg/L and depth. *This item is not used or displayed if the conductivity sensor is enabled in the Sensors menu.*

Pres=0 psi This selection allows you to set a value of pressure for calculating other parameters like salinity. *This item is not used or displayed if the pressure sensor is enabled in the Sensors menu.*

Latitude=40 This selection allows you to input the global position (latitude) where the sonde is sampling. The units are degrees. For accuracy, enter the decimal equivalent to indicate degrees and minutes. For example, enter 41^{o} 30 ' as 41.5. This value is used in the calculation of depth or level to account for global variations in the gravitational field. *This item will only appear if the pressure sensor is enabled in the Sensors menu.*

Flow Setup… This selection allows you to setup the sonde to output flow information. See **Appendix F, Flow** for detailed information on how to setup the Flow parameter. *This item will only appear if the sonde has shallow vented level.*

Altitude=0 This selection allows you to input the local altitude (relative to sea level) where the sonde is sampling. The units are feet. You may enter positive or negative values (range is -276 to 29028) to represent altitudes above or below sea level. This value is used in the calculation of depth or level. *This item will only appear if the pressure sensor is enabled in the Sensors menu.*

(*)Fixed probe This selection allows you to identify how your sonde is being used. If your sonde is "fixed" or secured to a dock, buoy, platform or similar, select this option. This information is used in the calculation of depth and level. *This item will only appear if the Pressure-Abs sensor is enabled in the Sensors menu.*

(*)Moving probe This selection allows you to identify how your sonde is being used. If your sonde is being used in depth profiling select this option. This information is used in the calculation of depth and level. *This item will only appear if the Pressure-Abs sensor is enabled in the Sensors menu.*

DO temp co=1.1%/C This selection allows you to input the Rapid Pulse dissolved oxygen temperature coefficient. Do not change this value unless you consult YSI Technical Support. *This item will only appear if a Rapid Pulse DO sensor is enabled in the Sensors menu.*

.

ODO temp co=1.32%/C This selection allows you to input the ROX Optical dissolved oxygen temperature coefficient. Do not change this value unless you consult YSI Technical Support. *This item will only appear if a ROX Optical DO sensor is enabled in the Sensors menu.*

DO warm up=40 This selection allows you to set the amount of time allowed for the Rapid Pulse DO sensor warm up in seconds. Normally the default value of 40 seconds is adequate for most applications. However, there may be certain situations in which greater DO accuracy can be attained by increasing this time. Consult YSI Technical Support if you feel that your DO warm up time is incorrect. *This item will only appear if the Rapid Pulse Polarographic DO sensor is enabled in the Sensors menu.*

(*)Wait for DO When this feature is enabled, the sonde is forced to wait for the Rapid Pulse DO warm up time to expire before displaying any readings. Note that in SDI12 mode or while calibrating the Rapid Pulse DO sensor, the warm up time is used regardless of the activation of this item. Disabling this item allows you to see data without having to wait during the Rapid Pulse DO warm up time. Under normal operating conditions, this item should be turned off. If you are using the sonde with a data logger in RS232 mode and will be turning the sonde "on" and "off" for each sample, then you may want to enable this item so that only stable DO data are recorded. *This item will only appear if the Rapid Pulse Polarographic DO sensor is enabled in the Sensors menu.*

Wipes=1 If any number of optical sensors are enabled, this selection will determine the number of cleaning cycles which will occur when the wiper is activated manually or automatically. Since the wiper functions bidirectionally, a selection of "1" results in two passes of the wiper over the optical face. In most applications, a single cleaning cycle is adequate to keep the optical surface free of bubbles and fouling. However, in particularly harsh environments additional cleaning cycles may be needed and can be selected here. *This item will only appear if a optical sensor is enabled in the Sensors menu.*

Wipe Int=1 In applications where an optical probe is installed in the sonde and the instrument is collecting data in the SDI-12 communication mode, the wiper mechanism of the probe should be activated automatically in a periodic manner to clean the optical surface for fouling and bubbles. The value entered at this selection is the number of minutes between each automatic cleaning cycle. Thus, if Wipe Int is set to "5" and the instrument is in the Run mode, the wiper will activate every 5 minutes with no manual input. *This item will only appear if an optical sensor is enabled in the Sensors menu.*

The value of Wipe Int is sometimes overridden when the instrument is set up in the Unattended sampling mode. Under these conditions, the wiper will be automatically activated at the interval assigned in the Unattended setup rather than that assigned in Wipe Int. Thus, in an Unattended study setup at a 15 minute sampling interval, the wiper will be activated only once every 15 minutes rather than at the indicated Wipe Int of 1 minute.

CAUTION: If Wipe Int is set to zero, then no wiping will occur either in Discrete or Unattended Sampling. Make certain that Wipe Int is set to some finite value prior to setting up an Unattended study or no automatic cleaning will occur.

SDI12-M/Wipe=1 This is the number of wiping cycles when the sonde is in SDI12 mode. The wiper for the 6026 and 6136 turbidity, 6025 chlorophyll, and 6130 rhodamine WT sensors will automatically wipe each time this many SDI12 "M" commands have been issued. If this value is set to zero, then no automatic wiping will occur. *This item will only appear if a turbidity, chlorophyll, or rhodamine WT sensor is enabled in the Sensors menu.*

Turb temp co %/C=0.3 This entry sets the coefficient for the temperature compensation of turbidity readings from the 6026 and 6136 sensors. The default values of 0.3 (6026) and 0.6 (6136) should not be changed by the user without consulting YSI Technical Support. *This item will only appear if a turbidity sensor is enabled in the Sensor menu.*

(*) Turb Spike Filter When this item is activated, the output of the turbidity sensor is mathematically processed to minimize the effect of unusual (or "bad") readings on the overall data presentation. In most cases, these "spike" events are the result of the chance passage of large suspended particles across the probe optics just at the time a reading is taken. Activation of this option generally results in a better display of the "average" turbidity of the water under examination and its use is recommended for most sampling and unattended applications. *This item will only appear if a turbidity sensor is enabled in the Sensors menu.*

Chl temp co %/C=0.0 This entry sets the coefficient for the temperature compensation of chlorophyll readings from the 6025 sensor. The default value of zero should only be changed by the user after establishing the temperature compensation factor for the phytoplankton sample in question. See Section 5.12, Chlorophyll and **Appendix I, Chlorophyll Measurements** of this manual for more information. *This item will only appear if a chlorophyll sensor is enabled in the Sensors menu.*

BGA-PC temp co %/C=0.0 This entry sets the coefficient for the temperature compensation of BGA-PC readings from the 6131 sensor. The default value of zero should only be changed by the user after establishing the temperature compensation factor for the phytoplankton sample in question. **See Section 5.16, Principles of Operation** of this manual for more information. *This item will only appear if a BGA-PC sensor is enabled in the Sensors menu.*

BGA-PE temp co %/C=0.0 This entry sets the coefficient for the temperature compensation of BGA-PE readings from the 6132 sensor. The default value of zero should only be changed by the user after establishing the temperature compensation factor for the phytoplankton sample in question. See **Section 5.17, Principles of Operation** of this manual for more information. *This item will only appear if a BGA-PE sensor is enabled in the Sensors menu.*

From the Advanced menu, select **4-Data filter** to display data smoothing options. Type the appropriate number to activate/deactivate any of the displayed features.

Sondes with **no optical (turbidity, chlorophyll, or rhodamine WT) probes** enabled will display the following menu.

```
------------Data filter setup----------
1-(*)Enabled
2-( )Wait for filter
3-Time constant=4
4-Threshold=0.001

Select option (0 for previous menu):
```

If any optical probe is enabled in the **Sensor** menu, then the menu will appear as follows.

```
------------Data filter setup----------
1-(*)Enabled
2-( )Wait for filter
3-Time constant. . .
4-Threshold. . .

Select option (0 for previous menu):
```

Choosing **3-Time Constant** will display the following the following or a similar menu to reflect your optical probe selection:

```
------------Time constant ----------
1- Turbid=12
2- Chl=12
3- Other=4


Select option (0 for previous menu):
```

Recommended settings for time constants are turbidity 12, rhodamine WT 12, chlorophyll 12, BGA-PC 24, BGA-PE 24, ODO 12, and "other" 4. Note that the time constant can be set independently for each optical probe and that time constant choices are only available for activated sensors. Rhodamine WT would appear in the display below if it had been activated as a sensor. All "other" sensors use the same time constant as shown below.

Choosing **4-Threshold** will display the following:

```
--------------Threshold-------------
1-Turbid=0.01
2-Chl=1
3-Other=0.001

Select option (0 for previous menu):
```

Setting thresholds is done in the same manner. Recommended threshold settings are 0.01 for turbidity, 1.0 for chlorophyll, 1.0 for rhodamine WT, 1.0 for BGA-PC, 1.0 for BGA-PC and 0.001 for “other”.

The following descriptions provide additional information about the **Data Filter** feature.

1-(*) Enabled. Activating this item will result in data filtering according to the values set in (2), (3), and (4).

2-(*) Wait for filter. If this feature is activated, readings will be available for output only after the unit has warmed up for a time period equal to the Time Constant plus an extra 4 seconds. This feature is useful, for example, if you are operating in SDI12 mode and want to average the data over a particular period of time. In such a case, you would not want the filter to be engaging and disengaging, so the value of the Threshold should be set to a large value like 1. This feature should not be activated for normal use of the sonde.

3-Time Constant. 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.

4-Threshold. This value determines when the software data filter will engage/disengage. When the difference between two consecutive unfiltered 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. For the purposes of the filter, consecutive readings are never more than 0.5 seconds apart. When sampling faster than 0.5 seconds consecutive readings will be at the faster rate and you may want to adjust the threshold accordingly. See section 2.9.1 for details on fast sampling.

The threshold feature is intended to speed response to large changes in a reading. For example, when changing from pH 7 buffer to a pH 4 buffer in a calibration, it is likely that the filter will disengage for a time showing unfiltered readings until the sensor has nearly equilibrated with the new buffer. At that time, the filter will re-engage and show filtered readings. Without disengaging the filter for awhile, much more time would be required to come to equilibrium after large changes in reading.

During the first time constant after the filter first engages, the output reflects a simple average of all the readings from the time the filter engaged until the present. Once the filter has been engaged for the period of the time constant, it becomes a simple filter with a time constant equal to that set in **3-Time Constant**. Each time the filter disengages and then re-engages, this process is repeated.

Filter engagement and disengagement occurs for each sensor independently. One parameter may be filtered while another is not because readings from one sensor are changing more than another.

Example: Moving a sonde from the air to a river water sample. Assume that the temperature of the sonde is similar to the temperature of the water, and that the water is in equilibrium with the air. The temperature and oxygen readings taken in the water will be very similar to those taken in the air. The conductivity reading in air is near zero, and quite likely, is a very different reading in the water. The filter for the conductivity readings will likely disengage when the sonde is first placed in the river water, but stay engaged for the temperature and dissolved oxygen readings.

The filters for turbidity, chlorophyll, and rhodamine WT are somewhat different. For these sensors, the filter is temporarily disengaged during mechanical wiping so that when wiping is finished, the reading is the most current. The filter then reengages if possible. Optical sensor readings are frozen to the output during wiping so that "bad" values are not output.

A value of 0.001 for the threshold roughly corresponds to the following changes in sensor readings:

Temp: 0.1 °C
Conductivity in the 100 mS/cm range: 0.1 ms/cm
Conductivity in the 10 mS/cm range: 0.01 ms/cm
Conductivity in the 1 mS/cm range: 0.001 ms/cm
Conductivity in the 100 µS/cm range: 0.1 us/cm
Dissolved Oxygen: 0.2 percent air saturation
pH, ORP, Ammonium, Nitrate and Chloride: 0.6 mV

A value of 0.01 for the threshold roughly corresponds to a 10NTU change in turbidity. A value of 1.0 for the chlorophyll and rhodamine WT sensors threshold effectively means that the filter will be engaged under all conditions.

2.10 CARE, MAINTENANCE AND STORAGE

This section describes the proper procedure for storage of the sensors that will maximize their lifetime and minimize the time required to get the sonde ready for a new application. This section will describe interim or short-term storage between applications where the sonde is being used at a regular interval (daily, weekly, biweekly, etc.). and long term storage, (e.g., over-the-winter), where the sonde will not be used on a regular basis for several months.

In the descriptions and instructions below, it is assumed that the user has retained the vessels (bottles, boots, etc.) in which the individual sensors were stored on initial delivery. If these specific items have been misplaced or lost, they can be replaced by contacting YSI Technical Support. Alternatively, the user may have similar (and equally acceptable) storage equipment on hand even though it was not part of the original YSI package. Common sense should be the guide on substitution of storage vessels.

REMEMBER: DO NOT ATTEMPT TO GAIN ACCESS TO THE INTERNAL CIRCUITRY OF THE SONDE.

2.10.1 SONDE CARE AND MAINTENANCE

The YSI 6570 Maintenance Kit is available for use with your sonde. The kit includes several items that will be helpful or necessary to perform the proper routine maintenance on your sonde.

The 6570 Maintenance Kit includes two types of O-rings (for probes and cable connector), probe/installation/replacement tools, two cleaning brushes for the conductivity sensor, O-ring lubricant, and a syringe for cleaning the depth sensor port.

The 6570 Maintenance Kit can be ordered from any authorized YSI dealer, or directly from YSI. See **Appendix C** for details.

When caring for your sonde, remember that the sonde is sealed at the factory, and there is never a need to gain access to the interior circuitry of the sonde. In fact if you attempt to disassemble the sonde, you would void the manufacturer's warranty.

O-RING CARE AND MAINTENANCE

Your 6-series sondes utilize user-accessible o-rings as seals to prevent environmental water from entering the battery compartment and the sensor ports. Please read the following instructions carefully prior to deploying your YSI Sonde. Following the recommended procedure will assure that no problems will occur with regard to water influx into your sonde.

If the o-rings and sealing surfaces on the sondes are not maintained properly, it is possible that water can enter the battery compartment and/or sensor ports of your sonde. If water enters these areas, it can severely damage the battery terminals or probe ports causing loss of battery power during a deployment, false readings and corrosion to the probes. Therefore, when the battery compartment lid is removed from 600XLM, 6920V2-1, 6600V2-2, 6600EDS V2-2, 6600V2-4 and 600 OMS V2-1(battery version) sondes, the o-rings that provide the seal should be carefully inspected for contamination (e.g. hair, grit, etc.) and cleaned if necessary using the instructions provided below. The same inspection should be made of the o-rings associated with the probes, port plugs, and field cable connectors when they are removed. If no dirt or damage to the o-rings is evident, then they should be lightly greased without removal from their groove. However, if there is any indication at all of damage, the o-ring should be replaced with an identical item from the YSI 6570 Maintenance Kit supplied with your sonde. At the time of o-ring replacement, the entire o-ring assembly should be cleaned as described below.

To remove the o-rings:
Use a small, flat-bladed screwdriver or similar blunt-tipped tool to remove the o-ring from its groove. Check the o-ring and the groove for any excess grease or contamination. If contamination is evident, clean the o-ring and nearby plastic parts with lens cleaning tissue or equivalent lint-free cloth. Alcohol can be used to clean the plastic parts, but use only water and mild detergent on the o-ring itself. Also, inspect the o-rings for nicks and imperfections.

CAUTION:
- Using alcohol on o-rings may cause a loss of elasticity and may promote cracking.
- Do not use a sharp object to remove the o-rings. Damage to the o-ring or the groove itself may result.

Before re-installing the o-rings, make sure that you are using a clean workspace, clean hands and are avoiding contact with anything that may leave fibers on the o-ring or grooves. Even a very small bit of contamination (hair, grit, etc.) may cause a leak.

To re-install the o-rings:

- Place a small amount of Teflon stopcock grease between your thumb and index finger. (More grease is NOT BETTER!)

- Draw the o-ring through the grease while pressing the fingers together. Use this action to place a VERY LIGHT covering of grease to all sides of the o-ring. Place the o-ring into its groove making sure that it does not twist or roll.

- Use the previously grease-coated finger to once again lightly go over the mating surface of the o-ring. DO NOT use excess grease on the o-ring or the o-ring groove.

CAUTION: Do not over-grease the o-rings. The excess grease may collect grit particles that can compromise the seal. Excess grease can also cause the waterproofing capabilities of the o-ring to diminish, potentially causing leaks into the compartment. If excess grease is present, remove it using lens cloth or lint-free cloth.

SONDE PROBE PORTS

Whenever you install, remove or replace a probe, it is extremely important that the entire sonde and all probes be thoroughly dried prior to the removal of a probe or a probe port plug. This will prevent water from entering the port. Once you remove a probe or plug, examine the connector inside the sonde probe port. If any moisture is present, use compressed air to completely dry the connector. If the connector is corroded, return the sonde to your dealer or directly to YSI Technical Support, see **Section 9, Warranty and Service Information**, for details. When you reinstall a probe or port plug, lightly grease the O-ring with lubricant supplied in the YSI 6570 Maintenance Kit.

CABLE CONNECTOR PORT

The cable connector port at the top of the sonde should be covered at all times. While communicating with the sonde, a cable should be installed and tightened in place. This will assure that a proper connection is being made and prevent moisture and contaminants from entering.

When a communications cable is not connected to the cable connector port, the pressure cap supplied with the instrument should be securely tightened in place.

If moisture has entered the connector, dry the connector completely using compressed air, a clean cloth, or paper towel. Apply a very thin coat of lubricant from the 6570 Maintenance Kit to the O-ring inside the connector cap before each installation.

2.10.2 PROBE CARE AND MAINTENANCE

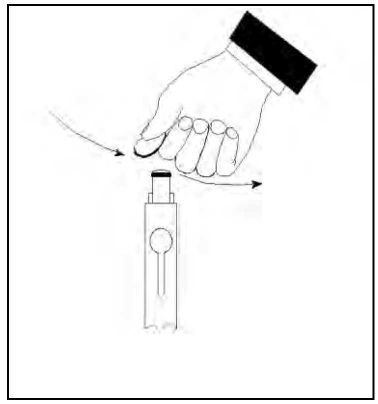
Once the probes have been properly installed, remember that periodic cleaning and DO membrane changes are required.

6562 RAPID PULSE DO PROBES

For best results, we recommend that the KCl solution and the Teflon membrane at the tip of the 6562 probe be changed prior to each sonde deployment and at least once every 30 days during the use of the sonde in sampling studies. In addition, the KCl solution and membrane should be changed if (a) bubbles are visible under the membrane; (b) significant deposits of dried electrolyte are visible on the membrane or the O-ring; and (c) if the probe shows unstable readings or other probe-related symptoms. See Section 2.3 for instructions on changing the DO membrane.

After removing the used membrane from the tip of the 6562 probe, examine the electrodes at the tip of the probe. If either or both of the silver electrodes are black in color, the probe should be resurfaced using the fine sanding disks which are provided in the 6035 reconditioning kit.

To resurface the probe using the fine sanding disk, follow the instructions below.



First dry the probe tip completely with lens cleaning tissue. Next, hold the probe in a vertical position, place one of the sanding disks under your thumb, and stroke the probe face in a direction parallel to the gold electrode (located between the two silver electrodes). The motion is similar to that used in striking a match. Usually 10-15 strokes of the sanding disk are sufficient to remove black deposits on the silver electrodes. However, in extreme cases, more sanding may be required to regenerate the original silver surface.

After completing the sanding procedure, repeatedly rinse the probe face with clean water and wipe with lens cleaning tissue to remove any grit left by the sanding disk. After cleaning, thoroughly rinse the entire tip of the probe with distilled or deionized water and install a new membrane.

IMPORTANT: Be sure to: (1) Use *only* the fine sanding disks provided in the 6035 maintenance kit in the resurfacing operation and (2) Sand in a direction parallel to the gold electrode. *Not adhering to either of these instructions can seriously damage the electrodes.*

NOTE: If this procedure is unsuccessful, as indicated by improper probe performance, it may be necessary to return the probe to an authorized service center. See **Section 9, Warranty and Service Information**, for contact information.

6150 ROX OPTICAL DO PROBES

CAUTION: The sensor membrane of the 6150 probe should be cleaned ONLY with a lens tissue which has been moistened with WATER. ALCOHOL should NOT be used in the cleaning process as it will dissolve the outer paint layer of the membrane assembly; other organic solvents will likely dissolve the dye itself. Under NO circumstances should you use organic solvents to clean your sensor membrane

When the 6150 sensor is not in field use, it MUST BE STORED IN A MOIST ENVIRONMENT, i.e., either in water or in water-saturated air with storage in water being preferable. If the sensor membrane is allowed to dry out by exposure to ambient air, it is likely to drift slightly at the beginning of your next deployment unless it is rehydrated. Thus, to make the use of the sensor as simple as possible, remember to store it WET whenever possible. The easiest storage method is to use the protective plastic cap (and enclosed sponge) which was on the probe at receipt. If you have retained this cap/sponge, then simply soak the sponge in water and replace the cap on the probe tip. Inspect the sponge every 30 days to make sure it is still moist. Alternatively, you can remove the probe from the sonde and place it directly in water (making sure that the water does not evaporate over time or leave the probe in the sonde and make certain that the calibration cup has an atmosphere which is water-saturated by placing approximately ½ inch of water in the bottom of the cup and then sealing it snugly to the sonde.

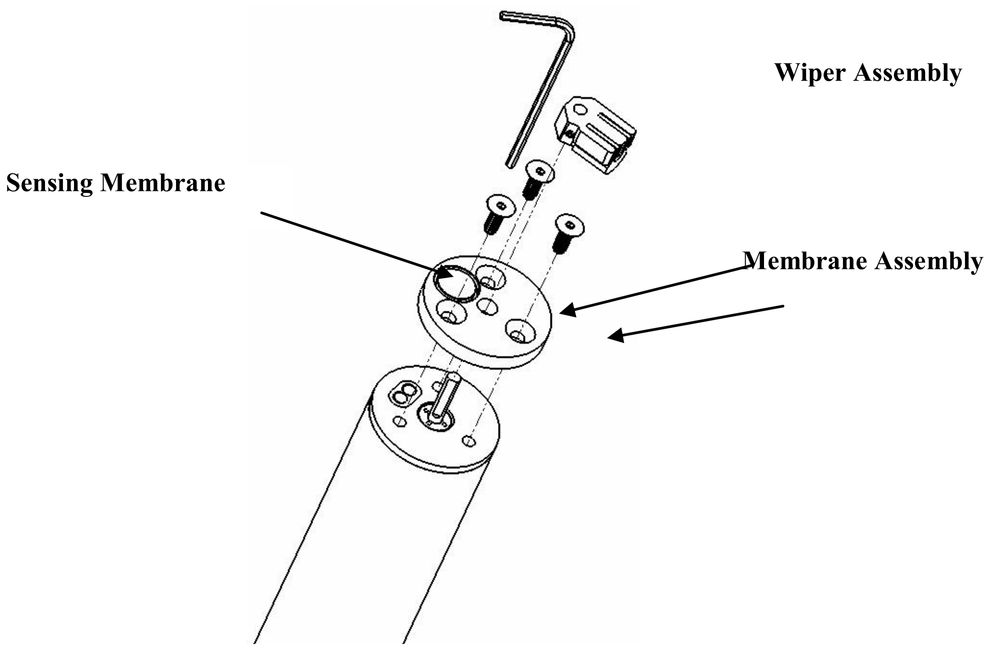
If you inadvertently leave your sensor exposed to ambient air for a period of more than approximately 2 hours, you can rehydrate the membrane by the following method: (1) Place approximately 400 mL of water in a 600 mL beaker or other similar glass vessel – do NOT use plastic vessels – and heat the water on a thermostatted hotplate or in an oven so that a consistent temperature of 50+/- 5 C is realized. Place the probe tip containing the sensor membrane in the warm water and maintain the elevated temperature for approximately 24 hours. Cover the vessel if possible to minimize evaporation. After rehydration is complete, store the probe in either water or water-saturated air at room temperature prior to calibration and deployment. **CAUTION: MAKE CERTAIN THAT THE WATER IN THE VESSEL DOES NOT COMPLETELY EVAPORATE DURING THE REHYDRATION STEP.**

YSI recommends the optical DO membrane assembly be replaced once a year in order to assure the maximum accuracy for the sensor and the 6155 kit allows the user to carry out this replacement without returning the sensor to the factory.   The following section provides detailed instructions for replacement of the optical DO membrane assembly on the YSI Optical DO sensor.

NOTE CAREFULLY: The 6155 optical sensor membrane has been shipped in a humidified atmosphere and the package SHOULD NOT BE OPENED until immediately before membrane replacement. Once the sensor membrane has been installed on the 6150 DO sensor as described below, it is important to keep the membrane in an environment which is characterized by 100% humidity. Thus, after replacement of the membrane and installation of the sensor system in your sonde, the DO probe with attached membrane should be stored either immersed in water or in a sealed calibration cup which contains enough water so that the atmosphere is water-saturated.   See sensor maintenance instructions below if you inadvertently leave the sensor in ambient air for a period of more than 2 hours.

Membrane Installation Instructions

Use the schematic below as an aid in replacement of the YSI Optical DO membrane.



Note: The following steps can be carried out with the probe either installed in the sonde or removed from it. Avoid touching the sensing membrane (shown in the above drawing) during the procedure.

- Remove the wiper assembly from the 6150 Optical DO Sensor and set it aside for later use.
- Using the 1/16 inch hex driver supplied in the 6155 Kit, remove the three screws from the sensor face as shown in the diagram above. Remove the old membrane assembly from the wiper shaft and set the screws aside for later use.
- Remove the new sensor membrane assembly from its hydrated container and dry the backside (the side with the cavity) completely. Be certain that there is no water remaining in the cavity which holds the sensing membrane. Use lens cleaning tissue, a gentle stream of compressed air, or both to assure that the membrane cavity is dry. Do not heat the membrane assembly.
- Make certain that there is an O-ring in place in the groove surrounding the sensor cavity.
- Place the sensor membrane assembly over the wiper shaft and align the holes in the membrane holder with those on the probe face so that the sensor cavity is located over the optical fiber ends on the probe face. Be absolutely certain that the sensor cavity lines up with the probe optics before proceeding.
- Place one of the screws in a hole in the membrane assembly and rotate the assembly slightly as needed to match the screw to the proper hole in the probe face. Partially tighten the screw using the 1/16 inch hex driver.
- Insert screws in the other two holes of the membrane assembly, rotating slightly as needed to match the screw to the hole in the probe face. Partially tighten the screws using the 1/16 inch hex driver. Take care not to scratch the membrane surface.
- Tighten all three screws securely using the 1/16 inch hex driver. CAUTION: INSERT LONG SHAFT OF THE HEX DRIVER INTO THE SCREW AND TURN WITH THE SHORT SHAFT AS SHOWN IN THE DIAGRAM TO AVOID OVERTIGHTENING THE SCREWS.
- Replace the wiper on the probe shaft and tighten with the proper 0.05 inch hex driver.

- **Store the probe with new membrane in either water or water-saturated air as described on the previous page.**

6560 CONDUCTIVITY/TEMPERATURE PROBES

The openings that allow fluid access to the conductivity electrodes must be cleaned regularly. The small cleaning brush included in the 6570 Maintenance Kit is ideal for this purpose. Dip the brush in clean water and insert it into each hole 15-20 times. In the event that deposits have formed on the electrodes, it may be necessary to use a mild detergent with the brush. After cleaning, check the response and accuracy of the conductivity cell with a calibration standard.

NOTE: If this procedure is unsuccessful, or if probe performance is impaired, it may be necessary to return the probe to an authorized dealer service center See **Section 9, Warranty and Service Information** for contact information.

The temperature portion of the probe requires no maintenance.

6561/6561FG pH AND 6565/6565FG/6566 COMBINATION pH-ORP PROBES

Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces of these probes or when the response of the probe becomes slow.

Remove the probe from the sonde. Initially, simply use clean tap water and a soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb (6561 and 6565) and platinum button (6561). 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 6561 or 6565, 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. You can also use a pipe cleaner for this operation if more convenient. DO NOT use toothbrush, steel wool, or abrasive cleaners on any glass sensor.

If good pH and/or ORP response is not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 10-15 minutes in clean tap water containing a few drops of commercial dishwashing liquid, or enzyme-containing detergent such as Terg-A-Zyme (by Alconox).

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the cleaning solution.

3. Rinse the probe in clean tap water, wipe with a cotton swab saturated with clean water, and then rerinse with clean tap water.

If good pH and/or ORP response is still not restored by the above procedure, perform the following additional procedure:

1. Soak the probe 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. Rinse the probe in clean tap water, wipe with a cotton swab saturated with clean water, and then rerinse with clean tap water. To be certain that all traces of the acid are removed from the probe crevices, soak the probe in pH 4 or 7 buffer for about an hour with occasional stirring.

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 probe for approximately 1 hour in a 1 to 1 dilution of commercially-available chlorine bleach.

2. Rinse the probe with clean tap water and then soak for at least 1 hour in pH 4 or 7 buffer with occasional stirring to remove residual bleach from the junction. (If possible, soak the probe for period of time longer than 1 hour in order to be certain that all traces of chlorine bleach are removed.) Then rerinse the probe with clean tap water and retest.

Dry the sonde port and probe connector with compressed air and apply a very thin coat of O-ring lubricant to all O-rings before re-installation. Keep pH probes moist when not in use but NEVER store in DI water.

DEPTH SENSOR

The depth sensor modules are factory installed options that are located between the bulkhead and the sonde tube. For 600XL and 600XLM sondes, there is a circular protective cap with two small holes. The cap cannot be removed, but a syringe is supplied in the maintenance kit to aid in cleaning the pressure port. Fill the syringe with clean water, place the tip of the syringe into one of the holes and gently force water through the pressure port. Ensure that the water comes out of the other hole. Continue flushing the pressure port until the water comes out clean.

CAUTION**:** Never try to remove the circular pressure port cap.

For 6920V2-1, 6920V2-2, 6600V2-2, 6820V2-1and 6600V2-2 sondes, the depth sensor is exposed to the water by either a circular access port on the side of the sonde or a though-hole on a module just above the sonde bulkhead. A syringe is supplied in the maintenance kit to aid cleaning the pressure port. Fill the syringe with clean water, place the tip of the syringe into one of the holes and gently force water through the access port. Ensure that the water comes out of the other hole. Continue flushing the pressure port until the water comes out clean.

CAUTION**:** Do not attempt to remove the depth module from the sonde body.

LEVEL SENSOR

For level sensors follow all the maintenance procedures given for depth sensors. In addition, ensure that the desiccant always remains active. Active desiccant is a distinctive blue color. When it can absorb no more moisture, it is a rose red or pink color. For either the cartridge or the canister, the end that is vented to atmosphere will begin to change color first. As long as the desiccant closest to the sonde is blue, no maintenance is required. Local conditions will dictate how long the desiccant will last. In humid environments, the desiccant may need to be changed or regenerated well before it is completely exhausted to ensure that it lasts the entire deployment.

You may regenerate the desiccant, replace the desiccant in the cartridge or canister, or replace the entire cartridge or canister. See **Appendix G, Using Vented Level**, for more information.

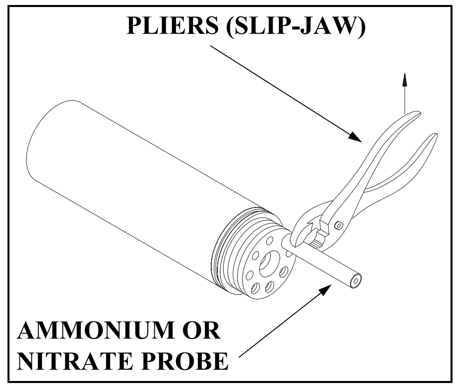
To regenerate the desiccant, remove it from the unit and spread it evenly, one granule deep, on a suitable tray. Heat for about one hour at about 200° C (about 400° F). The desiccant should then be cooled in a suitable, tight container before refilling the unit. The color of the desiccant will return to blue if the regeneration cycle has been successful. The felt filters should also be dried at about 100° C (about 200° F) for about 30 minutes before assembly.

Desiccant material is sold separately. Both the cartridge and canister can easily be opened, emptied, and refilled.

***CAUTION*:** It is important to keep the tube in vented sondes and cables dry. They are supplied with caps for closing the volume when not in use. Keep the caps on until just before calibration and deployment. For storage, replace the caps.

6882 CHLORIDE, 6883 NITRATE AND 6884 AMMONIUM SENSORS

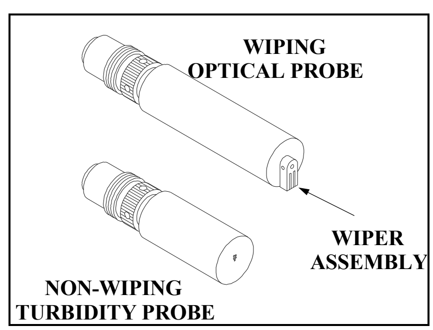
You should clean these probes whenever deposits or contaminants appear on the ion selective membranes located on the tips of these sensor modules. If possible, the module should be cleaned while installed in the sonde bulkhead. Use clean water and a moist piece of lens cleaning tissue to *gently* wipe the sensor membranes until no more contaminants are removed. However, under some conditions, it may be necessary to remove the module from the sonde bulkhead for cleaning and/or storage. To remove the module, follow the diagram at the side. Remove the module with finger pressure only, if possible. However, it is acceptable to use small pliers if necessary to loosen the module for final removal by hand. **Be very careful not to squeeze the module any more than is necessary for a firm grip. Use slipjaw pliers to minimize the chance of applying too much pressure on the module**. While the module is removed from the sonde, be sure to dry the sonde port and probe connector with compressed air and apply a very thin coat of lubricant to the O-ring before re-installation.



NOTE: The ion selective membranes are fragile. Be certain to: (1) Use only *moist*, high quality lens cleaning tissue for the cleaning procedure (not paper towels or other coarse materials); and (2) Stroke the probe face very gently with the tissue during the procedure. *If you do not adhere to these instructions, you can seriously damage the sensors.*

OPTICAL PROBES–6026 AND 6136 TURBIDITY; 6025 CHLOROPHYLL; 6131 BGA-PC; 6132 BGA-PE; 6130 RHODAMINE WT

The 6026, 6136, 6025, 6131, 6132, and 6130 probes require only minimal maintenance. After each deployment, the optical surface on the tip of the turbidity probe should be inspected for fouling and cleaned if necessary by gently wiping the probe face with moist lens cleaning paper. In addition, for the 6025, 6026, 6136, and 6130 probes, we recommended replacing the wiper periodically. The frequency of this replacement depends on the quality of water under examination. A replacement wiper is supplied with the probes, along with the small hex driver required for its removal and reinstallation. Follow the instructions supplied with the probe to ensure proper installation of the new wiper assembly. Additional wipers are available from YSI.



2.10.3 SONDE STORAGE

Proper storage of the your sonde 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.

GENERAL RECOMMENDATIONS FOR SHORT TERM STORAGE

The recommended short term or interim storage procedure is simple and identical for all sondes -- YSI 600R, 600QS, 600XL, 600XLM, 6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, 6600V2-4, and 600 OMS V2-1.

No matter what sensors are installed in the instrument, it is important to keep them moist without actually immersing them in liquid, which could cause some of them to drift or result in a shorter lifetime. For example, the reference junction of a pH sensor must be kept moist in pH 4 or 7 buffer, or tap water, to minimize its response time during usage, but continued immersion in pure water will compromise the function of the glass sensor and/or result in long term leaching of the reference junction.

YSI recommends that short term storage of all multi parameter instruments be done **by placing approximately 0.5 inch of water in the calibration and/or storage cup that was supplied with the instrument, and by placing the sonde with all of the probes in place into the cup.** The use of a moist sponge instead of a half inch of water, is also acceptable, as long as its presence does not compromise the attachment of the calibration cup to the sonde. **The calibration cup should be sealed to prevent evaporation.**

The key for interim storage is to use a minimal amount of water so that the air in chamber remains at 100 percent humidity. The water level has to be low enough so that none of the sensors are actually immersed. Any type of water can be used in this protocol: Distilled, deionized, or tap water. If the storage water is inadvertently lost during field sampling studies, environmental water can be used to provide the humidity.

Sondes with level sensors have a tube that vents the pressure transducer to the atmosphere**. It is important that the air in the tube remains dry at all times.** Sondes with integral cables should be stored with the desiccant in place and the vented end of the desiccant system sealed. Sondes with connectors should be stored with the connector cap firmly in place. When disconnecting the cable, put the cap on immediately. Vented cables should be stored with their caps in place, in a bag containing desiccant.

Interim multi parameter storage is easy. Simply remember the following key points:

- Use enough water to provide humidity, but not enough to cover the probe surfaces.
- Make sure the storage vessel is sealed to minimize evaporation.
- Check the vessel periodically to make certain that water is still present.
- For sondes with level sensors, keep the tube sealed and dry.

GENERAL RECOMMENDATIONS FOR LONG-TERM SONDE STORAGE

The following are long term storage recommendations listed by instrument type. They will be applicable for sondes with typical sensor configurations.

600XL, 600XLM -- Remove the pH or pH/ORP probe from the sonde and store it according to the instructions found in the following section on individual sensors. Cover the empty port with the provided plug. Leave the conductivity/temperature and the dissolved oxygen probes in the sonde with a membrane and electrolyte on the DO sensor. Place enough of deionized, distilled, or tap water in the calibration cup to cover the sensors, insert the sonde into the vessel, and seal with the cap/O-ring to minimize evaporation.

6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, and 6600V2-4 -- Leave the conductivity/temperature and the dissolved oxygen probes in the sonde with a membrane and electrolyte on the DO sensor. Remove all other probes from the sonde and store according to the instructions found in the following section on individual sensors. Cover the empty ports with the provided plugs. Place enough of deionized, distilled, or tap water in the calibration cup to cover the sensors, insert the sonde into the vessel, and tighten the threaded cup to attain a good seal and minimize evaporation.

600R and 600QS (with Replaceable Reference Electrode Module) -- Instruments of this design were generally sold after January, 1996 and can be identified by the presence of 4 probes -- temperature, dissolved oxygen, pH reference, and pH glass (600R) or pH glass/ORP (600QS) in the bulkhead. Remove the reference module, store it as described below, and plug the open port with the insert that was provided. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Place approximately 300 mL of tap water in the storage vessel, insert the sonde, and seal the vessel with the cap and O-ring. **Do not use deionized or distilled water in this case, as it may damage the pH glass sensor that must remain in the sonde.**

600 (with Combination pH Sensor) -- Instruments of this design were generally sold prior to January, 1996 and can be identified by the presence of only 3 probes (temperature, dissolved oxygen, pH) in the bulkhead. Be certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution that is 2 molar (2 M) in potassium chloride (KCl) to a level that completely covers the dissolved oxygen and pH probes. See the following section for instructions on preparation of the KCl storage solution. Seal the vessel with the cap and O-ring.

600 OMS V2-1 – Store sonde dry with optical probe left in port. Cover membrane on ROX sensor with moist sponge.

All Sondes with Batteries – Because batteries can degrade over time and release battery fluid, it is extremely important to remove the batteries from all 600XLM, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, 6600V2-4, and 600 OMS V2-1(battery version) prior to long term storage. Failure to remove batteries can result in corrosive damage to the battery terminals if the batteries happen to leak.

2.10.4 PROBE STORAGE

LONG-TERM STORAGE OF PROBES

The following sections provide additional details on the storage of individual sensors associated with instruments in the 6-Series product line from YSI.

TEMPERATURE

No special precautions are required. Sensors can be stored dry or wet, as long as solutions in contact with the thermistor probe are not corrosive (for example, chlorine bleach).

CONDUCTIVITY

No special precautions are required. Sensors can be stored dry or wet, as long as solutions in contact with thermistor probe 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.

RAPID PULSE DISSOLVED OXYGEN

Rapid Pulse dissolved oxygen sensors should always be stored with a membrane and electrolyte in place and in such a way that the drying out of the electrolyte on the probe face is minimized. For long-term storage, the medium should be water rather than the moist air used in interim storage. The long-term storage protocol is also dependent on the instrument under consideration.

ROX dissolved oxygen sensors should always be stored in a moist environment, i.e., either in water or in water-saturated air with storage in water being preferable. The easiest storage method is to use the protective plastic cap (and enclosed sponge) which was on the probe at receipt. If you have retained this cap/sponge, then simply soak the sponge in water and replace the cap on the probe tip. Inspect the sponge every 30 days to make sure it is still moist. Alternatively, you can remove the probe from the sonde and place it directly in water (making sure that the water does not evaporate over time or leave the probe in the sonde and make certain that the calibration cup has an atmosphere which is water-saturated by placing approximately ½ inch of water in the bottom of the cup and then sealing it snugly to the sonde.

For all 6-series sondes other than the 600R, 600QS, and 600 OMS V2-1, two long-term storage methods are equally acceptable.

1. Remove all probes other than dissolved oxygen (Rapid Pulse or ROX), conductivity, and temperature from the sonde and seal the vacant ports with the provided port plugs. Leave the electrolyte and membrane in place on the Rapid Pulse dissolved oxygen sensor. Fill the calibration cup with water (tap, deionized, or distilled are equally acceptable) and insert the sonde. Make certain the water level is high enough to completely cover the DO sensor. Seal the vessel to prevent evaporation of the water. At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

2. Remove the Rapid Pulse dissolved oxygen sensor from the sonde leaving the electrolyte and membrane in place. Store the probes in water (tap, deionized, or distilled are equally acceptable) in a beaker, flask, or other vessel of the user‟s choice. **Be sure not to damage the membrane or the probe tip when placing the probe on the bottom of the vessel.** If possible cover the vessel with parafilm or plastic wrap to minimize evaporation of the water during long-term storage. Monitor the water level in the storage vessel periodically and replenish if loss due to evaporation occurs. At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

Because the user cannot remove the dissolved oxygen probe of the 600R and 600QS from the sonde, a slightly different long-term storage protocol is required:

For 600 systems equipped with a replaceable reference electrode module, remove the reference module, store it as described below and plug the open port with the port plug that was provided. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution which is 2 molar (2 M) in potassium chloride (KCl), insert the sonde and seal the vessel with the cap and O-ring. This solution can be prepared by dissolving 74.6 g of KCl in 500 mL (approximately 1 pint) of water or 37.3 g of KCl in 250 mL (approximately 0.5 pint) of water. The water should be distilled or deionized. If KCl solution is unavailable, it is acceptable to store the dissolved oxygen and pH glass sensors in tap water. **Do not use deionized or distilled water in this case, as it may damage the pH glass sensor, which must remain in the sonde.** At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

ROX OPTICAL DISSOLVED OXYGEN

When the 6150 sensor is not in field use, it MUST BE STORED IN A MOIST ENVIRONMENT, i.e., either in water or in water-saturated air with storage in water being preferable. If the sensor membrane is allowed to dry out by exposure to ambient air, it is likely to drift slightly at the beginning of your next deployment unless it is rehydrated. Thus, to make the use of the sensor as simple as possible, remember to store it WET whenever possible. The easiest storage method is to use the protective plastic cap (and enclosed sponge) which was on the probe at receipt. If you have retained this cap/sponge, then simply soak the sponge in water and replace the cap on the probe tip. Inspect the sponge every 30 days to make sure it is still moist. Alternatively, you can remove the probe from the sonde and place it directly in water (making sure that the water does not evaporate over time or leave the probe in the sonde and make certain that the calibration cup has an atmosphere which is water-saturated by placing approximately ½ inch of water in the bottom of the cup and then sealing it snugly to the sonde.

pH

The key to pH probe storage, short or long-term, 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 (see dissolved oxygen section above for preparation of this solution). If potassium chloride solution is not available, soaking the sensor in commercial pH buffers or tap water may restore probe function. However in some cases the sensor may have been irreparably damaged by the dehydration and will require replacement. It is also important to remember not to store the pH sensor in distilled or deionized water as the glass sensor may be damaged by exposure to this medium.

The long-term storage protocol is dependent on the instrument.

For all YSI 6-series sondes other than the 600R and 600QS, the recommended long-term storage protocol is identical. Remove the probe from the sonde and seal the vacant port with the provided plug. Place the probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should contain a solution which is 2 molar in potassium chloride, or pH 4 or 7 buffer. Make certain that the vessel is sealed to prevent evaporation of the storage solution.

For YSI 600R and 600QS sondes, remove the reference module and plug the open port with the provided insert. Place the module in the storage vessel boot, which was in place on delivery, and seal the vessel with electrical tape. The vessel should contain a solution which is 2 molar in potassium chloride and should be sealed to prevent evaporation of the storage solution. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided sonde storage vessel with tap water, insert the sonde, and seal the vessel with the cap and O-ring. **Do not use deionized or distilled water in this case, as it may damage the pH glass sensor that must remain in the sonde.**

ORP

Long Term Storage: ORP is not available on the YSI 600R. For the 600QS, where the ORP sensor cannot be removed from the sonde, store the sensor in tap water in a sealed storage bottle. For all other YSI 6-series sondes, the recommended long term storage protocol is identical. Remove the probe from the sonde and seal the vacant port with the provided plug. Place the probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should contain a solution which is 2 molar in potassium chloride. Make certain that the vessel is sealed to prevent evaporation of the storage solution.

AMMONIUM, NITRATE AND CHLORIDE

The active element in the ammonium and nitrate ion selective electrode (ISE) sensors is a polyvinyl chloride (PVC) membrane that is impregnated with the reagent that provides specificity for either ammonium or nitrate. The useful life of this sensor can be reduced if the membrane is stored immersed in water. Thus, storage in dry air is recommended for long term storage. While dry air is slightly preferable for general storage, the short-term storage of these sensors in the sonde, with the entire sensor array in moist air, will have no significant detrimental effect on the life of the membrane. Remove the sensor module from the sonde and cover the vacant port with the provided plug. Place the sensor back in the storage boot that was provided, and set aside in room air.

The chloride ISE sensor utilizes a solid state membrane that provides specificity. For long-term storage, the module should be removed from the sonde, wiped clean with moist lens cleaning tissue, and placed in its storage boot to prevent abrasion.

TURBIDITY, CHLORPHYLL, BGA-PC, BGA-PE, AND RHODAMINE WT

No special precautions are necessary for either the short or long-term storage of these YSI optical probes. However, for long-term storage, the user may wish to remove the probe from the sonde, replace it with a port plug, and store the probe in dry in air to minimize any cosmetic degradation of the probe body and to maximize the life of the wiper.

DEPTH AND LEVEL

No special precautions are required for the sensor itself, but see instructions above with regard to maintaining a dry atmosphere in the vent tube. Sensors can be stored dry or wet, as long as solutions in contact with the strain gauge sensor port are not corrosive (for example, chlorine bleach).

Recommendations are identical for short-term and long-term storage.

SECTION 3 650 MDS DISPLAY/LOGGER

3.1 INTRODUCTION

The YSI 650 Multiparameter Display System (650 MDS) is a powerful, hand held microcomputer based instrument that allows the user to display sonde readings, configure sondes, store and recall data, upload data from sondes and transfer data to computers for analysis and plotting.

Key features of the YSI 650 MDS:
- Completely waterproof case that is submersible to 1 m. Meets IP-67 specification.
- Rugged design with high impact resistance
- Large, non-volatile memory
- Simple cellular phone style keypad.
- Simple intuitive user-interface
- Choice of alkaline batteries or optional rechargeable battery pack
- Fuel gauge display of battery capacity
- User selectable backlight
- Handstrap (standard) or hands free harness (optional) for user comfort
- Optional barometer
- Optional GPS interface
- Compatibility with YSI EcoWatch for Windows data analysis software
- User upgradeable software via the YSI Web page
- CE and Australian C-Tick Compliance.

Partnered with a YSI 6-Series sonde, the 650 will allow the user to easily:
- Display real-time readings from YSI 6-series sondes.
- Log real-time sonde data to internal meter memory with custom site lists.
- Calibrate 6-series sondes.
- Set up 6-series sondes for deployment.
- Upload data from sondes for transfer to PC.

3.2 GETTING STARTED

This section is designed to quickly familiarize you with the hardware and software components of the YSI 650 and its accessories. By the end of Section 3.2 you will have...

- o Unpacked the YSI 650 and confirmed that all components are present
- o Become familiar with the general features and setup configurations of your YSI 650.
- o Installed batteries in the YSI 650.
- o Established communication between your 6-series sonde and the YSI 650.
- o Viewed data from your 6-series sonde on the YSI 650 display.
- o Learned the basics of making alphanumeric entries from the keypad by setting the YSI 650 clock and entering an Instrument ID name.

Successful completion of the above list is essential for you to continue on to Section 3.3, which focuses on the custom setup of the 650. In subsequent sections, you will learn about how to set up sonde menus via the 650 interface, log data to both sonde and 650 memories, and use the GPS and barometer features of the 650.

3.2.1 UNPACKING

Remove the instrument from the shipping box, being careful not to discard any parts or supplies. Use the packing list to ensure all items are included, and inspect all assemblies and components for damage. If any parts are damaged or missing, contact your YSI representative immediately. If you do not know which YSI dealer you obtained your YSI 650 from, refer to Section 8 of your 6-series sonde manual for contact information.

The 650 is offered in four configurations:

- 650-01 – Low memory with no barometer
- 650-02 – High memory with no barometer
- 650-03 – Low memory with barometer
- 650-04 – High memory with barometer

All configurations include the 650 with hand strap and strain relief lanyard installed and the 655174 PC interface cable for use in data transfer to a PC and software updates from a PC. Make certain that you have received these two items (650 itself and PC Interface Cable) during the unpacking process.

The following optional accessories are offered for use with the 650.

- 6113 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6114 110 volt wall charger, and 6117 battery pack included
- 6126 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6123 universal charger, European power cable, British power cable, and 6117 battery pack included
- 6127 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6123 universal charger, China/Australia power cord, and 6117 battery pack included
- 4654 Tripod
- 614 Ultra Clamp
- 5085 Hands Free Harness
- 5065 Form-fitting Case
- 6117 Extra Rechargeable Battery Pack
- 6115 GPS Cable for interface with user-supplied GPS unit
- 616 Cigarette Lighter Charger

If you have ordered any of these accessories with your 650, make certain during the unpacking process that you have received them.

3.2.2 UNDERSTANDING THE 650 MEMORY

The 650 is available with two memory options – “low” and “high”.

The less expensive low memory option (650-01 and 650-03) is designed for users who typically use their 6-series sondes in sampling applications and store limited data to their logger. The available memory of the low memory option (ca. 10 kB) will allow the user to log approximately 150 field readings to a single file in the 650 although the exact logging capability is dependent on the number of parameters active in the 6-series sonde. Note also that if multiple files are utilized, the number of logged field readings will be reduced. In addition, the low memory option will also allow the user to upload small files to the 650 that have been logged to the internal memory of sondes during **Discrete** or **Unattended sampling** studies.

The high memory option (1.5 mB) of the 650 is designed for users who log large files directly to the 650 or who wish to upload large (or many) files to the 650 from the internal memory of sondes which have been used to log data in **Discrete or Unattended sampling** applications. For example, with the high memory option, it would be possible to easily upload the data from 7 sondes, each of which have data files in excess of 200 kB or approximately 75 days at a 15-minute unattended sampling interval.

No matter which memory option has been selected, it is important to understand that the memory resident in the 650 is "Flash", the same type of memory present in YSI 6-series sondes. Flash memory requires no battery backup and therefore stored data cannot be lost due to instrument malfunction – a significant advantage. However, it is not possible to erase individual files from flash memory – to free-up memory, the user must erase (or format) the entire memory chip. From a practical point of view, this means that, while named files which are already present in the 650 memory can be "overwritten" during multiple uploads, the previously written files still occupy space in the memory. These files are in fact designated "deleted" as will be described in Section 3.6.5 below. For example, if a file named "TEST" is uploaded initially with a memory allocation of 50 kB and then is uploaded at a later time (and "overwritten") with a memory allocation of 100 kB, the total memory occupied is 150 KB even though only one file with the designation "TEST" and a file size of 100 kB is shown in the file directory. For this reason, when dealing with large files, the user may wish to transfer files to a PC immediately after upload and then erase the entire flash in order to assure that maximum memory is present for subsequent uploads.

The storing of data directly from sondes to the 650 memory, the uploading of data stored in 6-series sondes to the 650, and the management of these data files are described in detail in Sections 3.5, 3.6, and 3.7 of this manual.

3.2.3 650 CONFIGURATIONS

There are a number of ways that you can configure the YSI 650. Below is a list of possible configurations and corresponding diagrams.

- 650 interfaced to a 6-Series sonde.
- 650 interfaced to a 6-Series Sonde and a user-supplied GPS unit.
- 650 interfaced to a PC for data transfer or software upgrade using the PC interface cable
- 650 with rechargeable battery pack being charged

Figure 1. 650 interfaced to a 6-series sonde.

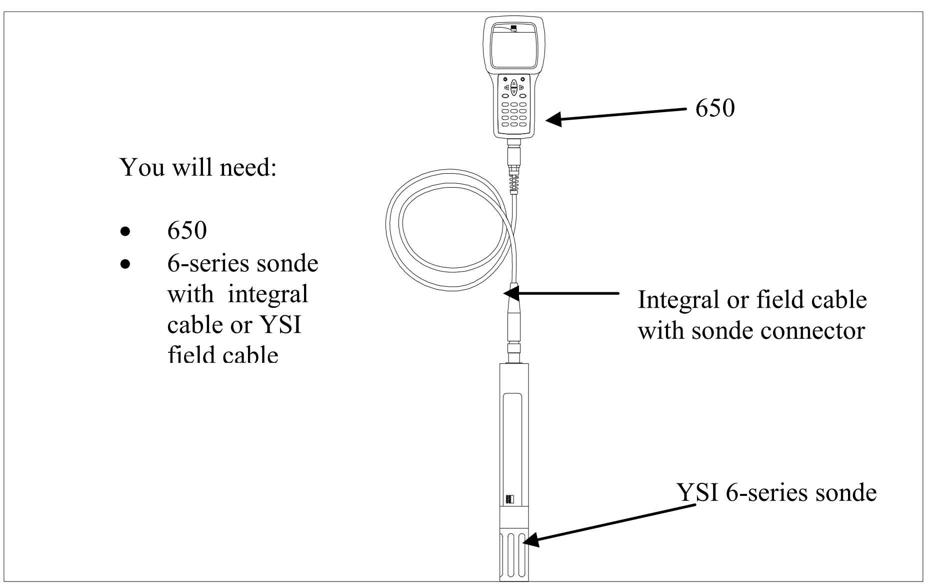


Figure 2. 650 interfaced to a 6-series sonde with user-supplied GPS.

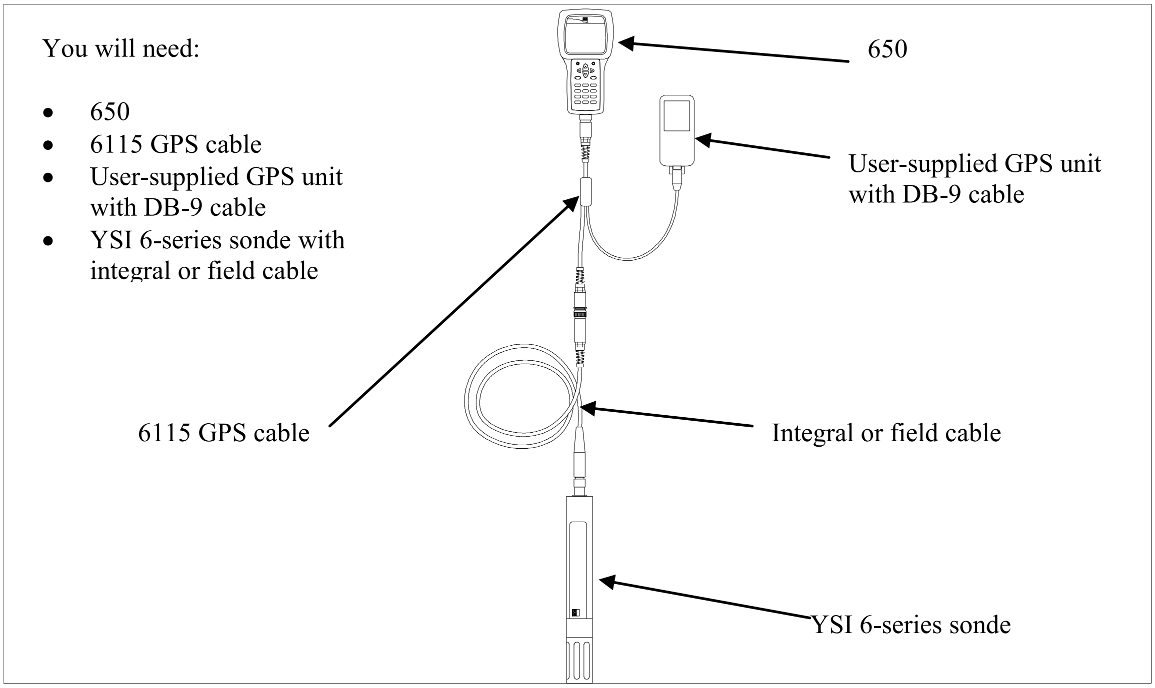


Figure 3. 650 interfaced to PC for data transfer or software upgrade.

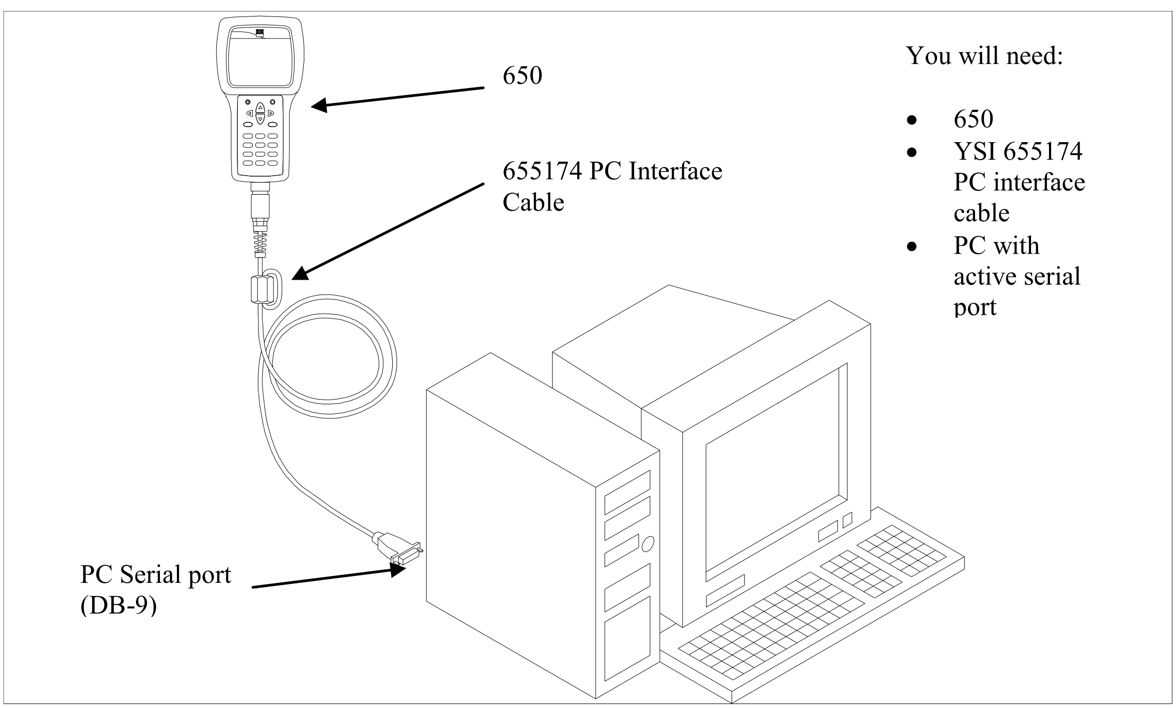
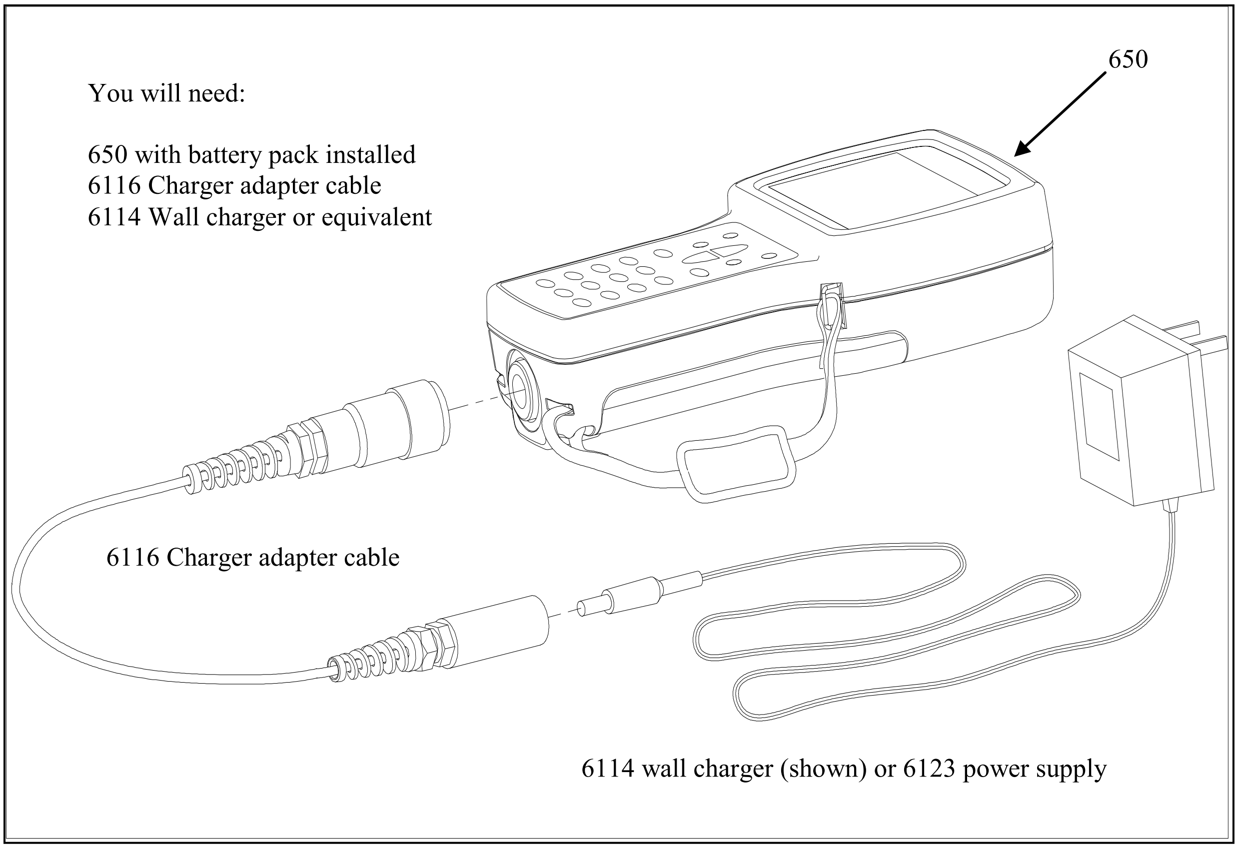


Figure 4. Charging of 650 rechargeable battery pack.



The setup of these configurations is described in detail in subsequent sections of this manual. They are presented here so that your will be able to ascertain if you have all of the parts necessary for your applications.

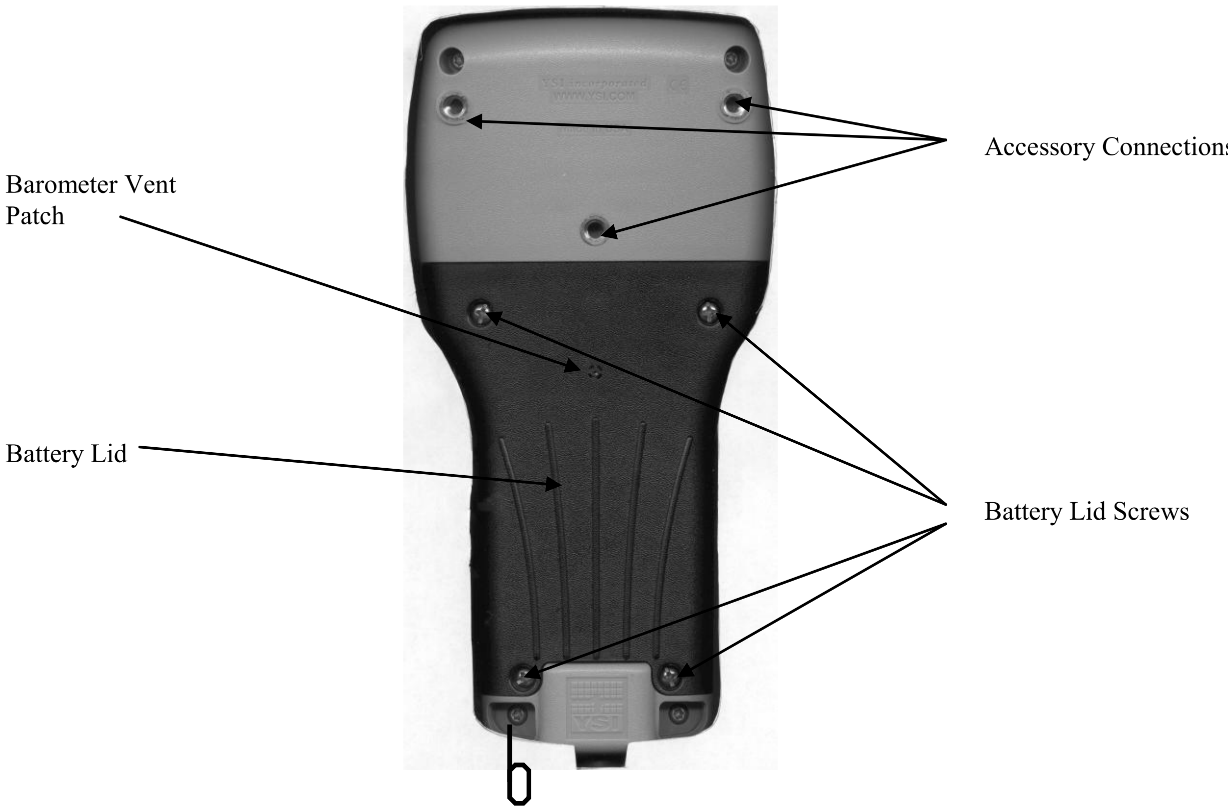
3.2.4 650 FEATURES

The key physical features of the 650 display and keypad are shown in the figures below.

650 Front View

Note that the YSI 650 keypad consists of 20 keys as shown in the diagram above. There are four function keys, up, down, right and left arrow keys and an alpha/numeric keypad. The top left key that has a green circle and line, , is the ON/OFF key. The top right key, , activates the display backlight. The **Escape** key is labeled Esc and is the **Enter** key.

650 Back View



Note that the back of the case contains the battery lid that is attached to the main case with four captive screws and has three fittings for attachment of the ultraclamp and tripod accessories. In addition, the battery lid has a hole that is covered with water-impermeable patch for venting of the optional barometer.

CAUTION: The barometer-venting patch is resident on the inside of the battery lid. Removal of or damage to this patch will result in water leakage into the battery compartment.

The short cord with loop (lanyard) which is attached to the bottom of the case is attached to the strain relief of the sonde cable. Simply open the D-ring, pass the lanyard loop through the opening, and then close the D-ring.

3.2.5 BATTERIES AND CHARGING

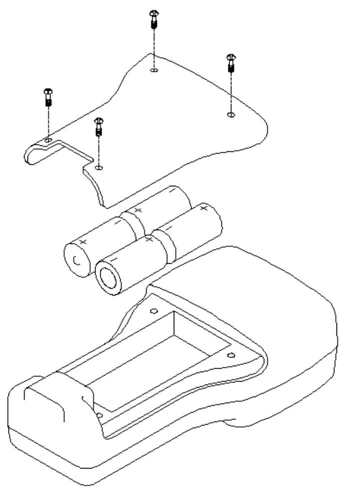
The YSI 650 can be powered either with 4 alkaline C cells or a rechargeable NiMH battery pack. With the C-cell configuration, the user will be able to power a typical YSI 6-series sonde (active dissolved oxygen and one optical sensor) for approximately 45 hours of continuous operation. The rechargeable battery pack will allow for about 15 hours of continuous use under these conditions. If the sonde is being powered by its own internal batteries, the 650 batteries will last much longer. YSI Sondes with internal battery capability are the 6920, 6600, 600XLM, and 600 OMS.

This instrument is powered by alkaline or optional nickel-metal hydride batteries, which the user must remove and dispose of when the batteries no longer power the instrument. Disposal requirements vary by country and region, and users are expected to understand and follow the battery disposal requirements for their specific locale.

The circuit board in this instrument contains a manganese dioxide lithium "coin cell" battery that must be in place for continuity of power to memory devices on the board. This battery is not user serviceable or replaceable. When appropriate, an authorized YSI service center will remove this battery and properly dispose of it, per service and repair policies.

3.2.5.1 BATTERY INSTALLATION – C CELLS

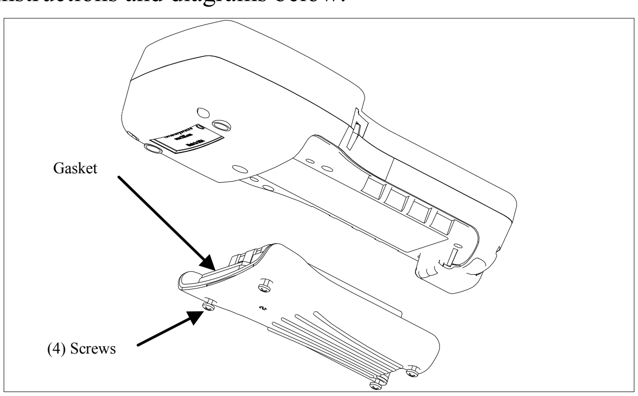
Four C cells install easily into the back of the 650. Follow the instructions and diagrams below to install the batteries properly:



- Using a Phillips or slotted screwdriver, loosen the 4 captive screws on the battery lid and then remove the battery lid completely.
- Insert the cells between the battery clips, being sure to follow the polarity (+ and -) as indicated on the bottom of the battery compartment.
- Make certain that the gasket is properly installed on the battery lid before reinstallation.
- Reinstall battery lid and tighten the 4 captive screws securely and evenly using a Phillips or slotted screwdriver. Do not overtighten.

3.2.5.2 BATTERY INSTALLATION – RECHARGEABLE BATTERY PACK

The YSI 6113 rechargeable battery pack is self-contained and is easily installed according to the instructions and diagrams below:



- Using a Phillips or slotted screwdriver, loosen the 4 captive screws on the battery lid and then remove the battery lid completely.
- Put the battery lid in a safe place so that it will be available for future use of C cells.

- Make certain that the gasket is properly installed on the rechargeable battery before installation.

- Insert the rechargeable battery pack assembly into the battery compartment of the 650.

- Tighten the 4 captive screws securely and evenly using a Phillips or slotted screwdriver. Do not overtighten

3.2.5.3 BATTERY CHARGING – RECHARGEABLE BATTERY PACK

The 6117 rechargeable battery pack is charged via the MS-8 connector on the bottom of the instrument and thus the pack must be installed in the 650 for charging. To perform the charging operation, the user will need to locate the proper power supply (6114 for US/Canada/Japan or 6123 with proper power cord for all other countries) and the 6116 charger adapter cable which were supplied with your rechargeable battery pack (6113 for US/Canada, 6126 for Europe, 6127 for China/Australia). As shown in Figure 4 above, first attach the charger adapter cable to the 650, then insert the barrel connector of the power supply into the barrel of the adapter cable, and finally plug the power supply into an appropriate AC power outlet. The pack can be recharged with the 650 either “on “or “off”. However, if the instrument is “on”, the progress of the charging operation can be viewed in the Status Bar (see Section 3.2.10 below).

To ensure that you get maximum operational time from the rechargeable battery pack, the user should follow the procedures below:

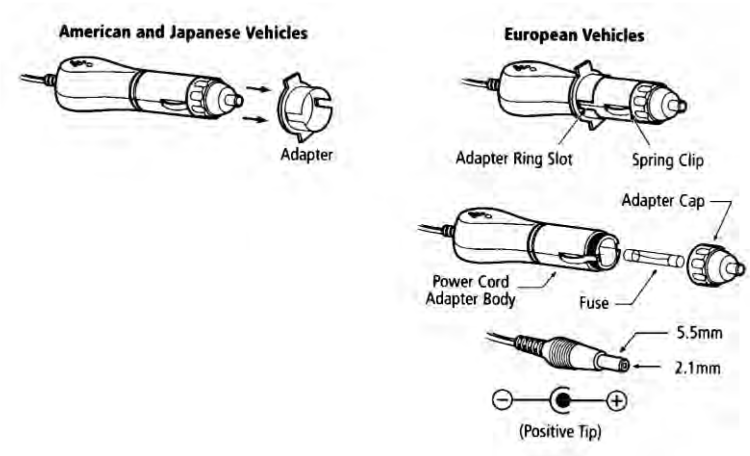
1. Place your display/logger on charge for approximately 2 hours to obtain an 80-90 % regeneration of battery capacity.
2. Place your display/logger on charge for approximately 6 hours to get a full charge.
3. Do not charge the batteries continuously for more than 48 hours.
4. For long term storage, keep your battery pack between the temperatures of –20 C and 30 C and remove it from the 650 case.
5. Do not charge your batteries at temperatures below 0 C or above 40 C.
6. Do not use or store the battery pack at high temperature, such as in strong direct sunlight, in cars during hot weather, or directly in front of heaters.

If the above steps are not followed, it may result in a decrease in the operational lifetime of your battery pack. In addition, pay particular attention to the method of long term storage of the battery pack as is outlined in the following warning:

CAUTION: If the battery pack/650 will not be used for extended periods of time, the user should remove the battery pack from the instrument. Failure to do this may result in overdischarge of the pack which can have a detrimental effect of its lifetime

Note that YSI provides recharge options for many countries in the selection or the 6116, 6126, and 6127 kits. However, it is possible that the power cord options in these kits will not be correct for some users. In these cases, users should purchase the 6126 or 6127 kit and substitute their local PC type power cord for the power cord shipped with the kit. This power cord is usually readily available at any local electronics store.

An optional automotive cigarette lighter charger (YSI 616) is also available for recharging the 650 battery pack. Note that the user will require the 6116 adapter cable to use the cigarette lighter adapter. Instructions and diagrams for configuring your cigarette lighter charger and changing fuses are shown below and are found on the back of the 616 package. The user should save these instructions when unpacking the accessory and keep them for later reference.



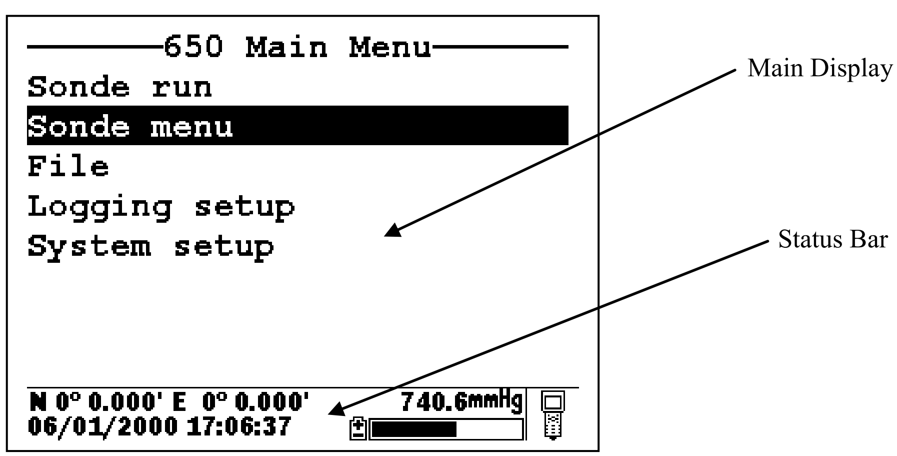
To use the device with an American or Japanese vehicle, slide the adapter ring off of the plug. To use the device with a European vehicle, leave the adapter ring on the plug and position it so the slots on the ring line up with the plug's spring clips. To begin charging your battery pack, first plug the barrel connector of the cigarette lighter charger into the mating end of the 6116 adapter cable. Then attach the MS-8 end of the 6116 adapter cable to the 650. Finally, plug the other end of the cigarette lighter charger into the vehicle's lighter socket.

The 616 cigarette lighter charger contains a 2-ampere fast-blow type fuse. If the power cord stops working properly, unscrew the adapter's cap, remove the tip, and then pull out and check the fuse. See diagram above to remove the fuse. If the fuse is blown or you are unsure, replace it with a new 2-amp fast-blow fuse that is available at electronics stores such as Radio Shack. Reassemble the adapter and securely screw the cap back onto the adapter body.

After you have installed batteries or the rechargeable battery pack into your 650, you are ready to proceed to the next sections.

3.2.6 TURNING THE INSTRUMENT ON

Turn the instrument on by pressing and releasing the on/off button on the top left of the instrument keypad. The following screen should be displayed.



Note that the screen is divided into two sections – the "Main Display" at the top and a "Status Bar" at the bottom. The Main Display will provide access to the 650 and sonde menus and will be used to view sonde sensor readings in real-time, to configure the 650 and the sonde, to calibrate the sonde sensors, and to log data to either sonde or 650 memory. The Status Bar will always show the date and time of the 650 clock (updated in real-time), the remaining battery capacity, the current barometer reading if you have purchased this option, the GPS readings from a user-supplied GPS instrument, and will indicate whether the menu being viewed in the Main Display is associated with your sonde or the 650. Additional information about the Status Bar will be provided in Section 3.2.10 of this manual.

You may also want to take the instrument into a dark room and, with the instrument turned ON, press the backlight key which is located at the top right of the keypad. The instrument backlight should illuminate the LCD so that the display can be read. Pushing the backlight key again will turn the backlight off. The backlight will power off automatically after two minutes of non-use.

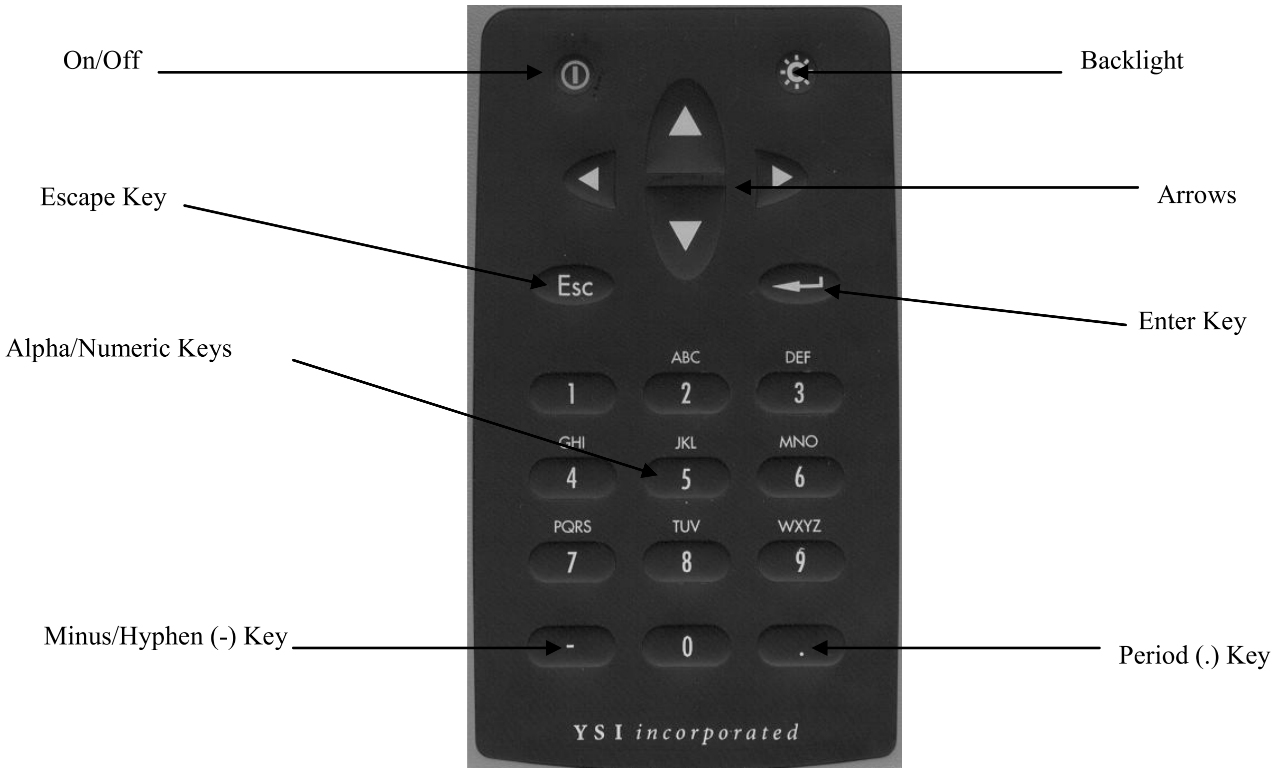
3.2.7 ADJUSTING THE DISPLAY CONTRAST

The contrast of the 650 display is automatically temperature compensated to provide a proper display under most field conditions (-10 to 40 C). Some users, however, may wish to alter the display contrast to meet their own preference. In addition, if the instrument is used at more extreme temperatures, the display is likely to require some adjustment.

The contrast is easily adjusted by pressing and holding down the backlight key in the upper right of the keypad and then pressing repeatedly or holding down the up/down arrow keys while observing the display. Pressing the up arrow while holding down the backlight key increases (darkens) the contrast; pressing the down arrow under these conditions decreases (lightens) the contrast.

NOTE: The backlight itself will only be activated if the backlight key is pressed and released. You must hold down the backlight key to adjust the contrast.

3.2.8 USING THE YSI 650 KEYPAD



The 650 keypad allows the user to navigate various sonde and 650 menu selections and to make alpha/numeric entries into both the 650 and sonde software. The arrow keys are used to select various options in the menus; the cellular phone-style alpha/numeric keys allow data entry; the **Enter** key is used to confirm selections; and the **Escape** key returns the user to the previous position in the menu structure.

The alpha/numeric keys of the 650 can be used to enter both numbers and letters. For many entries, however, where only numbers are appropriate, the software automatically allows ONLY numeric entry, e.g., the letters (ABC) associated with the "2" key cannot be activated. Examples of this type of fixed numeric entry include setting the clock of the 650 or sonde, entering calibration parameters for sonde sensors, and changing entries such as DO warm-up time and optical wiper interval in the **Sonde Advanced|Sensor** submenu. You will follow an example of this type of entry when you set the 650 clock in the example below.

When both numeric and alpha entry are appropriate for input, the 650 keypad provides a cellular phone-style interface for choosing the proper character. As shown in the above diagram, the 2-9 keys can also be used to input alpha characters. Basically, to activate a particular alpha/numeric character, the user must press the appropriate key repeatedly until the desired letter or number appears in the display. For example, to enter an M, press the numeric 6 key once and release. To enter an N, press the numeric 6 key twice in rapid succession and then release. Lower case letters are also available for input using this basic method. The following chart shows the alpha/numeric sequence available for each numeric key in the order they will appear as the key is pressed repeatedly.

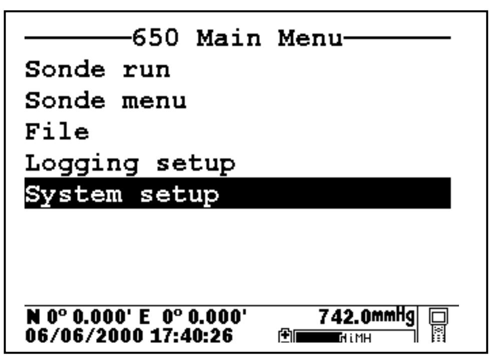
1 -- 1
2 – ABC2abc2
3 – DEF3def3
4 – GHI4ghi4
5 – JKL5jkl5
6 – MNO6mno6
7 – PQRS7pqrs7
8 – TUV8tuv8
9 – WXYZ9wxyz9
0 -- 0

Using this guide, it can be seen that the character "p" will appear and remain in the display by pressing the 7 key six times in succession. The other characters associated with this key ("P", "Q", "R", "S", and "7") will appear during the repeated pressing of the numeric 7 key. However, only the "p" entry will be retained after the key is released after the six keystrokes.

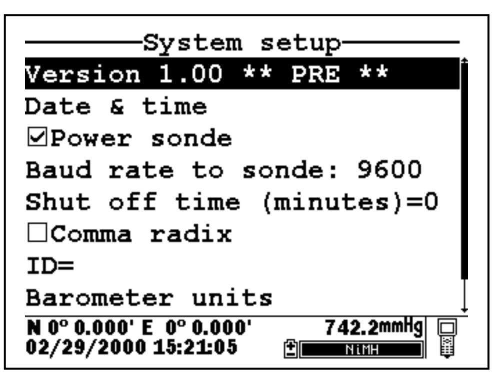
After release of the numeric key for approximately 1second, the cursor will automatically scroll to the right to prepare for the next alphanumeric input. If you make a mistake in the entry, simply return to the previous character with the left arrow key and reenter the number or letter. After the entry is complete, press the **Enter** key to confirm it. You will follow an example of this type of entry when you enter an Instrument ID name for your 650 in the example below.

To familiarize yourself with the basics of the keypad entry system, follow the instructions below to set the date and time for your 650 and to enter an Instrument ID:

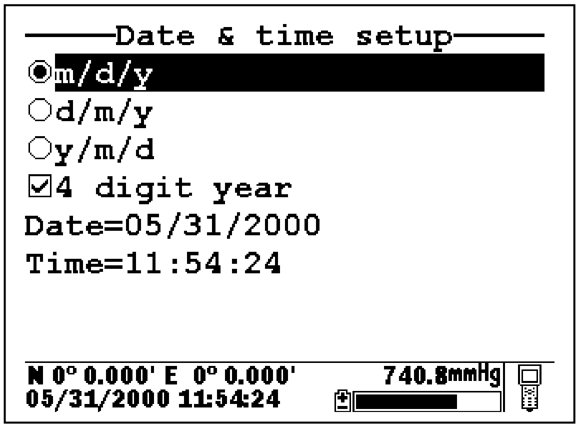
Turn the instrument on to display the **650 Main menu**.



Use the arrow keys to highlight the **System setup** selection and press the **Enter** key. A display similar to the following will appear (Note that the exact format of your displays will depend on the software version):



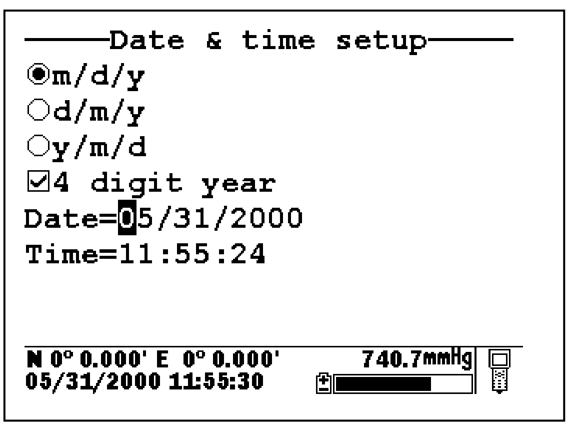
Use the arrow keys to highlight the **Date and Time** selection and press the **Enter** key. The following display will appear:



Highlight the selection for your desired date format and press **Enter** to confirm it.

Highlight the 4-digit year selection and press **Enter** to toggle between 2-digit (no check mark present) and 4-digit (check mark present) options.

Highlight the **Date** selection and press **Enter**. A cursor will appear over the first number in the date as shown in the following display.

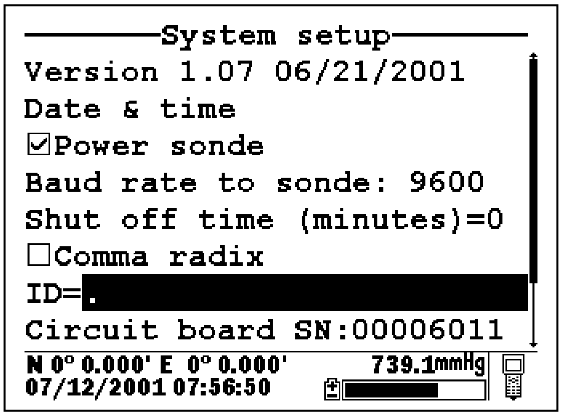


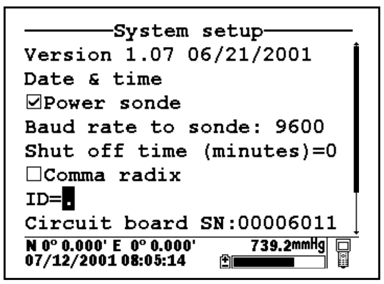
Enter the proper number from the keypad for the first date digit. Note that when you release the key, the cursor moves automatically to the next number. Repeat this process until the date is correct. Then press **Enter** to confirm the Date entry. Note also that, as described above, since alpha characters are inappropriate for this entry, only numeric entry is possible.

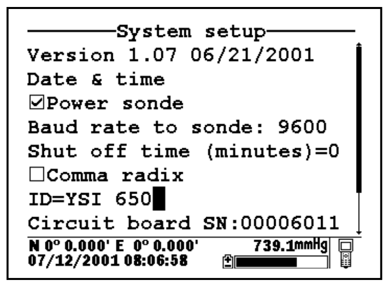
Highlight the **Time** selection and press **Enter**. Repeat the process described above for the **Date** to enter your correct local time using the military format. For example, 2:00 PM must be entered as 14:00.

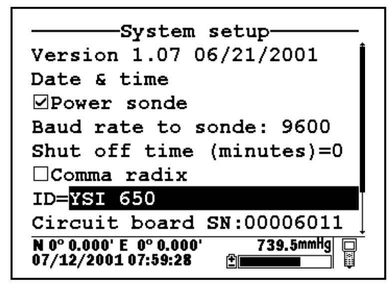
Finally, press the **Escape** key to return to the System setup menu.

Now highlight the **Instrument ID** selection and press **Enter**. The following display will appear.









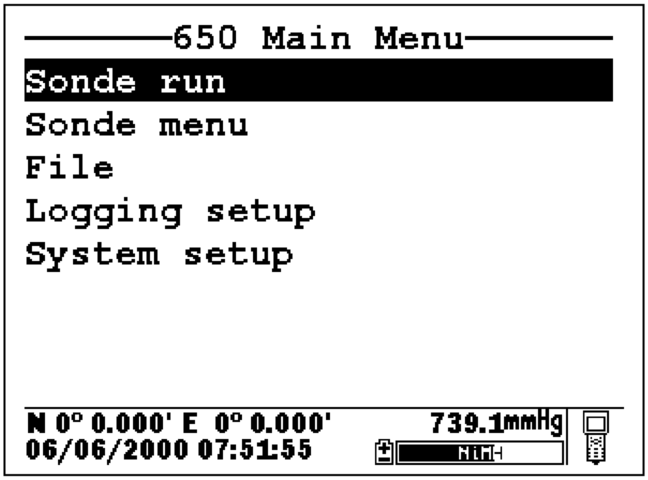
As shown above, enter the designation "YSI 650" using the general instructions outlined above. Start by pressing the numeric 9 key three times in rapid succession while viewing the characters on the display until a "Y" appears. After the entry is complete, pause and the cursor will automatically move to the next entry position. Now press the numeric 7 four times in succession while viewing the characters on the display. When an "S" appears, pause and the cursor will move automatically to the next entry position. Continue with the entries in this way until ID designation is complete. If you make a mistake, you can use the left arrow key to highlight the flawed entry and correct it. When the entry is complete, press **Enter** to confirm it. Note that for this example, where both alpha and numeric entries are appropriate, the user must press the numeric 2 key 4 times in succession to generate the number 2, as opposed to the previous clock-setting example where a single press of the numeric 2 key generated the number 2.

After completing the above example, press the **Escape** key repeatedly to return to the **650 Main menu** and then proceed to the next section.

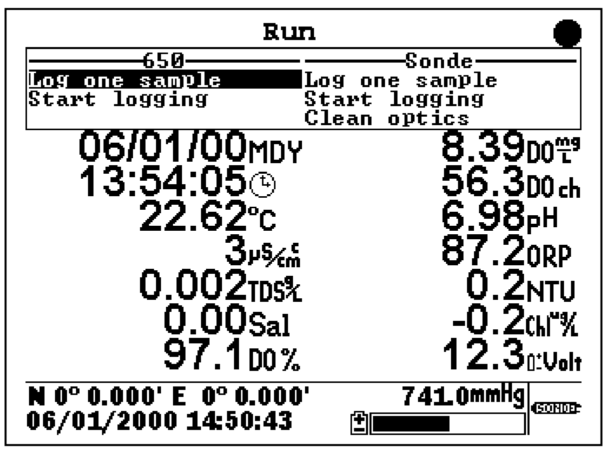
3.2.9 CONNECTING TO A SONDE

The primary use of the 650 is to interface with YSI 6-series sondes. In this configuration, you will be able to see data from the sonde sensors in real-time on the 650 display as well as to configure the sonde for your particular application. In addition, once sonde interface is established, you will be able to easily log data from the sonde sensors to either the memory of the sonde or the memory of the 650 for later analysis.

The connection between the sonde and the 650 is made via the mating of MS-8 connectors on the standard YSI field cable and the bottom of the 650 case. To make the connection, hold the 650 in one hand, place the 650 and cable connectors together, and rotate the field cable connector until engagement occurs. Then rotate the field cable connector approximately 1-quarter turn until it is fully engaged as evidenced by a “click”. After connecting the sonde to the 650, press the “on” button on the upper left of the 650 keypad to activate the **650 Main menu** as shown below:



Using the arrow keys, highlight the **Sonde run** entry in the Main 650 Menu and press the **Enter** key. Readings from the 6-series sonde sensors will appear on the 650 Main Display in real-time as shown in the following diagram.



The two windows at the top of the display give the capability of logging the displayed readings to either the 650 (top left) or the sonde (top right) memory and allow the user to activate the wiper on turbidity, chlorophyll, and rhodamine WT probes if they are present in the sonde. Instructions for use of these windows are provided in subsequent sections of this manual.   Note also that there is a disk with rotating segments in the upper right corner of the display whose movement confirms that the 650/sonde interface is functional.

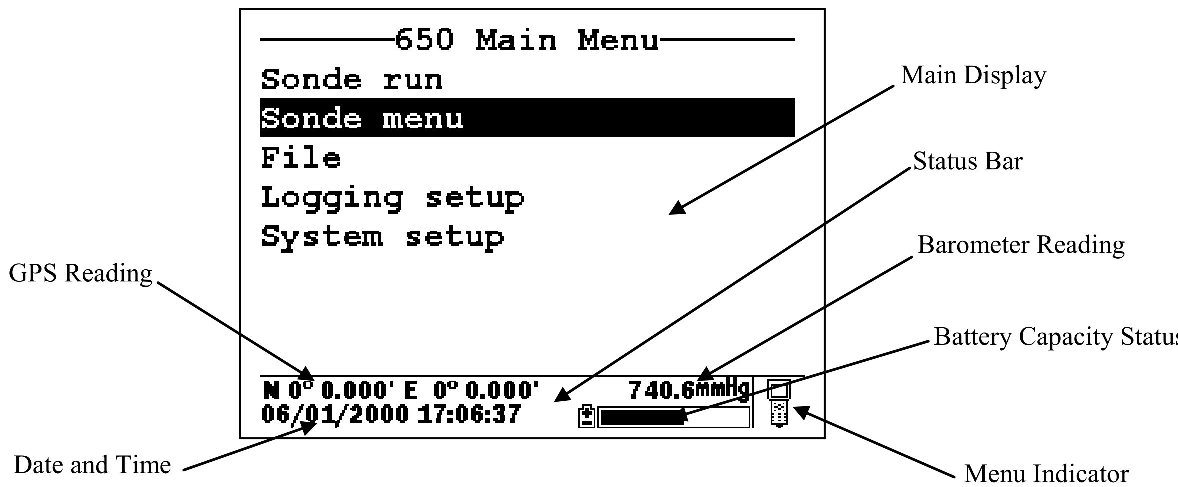
To return to the **650 Main menu**, press the **Escape** key.

CAUTION: When using the 650 MDS in field applications which are in close proximity to communication towers and heavy industrial equipment, or which involve very low humidity conditions, the user may experience problems with logger function.   If possible, the user should relocate the sampling site away from these potential sources of interference. In most cases, symptoms will involve instrument shutdown or display lockup. These problems can usually be overcome by either simply pressing the on/off key to reactivate the meter display or by resetting the instrument by removal of battery power as described in

Section 3.11 of this manual. If symptoms persist after these actions, consult YSI Technical Support for advice.

3.2.10 UNDERSTANDING THE STATUS BAR

The diagram below shows the various components of the Status Bar of your 650. Each item identified in the drawing is explained in detail below.



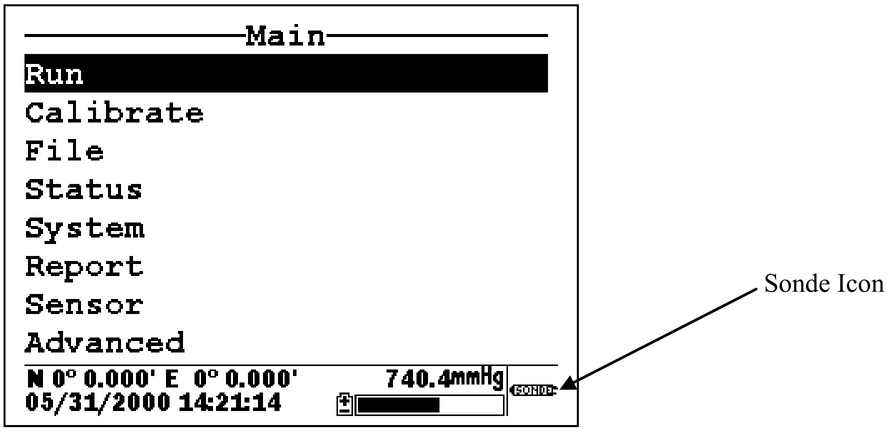
2.10.1 Date and Time. This is the date and time for the clock in the 650, set by the user from the **System setup** menu as described above. The date and time entries are updated in real-time in the Status Bar.

2.10.2 GPS Reading. This value will be present only if a user-supplied GPS unit with NMEA 0183 format is connected to the 650 by the optional YSI 6115 cable. The setup of a GPS interface is described in more detail in Section 3.8 below. Once properly connected to a GPS instrument, the values displayed in the Status Bar are updated in real-time as the system is moved from location to location.

2.10.3 Barometer Reading. This value is the current local barometer reading in units selected by the user in the **System setup** menu. The value is can be used simply as a meteorological parameter or can be used in calibration of sonde dissolved oxygen sensors. The barometer reading is NOT corrected to sea level and is updated in real-time.

2.10.4 Battery Capacity Status. The graphic indicator shows the portion of the battery capacity that is remaining, either for the 4-C cell configuration or for the optional rechargeable battery pack. If a 6117 rechargeable battery pack is in place, a "NiMH" label will appear as part of the indicator. During charging of the battery pack, the black portion of the icon will pulse horizontally until charging is complete. In addition, the entire battery indicator will flash when your batteries are almost exhausted and require replacement (C-cells) or recharge (optional rechargeable battery pack).

2.10.5 Menu Indicator. This icon is located in the lower right portion of the Status Bar and provides a guide as to whether the menu on the display of the 650 originates in the sonde or the 650 itself. The icon shown in the figure above represents a 650 menu; if the menu on the display had originated in the sonde, the Status bar would display a sonde-like icon as shown below.



3.2.11 UPGRADING ECOWATCH FOR WINDOWS SOFTWARE

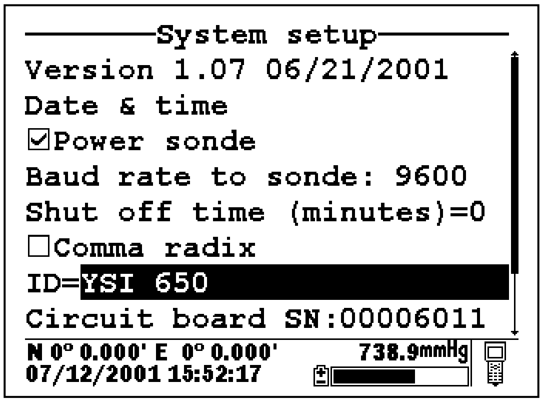
To utilize the full capability of the 650 MDS, you will need to upgrade your version of EcoWatch for Windows from the YSI World Wide Web page (www.ysi.com). Access the YSI Environmental Web Page, select “tech support” from the header, and then “Downloads”. After registration, select the EcoWatch for Windows upgrade entry and follow the instructions provided. After the upgrade is complete, your software version (viewed from the EcoWatch toolbar entry **Help|About EcoWatch**) should be 3.13.00 or higher.

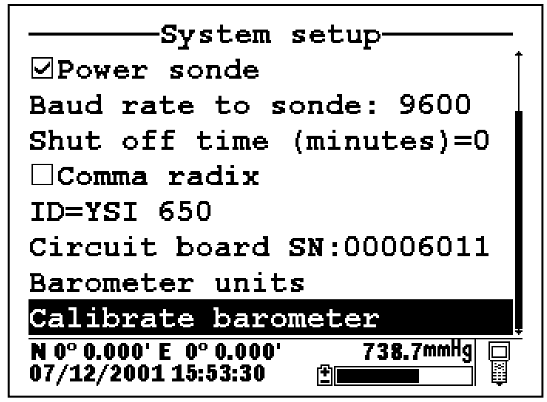
If you encounter difficulties in the upgrade procedures, contact YSI Technical Support for advice.

After reading the above sections and participating in the simple examples provided, you should be familiar with the basics of battery installation, keypad and display function, and keypad data entry. Please proceed to Section 3.3 where the setup of your 650 is described in detail.

3.3 SETTING UP THE 650

The 650 has a number of features which are user-selectable or which can be configured to meet the user’s preferences. Most of these choices and selections are found in the **System setup** selection in the Main 650 Menu. To explore the various setup possibilities of the 650, turn the instrument on, select **System setup**, and press **Enter**. The following display will appear. The second display can be observed by scrolling to the bottom of the **System setup** entries with the down arrow.





YSI suggests that the user become familiar with the features provided in the list below prior to using the 650 in field applications. Each item is described in some detail below.

3.3.1 Software version

The software version of your 650 is shown in the first line of the **System setup** menu. As enhancements are introduced to the 650, you will be able to upgrade your 650 from the YSI web page. This item will be used to track those upgrades and will be useful to YSI Technical Support personnel if you have questions about the function of the instrument.

3.3.2 Date and time:

As described above in Section 3.2.8, activate this selection to set the date and time from the 650 keypad.

3.3.3 Power sonde:

If this choice is active, your 6-series sonde will be powered directly from the 650 batteries. The choice MUST be active if you are using a sonde with no internal batteries (600R, 600XL, or 6820). If using a sonde with internal batteries (600XLM, 6920, 600 OMS battery version, or 6600), you can extend the life of your 650 batteries by deactivating this selection. Note that the selection MUST BE OFF in order to determine the voltage of the internal batteries of sondes – important information for Unattended studies.

3.3.4 Baud rate to sonde:

This entry allows the user to adjust the baud rate for communication with the sonde. It does not affect communication for upload of files to a PC. Highlight the entry and press **Enter**. Then select the baud rate of choice and press **Enter** to confirm it. **CAUTION:** The baud rate for the 650 MUST match that in the sonde (usually set at 9600) or communication with the sonde will not be possible. Unless you know that your sonde is set to a baud rate different than 9600, YSI strongly recommends that you leave the baud rate for the 650 set to the default value of 9600.

3.3.5 Shutoff Time:

This value represents the number of minutes until the 650 automatically shuts down to save batteries. Values can be integers from 1 to 15 or enter "0" to disable the shutoff completely.

3.3.6 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. If you change your radix mark in the 650, make sure that you also change it to the same symbol in the sonde **Advanced|Setup** menu.

3.3.7 ID
Activate this item and **Enter** choice of instrument identification (limit 11 characters) for your 650 as described in Section 3.1.8 above.

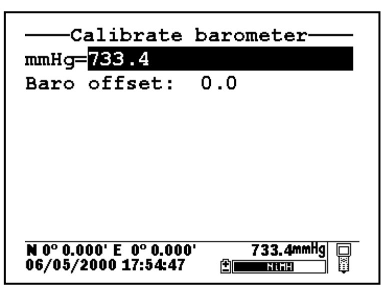
3.3.8 Circuit board SN
This item identifies the serial number of the circuit board resident in your 650. It cannot be changed by the user.

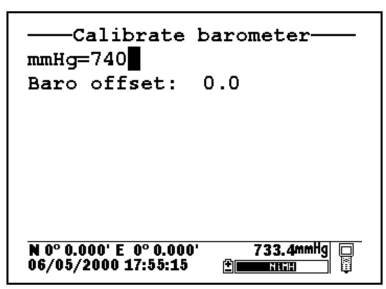
3.3.9 Barometer Units:
Highlighting this selection and pressing **Enter** will activate a display which will allow you to select the units of barometric pressure which will appear in real-time in the display Status Bar. Highlight the desired units and press **Enter** to confirm the selection. This entry will only appear if you have ordered your 650 with the barometer option.

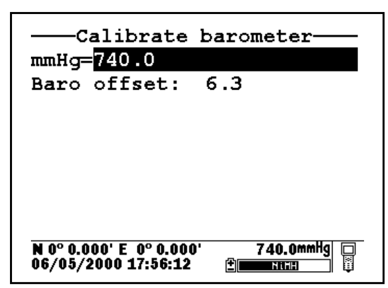
3.3.10 Calibrate Barometer
You may need to scroll down with the arrow keys to view this selection which allows you to calibrate the optional barometer to your local barometric pressure. While the barometer has been factory calibrated and should provide accurate readings on receipt, some sensor drift may occur over time, requiring occasional calibration by the user. Proceed as follows:

Determine your local barometric pressure. This value is usually obtained from an independent laboratory barometer. You can also obtain a barometric pressure value from your local weather service. This latter value has usually been corrected to sea level and therefore must be "uncorrected" before it can be used in calibration of the 650 barometer. See Section 3.9 of this manual for details.

Select **Calibrate barometer** and press **Enter**. Input the known barometric pressure from the 650 keypad in the selected units (mm Hg in the following example) and press **Enter**. Note that in the example, the barometer output has changed from 733.4 (the previous incorrect value) to 740 (the correct value from your laboratory barometer). Note also that a value of the approximate barometer offset which occurred during the calibration (6.3 mm Hg) is present in the display. The offset value is approximate due to the variation in the tenths of a mm digit of the sensor. This value can be used to return the sensor to its factory calibration; simply recalibrate the sensor to a new value which is determined by (current value) – (offset).







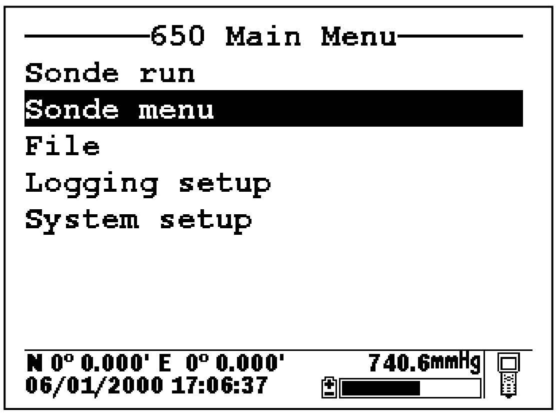
Note that this entry will only appear if your have ordered your 650 with the barometer option.

NOTE: After initial calibration of the barometer, a file with a name defined by the Circuit Board ID and a .glp extension (e.g., 00003245.glp) will automatically be generated and stored in 650 memory. Each additional barometer calibration record for will also be stored. See Section 6.3 below for the transfer of this file to a computer for viewing and storage.

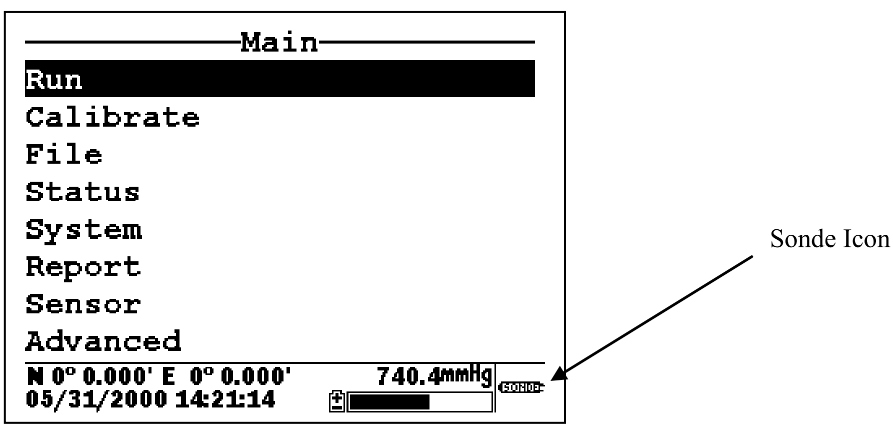
3.4 SONDE MENU INTERFACE

3.4.1 INTRODUCTION

The **Sonde menu** selection in the **650 Main menu** provides a terminal-like interface simulating the connection of the sonde to a PC as described in detail in Section 2 of the 6-series manual. Thus, this item provides access to the entire menu structure of your 6-series sonde software so that you can perform custom setup in the same way that would be possible if the sonde were attached to a PC.



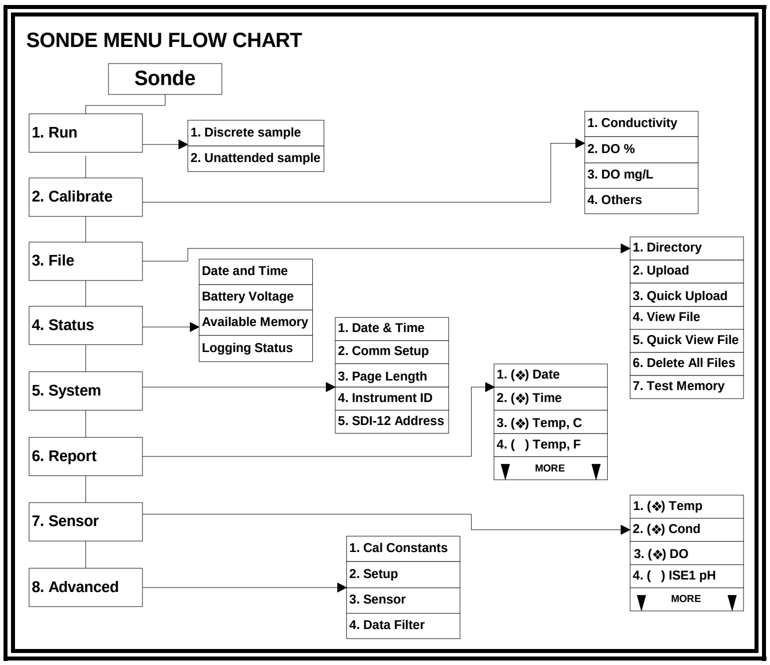
From the **650 Main Menu**, select **Sonde menu** and press **Enter**. A display similar (depending on sonde type and sonde software version) to that shown below will appear:



Note that the icon in the lower right of the screen has changed from “meter” to “sonde” indicating that the menu shown originates in the 6-series sonde. Note also that the 650 display has been designed to be very similar to that presented on a monitor when a 6-series sonde is attached to a PC as shown below.

```
------------------Main--------------
---
1-Run                5-System
2-Calibrate          6-Report
3-File               7-Sensor
4-Status             8-Advanced
```

In fact, the only significant difference between the two interfaces is that, for the PC mode, submenus are accessed by entering the number associated with the specific item, while for the 650 mode the user must use the arrow keys to highlight the item and press the **Enter** key to activate it. Thus, the description of the 6-series sonde menu structure and function which is found in your sonde manual is completely valid as a reference for setting up your sonde for all types of studies. The menu structure of the sonde is presented in diagram form below, followed by two examples in Section 3.4.2 of how to use the **650 Sonde Menu** interface. In addition, brief instructions for frequently performed sonde operation are provided as a reference in Section 3.4.3 below.



NOTE: When using the 650, all sonde functions are accessed through the **Sonde menu** prompt. These include:

- Activating/Deactivating sensors
- Setting up the desired Report output
- Calibrating the sensors
- Changing the sample interval for Discrete Sample studies
- Performing file management functions on the memory in the sonde
- Checking the **Status** or **System setup** of the sonde.
- Setting up sondes for **Unattended sample** deployments.
- Setting up sondes for **Discrete sample** logging studies to sonde memory.
- Uploading files from the sonde memory to the 650.

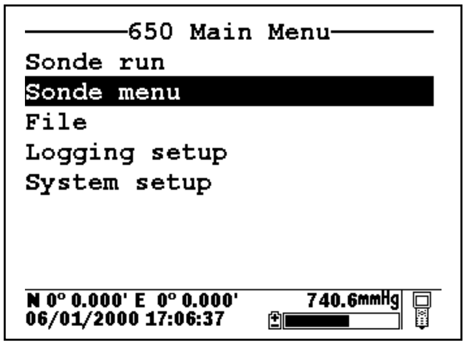
Earlier YSI display/loggers, such as the 610 D and 610 DM, had many of these functions as distinct items in the display menu structure – a significant difference from the 650.

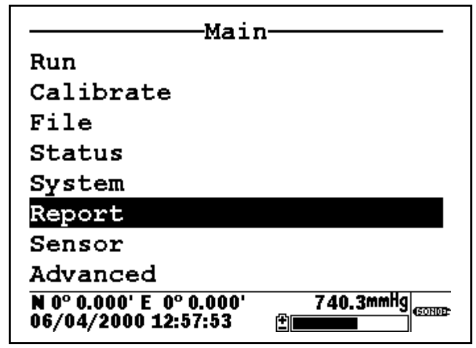
3.4.2 SONDE MENU EXAMPLES

To become familiar with the **650 Sonde menu** function, YSI recommends that the user connect a sonde to their 650 and proceed through the following two examples of common sonde interface operations.

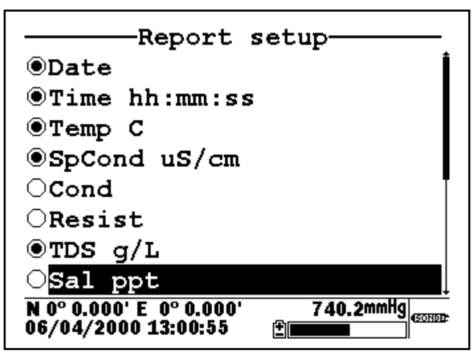
Example 1: Setting up the Report Output – Activation of the Salinity Parameter

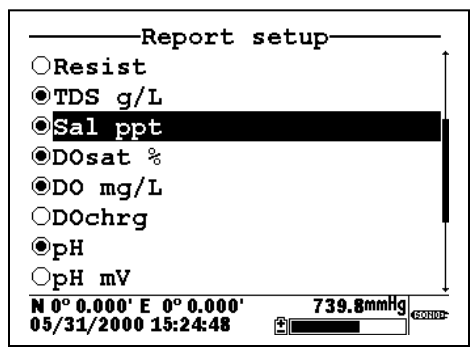
Highlight the **Sonde menu** selection in the 650 Main menu and press **Enter**. Then use the arrow keys highlight the **Report** selection and press **Enter** again.





Use the arrow keys to highlight the **Salinity** selection and then press the **Enter** key to activate the parameter as shown by a dot in the open circle. Note that the entire report list can be accessed by continuing to scroll the highlighting block down with the arrow key. After activation of salinity in the **Report** setup of the sonde, press the **Escape** key twice in succession to return to the **Main sonde** menu.



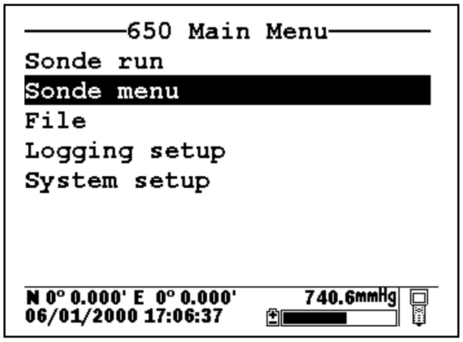


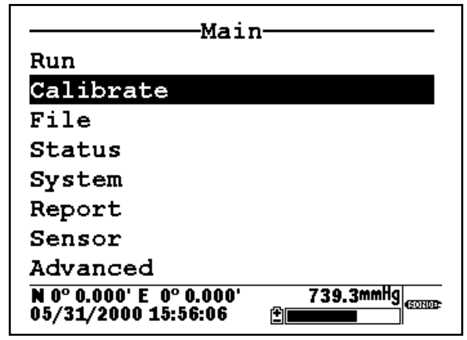
Example 2: Calibrating the Dissolved Oxygen Sensor

NOTE: In the following example, it is assumed that the **Autosleep RS232** function of your sonde has been disabled in the sonde **Advanced|Setup** menu. If **Autosleep** were active, then the display would indicate a countdown of the DO warm-up time and calibrate automatically at the end of this time period. See Section 3.4.9 of this manual and Section 2 of your 6-series manual for more information on the **Autosleep** function.

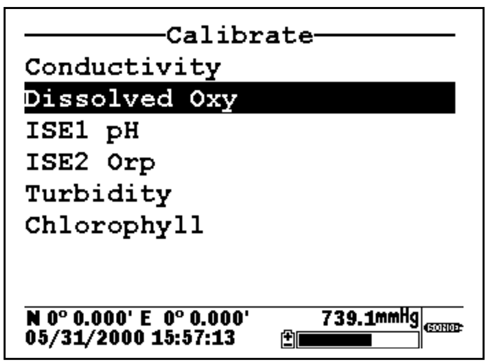
Place the sonde in the calibration chamber with the dissolved oxygen probe in water-saturated air.

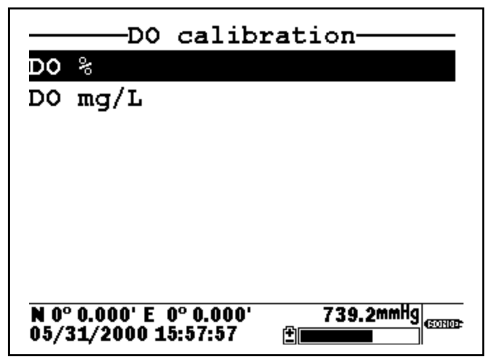
Highlight the **Sonde menu** selection in the 650 Main menu and press **Enter**. Then, use the arrow keys to highlight the **Calibration** selection and press **Enter**.





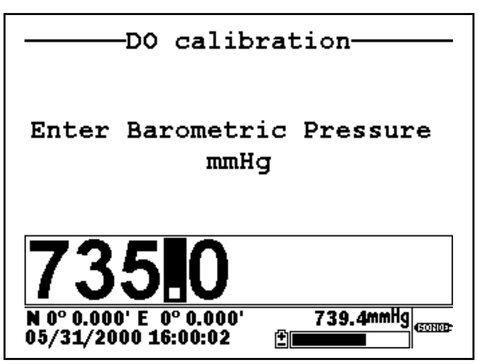
Use the arrow keys to highlight the **Dissolved Oxygen** selection and press **Enter**. Then, Use the arrow keys to highlight the **DO%** selection and press **Enter**.

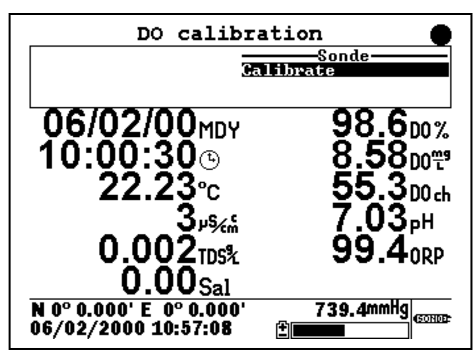




Use the 650 numeric entry keys and the right/left arrow keys to enter the current local barometric pressure. Then, press the **Enter** key and observe the dissolved oxygen reading until stabilization occurs. Make sure the **Calibrate** selection is highlighted in upper window.

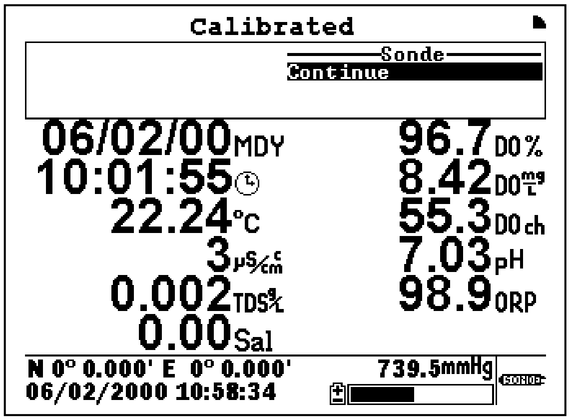
NOTE: The current barometric pressure as read by your 650 will automatically appear as the default value if your 650 is equipped with a barometer.

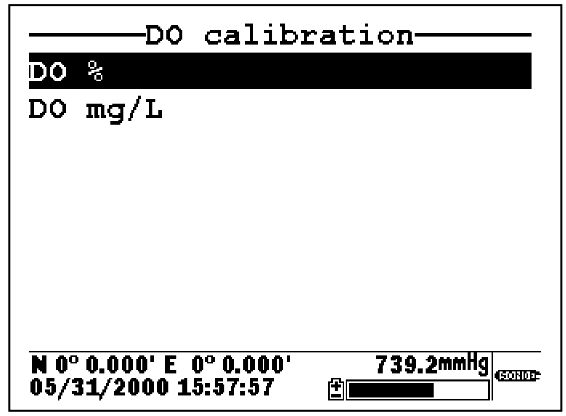




When the dissolved oxygen reading is stable, press the **Enter** key to confirm the calibration as indicated by the message "Calibrated" in the header. In addition, the message in the upper window will change from

“Calibrate” to “Continue”. Make sure that “Continue” is highlighted and press **Enter** to return to the **DO calibration** menu.





3.4.3 COMMON OPERATIONS USING THE 650 SONDE MENU SELECTION

The following section provides brief instructions for carrying out frequently used sonde activities via the **Sonde menu** selection of the 650. The instructions do not provide the detail of the examples above, assuming that the user understands how to navigate the menus with the **Enter**, **Escape**, and **Arrow** keys and is able to make alpha/numeric entries from the keypad.

3.4.3.1 Running the sonde in real-time

This function can be accomplished either automatically from the **Sonde run** selection of the 650 menu or by using the **Sonde menu** selection to activate the **Run|Discrete Sample** submenu of the Main 6-series menu. If the **Sonde run** selection is made, data automatically appears on the screen at a sample interval of approximately 1 second. However, if the user chooses to use the **Run** function from the sonde menu, the sample rate can be set to higher values in the Discrete Sample menu. This feature will be described in detail in Section 3.5.2. To **Run** the sonde from the **Discrete sample** menu, highlight **Start sampling** and press the **Enter** key.

3.4.3.2 Setting up a sonde for deployment

Use the **650 Sonde menu** selection to access **Run|Unattended sample** and then proceed with the setup for the monitoring study as described in detail in Section 2 of the 6-series manual. Use the keypad to set the sample interval and input file and site names. Then highlight **Start logging** and press **Enter** to begin the Unattended study in which data is logged directly to the sonde memory. Finally, disconnect the 650 and deploy the sonde.

3.4.3.3 Uploading data from sondes to the 650

Use the **650 Sonde menu** selection to access the sonde **File** menu and then choose either a **Quick upload** (all data in the last file) or **Upload** (complete or partial data in any sonde file) as described in detail in Section 2 of the 6-series manual. After the proper selection is made, press **Enter** and the file will be transferred automatically to the 650 memory with the 650 display indicating that an upload is in progress. The uploading of data files from sondes to the 650 is demonstrated in greater detail in Section 3.7 below.

3.4.3.4 Calibrating sonde sensors

Use the **650 Sonde menu** selection to access the sonde **Calibrate** menu. Once the menu has been activated, use the arrow keys to highlight a sensor for calibration and follow the instructions on the screen. Use the keypad to enter numeric values associated with the calibration standards and press **Enter** to confirm your input. View the data from each calibration standard in real-time and then highlight the **Calibrate** selection in the upper frame. When the output is stable, press **Enter** to confirm the calibration point. Then highlight **Continue** and press **Enter** to either move to the next calibration point or to finalize the calibration. See the example in Section 3.4.2 above for a typical calibration procedure.

NOTE: To return a sensor calibration setup to its factory default setting, access any calibration routine for that particular sensor which asks for numeric input. However, instead of entering numbers, hold the **Enter** key down and press the **Escape** key. Highlight "yes" and press **Enter.** This protocol is the equivalent of entering the command "uncal" from a computer keyboard.

3.4.3.5 Changing the sonde Sensor setup

Use the **650 Sonde menu** selection to access the sonde **Sensor** menu. Once the menu has been activated, use the arrow keys to highlight a sensor for activation/deactivation and press **Enter** to confirm your choice.

3.4.3.6 Changing the sonde Report setup

Use the **650 Sonde menu** selection to access the sonde **Report** menu. Once the menu has been activated, use the arrow keys to highlight a sensor for activation/deactivation and press **Enter** to confirm your choice. See the example in Section 3.4.2 above.

3.4.3.7 Viewing data stored in the sonde

Utilize the **650 Sonde menu** selection to access the **File** menu of the sonde. Highlight the "View file" selection and press **Enter**. Select the file that you want to view. Choose **Proceed** and press **Enter** to view the entire file or select the portion of the data that you want to view and then select **Proceed** and press **Enter** to confirm your selection. After data has appeared on the screen, use the arrow keys to select the particular sensor data that you wish to view.

IMPORTANT: The sonde **Quick view file**, which is designed to show the last page of data of the last logged file when the sonde is interfaced to a PC is slightly different for the sonde/650 interface. Making this selection will indeed show data from the last logged file, but all data (not just the last page) will be displayed. It is still possible, however, to quickly view the last few logged data points which may be important in checking a sonde's current performance in the field. To rapidly move to the end of the file (in either **View file** or **Quick view file**), press and HOLD the down arrow to accelerate the transition to the final data points. Then use the arrow keys to view the data of interest.

3.4.3.8 Configuring and setting the sonde clock

Utilize the **650 Sonde menu** selection to access the **System** menu of the sonde. Highlight the **Date & Time** selection and press **Enter**. Use the arrow keys to highlight the preferred date format and press **Enter** to confirm your selection. Activate/deactivate the **4-digit year** selection, as desired, using the **Enter** key to toggle between choices. Finally, set the date and time by highlighting the entries and inputting new values from the keypad.

3.4.3.9 Setting the sonde Autosleep configuration

As explained in Section 2 of the 6-series manual, the setup of the **Autosleep RS-232** function of the sonde should be governed by the following rules:

- Unattended sample studies/Remote deployments – Autosleep Active
- Discrete sample studies with user present – Autosleep Inactive

The rules are particularly important with regard to the method of dissolved oxygen calibration – automatic at the Unattended sample interval if Autosleep is Active; manually controlled by the user if Autosleep is inactive. See Section 2 of the 6-series manual for additional information on the Autosleep function.

To set the Autosleep function, utilize the 650 **Sonde menu** selection to access the **Advanced|Setup** menu of the sonde. Use the up/down arrow keys to highlight the **Autosleep RS232** selection and toggle the function on/off with the **Enter** key until it is correct for your application.

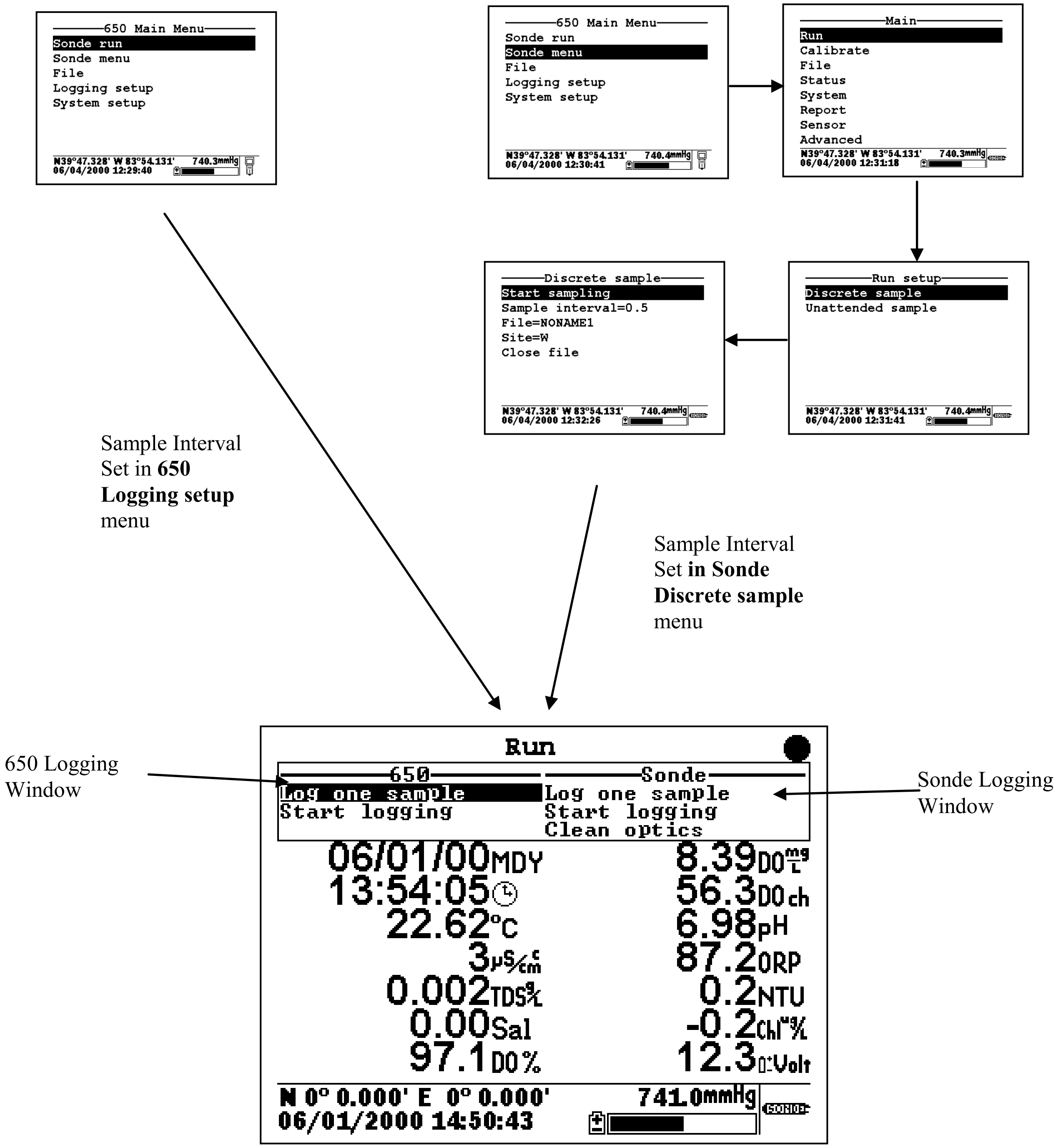
3.5 LOGGING DATA WITH THE 650

3.5.1 INTRODUCTION AND BASICS OF LOGGING

A primary function of the 650 is to facilitate the storage of field data from 6-series sonde sensors for later analysis. It is important to understand that sonde sensor data can be logged to two memory locations using a system consisting of a 650 interfaced with a sonde: (1) memory resident in the sonde and (2) memory resident in the 650 itself. Different applications may favor one logging choice over another. In addition, data can be logged either as single points (after the user has verified stabilization) or as a continuous data stream at a fixed sample interval. No matter where or how the user decides to log field data with a 650/sonde system, the 650 software plays the key role in controlling the process.

When setting up the 650/sonde system for your logging application, it important to realize that the **650 Run** display, from which all logging is initiated can be activated by two methods. The first is to simply highlight the **Sonde run** selection from the 650 menu. The second is to use the **Sonde menu** command from the **650 Main menu** to enter the sonde menu structure and then to activate a **Discrete sample** study. Either of these methods can be used to log data to both the sonde and the 650. However, for most applications, the latter method (Run screen from sonde **Discrete sample**) should be used to activate logging to sonde memory with the sample interval between logged points in a continuous data stream set from the **Discrete sample** menu of the sonde. Likewise, the former method (direct activation of the **650 Run** display from the **Sonde run** command) should usually be used to activate logging to 650 memory with the sample interval set in the Logging setup menu of the 650.

NOTE: Logging to sonde memory may not be possible for some older version 600R, 600XL, and 6820 sondes that were purchased prior to September 1999.



The user should also note the two windows in the upper portion of the display above, one designated "650" and the other "Sonde". All logging, either to sonde or 650 memory is controlled from these windows. As indicated, data storage to the 650 is controlled from the upper left logging window. Storage to the sonde memory is controlled from the upper right logging window. The highlighting cursor associated with the logging windows can be moved within a particular window using the up/down arrows and toggled from window to window using the left/right arrows. Note also that, if your sonde contains an optical sensor, it is possible to activate the probe wiper prior to logging from the Sonde logging window.

While the following sections will show that the logging functions of the 650 have a high degree of flexibility and capability, from a basic point of view, logging with the 650 is simple:

- Decide if you want to log data continuously, and, if so, determine what sample interval between data points is appropriate for you study. If you will be logging to 650 memory, highlight the **Logging setup** selection from the 650 Main menu, then highlight the **Interval** selection and set the interval as desired. If you will be logging to sonde memory, select the **650 Sonde menu** and then **Run|Discrete sample** from the sonde menu. Set the sample interval and then activate the data display by selecting **Start sampling**.

- Select the memory (sonde or 650) in which you want to store your data by toggling between the logging windows.

- Highlight the logging method desired – “Log one sample” for a single logged point or “Start logging” to store a continuous data stream.

- Press **Enter** to activate the logging selection.

- To end the study if a continuous data stream was selected, press **Enter** with the highlight cursor on the **Stop logging** command or press the **Escape** key.

Sections 3.5.2 and 3.5.3 below provide details and real-life examples of logging data to sonde memory and to 650 memory, respectively, using the 650 as the interface.

3.5.2 LOGGING DATA TO SONDE MEMORY

3.5.2.1 INTRODUCTION

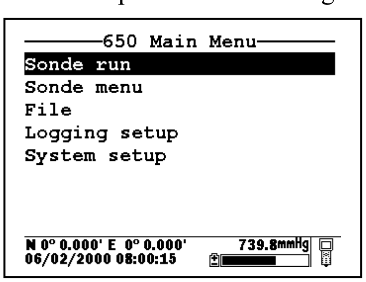
All YSI 6-series sondes sold since September 1999 have memory present on their internal PCBs. In addition, all 600XLM, 6920, and 6600 sondes have internal memory, regardless of the date of purchase. Interface of these sondes to a 650 allows the user to easily store data (either a single point or a continuous stream) to the sonde memory. If a continuous stream of data is desired, the interval between the stored points is controlled by the **Sample interval** in the sonde’s **Discrete sample** function. The file name under which this data is stored and the site name associated with the file are also input in the **Discrete sample** function of the sonde using the 650 keypad as the input method. When logging to sonde memory, be sure to follow the instructions above with regard to entering the **650 Run** display either directly from the **650 Sonde run** menu or indirectly from the 650 **Sonde menu** selection to control your sample interval.

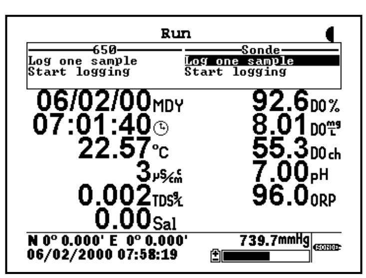
The following examples show the setup and implementation of logging to sonde memory using the 650 as the interface device.

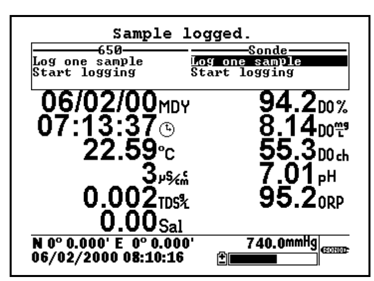
3.5.2.2 EXAMPLE 1 – SIMPLE SINGLE POINT LOGGING TO SONDE MEMORY

A user with a 600XL/650 system wants to store data electronically from a single site rather than writing down the information manually in the field.

To log this data point to the sonde memory, the user highlights the **Sonde run** selection in **the 650 Main menu** and presses **Enter** to begin data display.

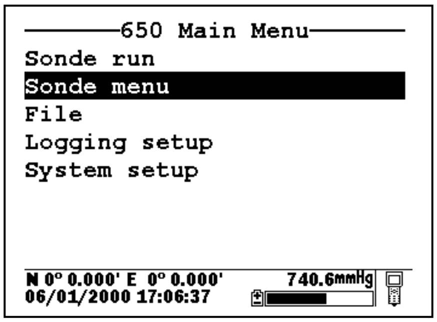


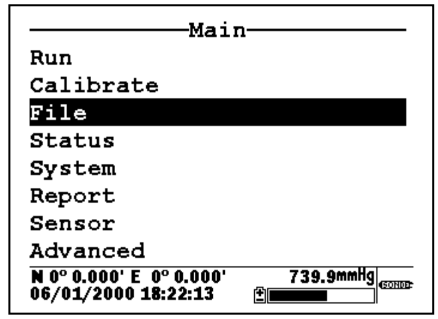




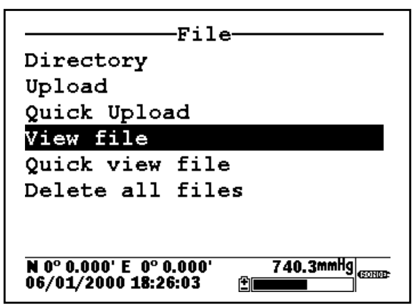
The user places the sonde in the water and watches the readings on the 650 display until they are stable. When stable, the **Log one sample** selection in the Sonde logging window (upper right) is highlighted as shown above and the **Enter** key is pressed. The header changes from "Run" to "Sample logged" to confirm that the data storage to sonde memory was successful and then returns automatically to the **Sonde run** display. The user turns the 650 off and returns to the office to retrieve the data.

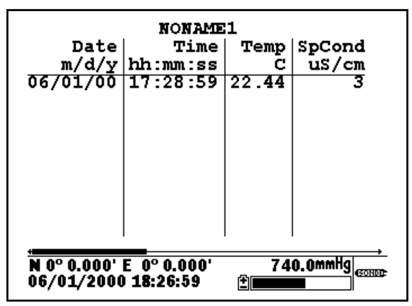
The single data point is stored in the sonde memory under the automatically generated file name NONAME1. The file can be viewed by selecting **Sonde menu** from the 650 Main menu and pressing **Enter**.

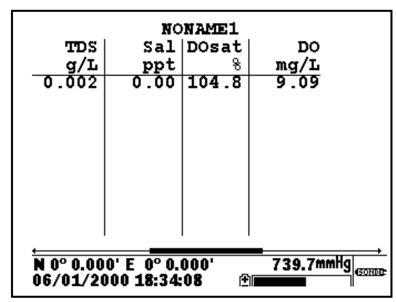




To view the data on return from the site, the user selects the sonde menu **File** selection, presses **Enter** to confirm the entry, and then highlights the**View file** selection and presses **Enter**. Following these instructions generates a display of the data that is stored in the sonde memory under the default name NONAME1. Use the right/left arrow keys to scroll horizontally to view all of the data.







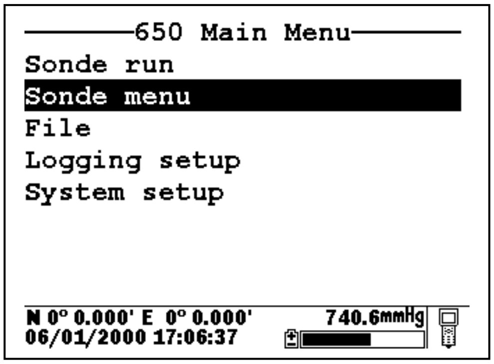
The user manually records the data from the site and turns the system off.

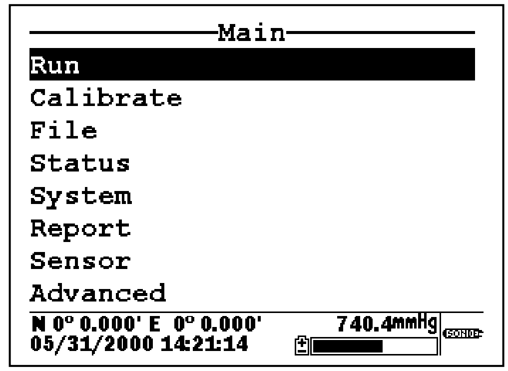
3.5.2.3 EXAMPLE 2 – CONTINUOUS LOGGING APPLICATION TO SONDE MEMORY

A user wants to carry out a vertical profile of a lake from 0 to 30 feet in order to detect the presence of a thermocline, and, if identified, to locate its position in the water column. The experiment will involve lowering a 6920 sonde in 1 foot increments until the bottom of the lake is detected, leaving the sonde at each depth for 3 minutes to allow the sensor readings to stabilize while logging data continuously. Thus, the user will generate data over a 90 minute time period (30 increments times 3 minutes per increment). If data were logged directly to sonde memory at the default 0.5 second sample interval, a very large data file containing 5400 data points would be generated, with little benefit gained from its size.

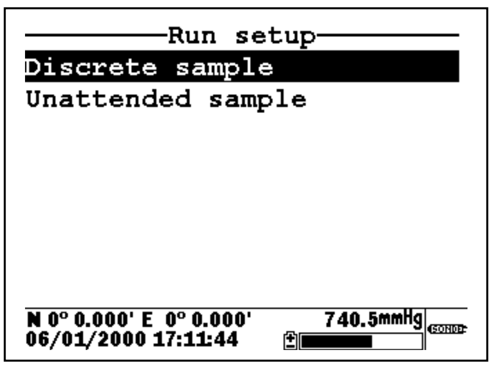
With this in mind, the user decides to increase the sample interval to 16 seconds, thus greatly reducing the amount of data in the file with no loss of real resolution. As explained above, the sample interval for logging to sonde memory is set in the Discrete sample menu of the sonde, and thus the user MUST activate the **650 Run** display indirectly using the **650 Sonde menu** selection as detailed above.

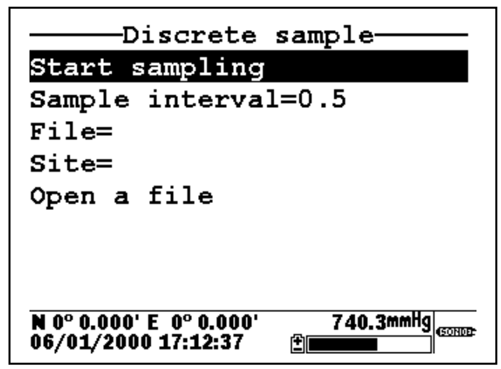
The user attaches the 6920 sonde to a 650. After turning on the 650, the user selects **Sonde menu** from the **650 Main menu** and presses **Enter** to display the **Main** sonde menu.



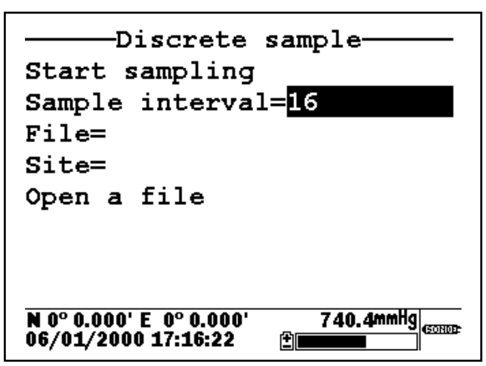


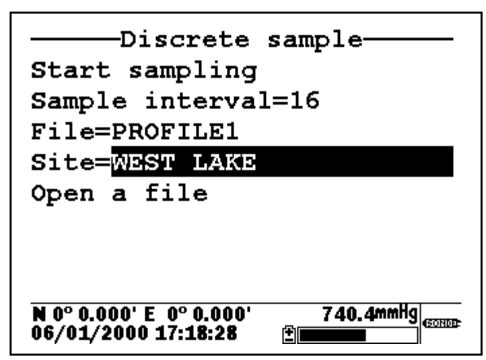
The user then selects **Run** from the sonde Main menu and **Discrete sample** from the **Run** menu, pressing **Enter** to confirm each selection.



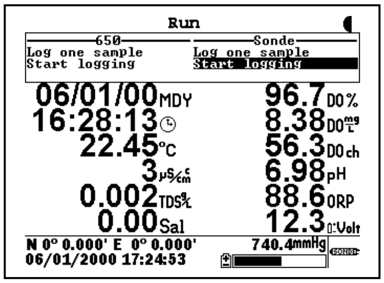


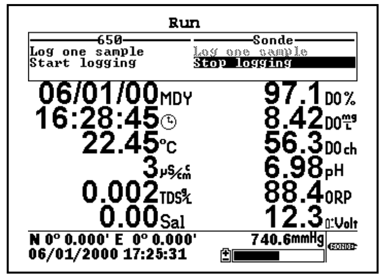
To set up the desired study parameters, the user uses the 650 keypad to change the Sample interval from 0.5 seconds to 16 seconds and inputs custom file (PROFILE1) and site (WEST LAKE) designations.

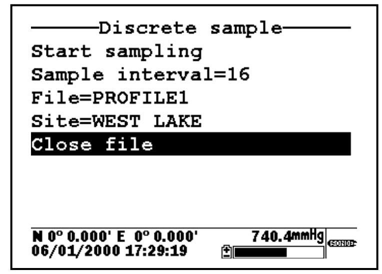




The user then highlights **Start sampling** and lowers the instrument into the water to begin the study. The data displayed on the screen is updated every 16 seconds. The user then highlights the **Start logging** selection in the sonde logging window in the upper right of the display and presses **Enter** to begin logging data to sonde memory. The message in the sonde logging window changes to **Stop logging,** indicating that logging has successfully been activated.

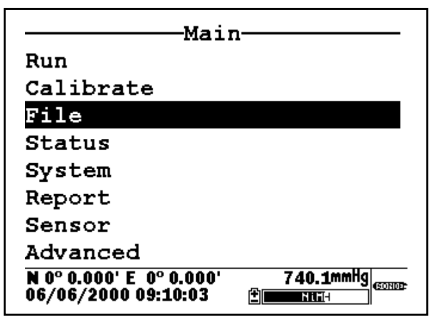


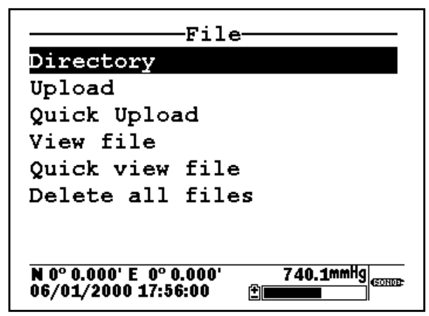




At the end of the 90 minute profile determination, the user either confirms the **Stop logging** command by pressing **Enter** or simply presses the **Escape** key to return to the sonde **Discrete sample** menu, highlights the **Close file** selection, and confirms the file closing by pressing **Enter**.

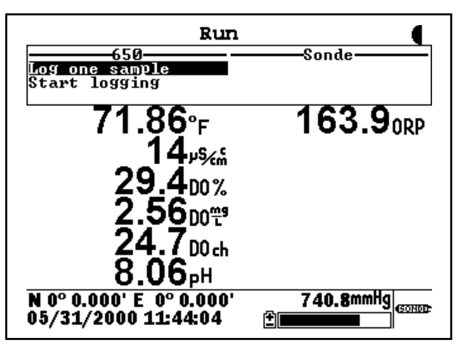
The profile data taken at a 16 second sample interval is now stored in the sonde memory under the file name PROFILE1. It can be viewed on the 650 display and/or uploaded to the 650 memory or directly to a PC by accessing the sonde **File** menu.





3.5.2.4 SONDES WITHOUT MEMORY

If your sonde is a 600R, 600XL, or 6820 purchased prior to September 1999, it may contain a circuit board that does not have memory. With sondes of this type, you will not be able to log data to the sonde – only to the 650 as detailed in the following section. With these no-memory sondes attached to your 650, the **Run** display will show a blank Sonde logging window as shown below.



3.5.3 LOGGING DATA TO 650 MEMORY

3.5.3.1 INTRODUCTION

Even if the sonde in your 650/sonde system has its own memory, it may be more convenient for you to log data directly to the 650 memory simply because you eliminate the need to upload the data after logging, i.e., it will already be resident in 650 memory. In addition, logging directly to 650 memory allows you to log GPS and barometric pressure readings along with sonde sensor data. Barometer and GPS data cannot be logged to sonde memory. Finally, the file/site list capability associated with the 650 is more powerful than that of the sonde, allowing you to log data from several sites to a single file. If these applications are important to you, then it is likely that logging directly to 650 memory should be your first choice. Naturally, if your sonde is a 600R, 600XL, or 6820 with no memory (pre-1999), then you will be REQUIRED to log your sonde data directly to the 650.

Before proceeding in this section, be sure that you review Section 3.5.1 above which describes the basics of logging with a 650 (either to sonde or to 650 memory).

The following sections will provide details and examples of the flexibility of logging sonde data to 650 memory. The distinction between (a) simple occasional logging with file and site names entered at the logging site and (b) logging to a more sophisticated file structure where file parameters are entered into a site list prior to going to the field will be described.

3.5.3.2 SIMPLE LOGGING TO 650 MEMORY

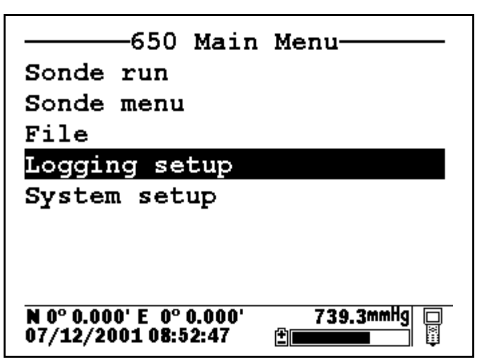
The term "simple logging" to 650 memory refers to the method of defining file and site names for the study. In applications of this type, the user inputs new file and site (optional) names for each study at the time the data is logged.

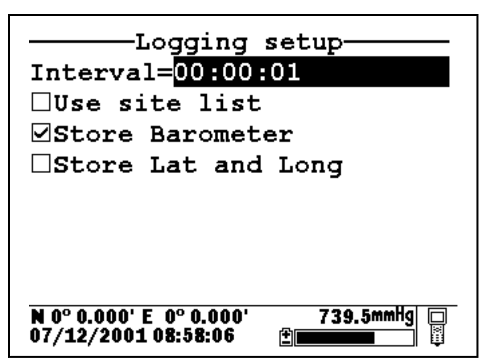
IMPORTANT: The **Use site list** selection in the **650 Logging setup** menu should be INACTIVE for the example below which demonstrates simple logging.

A user with a 600XL/650 system wants to store a continuous stream of data electronically for a single site at a sample interval of 10 seconds between data points. Note that this is a similar example to that in 3.5.2.2 above, except that the logging is to 650, rather than sonde, memory and a data stream, rather than a single point, will be logged.

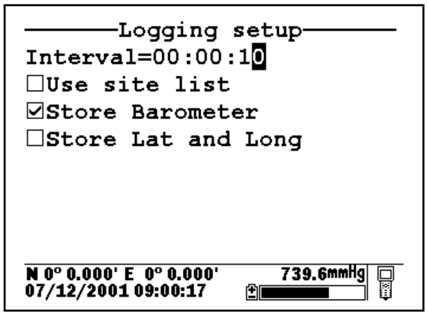
The first step in this application is to make certain that the sample interval is set correctly for the logging study. The factory default sample interval of 1 second will therefore need to be changed to 10 seconds.

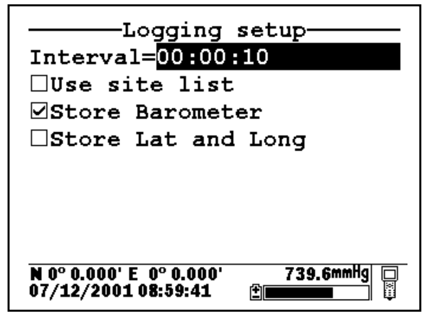
To set the sample interval, highlight the **Logging setup** entry in the **650 Main menu** and press Enter.



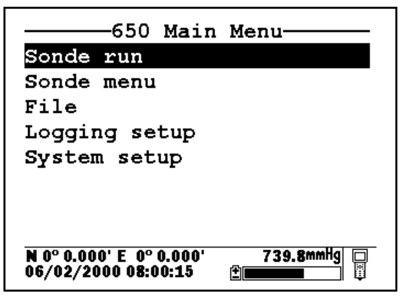


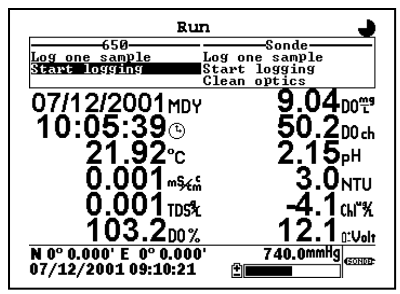
Press Enter at the highlighted **Interval** selection and use the arrow keys to scroll to the right and change the interval from 1 second to 10 seconds. Confirm the selection by pressing **Enter** and then press **Esc** to return to the **650 Main menu**.



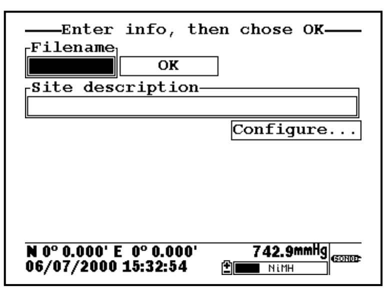


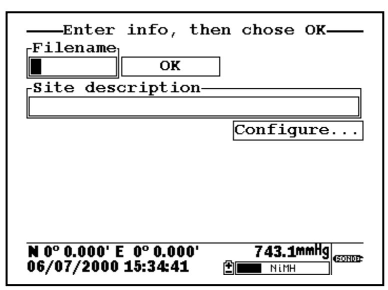
Once the sample interval is set correctly in the **650 Logging setup** menu, the user simply highlights the **Sonde run** selection in the **650 Main menu** and presses **Enter** to begin data display.

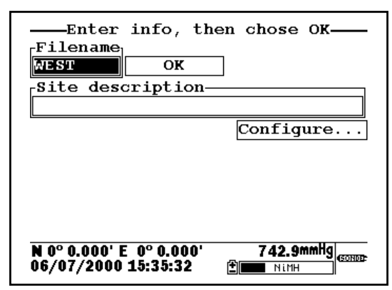


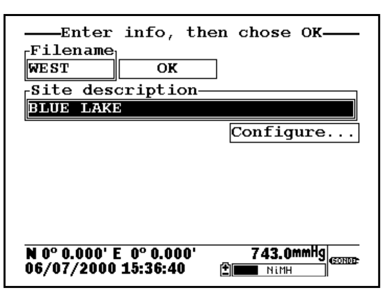


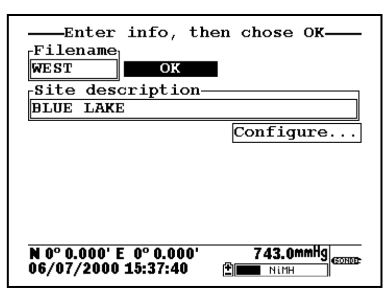
The user places the sonde in the water and then highlights the **Start logging** selection in the 650 logging window (upper left) and presses **Enter**. The user is then prompted to enter a **Filename and Site description** for the study as shown below.

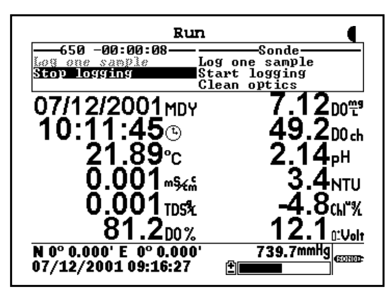








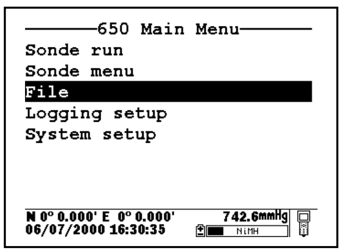


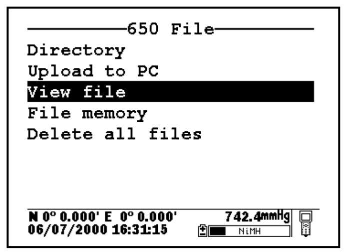


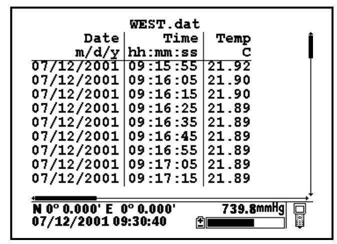
Using the arrow keys, the **Filename** window is highlighted, the user presses the **Enter** key and then inputs the file name (in this case, WEST) from the keypad as shown above. A site name (BLUE LAKE) is then entered from the keypad by highlighting the **Site description** window and proceeding as for the **File** name. Pressing **Enter** confirms the **Site** entry. The user then highlights the **OK** window and presses **Enter** to log the point. The header of the 650 logging windows changes to **Stop logging** to confirm that the data storage to 650 memory is active and a countdown timer appears at the top of the display to show the exact moment a point is logged to 650 memory. When the study is complete, the user highlights the **Stop logging** selection and presses **Enter** to terminate logging.

NOTE: For ultimate simplicity, it was not necessary to enter either a file or a site name in the above application. If the **OK** window had been highlighted immediately and **Enter** pressed, a point will be logged to a file in the 650 memory under the designation NONAME1. It is also possible to input a custom file name, but not enter a site name and then log the point.

The stream of data is stored in the 650 memory under the file name WEST that was input by the user. The file can be viewed by selecting **File** from the 650 Main menu and pressing **Enter**. Then highlight the **View file** selection and then the selected file (WEST), pressing **Enter** after each entry. The data in the file will be displayed as shown below. Use the arrow keys to scroll horizontally in order to view all of the data.

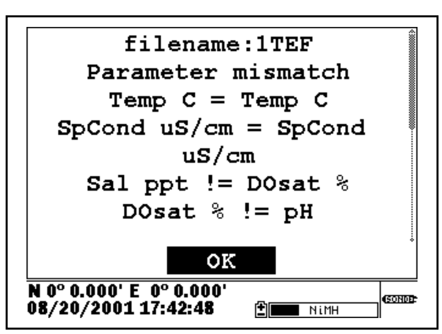






Note that, using these same basic guidelines, data could have been logged at another site on the same day with the user inputting a different site designation (file name and site name) in the field. Data could also have been logged single points or as a continuous data stream at each site simply by the choice of **Log single point** or **Start logging,** respectively, in the 650 Logging window.

Data can also be appended at later times to existing site designations. However, there is a limitation on this process**: the parameter setup during subsequent logging runs MUST be exactly the same as for the first entry.** For example, if you add a sonde parameter to the Report for the second logging run to a particular site, you will not be able to append this data to the existing file. If you logged Barometer or GPS readings to the initial file you will be required to maintain the logging of these files on subsequent logging runs. If your current parameter setup is different from the one used initially, a "Parameter Mismatch" screen similar to that shown below will appear when you try to log data to the old site designation. The screen should help in pinpointing the change in your parameter setup that is causing the inability to append the file. In the example below, the old parameter setup is shown on the right of the screen and the new parameter setup is on the left. It is evident that the mismatch occurs in the third line where salinity from the new setup is "mismatched" with "DO %" from the old setup. The screen thus shows that salinity has been added to the parameter list between the two logging studies and must be removed if the original file is to be appended with further data.



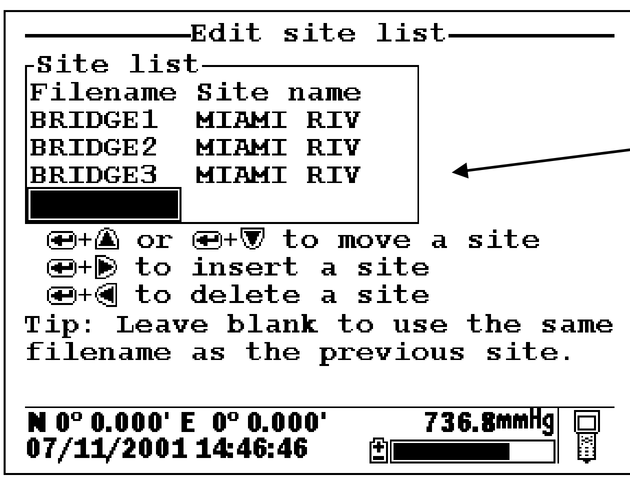
3.5.3.3 LOGGING TO 650 MEMORY WITH A SITE LIST

In the example above, you learned how to log data to 650 memory that had file and site designations input to the logger at the time that the data was logged in the field. It is also possible, and in most cases more convenient, to place file and site designations into the 650 memory in the office or laboratory before moving to field for logging studies. This is particularly true if you are aware of the sites at which you will be determining water quality data and/or which you will be visiting on a regular basis. The following section describes how to set up site lists which contain entries designated "Site Designations" that will be instantly available to the user in the field to facilitate the logging of data in the field with pre-established naming of files and sites. There are two kinds of **Site Designations** available for use in Site lists:

- **Site Designations** associated with applications where data from a single site is always logged to a single file. This type is referred to as a "Single-Site Designation" and is characterized by two parameters – a file name and a site name. Files logged to 650 memory under a **Single-Site Designations** will be characterized primarily by the file name, but will also have the Site name attached, so that it is viewable in either the **650 File directory** or in EcoWatch for Windows after upload to a PC

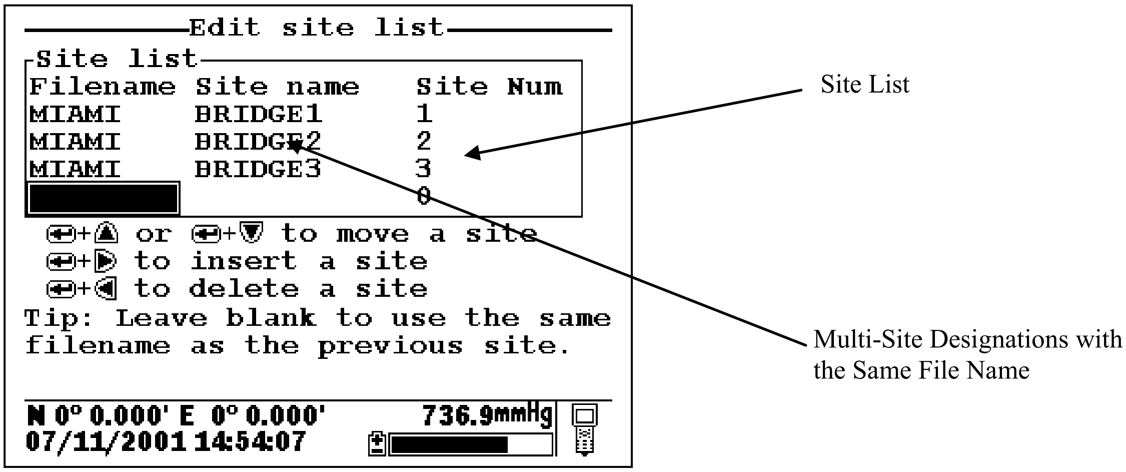
- **Site Designations** associated with applications where data from multiple sites are logged to a single file. This type is referred to as a "Multi-site Designation" and is characterized by three parameters – a file name, a site name, and a site number. Files logged to 650 memory under **Multi-site Designations** 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 **650 File** menu or processing the data in EcoWatch for Windows after upload to a PC.

When reading the following section on the use of the **650 Site list**, remember that a **Site List** is a compilation of individual entries called **Site Designations**. **Single-Site Designations** are used when the data from a particular location is always logged to the same single file. **A Single-Site Designation** is characterized by a unique file name. **Multi-Site Designations** are used when data from several locations are logged to a single file. For **Multi-site Designations**, there will a single **File Name** with multiple **Site Names** and **Site Numbers**. The following displays show examples of **Single** and **Multi-Site Designations**.



Site List

Single-Site Designations with Different File Names



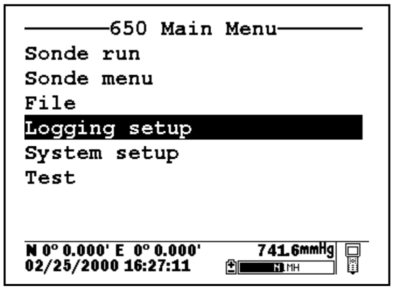
Note that Site lists containing Single Site Designations are usually input with the designation Store Site Number INACTIVE in the **650 Logging setup** menu. Thus, no site numbers appear in the first **Site list** example. Conversely, **Site lists** containing **Multi-Site Designations** MUST be input with the **Store Site Number** selection ACTIVE as shown in the second example.

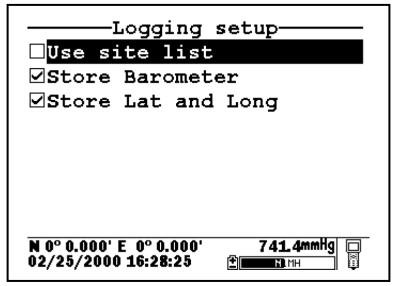
As noted above, establishment of either of these two types of **Site Designations** that are stored in 650 memory in a **Site List** will allow you to log field data to the 650 memory without entering file/site information from the 650 keypad in the field at each site. You will easily be able to access previously entered **Site Designation** information from this the **Site List** at each field site and thus simplify your record keeping and logging procedures. To utilize the full capability of the 650 logging system, you will need to understand how to set up and use these two types of **Site Designations**, particularly if you are performing multiple or replicate logging studies at various field sites. The following discussion and examples should help you understand how to set up site lists for various applications.

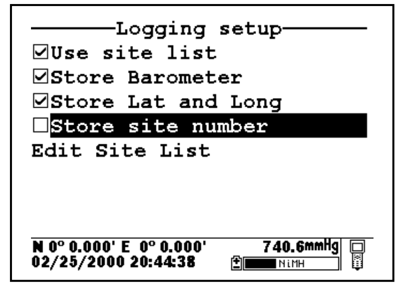
LOGGING OF DATA TO 650 MEMORY FROM SINGLE SITES TO SINGLE FILES – USE OF SINGLE-SITE DESIGNATIONS IN A SITE LIST

The setup and use of **Single-Site Designations** will be provided in the following application example: Water quality data needs to be collected for two sites at the West and East ends of a lake (Blue Lake) at various time intervals for 30 days. The environmental scientists want all of the data for each site to be in a separate data file that can be reported from EcoWatch for Windows or from a spreadsheet. The key to this application is that each physical location will need to be characterized by a different **File Name** in the **Site Designation**.

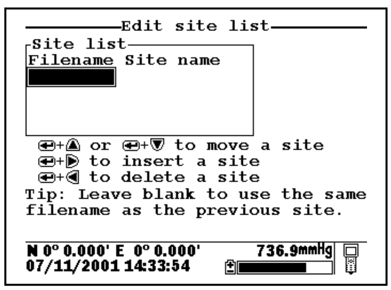
To establish a site list in the 650 memory for this application, highlight the **Logging setup** selection in the 650 Main menu and press **Enter**. The following screen will appear. Make certain that the selection **Use Site list** is active to display the full capability of the Logging setup as shown below. To set up a list with Single-Site Designations the selection **Store Site number** should be INACTIVE (as shown below) before proceeding.

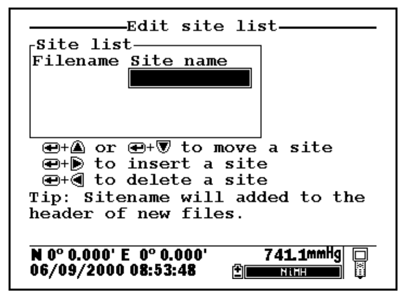






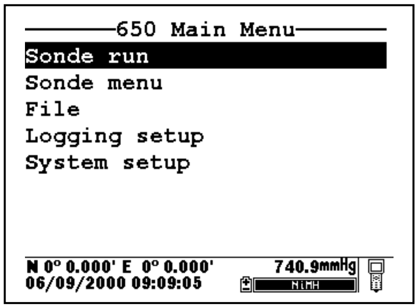
Note also that if you have purchased a 650 without the barometer option, the selection **Store barometer** will not be present. Decide whether or not you want to store GPS and barometer information with your data file and activate/deactivate the **Store Lat and Long** and **Store Barometer** selections appropriately. Leaving these selections active will occupy memory in the 650 during logging and this factor may be a consideration if you have purchased a 650 with "Low" memory and you do not really require this information in your file. Once these selections have been made, highlight the **Edit site list** selection and press **Enter** to display the screen below. Note that you can use the left/right arrows to scroll between the **Filename** and **Site name** selections and that tips about the meaning of these terms is provided at the bottom of the display depending on the position of the cursor.

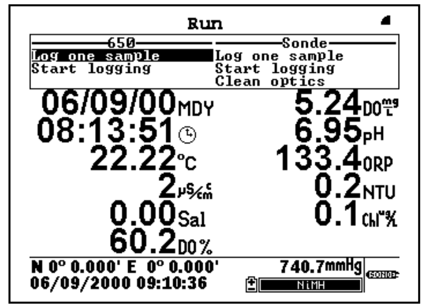




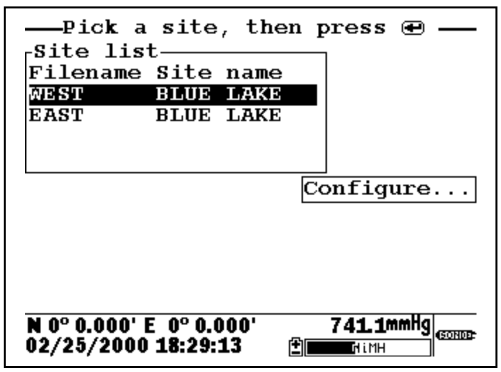
To make **Site list** entries for this application, begin by highlighting the **Filename** position, pressing **Enter** and inputting the file name (WEST, in this case) from the keypad. Press **Enter** to confirm the entry and the cursor will automatically move to the right for the entry of a **Site name**. Enter BLUE LAKE for the site and press **Enter** to confirm the entry. The cursor will move automatically to the next **Filename** entry position. Now enter EAST for the file name and BLUE LAKE for the site name, pressing **Enter** after each entry to confirm. Your site list should appear like that in the following display.

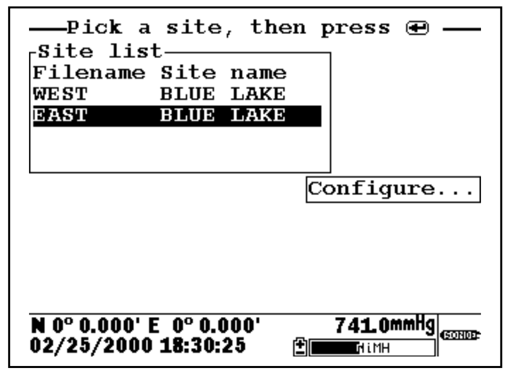
You have now established a site list that will be available in the field for logging of data to two files on BLUE LAKE -- EAST and WEST. To use this list, you need to first make certain that the entry **Use site list** is active in the **650 logging setup**. Then travel to the first location, identified by the **Filename** WEST, activate the **650 Run** display, and then select either a continuous data stream (**Start logging**) or a single data entry (**Log single point**) from the 650 logging window.





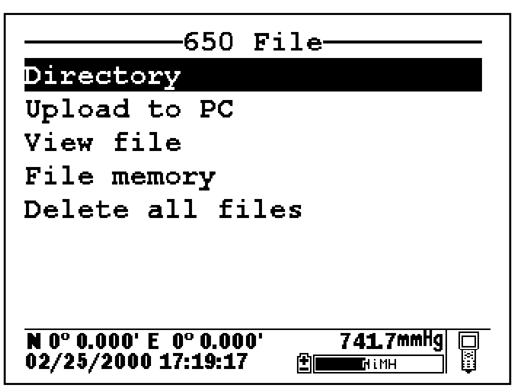
Then press **Enter.** When the logging prompt is activated, the site list will automatically appear on the display and be available for use in your study as shown below. First highlight the WEST file (since you are at that location) and press **Enter** to log data to the 650 memory. An indication that the logging was successful will appear in the 650 logging window. Then move to the next location (EAST), activate the 650 logging function, and repeat the logging process, but this time highlighting the EAST Filename entry.

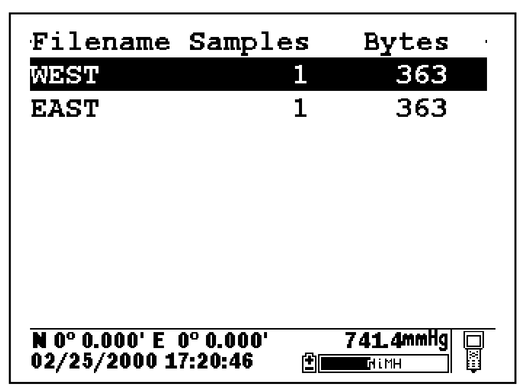




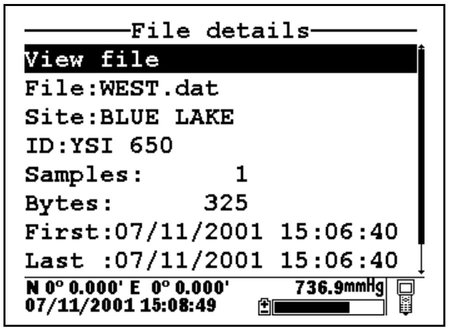
NOTE: If you want to return to the **Edit site list** display for changes before logging, use the RIGHT ARROW KEY to highlight the **Configure** selection and press **Enter**. The up/down arrows will only scroll within the Site list.

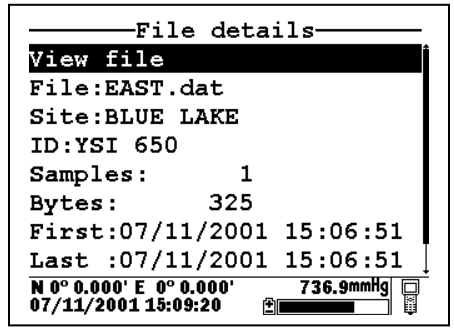
The data from the two locations has been logged to the selected files that can be either viewed manually using the 650 **View file** menu or uploaded to EcoWatch for Windows from the **650 File** menu. This means that all data for the West and East sites are located in separate files identified by the **Filenames** WEST and EAST as shown in the 650 File Directory below.





Details of the files (shown by pressing **Enter** when the File is highlighted in **Directory**) are shown below. Note that the site name (BLUE LAKE) is listed in the file since the data was logged using **Single-Site Designations**.





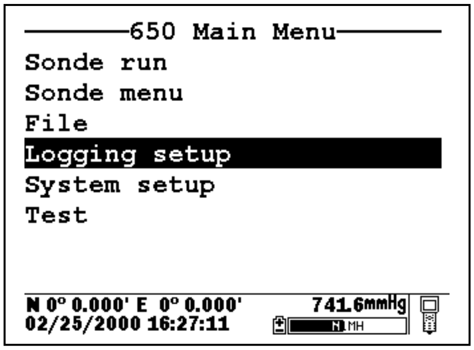
These files will remain "open" in 650 memory so that you can return to each location at a future time and log more data to the file designations WEST and EAST (but see note below). The key for this **Site list** setup is that all data logged will be stored in a separate file for each location (WEST and EAST) which were designated as file names at the site BLUE LAKE.

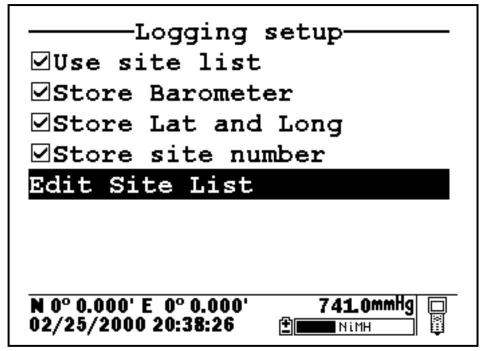
NOTE CAREFULLY: As described above for non-site list files, there is a limitation on appending data to existing files: the parameter setup during subsequent logging runs MUST be exactly the same as for the first entry. For example, if you add a sonde parameter to the Report for the second logging run to a particular site, you will not be able to append this data to the existing file. If you logged Barometer or GPS readings to the initial file you will be required to maintain the logging of these files on subsequent logging runs. If your current parameter setup is different from the one used initially, the **Site Designation** for that file will be "grayed-out" in the **Site list** and will not be available until you adjust your parameter setup. If you try to log data to the grayed-out file, you will be shown a "Parameter Mismatch" screen similar to that for non-site list files which will aid in diagnosing the differences in the parameter setup that is preventing the existing file from being appended with new data

LOGGING OF DATA FROM SEVERAL DIFFERENT SITES TO THE SAME FILE – USE OF A "MULTI-SITE" LIST

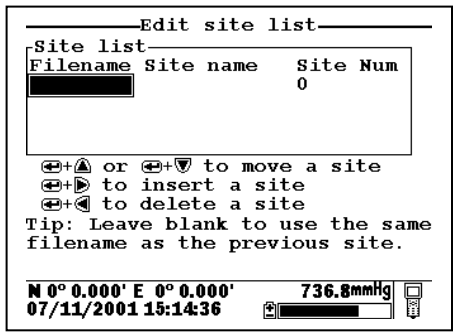
The setup and use of **Multi-Site Designations** will be provided in the following example which deals with a different approach to the application in the previous example on **Single-Site Designations**: Water quality data needs to be collected for two sites at the West and East ends of a lake (Blue Lake) at various time intervals for 30 days. In this case, the environmental scientists want all of the data in a single file for recording keeping convenience. The key to this application is that the **Site list** will need to contain **Multi-Site Designations** with the same **Filename,** but with different **Site names and Site numbers** to characterize each physical location.

To make Site list entries for this application, highlight the **Logging setup** selection in the 650 main menu and press **Enter**. The following screen will appear. As in the previous **Site list** setup, make certain that you have activated/deactivated the **Store barometer** and **Store Lat and Long** settings as appropriate for your application. The real key, however, in configuring the **Logging setup** display for use with a Multi-site list is that you MUST make certain that the selection **Store Site number** is ACTIVE (as shown below) before proceeding.

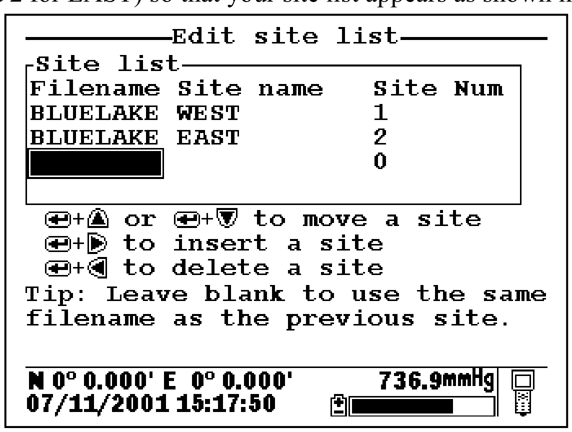




Then highlight the **Edit site list** selection and press **Enter** to display the following screen.

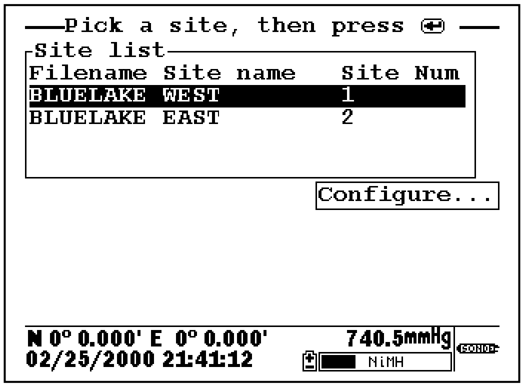


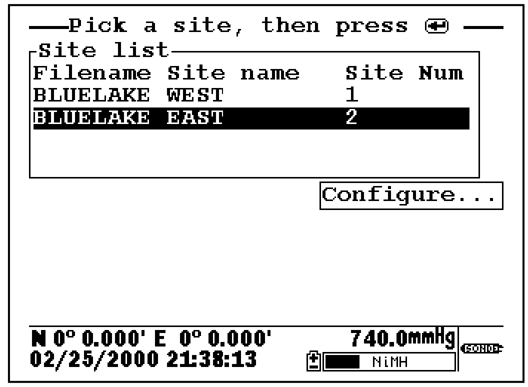
To generate a list of **Multi-Site Designations** for storing readings from various sites to the same file, establish two entries in the site list with the same file name (BLUELAKE). The entries will be differentiated by different **Site names** (WEST and EAST), and, more importantly, by different **Site Numbers** (1 for WEST and 2 for EAST) so that your site list appears as shown in display below.



You have now established a site list that will be available in the field for logging of data from two sites (WEST and EAST) to a single file (BLUELAKE). To use this list, you need to first make certain that the entry **Use site list** is active in the **650 logging** setup. Then travel to the WEST site, activate the 650 **Run** display and then select either a continuous data stream (**Start** logging) or a single data entry (**Log single point**) from the 650 logging window, and press **Enter** When the logging prompt is activated, the site list will automatically appear on the display and be available for use in your study as shown below. First highlight the entry with the WEST **Site name** (since your are at that location) and press **Enter** to log data to the 650 memory. An indication that the logging was successful will appear in the 650 logging window.

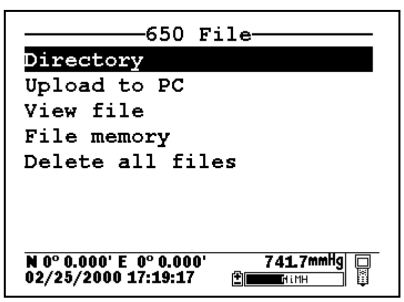
Then move to the next location (EAST), activate the 650 logging function, and repeat the logging process, but this time highlighting the EAST **Site name** entry.

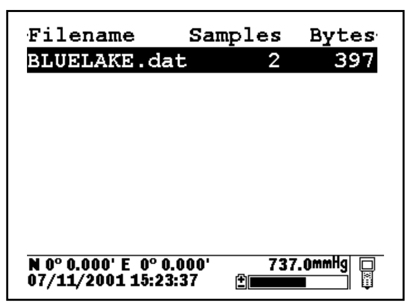


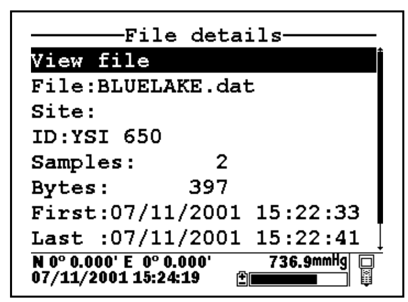


NOTE: If you want to return to the **Edit site list** display for changes before logging, use the RIGHT ARROW KEY to highlight the **Configure** selection and press **Enter**. The up/down arrows will only scroll within the **Site list**.

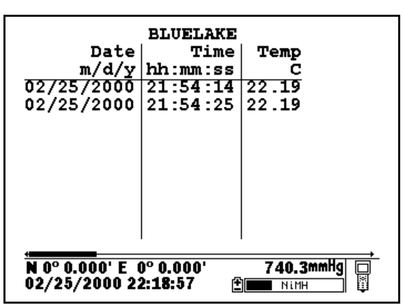
The data for two different sites has now been logged to the single file (BLUELAKE) that can be either viewed manually using the **650 View file** menu or uploaded to EcoWatch for Windows from **the 650 File|Upload to PC** menu. The Site Number ("1" for the WEST site and "2" for the EAST site) will be stored with each data point and will be thus be available for identifying where the data was taken. The file BLUELAKE can be examined by use of the 650 **File** selection. In the 650 **File** menu, highlight **Directory** and press **Enter** as shown below. Then press **Enter** with the cursor on the BLUELAKE file to show the file details.

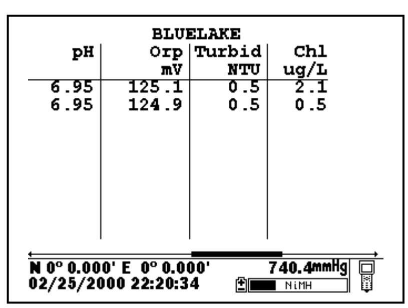


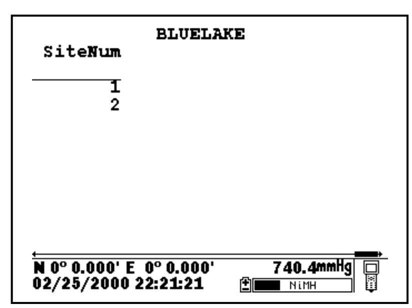




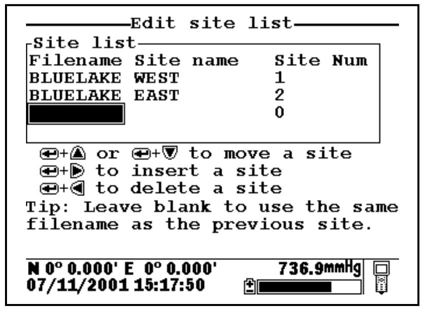
Note that there is NO Site name listed for the file BLUELAKE since data from more than on site was logged to it. Now highlight the **View file selection** and press **Enter** to display the data in BLUELAKE as shown below.







Note that the data from two sites is identified by the **Site Number** attached to each data record. To index these numbers to the appropriate locations, the user must consult the **Site list** by activating **Edit site list** from the **650 Logging setup** menu. The correlation between site names and numbers is found here, indicating that Site 1 is WEST and Site 2 is EAST.

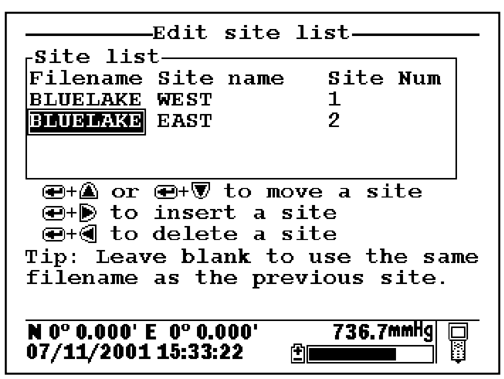


This file will remain in 650 memory so that you can return to each location at a future time and log more data to the **Site designations** WEST and EAST. The key for this site list setup is that all data logged will be stored in the same file (BLUELAKE) under different **Site Numbers** for each location (1 for WEST and 2 for EAST).

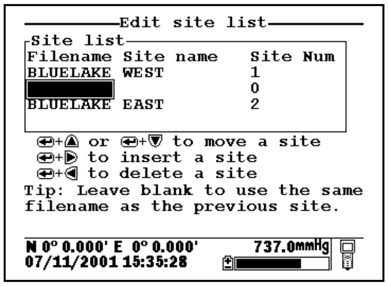
NOTE CAREFULLY: The same limitation noted above applies for appending the file BLUELAKE with additional data from these or other sites – the logging setup (sonde parameters, barometer, GPS) must be identical to that for the initially-stored data. If there has been a change in setup, the **Site Designation** will be “grayed-out” in the **Site List** indicating a parameter mismatch.

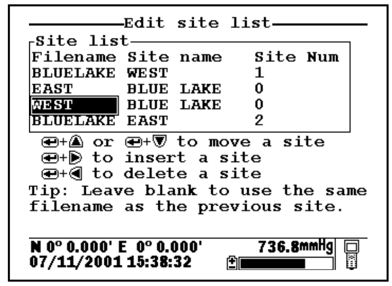
3.5.3.4 EDITING YOUR SITE LIST

The 650 software provides powerful tools for editing your site list. Actions such as inserting (adding) new entries, deleting existing entries, and moving entries within the list can be carried out easily from the keypad**.** Highlight the **Edit site list** entry in the **650 Logging setup** display and press **Enter** to show the following screen.

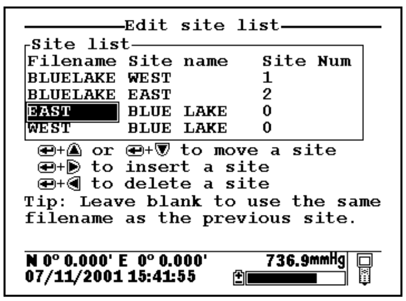


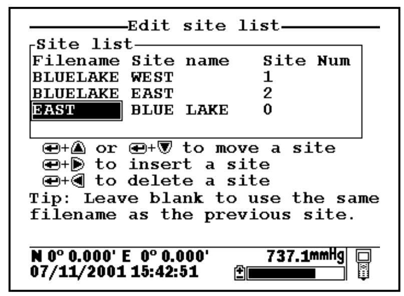
Note that the keystrokes for editing the site list are shown in the bottom of the Main Display. Thus, to insert (add) a file above the present cursor position, simply highlight the proper entry and press the **Right arrow** key while holding down the **Enter** key as shown in the following example. Note that two sites were inserted in the initial site list using this method.



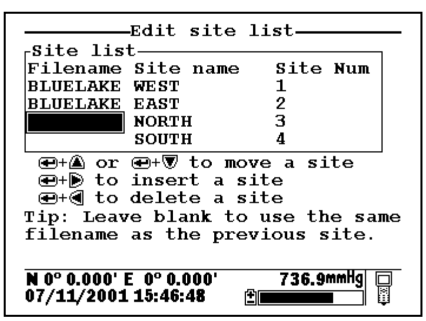


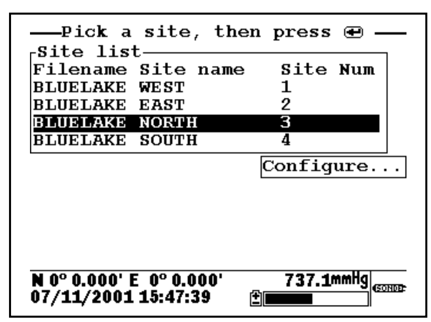
The two inserted entries can be moved either up or down in the list by highlighting them and pressing the **Up or Down arrow** key while holding down the **Enter** key or completely deleted by highlighting the entry and pressing the **Left arrow** key while holding down the **Enter** key as shown below.





Finally, the user should be aware of a timesaving tip that is displayed when the **Filename** entry is highlighted. The tip allows much easier generation of **Multi-Site Designations** where the **Filename** is identical for several files. To "copy" the Filename from the previous file to a new entry below, simply highlight the new **Filename** block, press **Enter** and then enter site names and site numbers**.** The site list will show these blanks in the **Edit site list** mode as shown on the left below, but when the site list is accessed for logging studies the actual **Filename** will appear to avoid confusion. This is shown at the right below. Note that, by using this tip, two new sites have been easily added to the BLUELAKE Multi-site list with no need to enter "BLUELAKE" Filename for each new site.





Remember that, when editing your Site list, you will have no effect on the actual files which were previously logged to 650 memory nor on the data in the files. See Section 3.6 below.

3.5.4 650 LOGGING – "CANS" AND "CAN'TS"

The use of the 650 to facilitate the storage of data from YSI 6-series sondes has been described in some detail in the sections above. Unfortunately, the high levels of capability and flexibility of the 650 logging function might also be viewed as complexity which, in turn, can confuse some users about how to employ the 650 in their particular application. This section is designed to help with any confusion that exists by listing what "can" be done with the 650 logging system and what "can't" be done.

3.5.4.1 SUMMARY OF 650 LOGGING CAPABILITIES

WITH A 650/YSI SONDE SYSTEM, THE USER CAN:

- Log sonde sensor data to either sonde memory (if your sonde is so equipped) or 650 memory.
- Log data as either a single point or as a continuous data stream.
- Log data in both single point form and continuous stream form to the same file in 650 or sonde memory.
- Log continuous data stream data at long or short sample intervals to sonde memory, as long as the study is started from the Run menu of the sonde.
- Log continuous data stream data at long or short sample intervals up to 15 minutes to 650 memory using the **Sample interval** selection in the **Logging setup** menu of the 650.
- Log data from the 650 internal barometer to the memory of the 650.
- Log data from a user-supplied GPS unit to the memory of the 650, as long as the GPS unit is set up in NMEA format and has the proper cable.
- Log data with minimal keypad entry from the 650 display by using default file naming.
- Assign custom file and site names using the 650 keypad at the logging site.
- Set up custom site lists in the office or laboratory that are instantly available in the field to simply file/site management.
- Set up Site Designations that are characterized by a File Name and a Site Name for simple logging of data from a single site to a single file.
- Set up Site Designations that are characterized by a File Name, a Site Name, and a Site number which correlates with the Site name. These lists allow the logging of data from more than one site to the same file.
- Easily view data on the 650 display that has been stored to either sonde or 650 memory.
- Easily upload data that has been stored in either sonde or 650 memory to a PC for analysis using EcoWatch for Windows software from YSI.

3.5.4.2 SUMMARY OF 650 LOGGING LIMITATIONS

WITH A 650/YSI SONDE SYSTEM, THE USER CANNOT:

- Log GPS and/or barometer data to sonde memory.
- Log GPS and/or barometer to 650 memory without a sonde attached and the 650 in **Run** mode. See Sections 3.8.2 and 3.9.4 below.
- Log data to existing files in 650 memory if the data format does not EXACTLY match that of the data already in the file. Typical examples of this type of "file mismatch" include:
    - Attempting to append existing data files after changing the parameter list.
    - Attempting to append existing data containing a Site Number to a file that contains data without Site numbers.
    - Attempting to append existing data containing NO site number to a file that contains data with Site numbers.
    - Attempting to append existing files containing GPS and/or barometer data after deactivating the storage of these parameters in **Logging setup**.
- Delete individual files from 650 or sonde memory. The memory is "flash" and therefore all files must be deleted in order to regenerate the storage capacity.
- Enter more than 8 characters for a File name or more than 13 characters for a Site name.

3.6 MANAGING 650 FILES

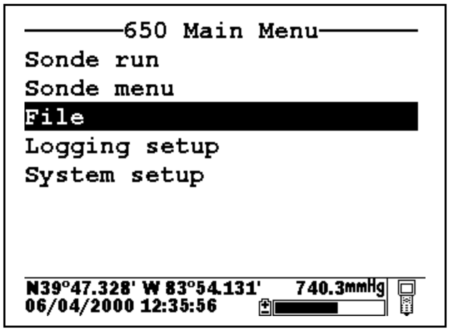
3.6.1 INTRODUCTION

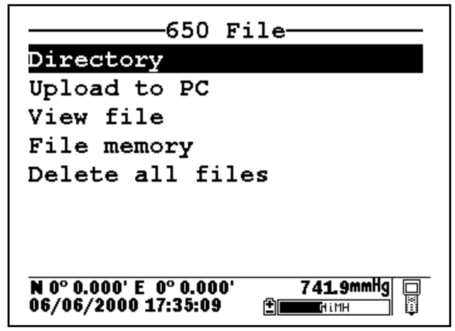
This section deals with the management of data that have been placed in 650 memory either through direct logging from your sonde or from the upload of data stored in sonde memory. A "file" by definition contains data and is distinct from the **Site Designations** in a **Site list** that are used to configure actual data files. For example, deleting an entry from the site list after points have been logged under this designation will have no effect on the actual logged data, i.e., the file itself will still be present in 650 memory. Conversely, deleting data files from the 650 memory will not delete the **Site Designations** from the **Site list**. The management of data stored in the 650 is controlled from the **650 File** command; the management of the list of file/site designations is controlled from the **Edit site list** command in the **650 Logging setup** menu as described in Section 3.5.3.4 above. Understanding this distinction will help the user avoid confusion in file and site list management.

It is also important to remember that, as described in Section 3.2.2 above, the memory of the 650 is "flash" and that, while this type of memory has many advantages, its use does impose two limitations on file management.

1. The files are listed in the order that they are logged to memory and this order cannot be changed.
2. It is not possible to delete individual files to free up memory. The only way to regenerate the 650 memory is to delete ALL files present, i.e., format the flash.

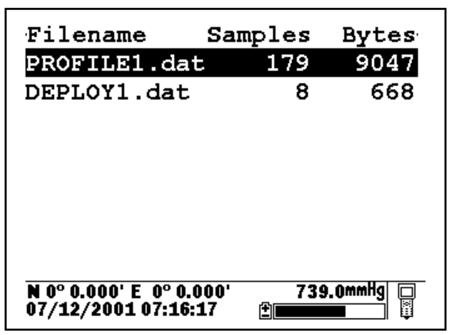
To proceed with the details of 650 File management, turn the instrument on, highlight the **File** entry in the **650 Main menu,** and press **Enter** to display the File commands as shown below.



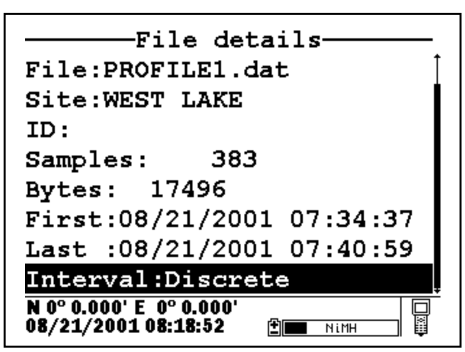


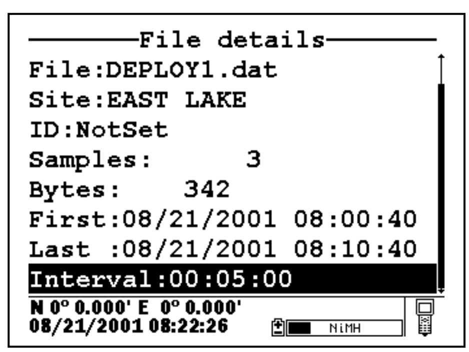
3.6.2 DIRECTORY

Use the arrow keys to highlight the **Directory** selection in the **650 File** menu and press **Enter** to display the list of files resident in the 650 memory.



Note that the size of the file is shown in two different ways: (1) the number of samples (logged data points of several parameters) and (2) the total number of bytes of memory occupied by the file. Highlight the top file (PROFILE1) and press **Enter** to generate a display of the details of this file. Press **Escape** and then highlight the second file (DEPLOY1) and press **Enter** to again display information about the file.

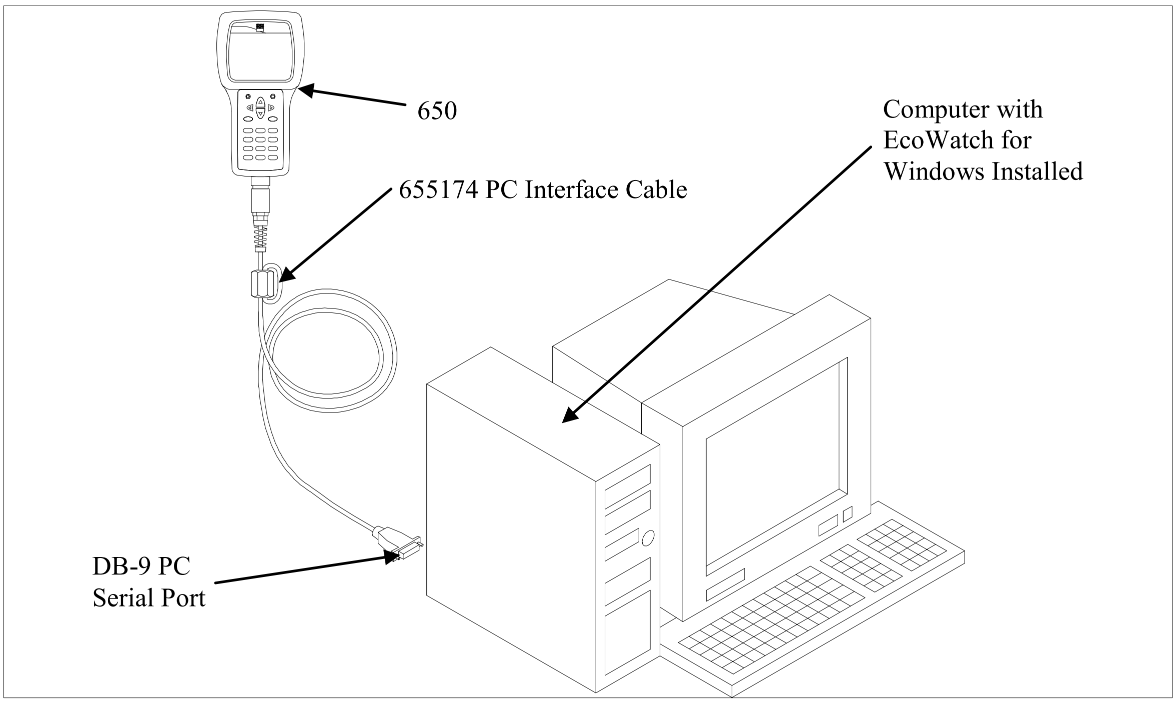




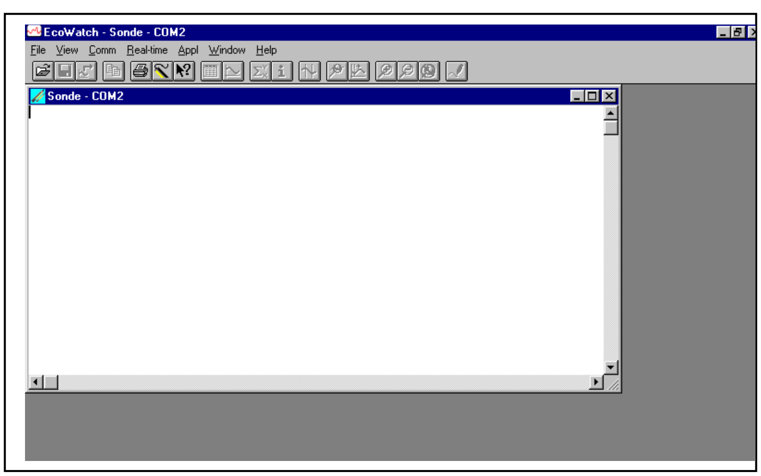
For both files, the file name, site name, file size and time of the first and last samples logged are shown. The information under **Interval** will identify whether the data were logged by manual control of the system (Discrete) or to the memory of a sonde set up in an **Unattended sampling** study. Only for **Unattended sampling** studies will the actual sample interval be displayed. When the Interval has the designation "Discrete", the time between samples can be determined by viewing the data as described below.

3.6.3 UPLOAD TO PC

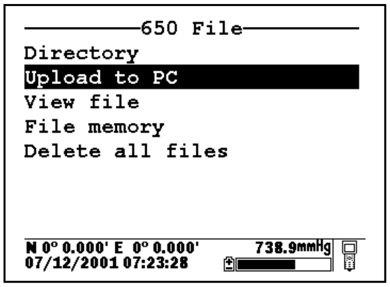
This frequently used command is used to transfer data files resident in the 650 memory (either logged directly or uploaded from sonde memory) to a PC that is running YSI EcoWatch for Windows software. Once transferred, the data can be custom configured, plotted, and reported in tabular form using this software package. The data can also be exported from EcoWatch in spreadsheet compatible form if the user prefers this method of data analysis and management. In order to carry out the upload of data files to your PC, you must first connect the 650 to a serial port of your computer via the 655174 PC Interface cable as shown in the following diagram:

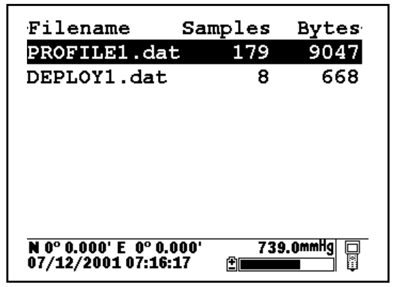


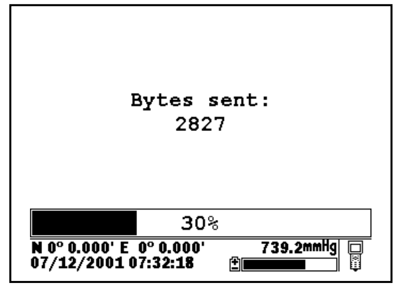
After the connection is made, run EcoWatch for Windows, click on the sonde icon in the upper toolbar, and set the Comm port number to match your interface. After this setup procedure, the following screen will be present on your PC monitor:



To transfer data from the 650 to your PC, highlight the **Upload to PC** selection in the 650 File menu and press **Enter** to view a list of the files. Highlight the file that you wish to transfer and press **Enter**. The 650 and PC displays will show the progress of the file transfer until completion.





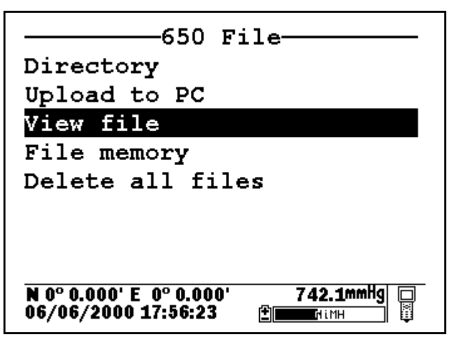


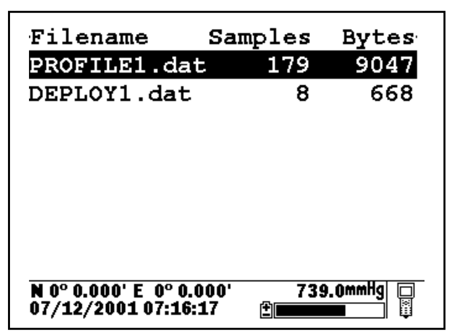
Note that there are three file types (with different extensions) in the above directory: (1) Files with .dat extensions which are data files logged to either sonde memory of 650 memory and which are in YSI PC6000 format; (2) Files with a .txt extension which are data files logged to sonde memory and then transferred to 650 memory in either ASCII or CDF format; and (3) Files with a .glp extension which are calibration records of either the sonde sensors or the 650 barometer. For files with a .dat or .txt extension, transfer to a PC using the **Upload to PC** command will proceed automatically and retain the file type that is present in 650 memory. For files with a .glp extension, an additional screen will appear on activating the transfer that gives a choice of binary, CDF, or ASCII for moving the file to the computer. You currently MUST use either the CDF or ASCII format for transfer so that the .glp file can be viewed in NotePad or other word processing program. The binary transfer option is for future YSI upgrades.

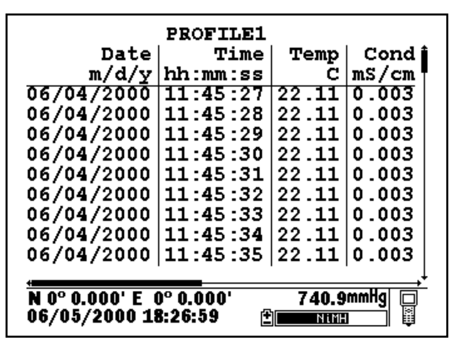
After transfer the file will be located in the C:\ECOWWIN\DATA subdirectory of your PC hard drive.

3.6.4 VIEW FILE

The **View file** selection in the 650 File menu allows the user to examine the data in files logged or uploaded to 650 memory. Highlight the **View file** selection and press **Enter** to display a list of files present. Then highlight the file of interest and press **Enter** to view the data on the 650 display.



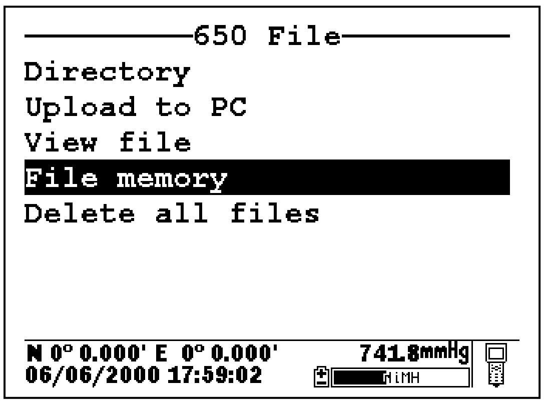


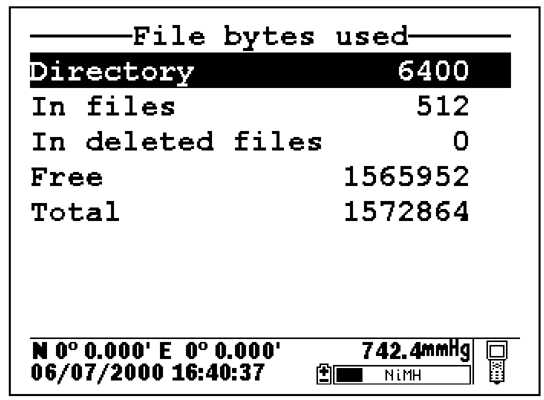


Use the arrow keys to scroll vertically to view more data points with regard to time or horizontally to view more sensor data within a particular data entry. The vertical and horizontal scroll bars identify your location within the data file.

3.6.5 FILE MEMORY

The **File memory** selection in the 650 **File menu** allows the user to get a complete picture of how the memory of the instrument is presently allocated. To view details of the allocation, highlight **File memory** and press **Enter** to display the following screen.





The key number in the **File bytes used** display is the **Free** memory listing which can be used to determine when you need to format the 650 memory ("Delete all files" as described in the next section). The value under **Total** memory will reflect whether you purchased a 650 with high or low memory. The top three items in the display summarize the allocation of the used memory space. In the example above, 6400 bytes are used in defining the memory directory, 512 bytes are taken up with accessible files, and 0 bytes are taken up in "deleted" files. As described in Section 3.2.2 above, "deleted" files arise when the same file is uploaded from a sonde several times with the file "overwritten".

There is a lot of information on the **File memory** display, but the number of greatest importance is the **Free** memory value.

3.6.6 DELETE ALL FILES

Use this selection to remove all files from the 650 memory. Remember that you cannot delete individual files from flash memory. Highlight the selection and press **Enter**. Use the arrow keys to confirm that you really want to delete all files and press **Enter**.

CAUTION: When you use this command, all data currently stored in the 650 memory will be irretrievably lost, so make certain that you have transferred all files of interest to your PC before carrying out the procedure. Note, however, that use of the **Delete all files** command will have no effect on any **Site Designations** which have been entered from the **Edit site list** selection.

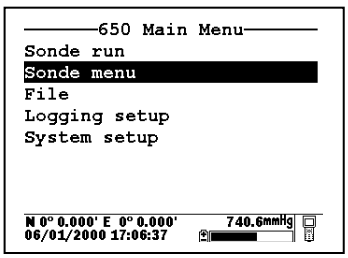
3.7 UPLOADING DATA FROM SONDES

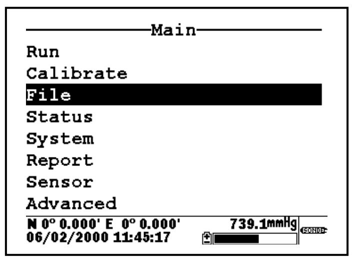
3.7.1 INTRODUCTION

A primary function of the 650 is to serve as an intermediate location for transfer of data stored in deployed 6-series sondes to a PC without bringing the sondes back to the base facility. In this application, the user connects the 650 to the sonde at the deployment site via a standard YSI field cable and, using the proper keypad commands, transfers the data stored in the sonde to the memory of the 650. The sonde is then redeployed without disturbing the study and the data transferred to a PC on return to the base facility.

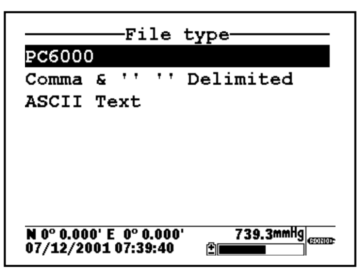
3.7.2 UPLOAD PROCEDURE

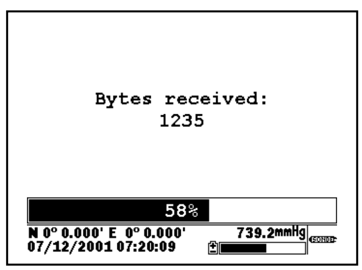
After attachment of the sonde to the 650 with a YSI field cable, turn on the 650, highlight the **Sonde menu** selection and press **Enter** to display the Main sonde menu. Highlight the File selection and press **Enter**. **NOTE: The upload MUST be made from the File menu of the sonde, not the File menu of the 650.**

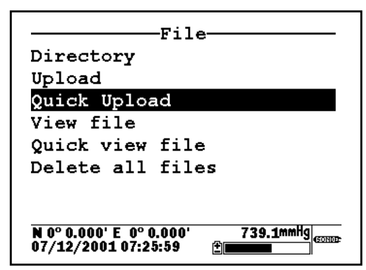




Select the **Upload** or **Quick upload** (last file) and press **Enter**. Then follow the instructions including selection of file format – YSI recommends the PC6000 format. Press **Enter** and the display will indicate that upload of data from sonde to 650 is in progress as shown below. When the upload is complete, the display will return to the **Sonde File** menu.







After the sonde file has been uploaded to the 650, the data is resident in the flash memory of both sonde and 650. Note that, if you choose to upload files from the sonde in CDF or ASCII format, the files will be characterized by a .txt extension in the 650 Directory and will NOT be viewable on the 650 display. To view the files, you must first transfer them from the 650 to your PC and then open them in a spreadsheet.

3.8 USING GPS WITH THE 650

3.8.1 SETTING UP THE GPS-650 INTERFACE

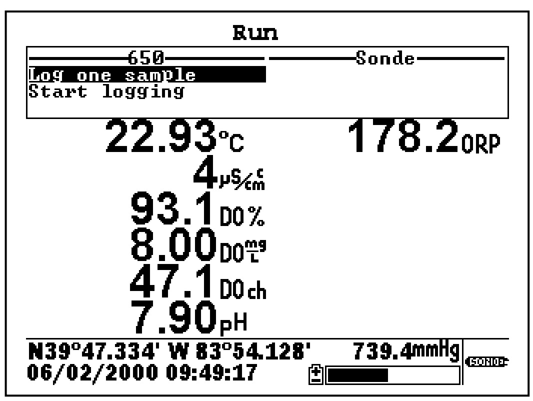
The 650 allows the user to display GPS readings of latitude and longitude from a commercially-available, user-supplied unit in the Status Bar of the 650 display. The interface of the GPS unit to the 650 is accomplished via the 6115 GPS cable that can be purchased as an optional accessory. Using the 6115 cable, GPS readings can also be logged to the 650 memory along with sonde sensor readings taken at a particular geographical location, which can then be relocated for subsequent studies.

The use of the GPS interface is easy, but the user must configure the hardware and software of the GPS unit as follows before proceeding:

- Consult the user manual of the GPS unit and configure the instrument so that readings in the NMEA 0183 protocol are generated.
- Purchase from your GPS manufacturer a cable that connects at one end to the GPS unit and has at its other end a female DB-9 connector for interface with the YSI 6115 GPS cable.

Once these requirements are met, proceed according to the following instructions, consulting Figure 2 in Section 3.2.3 above for assistance:

- Connect the 6115 GPS cable to the 650 via the MS-8 connector.
- Connect the other MS-8 connector of the 6115 GPS cable to the MS-8 connector or your sonde cable.
- Attach the male DB-9 connector of the 6115 GPS cable to the mating female connector of your GPS unit.
- Turn on the 650 and make certain that appropriate GPS readings are displayed in the upper left corner of the Status Bar as shown in the following display.



3.8.2 LOGGING GPS READINGS

To log latitude and longitude readings from a user-supplied GPS unit, the following conditions must be met:

- GPS readings can ONLY be logged to 650 memory – the system does NOT support logging to sonde memory.

- The GPS readings must be logged to 650 memory from the **650 Run** display along with sonde sensor readings. This means that you must have a sonde attached to your 650 via the 6115 cable in order to log GPS readings. Logging of GPS readings is not supported without sonde attachment even though these readings can be viewed in the Status Bar with no sonde attached.

- If your want to log the GPS readings to 650 memory along with sonde sensor readings at a particular location, you must make certain that the **Store Lat and Long** option is active in the **Logging setup** menu of the 650.

Once these conditions are met, follow the instructions in Section 3.5.3 above for logging of sonde sensor readings to 650 memory. The GPS readings will automatically be added to the file at the sample interval selected for the sonde readings.

GPS readings stored in 650 memory will remain as part of the sensor data file that can be viewed from the 650 display and/or uploaded with the data file for analysis in EcoWatch for Windows. Latitude and longitude are, however, displayed somewhat differently by the 650 and EcoWatch as noted below:

- For both display formats, the GPS are indexed relative to the point where the Greenwich Mean Time line crosses the equator.

- For the 650 Status Bar, readings are displayed in degrees and then decimal minutes relative to this point with actual "N" (north), "S" (south), "E" (east) and "W" (west) designations relative to the index point.

- When analyzing data in EcoWatch, the user will have the choice of two formats, decimal degrees (e.g., 47.5400 degrees) or degrees/decimal minutes (e.g., 47 ^{o} 32.400'). For EcoWatch, alpha directional characters ("N", "S", "E", and "W") are NOT used. Instead, points <u>north</u> and <u>east</u> of the index point are designated as <u>positive</u>, while points <u>south</u> and <u>west</u> are designated as <u>negative</u>.

These criteria mean that the GPS coordinates of Yellow Springs, Ohio, USA are approximately 39 ^{o} 47.33' latitude and -83 ^{o}54.13' longitude as read in EcoWatch, but N 39 ^{o} 47.33' W 83 ^{o} 54.13' as displayed by the 650.

3.9 USING THE 650 BAROMETER

3.9.1 PRINCIPLES OF OPERATION

The optional barometer operates on the strain-gauge principle and is located on the internal PCB of the 650. To make certain that the barometer is sensing true atmospheric pressure under conditions of temperature and pressure changes, the interior of the case is vented to the atmosphere with patches of material which are permeable to air, but impermeable to water. One of these patches is located in the rear section of the case and the other is attached to the battery lid. The patch on the case rear is not accessible to the user, but the one on the battery lid can be damaged by abuse. Be certain to identify the location of the patch on the interior of the battery lid and take care not to puncture it with sharp objects or to peel it away from the plastic. If you suspect that the venting patch on your battery lid has been damaged, make certain that you do not expose the 650 to water (either spraying or submersion). Then contact YSI Technical Support as soon as possible for advice.

The 650 barometer reads true barometric pressure and therefore is unlikely to agree with values from your local weather service which are usually corrected to sea level before being distributed. Note, however, that the primary purpose of the barometer is for use in calibrating your sonde dissolved oxygen sensor and the “true” value as shown in the 650 Status Bar is the required parameter for this procedure.

3.9.2 CALIBRATING THE BAROMETER

The 650 barometer is factory calibrated to provide accurate readings in the 500-800 mm Hg range which will be useful for dissolved oxygen calibration at most locations. This factory calibration should provide readings that are useful for dissolved oxygen calibration for many months with no user attention. However, if the user wishes to either increase the accuracy of the sensor in the local barometric pressure range or to compensate for the small drift associated with any sensor, the 650 provides a single point calibration routine which is accessed in the **650 System setup** menu and is described in Section 3.3.5 above.

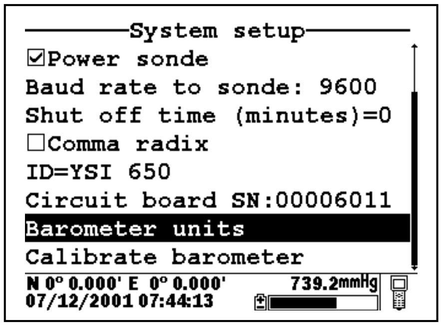
The critical factor in carrying out the single point calibration is the accuracy of the “standard” barometer that is used to determine the true barometric pressure. Common sources of this “standard” reading are high quality laboratory barometers (either mercury-based or electronic) and data from your local weather service. Laboratory barometer readings are usually “true” (uncorrected) values of air pressure and can be used “as is” for a standard as long as the system is known to be accurate. Weather service readings are usually not “true”, i.e., they are corrected to sea level, and therefore cannot be used until they are “uncorrected”. An approximate formula for this “uncorrection” (where the BP readings MUST be in mm Hg) is:

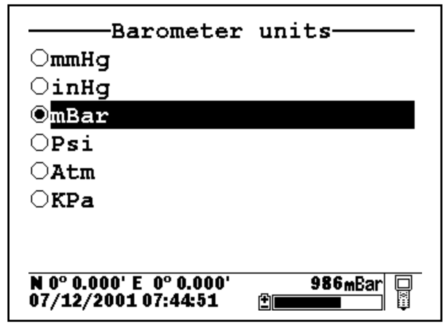
True BP = [Corrected BP] – [2.5 * (Local Altitude/100)]

Overall, the key point to remember in calibration of your barometer is to make certain that your “standard” reading is correct. If the “standard” is not accurate, you are likely to do more harm than good with your user-calibration.

3.9.3 CHANGING BAROMETER UNITS

The 650 offers the user a choice of six commonly used units of barometric pressure which can be displayed in the Status Bar. When received from the factory, the 650 will show values in mm Hg. If the user wants to change to other units, the selection is found in the **650 System setup** menu as shown below. Highlight the selection and press **Enter** to show the possible units. Then highlight the unit of choice and press **Enter** to activate it. The barometer reading in the Status Bar will automatically change to the newly selected unit.





3.9.4 LOGGING BAROMETER READINGS

To log barometric pressure readings with the 650, the following conditions (similar to those above for logging GPS readings) must be met:

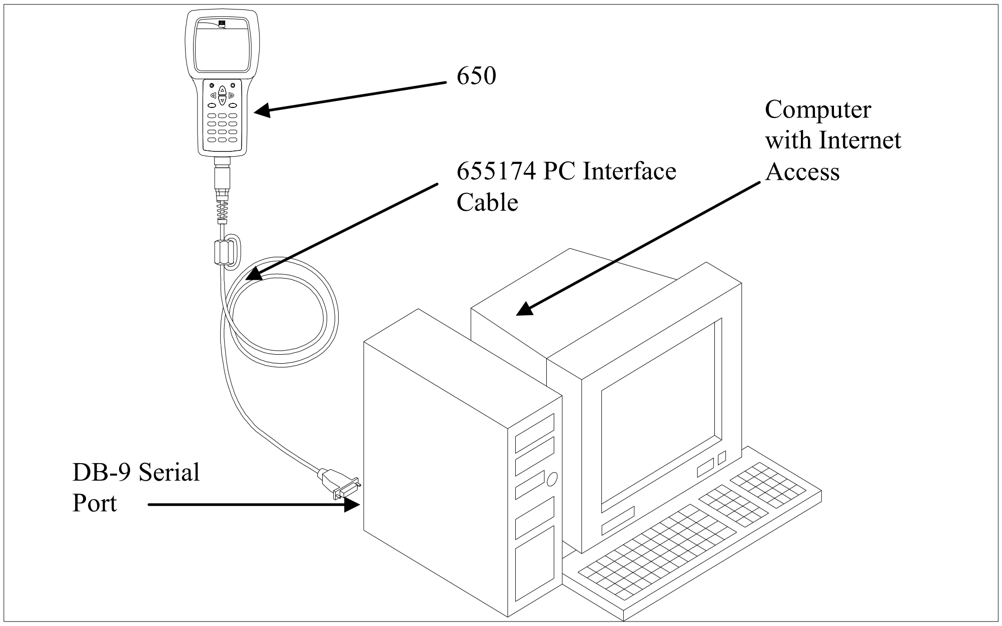
- Barometer readings can ONLY be logged to 650 memory – the system does NOT support logging to sonde memory.
- The barometer readings must be logged to 650 memory from the **650 Run** display along with sonde sensor readings. This means that you must have a sonde attached to your 650 in order to log barometer readings. Logging of barometer readings is not supported without sonde attachment even though these readings can be viewed in the Status Bar with no sonde attached.
- If your want to log barometer readings to 650 memory, you must make certain that the **Store Barometer** option is active in the **Logging setup** menu of the 650.

Once these conditions are met, follow the instructions in Section 3.5.3 above for logging of sonde sensor readings to 650 memory. The barometer readings will automatically be added to the file at the sample interval selected for the sonde readings.

Barometer readings stored in 650 memory will remain as part of the sensor data file that can be viewed from the 650 display and/or uploaded with the data file for analysis in EcoWatch for Windows. The barometric pressure readings are processed as a normal parameter by EcoWatch, with the user having the ability to change units from the EcoWatch menus. For example, data stored in 650 memory in units of mm Hg units can easily be converted to readings in mBar after upload.

3.10 UPGRADING 650 SOFTWARE

The 650 software can easily be upgraded from the YSI World Wide Web page (www.ysi.com). However, before accessing the Web page, the instrument should be prepared for upgrade by attaching the MS-8 end of the YSI 655174 PC Interface cable to the 650 and the DB-9 end of the 655174 to a serial port of a PC which has Internet access as shown below:



Once the setup is complete, access the YSI Web Page and locate the section on software upgrades. Select the 650 upgrade entry and follow the instructions provided on the Web Page. If you encounter difficulties in the upgrade procedure, contact YSI Technical Support for advice.

3.11 TROUBLESHOOTING

The following sections describes problems which you might encounter when using the 650 MDS and provides suggestions which might allow the user to overcome the symptom without additional assistance.

PROBLEM	POSSIBLE SOLUTION
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.
No interaction with the sonde occurs when pressing **Sonde run** or **Sonde menu** from the 650 menu.	Make certain that (a) the cable is connected properly between sonde and 650 and (b) that Sonde power is activated in the 650 **System setup** menu.
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.
Upload of files to 650 from sonde fails.	(1) Make sure that cable is connected properly to both 650 and sonde; (2) Make certain that you are accessing the upload routine from the sonde File menu and NOT from the 650 File menu.
Upload of files from 650 to PC fails	1) Make sure that cable is connected properly to both 650 and PC; (2) Make certain that the proper Comm port is selected in EcoWatch for Windows.
GPS and/or barometer data is not stored with sonde data file.	Make sure **Store barometer** and **Store Lat and Long** are active in 650 **Logging setup** menu.
Site Designations in the **Site List** are "grayed-out" and not available for appending files with additional data. A "Parameter Mismatch" screen is displayed.	There is a parameter mismatch between the current 650 setup and that initially used. Use **650 File view** and the Parameter Mismatch screen to determine the sonde parameter, barometer, and GPS format of file already present in memory and readjust the setup to match that initially used.
GPS data is not shown in Status Bar.	Make sure that (a) the cables are attached properly; (b) that the GPS unit is configured for NMEA 0183 format; (c) that the GPS unit is "locked in" and that the GPS unit display is showing proper readings.
The 650 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.
The sonde/650 resets when optical wipers are activated in the sonde.	The battery voltage is low. Change to new C cells or recharge the 6117 battery pack.

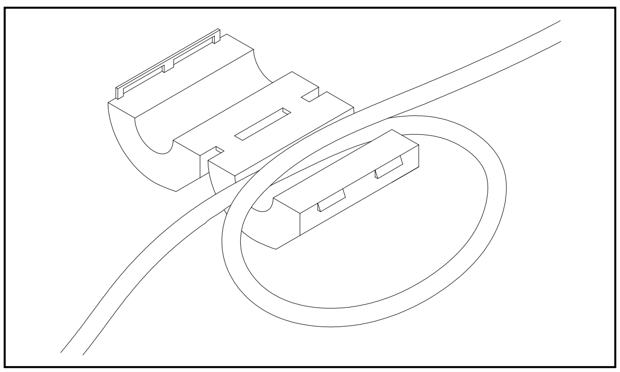
If these guidelines and tips fail to correct your problem or if any other symptoms occur, contact YSI Technical Support for advice. See Section 8 of the 6-series manual for contact information.

3.12 FERRITE BEAD INSTALLATION

WARNING: If you are using your 650 in a European Community (CE) country or in Australia or New Zealand, you must attach a ferrite bead to the 655174 PC Interface Cable and the 6116 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.

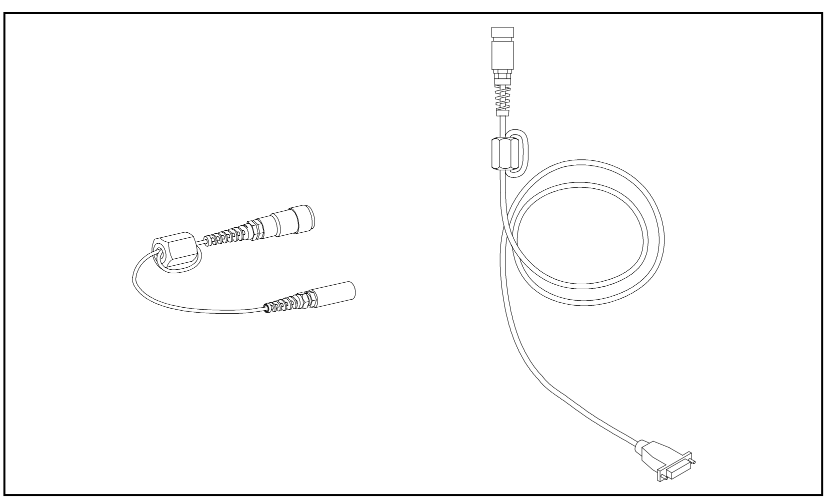
To install the beads, follow these steps:

- Make a small loop (approximately 5 cm in diameter) in the cable near the 650 MS-8 connector.
- Lay the open ferrite bead assembly under the loop with the cable cross-over position within the cylinder of the ferrite bead. See the drawing below for assistance.



- Snap the two pieces of the bead together making certain that the tabs lock securely.

When the installation is complete, the 655174 and 6116 cables should resemble the following schematic drawings.



3.13 650 SAFETY CONSIDERATIONS

⚠IMPORTANT SAFETY INSTRUCTIONS!

⚠SAVE THESE INSTRUCTIONS!

⚠In essence, the most important safety rule for use of the 650 is to utilize the instrument ONLY for purposes documented in this manual. This is particularly true of the 6117 rechargeable battery pack that contains nickel metal hydride (NiMH) batteries. The 650 user should be certain to read all of the safety precautions outlined below before using the instrument.

⚠6113 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 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 Technical Support.

8. If the battery pack is removed from the 650, 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 650, 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 Technical Support.

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.

⚠616 Cigarette Lighter Charger Safety Information

1. This section contains important safety and operating instructions for the 650 cigarette lighter battery charger (YSI Model 616; RadioShack Number 270-1533E). BE SURE TO SAVE THESE INSTRUCTIONS.

2. Before using the 616 cigarette lighter charger, read all instructions and cautionary markings on battery charger, battery pack, and Model 650.

3. Charge the 6117 battery pack with the 616 cigarette lighter charger ONLY when the 6117 is installed in the YSI 650.

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 Technical Support.

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. 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.

⚠650 Water Leakage Safety Information

The 650 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 Technical Support for instructions.

If leakage into the battery compartment is observed when using the 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 Technical Support for instructions.

⚠**CAUTION:** If water has contacted the rechargeable battery pack, do not attempt to reuse it until it has been evaluated by YSI Product 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.

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

3.14 650 MDS SPECIFICATIONS

Resistance to Water Leakage: IP 67 for both the standard alkaline battery configuration and for the rechargeable battery pack option.

Operating Temperature Range for Visible Display: -10 to 60 Degrees Celsius

Storage Temperature Range: -20 to 70 Degrees Celsius

Dimensions: 9.13 inches long by 4.75 inches wide by 2.25 inches deep

Weight with 4 Alkaline C cells and no attached sonde or cable: Approximately 2.1 lbs. (960 g).

Display: ¼ VGA; LCD with 320 by 240 pixels with backlight

Connector: MS-8; Meets IP 67 specification

Standard Battery Configuration:

4 Alkaline C Cells with detached battery cover

Optional Battery Configuration:

Nickel Metal Hydride Battery Pack with attached battery cover and 110 volt charger

Battery Life:

Approximate battery life for typical sampling applications with 4 alkaline C cells – 3 hours of "on" time per day for 0.5 month (10 working days) with the meter powering a 6600 sonde with all probes active.

Approximate battery life for typical sampling applications with rechargeable battery pack – 3 hours of "on" time per day for 0.2 months (4 working days) with the meter powering a 6600 sonde with all probes active. Battery capacity restored completely with a 6-hour charge and charged to approximately 85 % with a 2-hour charge.

Barometer:

Range: 500 to 800 mm Hg
Resolution: 0.1 mm Hg
Accuracy: +/- 3 mm Hg within +/- 10° C of the calibration temperature

Communication Protocol:

RS-232 to all sondes and for data transfer to PC and for software updates

GPS via Y-cable – NMEA 0183

Standard Backlight Feature: 4 LEDs illuminating LCD

Keyboard: 20 keys including Meter On/Off, Backlight On/Off, Enter, Escape, 10 Number/Letter Entry Keys, 2 Vertical arrow keys, 2 Horizontal arrow keys, 1 minus/hyphen entry key, 1 decimal point/period

DECLARATION OF CONFORMITY

Manufacturer: YSI Incorporated
1725 Brannum Lane
P.O. Box 279
Yellow Springs, OH 45387
USA

Product Name: Multiple Parameter Display/Data Logger

Model Numbers: 650 (with accessories: 6117 Rechargeable Battery Pack, 616 Vehicle Cigarette Lighter Adapter, 6116 Adapter Cable)

Conforms to the following:

Directives: EMC Directive

Harmonized Standards: EN 61326: Electrical Equipment for Measurement Control and Laboratory Use. *Specifically the following:* Emissions Standard (EN 55011: Class B; Residential, Commercial & Light Industrial) Safety Standard (EN61010)

Supplementary information:

The Model 616 Vehicle Cigarette Lighter Adapter was evaluated for conformity to UL 2089, including testing per section 23, 24, 25, & 27, with no failures observed.

Exposure of Model 650 to conditions per EN61000-4-3 at 1000-Volts and EN61000-4-2 at 8-Kv Contact, caused loss of instrument status and software lock-ups. Exposure to conditions per EN61000-4-4 at 3V/m or EN61000-4-6 at 3VRMS may cause similar malfunctions. Chronic exposure may lead to damage.

Lisa Abel
Director, Quality Assurance

Date: February 16, 2007

Authorized EU-representative: YSI Hydrodata Ltd
Unit 8
Business Centre West
Avenue One
Letchworth, Hertfordshire
SG6 2HB

YSI Incorporated
Yellow Springs, Ohio 45387 USA•Phone 937-767-7241•800-765-4974•Fax 937-767-9353

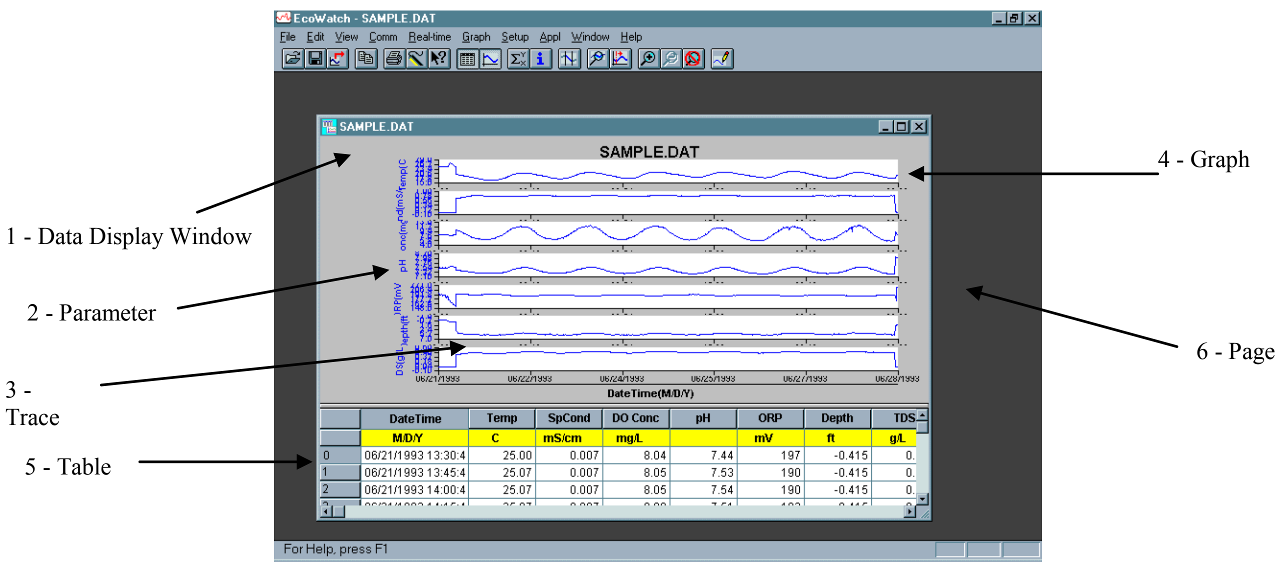
SECTION 4 ECOWATCH FOR WINDOWS

4.1 INTRODUCTION

EcoWatch for Windows is intended to be the PC software interface to YSI's 6-Series environmental monitoring systems equipment. From EcoWatch you can program field equipment, upload data collected on the equipment, and format the data in easy to understand graphs and tables.

4.1.2 GLOSSARY

These are a few of the more commonly used terms used in EcoWatch.



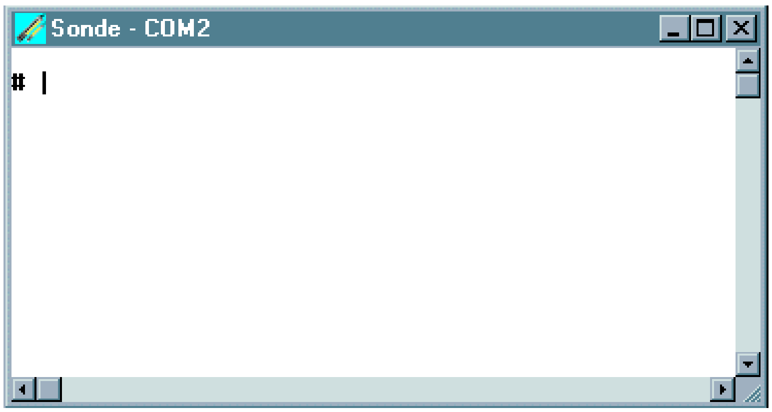
Term	Definition
1 - Data display window	The window that appears when you open a .DAT file.
2 - Parameter	A measurement such as temperature, dissolved oxygen, pH, etc. On a graph, the data of a parameter is displayed as a trace.
3 - Trace	The plot of the data of any one parameter. There may be one or two traces per graph.
4 - Graph	There may be one or more graphs depending upon how many parameters are selected. Each graph may have one or two traces. Data can be displayed either in graphs or in a table, or both.
5 - Table	Numbers arranged in rows and columns. Data can be displayed either in graphs or in a table, or both.

6 - Page

The Data Display Window can be divided in two pages, a graph page and a table page. A page becomes active when you click on it.

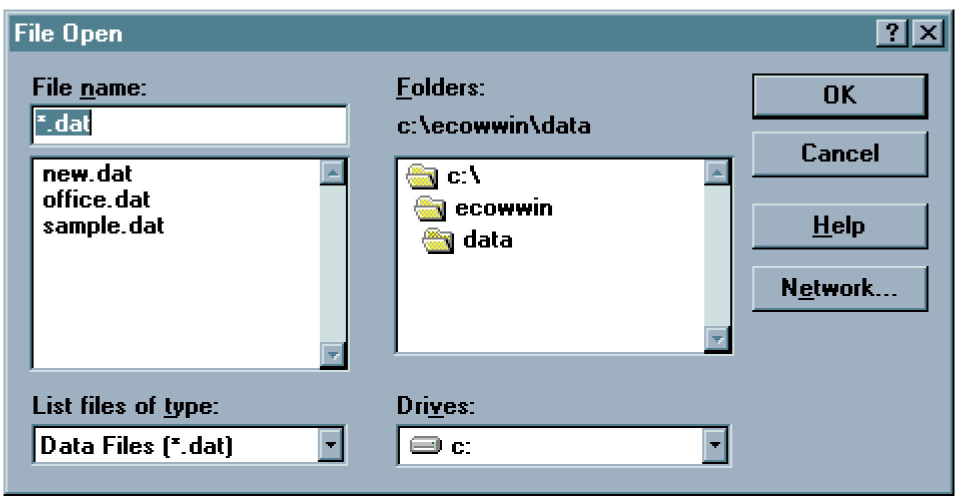
7 - Terminal window

This is the window that is open to display the sonde's internal menu. Allows the user to interact with the sonde or display/logger. The terminal window is a communication interface with another piece of equipment, whereas the Data Display Window is direct interaction with the EcoWatch software.



8 - Dialog box

A dialog box opens to display choices. Such as File Open.



9 – PC6000 data file

A data file that is in a format compatible with EcoWatch for Windows or PC6000 software.

9 – Study

A single data file in PC6000 format.

4.1.3 TUTORIAL

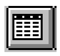
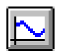
This brief EcoWatch tutorial is to be used with the sample data file that is provided with EcoWatch.

EcoWatch starts without an open data file (or .DAT file). When a data file is not open, a shortened menu bar is visible and many of the tools in the toolbar appear dimmed. Opening a data file will better demonstrate the capabilities of EcoWatch software.

To open the sample data file:

1. Click the **File** menu  button in the toolbar.
2. Select the **SAMPLE.DAT** file.
3. Click **OK** to open the file.

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.

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.

From the **Setup** menu, click **Graph**. Click **2 Traces per Graph** and notice that the parameters are now graphed in pairs. 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**  button on the toolbar. On the statistics window, click on any min or max value to display the time when it occurred. Double-click in the upper left of the Statistics window to return to the normal display.

End the tutorial by saving the Data Display in the format shown. To do this:

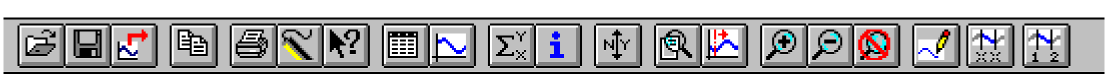
1. From the **File** menu, click **Save Data Display**.
2. Type Default for the file name when prompted for the Data Display Name.
3. Click **Save**.

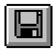
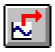
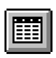
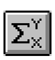
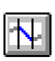
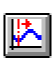
The parameters, colors, format, and x-axis time interval associated with the current display are now saved and can be accessed any time in the future. Nine different data displays may be saved for any data file. You can easily switch between various displays of the data.

This demonstration shows only a small part of the capability of EcoWatch. You may wish to also review the procedures involved in the **Section 4.1.5**, **Typical Application**.

4.1.4 USING THE TOOLBAR

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.

4.1.5 TYPICAL APPLICATION

Suppose you want to measure Dissolved Oxygen, pH, Temperature, and Turbidity in a nearby stream and decide to start with a 30-day deployment using the YSI 6920 sonde. The task can be organized into several steps:

1. Calibrate and setup the sonde.

First connect your sonde to one of the serial communications ports on your PC. In the **Comm** menu, click **Sonde** and you will get a terminal window where you can calibrate the sonde and set it up for logging. You are now communicating directly with the sonde software. See **Section 2.6, Calibration** for more detailed instructions on calibration of sensors. See **Section 2.5, Sonde Software Setup** for sonde setup.

2. Deploy the Sonde

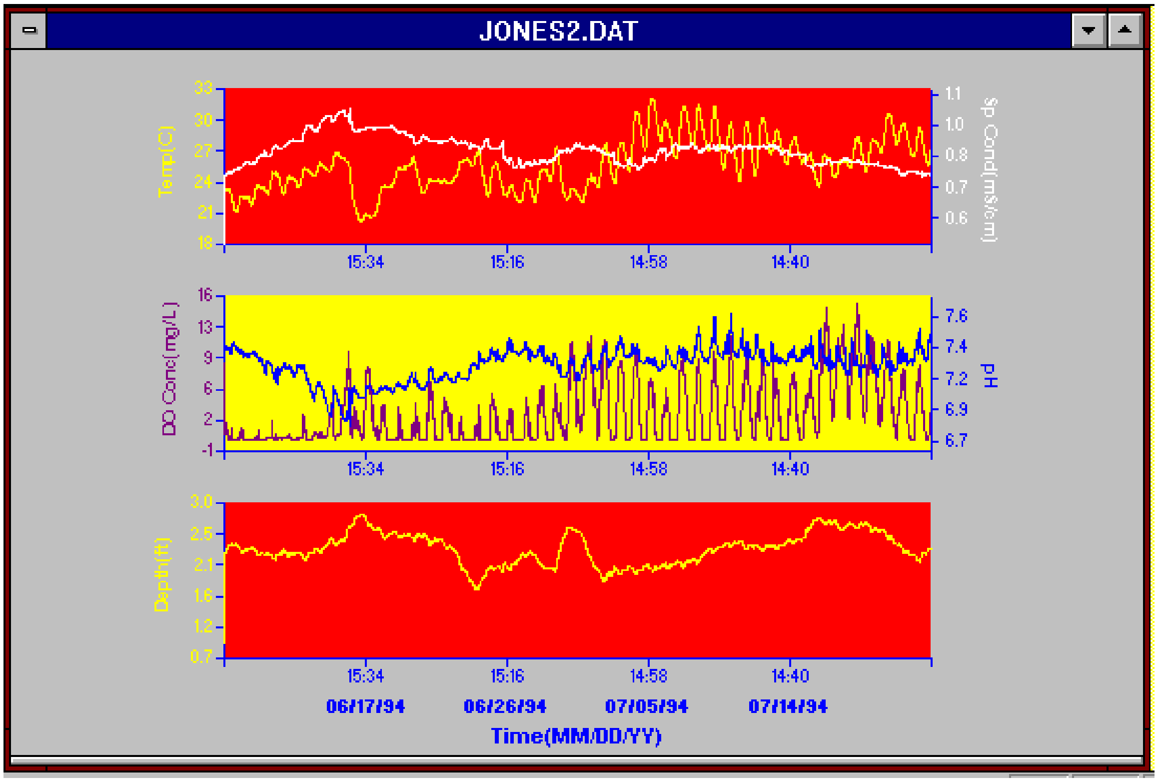
For more details, see **Section 2, Sondes and Section 3, Displays/Loggers**.

3. Retrieve the Sonde and Upload the Data

After retrieving the sonde, connect it to your PC and upload the data. As with calibration and setup, you can use the Sonde  button in EcoWatch to communicate with the sonde. Using the sonde menu, upload the data to EcoWatch. The data will now be in a .DAT file on your PC.

4. Graph the Data and Adjust the Graphs to Your Liking

Open the newly uploaded .DAT file. In this example, the file is called JONES2.DAT. Upon opening the file it looks like the graphic at the end of this tutorial. You can then use the commands in the **Graph** menu to **Zoom** to the portion of the graph that you are most interested in. You can use the **Setup** menu to add a title or change colors, scale the graphs or select the parameters to be shown.



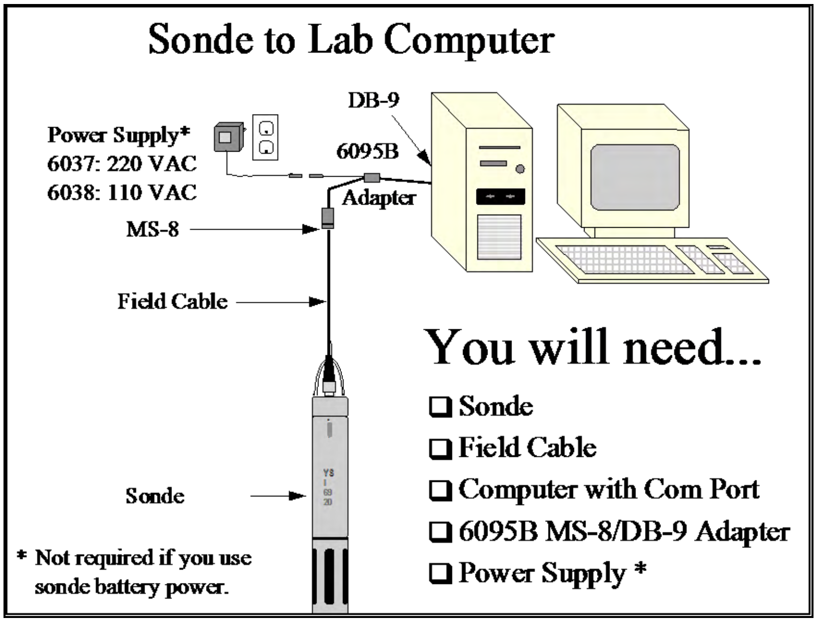
5. Print Your Graph

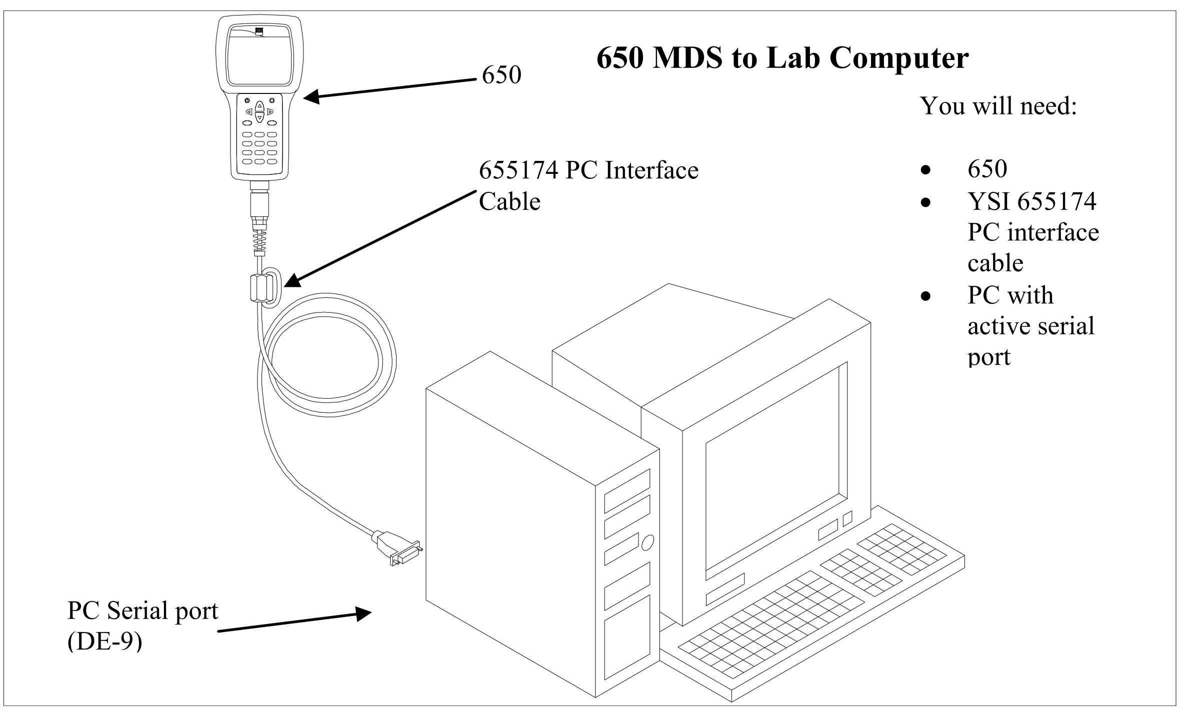
To print the graph, open the **File** menu, choose **Print Setup** or **Print** to choose exactly how the print should look.

4.2 DATA ACQUISTION AND ANALYSIS

4.2.1 CONNECT A YSI SONDE OR A 650 DISPLAY/LOGGER

EcoWatch may be used with various sondes or display/loggers. To utilize the configuration that will work best for your application, make sure that you have all of the components that are necessary.





A sonde or 650 display/logger must be connected to one of the serial communication ports on the back of your PC. These ports are usually referred to as COM1, COM2, etc. Most computers have at least two COM ports but they are often not labeled. To identify a COM port, look for unused 9 or 25 pin, D-shaped connectors with pin contacts.

Some sondes have integral cables and others require a separate cable sold especially for use with the sonde. Depending on the exact connector on your PC, you may also need a 9 to 25 pin adapter.

There is an PC interface cable for the 650 display/loggers that has a 9 pin D-shaped connector. This connector must be attached to your computer.

Once physically connected, you are ready to communicate using EcoWatch. Use the **Sonde** command in the **Comm** menu or the sonde button on the toolbar. This will give you a terminal window. From this window you interact with the sonde software using its menu system, or upload a file from a 650 display/logger. See **Section 2, Sondes** for details on how to use the sonde software.

4.2.2 UPLOAD A FILE FROM A SONDE

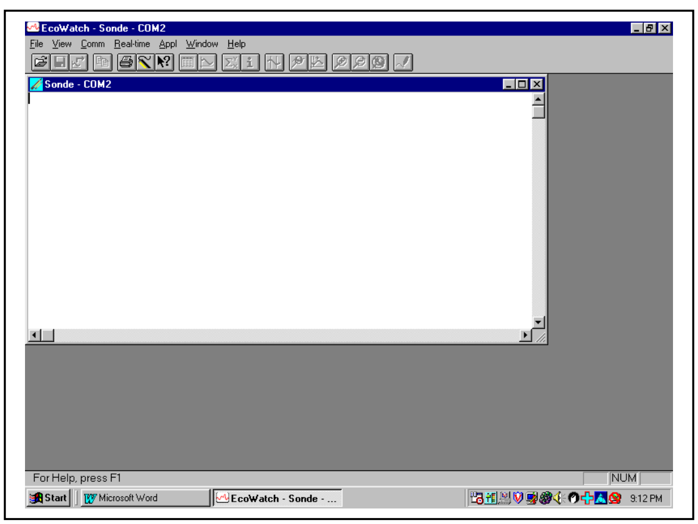
Data that is processed in EcoWatch typically originates in a sonde with batteries and is uploaded to a PC. To upload data from a YSI sonde, connect the sonde to your PC and open the EcoWatch software. Use the Sonde button on the toolbar to communicate with the sonde software.

Using the sonde software, go to the **Main menu** by typing "**menu**" on the blank terminal screen. Then choose **3-File Menu**. You will most likely be uploading the most recently recorded data. If so, simply press **3-Quick Upload**. Otherwise, press **2** to choose a file to upload. The sonde will ask you to choose a format for the file. Be sure to choose **PC6000 format**. After it is uploaded, the data will be in a **.DAT** file on your PC. You can then use EcoWatch to view, manipulate and print the data file.

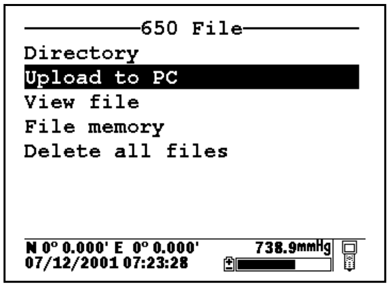
4.2.3 UPLOAD A FILE FROM A 650 DM DISPLAY/LOGGER

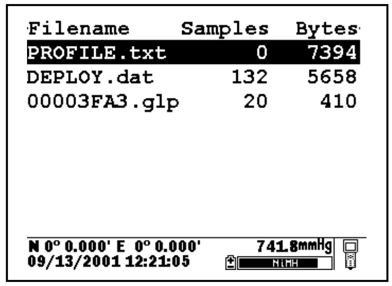
To transfer data files resident in the 650 memory (either logged directly or uploaded from sonde memory) to a PC that is running YSI EcoWatch for Windows software, you must first connect the 650 to a serial port of your computer via the 655174 PC Interface cable as shown in the diagram above.

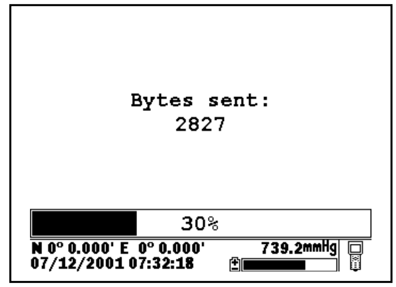
After the connection is made, run EcoWatch for Windows, click on the sonde icon in the upper toolbar, and set the Comm port number to match your interface. After this setup procedure, the following screen will be present on your PC monitor:



To transfer data from the 650 to your PC, highlight the **Upload to PC** selection in the 650 File menu and press **Enter** to view a list of the files. Highlight the file that you wish to transfer and press **Enter**. The 650 and PC displays will show the progress of the file transfer until completion.







Note that there are three file types (with different extensions) in the above directory: (1) Files with .dat extensions which are data files logged to either sonde memory of 650 memory and which are in YSI PC6000 format; (2) Files with a .txt extension which are data files logged to sonde memory and then transferred to 650 memory in either ASCII or CDF format; and (3) Files with a .glp extension which are calibration records of either the sonde sensors or the 650 barometer. For files with a .dat or .txt extension, transfer to a PC using the **Upload to PC** command will proceed automatically and retain the file type that is present in 650 memory. For files with a .glp extension, an additional screen will appear on activating the transfer that gives a choice of binary, CDF, or ASCII for moving the file to the computer. You currently MUST use either the CDF or ASCII format for transfer so that the .glp file can be viewed in NotePad or other word processing program. The binary transfer option is for future YSI upgrades.

After transfer the file will be located in the C:\ECOWWIN\DATA subdirectory of your PC hard drive.

4.2.4 USING THE GRAPH

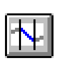
Once uploaded, data can be easily displayed in EcoWatch. Open a **.DAT** file. The six buttons on right side of the toolbar help you get a closer view of that portion of the graph you desire.

Zoom Window 

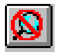
Use this to select a certain portion of the graph to be displayed. Click the button and then click and drag on the graph to select the portion you want to view. The pointer will change to a magnifying glass. The button will stay active until you click on it again.

Center Scroll 

Use this to scroll through the study. Click the button and the pointer will change to a bullseye. Click anywhere on the graph and that spot will move to the center.

Limit Data Set 

Use this button to reduce the data being processed and speed up operations. Click the button and move the pointer to the graph. A vertical arrow will appear with an N on the left and an Y on the right. Bracket the desired portion of the graph by moving the cursor to the left limit, clicking, moving to the right limit and clicking again. To limit the data in a table, move the pointer to the far left of the table into the row numbers area and highlight from the desired cutoff point to the beginning or end of the data set, whichever is desired. Then select the **Limit Data Set** option from the **Graph** menu or use the toolbar shortcut. To remove the limits, from the **Graph** menu choose **Cancel Limits**. You may also remove the limits using this button by clicking first on the right and then the left.

Unzoom 

Use this button to view the study from the beginning limit to the end limit. This command can be used on both graphs and data tables.

Zoom In 

Click this button to magnify by 20%. This command can be used on both graphs and data tables.

Zoom Out 

Click this button to reduce magnification by 20%. This command can be used on both graphs and data tables.

4.2.5 GRAPH DATA IN REAL TIME

Choosing the **New** command from the **Real-time** menu will bring up a window with graphs that plot data from the sonde as the measurements are being taken. If you do not have a default COM port set in the **Communications Settings** dialog, then you will be asked which COM port to use for the real-time measurements. If you do have a default port selected, then the program will use that port automatically.

The number of parameters displayed during real-time is set by the sonde. If four parameters are set in the Report setup in the sonde, then those same parameters will be displayed in real-time. If you want to change the parameters displayed, then you must close the real-time window, open a sonde terminal window, change the number of parameters in the sonde software menu, and then return to real-time measurements.

The **Settings** command in the **Real-time** menu takes you to a dialog where you can set the x-axis time and the sample interval.

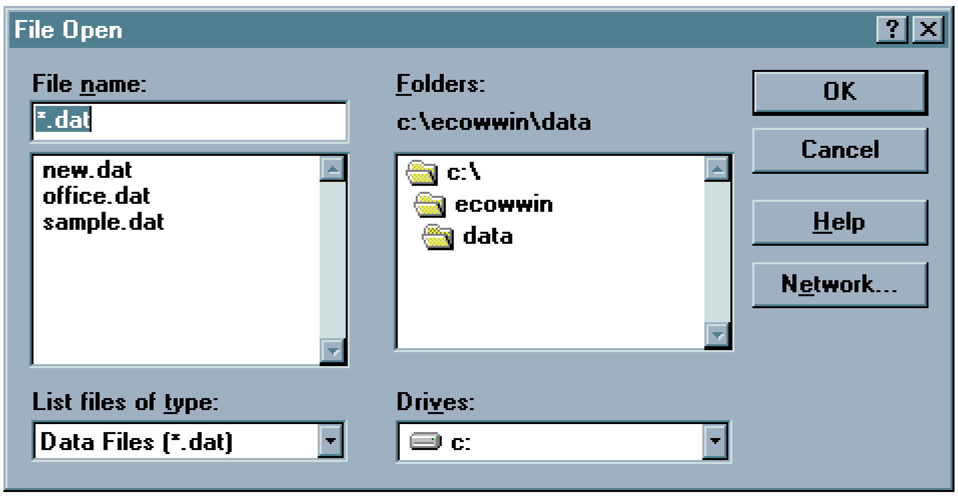
4.3 ECOWATCH MENU

4.3.1 FILE

The **File** menu offers the following list of commands. Some commands are available only when a file is open.

OPEN

Use this to open sonde data file (.DAT).



File Name Type or select the filename you want to open. This box lists files with the extensions you select in the **List Files of Type** box.

List of Files of Type Select the type of file that you want to open.

*.dat	Sonde binary data file
*.txt, *prn	ASCII text file
*.cdf, .csv, .sdf	Comma delimited file
*.rt	Real-time file
*.cr1	CR10 file

Drives Select the drive where the PC6000 data file resides.

Directories Select the directory where the PC6000 data file resides.

Network... Choose this button to connect to a network location, assigning it a new drive letter. This button is hidden if your computer is not connected to a network. The screen above has the network button hidden.

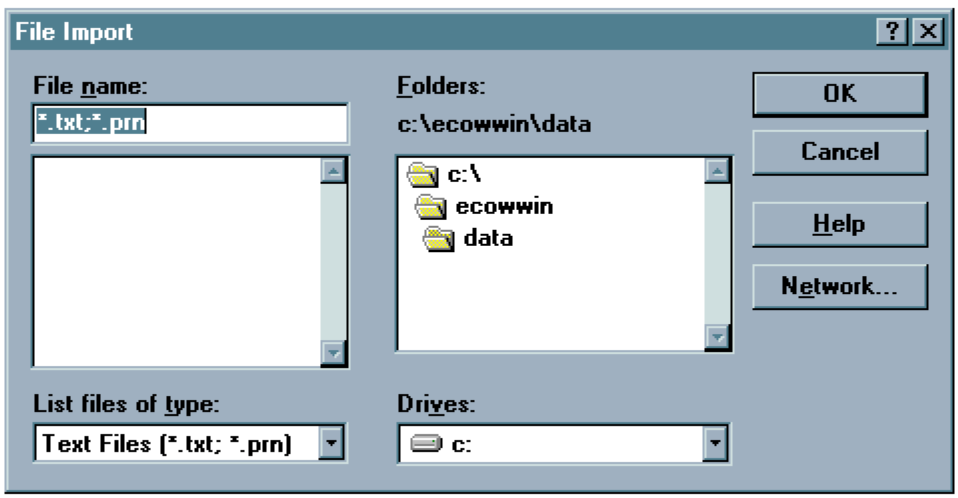
CLOSE

Use this command to close all windows containing the active document. EcoWatch automatically saves any changes before the file is closed.

You can also close a document by using the **Close** icon on the document's window, as shown below:

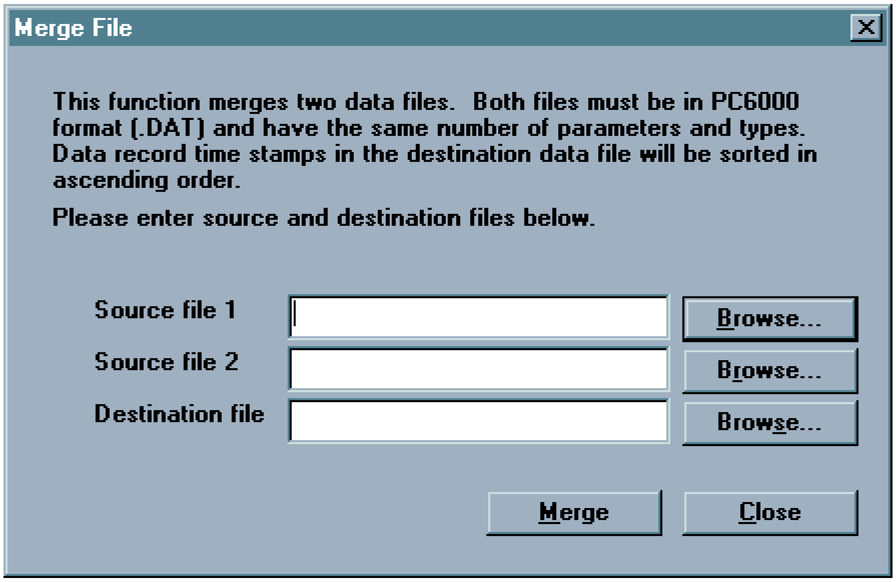
IMPORT

With this command, you can import common ASCII files into EcoWatch. The file will be converted into PC6000 format and again with a .DAT extension.



MERGE

This function takes two existing data files and merges them into one new file. Both files must be in PC6000 format (.DAT), have the same number of parameters, and the same parameter types (the parameter setup must be identical). Data record time-stamps in the destination data file will be stored in ascending order.



COPY TO CLIPBOARD

If a graph or table is active, then choosing this command will send its contents to the Windows clipboard so that it can be pasted into other programs. This is a normal method of transfer data between different Windows programs.

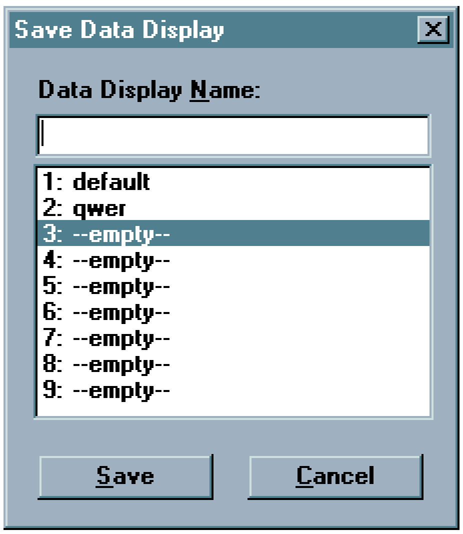
Shortcuts

Toolbar: 
Keys: CTRL+C

SAVE DATA DISPLAY

When opening a data file, you will probably want to look at the data in graph form. You may also want to rearrange the default graph by selecting or reordering parameters, zooming in to a portion of the graph, or even changing colors or changing fonts. You may sometimes choose to look at the data or a portion of it in table form. All of this work is done in the Data Display window.

This command allows you to save the settings and content of the Data Display window so that you can load it at another time and have it look exactly the same as when you saved it. This saved display is associated with the data file. Up to 9 data displays can be saved per data file. When you save a display you will be asked to give it a name in the following dialog box.

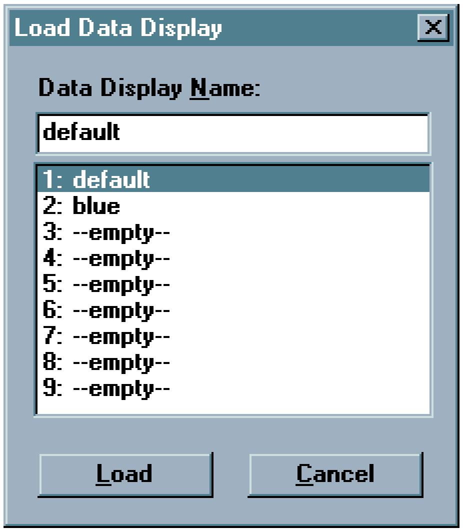


There must be an open data file for this command to be available. See also **Load Data Display.**

Shortcuts
Keys: CTRL+S

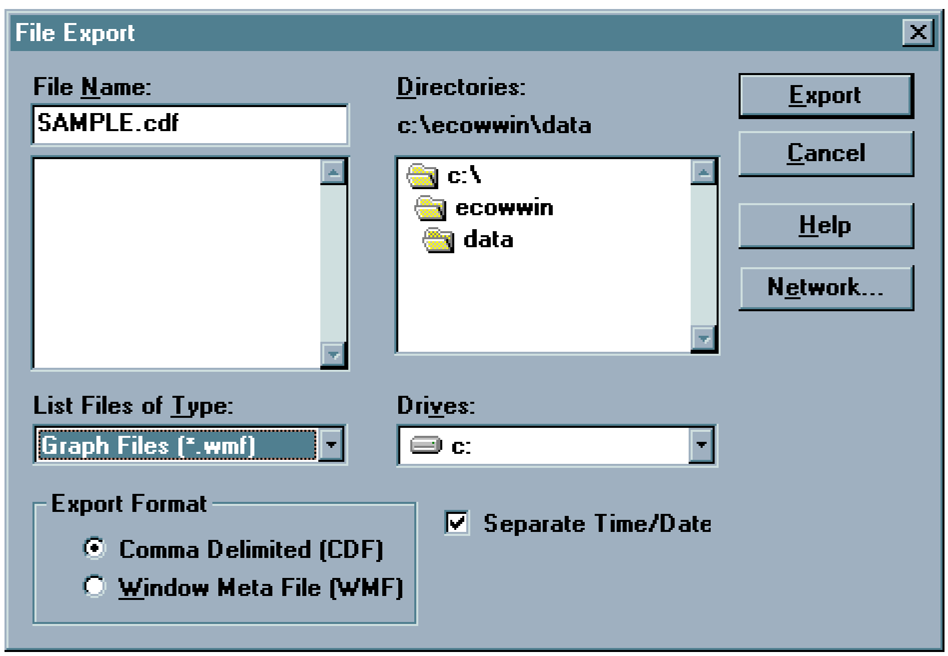
LOAD DATA DISPLAY

This command is only available when a data file is open. If you have previously used the **Save Data Display** command for the open data file, then you can load the saved display and have it look exactly the same as when you saved it. Saved displays are associated with the data file. You can have as many as nine saved displays for each data file. When loading a display you will be asked to choose from among the names of saved displays.



EXPORT

Use this command to send the current data to a file. Typically, some other program will read the file. You will see the following dialog box.



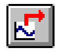
You may export the file in either of two forms: a WMF file, or a .CDF file.

WMF stands for Windows MetaFile and is a format that describes any image in a way that is independent of the program that generated the image. For example, you can generate a graph in EcoWatch, export it as a .WMF file and then import it into another Windows program.

CDF stands for Comma Delimited, sometimes referred to as a Comma and Quote Delimited File. This format is commonly used by spreadsheet and database programs. In this type of file, commas separate individual data entries, quotation marks surround any text and no formatting or marking is performed on numbers. EcoWatch can also open files in CDF formats.

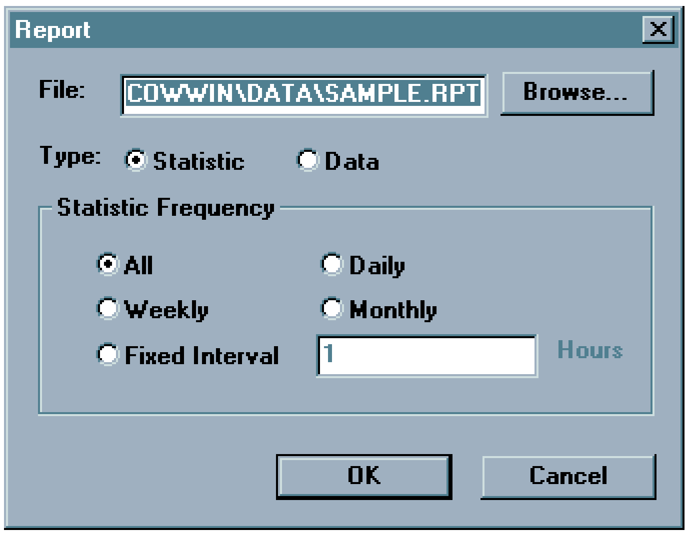
When the exported file is to be imported into a spreadsheet, it is sometimes convenient to reduce the number of data. Averaging them can easily do this. See **Change Parameter Attributes** for more information.

Shortcuts

Toolbar: 

REPORT

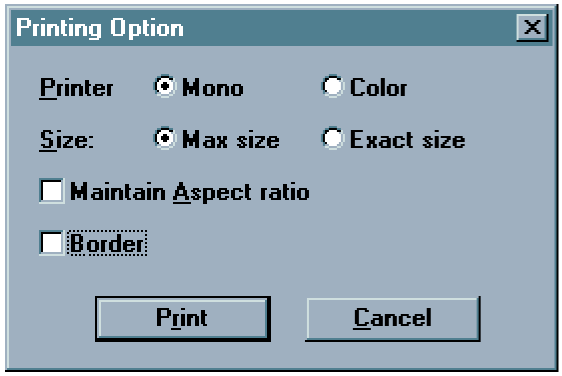
Use this command to send data or statistics to an ASCII text file. The information is easy to read in this format. When choosing this command the following dialog box will appear.



- You must enter a filename (under **File**; use the **Browse** button if needed). If you want to simply have a report **Type** listing the data, then click **Data**. If you want **Statistics** (minimum, maximum, average, and standard deviation), then the statistics frequency button applies.
- If you want to have **Daily** statistics, keep in mind that every day actually starts at midnight. It would be likely then that the first and last days would have very different statistics because they would only be partial days. **Daily, Weekly** and **Monthly** statistics behave similarly.
- When you click **OK**, EcoWatch will send the report to the specified file and open **Windows Notepad** where you can view and/or print the report. Note: Notepad can only open report files that are 64K or less in size. You can use the Windows Wordpad to open reports that are larger than 64K. Unless you change it, the report file will have the same location as your data file (.DAT) and has the same name with a .RPT file extension.

PRINT

Use this command to print a document. If a graph is selected, this command presents a **Print Option** dialog box with the options below. When a table is selected, a standard print window is



presented.

Shortcut

Toolbar: 
Keys: CTRL + P

Printer
If you have a color printer, you can choose to print in **Color**. Otherwise you should choose **Mono** (black and white).

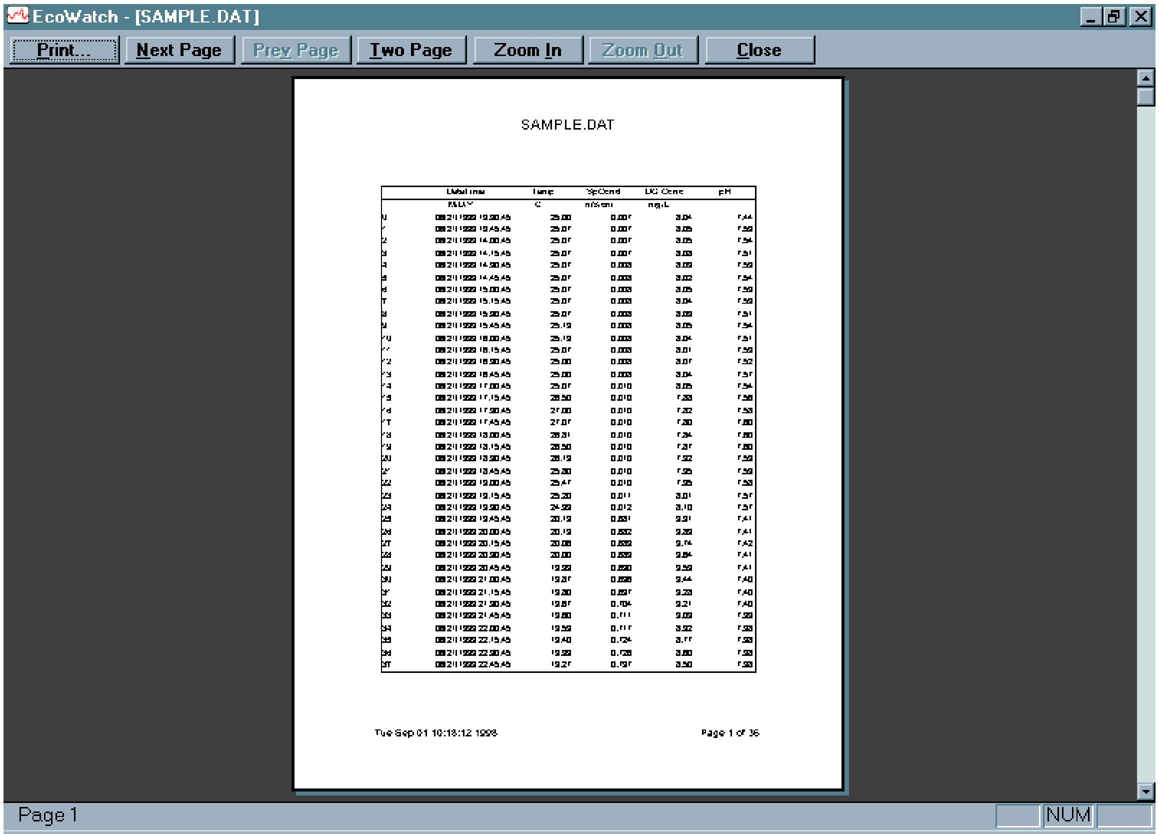
Size
If you choose **Max** size, then the program will size the graph so that it fits on one page. If you choose **Exact** size, then program will print the graph as close as possible to the size that is displayed.

Maintain Aspect Ratio
If you choose to maintain the aspect ratio, then the program will size the graph until either the height or the width is maximized and then leave the graph in the same height width ratio that is displayed.

Border
You can also choose whether or not to print a border.

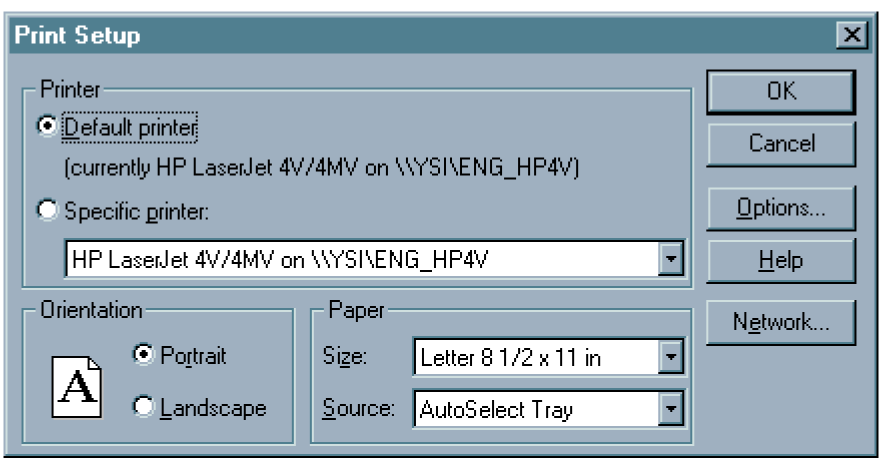
PRINT PREVIEW

This command allows the user to preview how the document will appear when it is printed. This command only works for data that is displayed in a table format, not when the data is in graph format.



PRINT SETUP

Use this command to select a printer and a printer connection. This command presents the **Print Setup** dialog box. The following options allow you to select the destination printer and its connection.

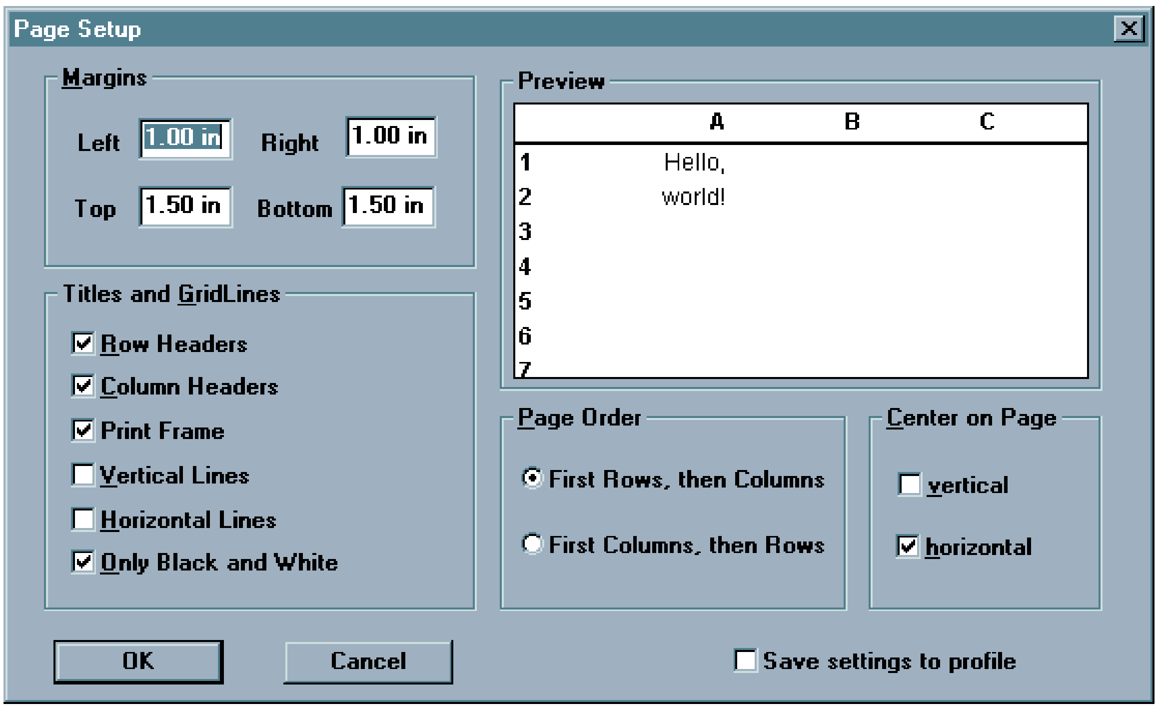


Printer Select the printer you want to use. Choose the **Default Printer**; or choose the **Specific Printer** option and select one of the current installed printers shown in the box. You install printers and configure ports using the Windows Control Panel.

Orientation	Choose **Portrait** or **Landscape**.
Paper Size	Select the size of paper that the document is to be printed on.
Paper Source	Some printers offer multiple trays for different paper sources. Specify the tray here.
Options	Displays a dialog box where you can make additional choices about printing, specific to the type of printer you have selected.
Network	Displays a dialog box that allows you to choose a printer if you are on a network.

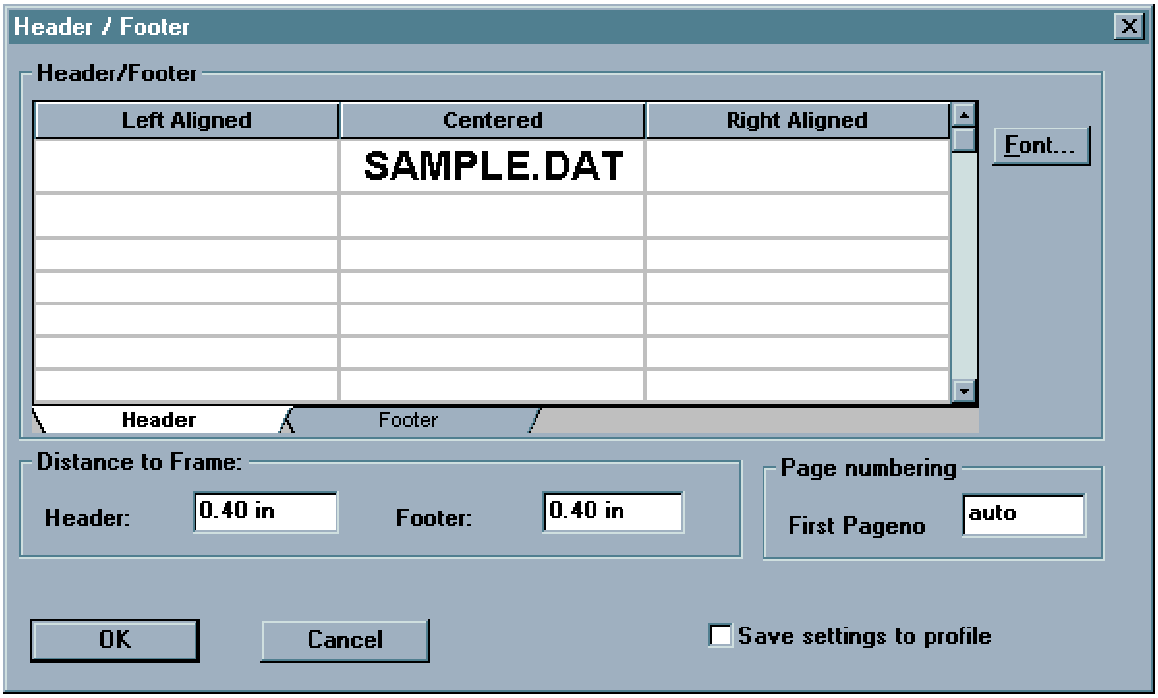
PAGE SETUP

Layout options for printable data tables may be specified. Page margins, table setup, page orientation, and page order are adjustable.



HEADER/FOOTER

Page headers and footers can be customized with respect to font and placement. Both the header and footer have separate tabs as shown below. Once the desired profile is created, it can be saved for use every time the particular data file is opened.



4.3.2 EDIT

The edit menu appears whenever a data file is opened in EcoWatch. It allows you to locate, format, and manage data.

COPY

Copies the selection to the clipboard. If a graph or table is active, then choosing this command will send its contents to the Windows clipboard so that it can be pasted into other programs. This is a normal method of transfer data between different Window programs.

Copying data to the clipboard replaces the contents previously stored there.

Shortcuts

Toolbar: 
Keys: CTRL+C

PASTE

This command does not function in this version of EcoWatch.

REMOVE PARAMETERS

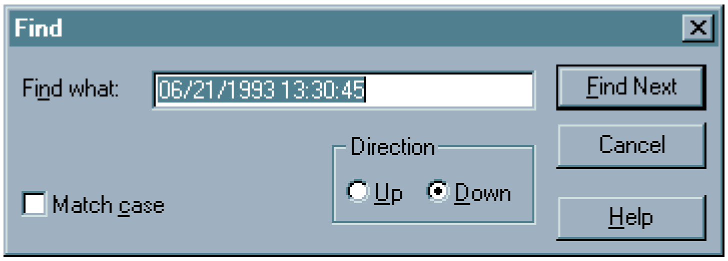
When entire column(s) of data is selected, including the heading(s), this command will remove the parameter(s) from both the data table and graph.

INSERT PARAMETER

Adds an additional parameter to the data table and graph. All available parameters that can be added are shown on a list.

FIND

Locates text within the selected parameter. Only one parameter may be searched at a time. A system beep indicates that there are no more occurrences of the desired text.



FIND AGAIN

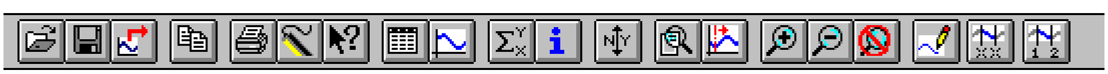
Locates the text that was most recently searched for within the selected parameter. Only one parameter may be searched at a time.

4.3.3 VIEW

The **View** menu offers the following commands:

TOOLBAR

Use this command to display and hide the **Toolbar**, which includes buttons for some of the most common commands in EcoWatch, such as **File Open**. A check mark appears next to the menu item when the **Toolbar** is displayed.

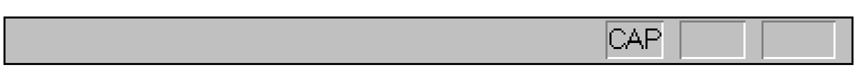


Shortcut: To hide or display the Toolbar, choose **Toolbar** from the **View** menu.

See **Section 4.2.6, Using the Toolbar,** for a list of the toolbar icons and their functions.

STATUS BAR

Use this command to display and hide the **Status Bar**, which describes the action to be executed by the selected menu item or statuses of keyboard latch state. A check mark appears next to the menu item when the **Status Bar** is displayed.



The right areas of the status bar indicate which of the following keys are latched down:

CAP The Caps Lock key is latched down.

NUM	The Num Lock key is latched down.
SCRL	The Scroll Lock key is latched down

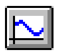
4-DIGIT YEAR

Use this command to toggle between a date with a two or four digit year on the graph and table.

GRAPH

Use this command to display and hide the **Graph** page when viewing a file. The graph page contains plots of data.

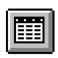
Shortcuts

Toolbar: 

TABLE

Use this command to display and hide the **Table** page while viewing a data file.

Shortcuts

Toolbar: 

GRID

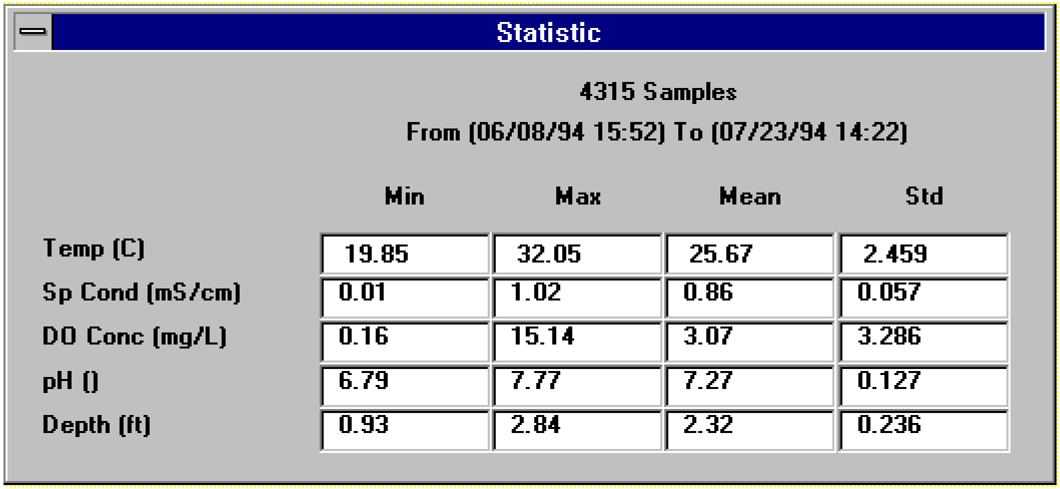
Turns on or off the gridlines on graphs.

MARKERS

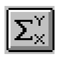
Turns on or off data point markers on the graphs. For graphs with more than a few data points we recommend that **Markers** be left off.

STATISTIC

This command will display statistics for the current study. It will show the minimum, maximum, mean, and standard deviation for each of the current parameters. If you click on any minimum or maximum value, then a small box will appear showing the date and time when the minimum or maximum point occurred.

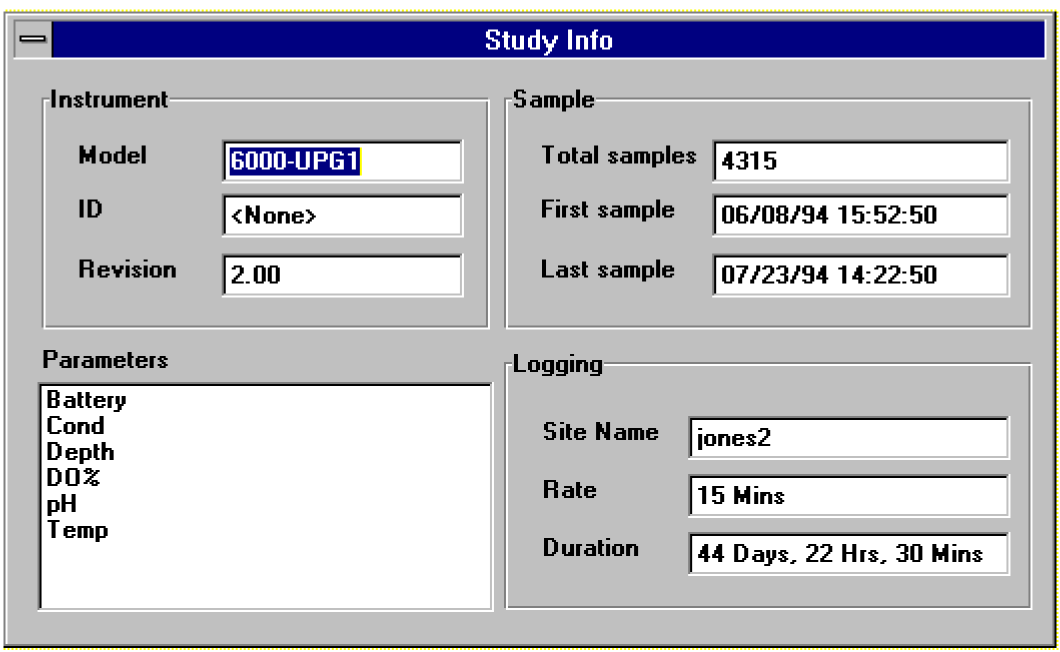


Shortcuts

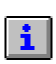
Toolbar: 

STUDY INFO

This command will display a dialog box describing the study. It will show the sonde type and serial number that was used to collect the data, the parameters available, the logging interval, and the beginning and ending times of the sample.



Shortcuts

Toolbar: 

ZOOM IN

Enlarges graph or data table (whichever is currently active) by 20%.

Shortcuts

Toolbar: 

ZOOM OUT

Reduces graph or data table (whichever is currently active) by 20%. If the graph already extends to both ends of the **Study Limits**, then it is not possible to zoom out any farther and this command will be dimmed.

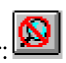
Shortcuts

Toolbar: 

UNZOOM

Displays the graph all the way to both ends of the **Study Limit** if a graph is selected. Displays the data table in default size, if a data table is selected.

Shortcuts

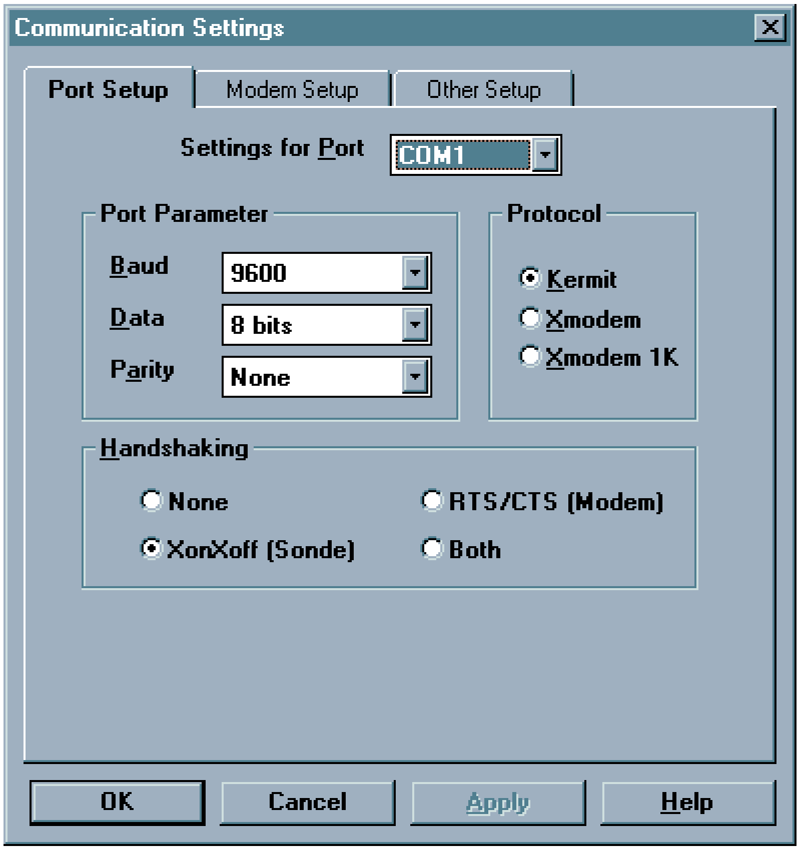
Toolbar: 

4.3.4 COMM(UNICATION)

The **Comm** (Communications) menu commands let you control your communications settings with sondes, modems, and other devices. Several communication menu options are only available when a terminal window is opened.

SETTINGS

The **Communications Settings** dialog box is where you can configure the communications ports. The settings are organized into the following three tabs.



Port Setup

This is where you can set port parameters, file transfer protocol and handshaking for each of the ports that you will use.

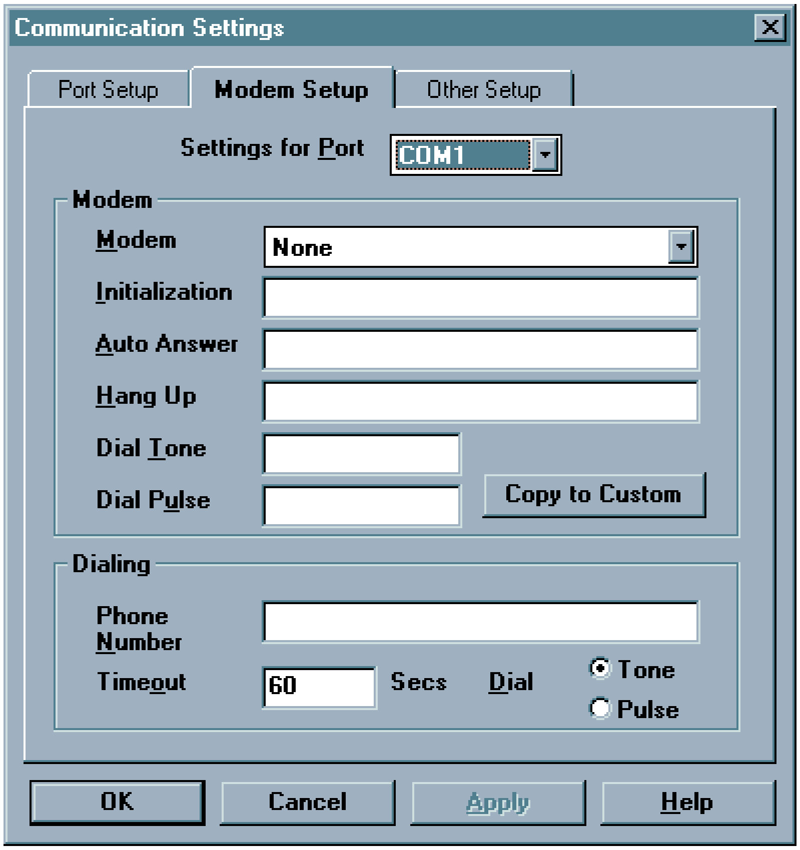
- **Port Parameter Setup**
  These include the most common settings for each communication port. These settings are **Baud Rate,** number of **Data** bits, and **Parity**. These settings must be identical to the settings on the device that is connected to the port. You may choose independent settings for each communication port.

- **Protocol**
  You may choose **Kermit**, **Xmodem** or **Xmodem 1K** protocol for file transfer through the communications port. 6820, 6920, 600R, 600XL, 600XLM and 6600 sondes use only **Kermit** protocol.

- **Handshaking**
  You may choose **Xon/Xoff**, or **RTS/CTS**, or **Both** or **None**. **Xon/Xoff** is often referred to as software handshaking and RTS/CTS as hardware handshaking. If you are using a YSI sonde select **Xon/Xoff**. Modems usually require **RTS/CTS**.

- **Modem Setup**
  This is where you enter the settings for your modem. Note that you can have several modems, each on separate COM ports, and each with its own settings.

If a modem is selected for a particular COM port, then every time that port is opened, EcoWatch will attempt to initialize a modem on that port. If the attempt fails, then EcoWatch will open a terminal window and you can communicate to that port with the computer keyboard. This can be very helpful in troubleshooting a connection to your modem or in determining exactly which settings work with your modem.



- **Modem**
  To setup a particular modem on your first try, select that modem from the **Modem** list. The only settings that you can edit are for the **Custom** modem.

  If your modem does not work, select "Hayes Compatible" modem. Those settings are quite common and might work for your modem. If neither approach works, then you will have to define your own settings. You will need the instruction manual for your modem. It should list all of the proper settings. Choose **Custom** from the **Modem** list and enter the settings for your modem.

  The **Auto Answer** setting is included in the dialog for completeness. EcoWatch currently does not use **Auto Answer**.

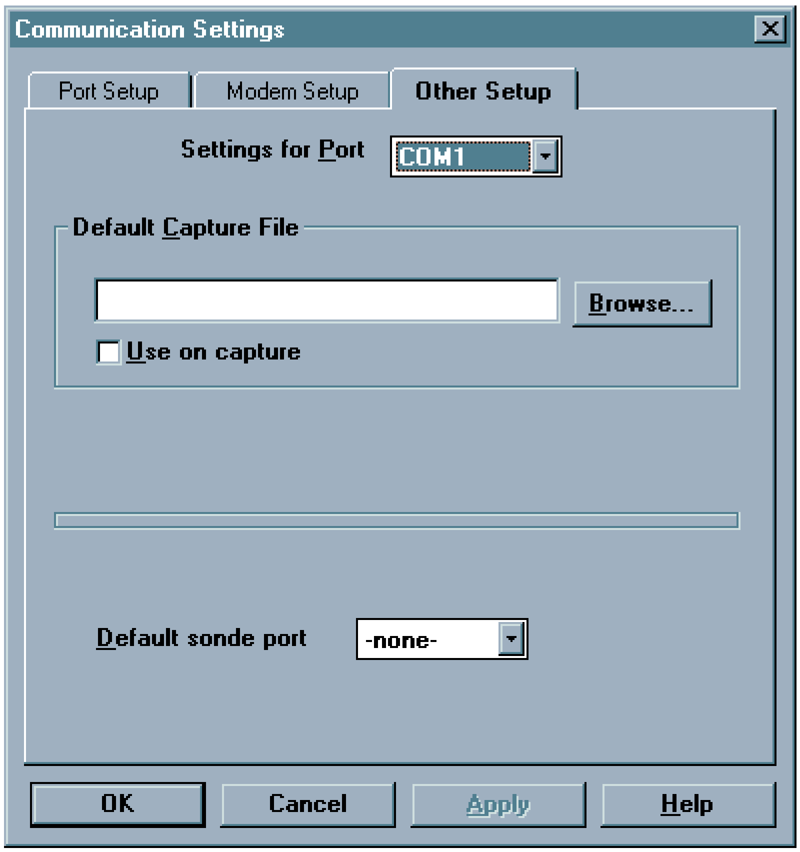
  - **Copy to Custom**
    The **Copy to Custom** button is sometimes helpful in defining your own settings. If there is a similar modem, choose it from the list, and then click **Copy to Custom**. Choose **Custom** from the list and edit the settings. It transfers all modem settings from the currently selected modem to the "Custom" modem so you can modify the setting later.

- **Dialing**

  If there is no entry for **Phone Number**, then every time you choose an option that opens the COM port that connected to a modem, EcoWatch will ask you for a phone number. **Timeout** specifies how long in seconds EcoWatch will wait for the phone to answer.
  Use the **Dial** option to select **Tone** or **Pulse** dialing.

Other Setup

This is where you choose a default port for communicating with a sonde and default capture files for each sonde port. This tab addresses several COM port settings not covered on the other two tabs.



- **Default Capture File**

  While communicating to a sonde in terminal mode using the Sonde command, you may want to capture measurements to a file. You may type in a default file name in the accompanying text box.

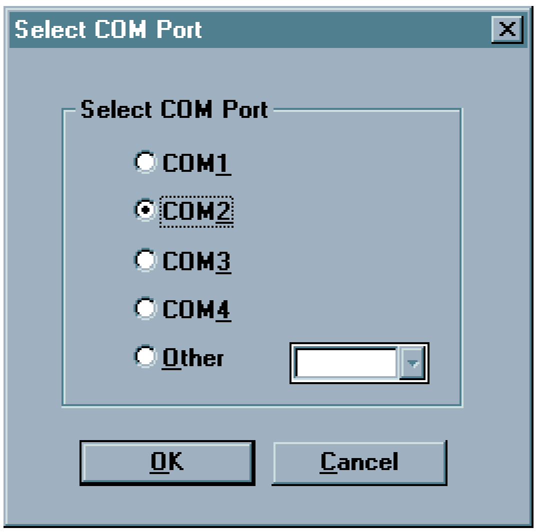
  If you specify a file name here and select the Use on Capture check box, then whenever you capture data, the program will write to that file without first asking you to confirm. If you specify a file but do not select the check box, then you will have to confirm that this is the file you wish to have your data written to before starting to capture.

- **Default Sonde Port**
  This refers to the COM port you will most commonly use to connect to your sonde. If you select a port here, EcoWatch will automatically use this port as the default COM port when you use the Sonde command.

The **Apply** button in the bottom of this dialog box is not used in EcoWatch.

SONDE

This command opens a terminal window for communicating with a sonde. From the terminal window you can communicate to a sonde using the sonde menus. Unless you have chosen a default sonde port in the **Communications Settings** dialog box the following dialog box will appear asking you which COM port to use.



Shortcuts

Toolbar: 

TERMINAL

Opens a new terminal window for communicating with any compatible RS-232 devices.

FONT/COLOR

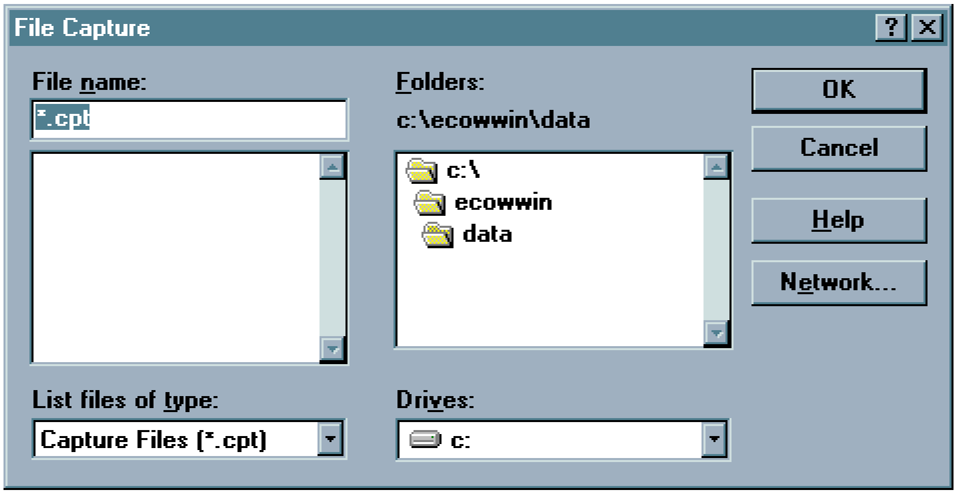
Adjust font color, size, and style for any text that appears in the terminal window.

BACKGROUND COLOR

Adjust the background color of the terminal window.

CAPTURE

Turns COM port capture **On** or **Off**. This is typically used while communicating with a sonde that is taking measurements. Capture will send all communications received on the COM port to a file. After selecting the command, a dialog box will appear for selecting the name of the file to use. If “Use default capture” file was checked in Communications Settings, EcoWatch will not display this dialog.



A common example is using a sonde in **Run Mode**. The sonde is simply taking readings and sending them to the COM port. If you want to keep a record of these readings, then a simple way to do so is to turn **Capture** on. When you are finished, run the **Capture** command again to turn it off.

FILE UPLOAD

Use this command to upload files from any device that uses **Xmodem** file transfer protocol. First initiate the upload from the device, then choose this command. This command is enabled only when the **Xmodem** or Xmodem 1K protocol has been selected in **Port Setup**.

DIAL MODEM

If you have specified a default phone number in the **Modem** tab of the communications **Settings** dialog box, then this command will call that number. If you have not specified a default number, then you will be asked for a number.

HANG-UP MODEM

Hangs up phone and halts communication with the modem.

SEND ASCII FILE

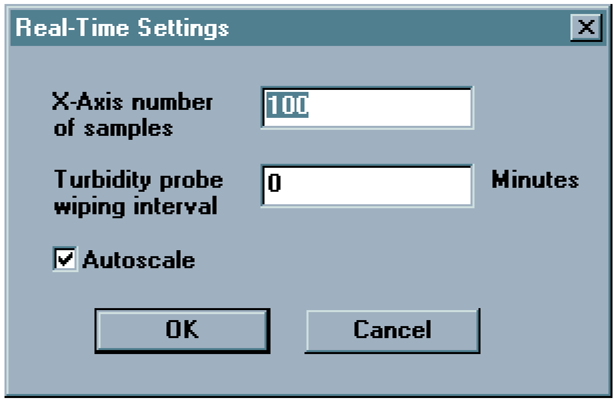
Sends a file in to the device connected to the terminal using plain ASCII protocol. No handshaking or error correction is involved.

SEND XMODEM FILE

Sends a file to the device connected to the terminal using **XModem** protocol.

4.3.5 REAL-TIME

The **Real-time** menu offers the following commands that allow you to control how your data will be presented.



SETTINGS

This command is only active when there is a real-time window open. This command takes you to the **Real-time Settings dialog** where you can set the length of the x-axis.

In the Real-Time Settings box you will set the number of samples graphed across the axis. (The interval between samples is set in the sonde using the sonde menus.) After the graph is full, each new data point will cause the trace to scroll left so that you see only the most recent set of measurements.

If you have a YSI 6026 or 6136 turbidity, 6025 chlorophyll, or 6130 rhodamine WT probe with a wiper, then you may want to clean the optics periodically. Set that interval in this dialog.

Autoscaling will keep the trace comfortably on the graph as the measurement changes.

To **Manually Scale** a graph; double-click on its Y-axis labels. The Graph Y-Axis box will come up where you can set the scale. Note that you can manually set the scale for some parameters and autoscale others. When the autoscale box is checked, the high and low limits will be unavailable. See also the **Autoscale** command in the **Graph** menu.

NEW

Choose this to start a new real time study.

OPEN

Choose this to open a previous real time study.

CLOSE

Choose this to close a real time study.
Two files are formed every time a real time study is started. You will choose a .RT file that will store colors, scaling information, number of parameters and other information useful to the program. At the same time, the program starts another file with the same name but a .DAT extension for the actual measurements that are taken during the study.

4.3.6 GRAPH

ZOOM WINDOW

Enlarges a section of the graph. The pointer will change to a magnifying glass and then you can click and drag on the graph to indicate the section you want to view. This command stays active until you execute it again.

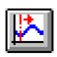
Shortcuts

Toolbar: 

CENTER SCROLL

Centers graph at the mouse cursor. The pointer will change to a bullseye. Clicking anywhere on the graph will cause that point to be moved to the center. This command stays active until you execute it again.

Shortcuts

Toolbar: 

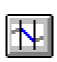
LIMIT DATA SET

This command limits the amount of data being processed. If you are not presently interested in portions of the graph or table at the beginning or end of the study, you may want to use this command to indicate only that portion that you are interested in. The program will have fewer data points to handle and will respond to your commands quicker. Executing this command when modifying a graph will change the pointer to a vertical arrow. Click once on the left end of that part of the graph that you want and then click again at the right end. This command stays active until you execute it again.

To limit the data in a table, move the pointer to the far left of the table into the row numbers area and highlight from the desired cutoff point to the beginning or end of the data set, whichever is desired. Then select the **Limit Data Set** option from the graph menu or use the toolbar shortcut.

To undo the limits choose **Cancel Limits** below. Alternately, you may remove the limits on a graph by executing this command backwards. That is, click anywhere on the right side of the graph first, and then click anywhere on the left side. The limits will be moved to the ends of the file.

Shortcuts

Toolbar: 

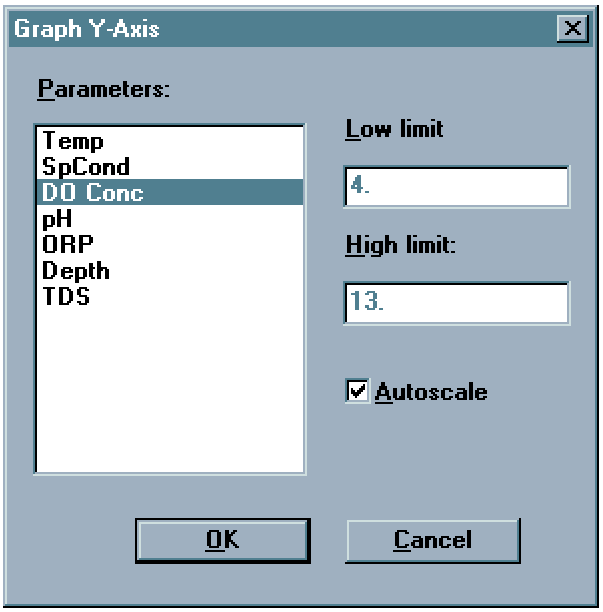
AUTOSCALE

Sets the scale of each parameter so that the minimum and maximum points fit comfortably on the graph.

MANUAL SCALE

Takes you to the **Graph Y-Axis** dialog box where you can set the scale for each parameter.

Graph Y-axis dialog box
To manually scale a graph, double click on its Y-axis labels. A dialog will come up where you can set the scale. Note that you can manually set the scale for some parameters and autoscale others. When the autoscale box is checked, the high and low limits will be dimmed. See also the Autoscale command in the Graph menu.



.

REDRAW

If part of a graph is not displayed it could be because your window is sized too small to display it or because you have just returned to EcoWatch from some other application. Maximizing the window and choosing this command should display your graph correctly

Shortcuts

Toolbar: 

CANCEL LIMITS

Choose this command to cancel the limits set by the **Limit Data Set** command.

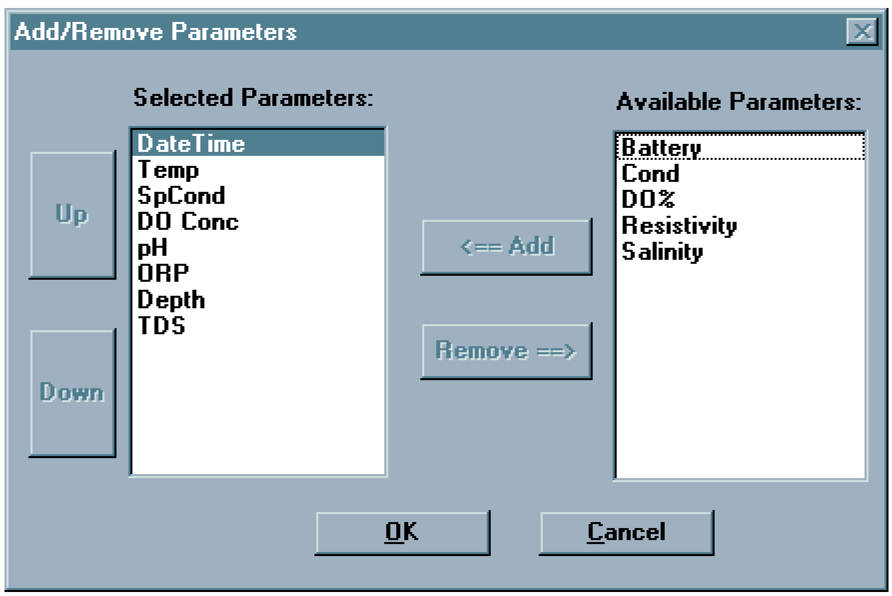
4.3.7 SETUP

PARAMETER

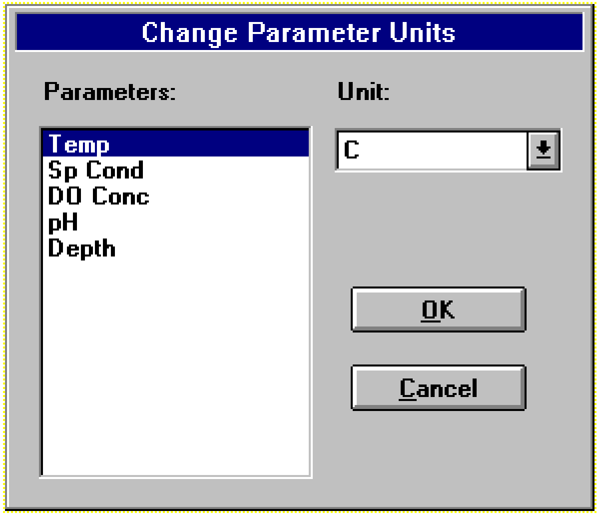
Lets you select which parameters you want to analyze and how they will appear.

Add/Remove
There are two lists, **Selected Parameters** and **Available Parameters**. If, for example, you wish to graph another parameter, you must highlight it on the **Available Parameter** list and then click the Add button to move it over to the **Selected Parameters** list.
This is also where you decide the order in which the parameters will appear in both the table and the graphs. If you choose to have two traces per graph, then the first graph will have the first and second parameters on this list, the second graph will have the third and fourth parameters and so forth. The parameters will appear in the **Selected Parameters** list in the order that they were added. To rearrange the order, highlight the parameter you wish to move and then use the up and down buttons to move it to the desired spot in the order.

The **TSS parameter** (only available if your sonde has a Turbidity sensor) is a parameter that is not part of your original collected data. TSS is calculated by EcoWatch, which uses the Turbidity data and a set of correlation points that you enter. When you add TSS, a TSS calibration window will popup and prompt you for a set of correlation points. For more information see **Calibrate TSS**.

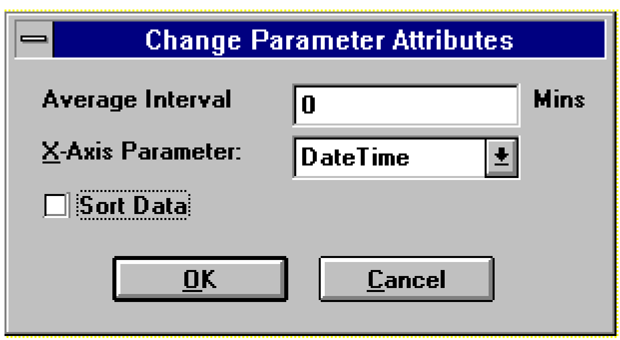


Units
Select the units for any parameter. It will take you to the **Change Parameter Units** dialog box. You may choose the units for each of the selected parameters. Many parameters have only one possible choice of units. DO concentration, for example; can only be expressed in mg/L. pH has no units at all.



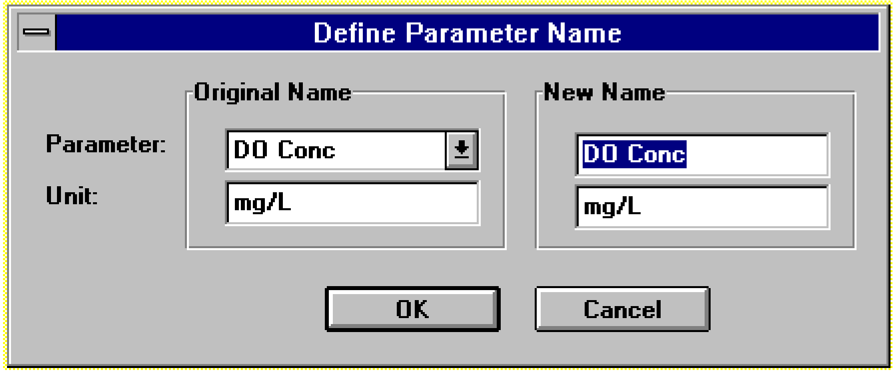
Attributes
This command takes you to the **Change Parameter Attributes** dialog box where you have access to two powerful features. You can choose to display an average of your data, or graph the data with some parameter other than time for the x-axis. The most common use for this latter feature is to graph temperature and DO versus depth. Other combinations are possible. You may choose to average the data before it is graphed. An interval of 0 will cause there to be no averaging at all. The larger the averaging interval, the more points will be used in each average. For example, if you acquired data every 15 minutes and you set the average interval to 60 minutes, each set of four points will be averaged and then plotted as a single point. This feature will not only smooth a graph, but will also reduce the amount of data exported that is sometimes convenient when exporting to a spreadsheet.

The x-axis parameter is normally **Time**, but you can choose any parameter you like. By default, data files are sorted by increasing time. If you have chosen another parameter for the x-axis, then you may want to have the data sorted before graphing it.



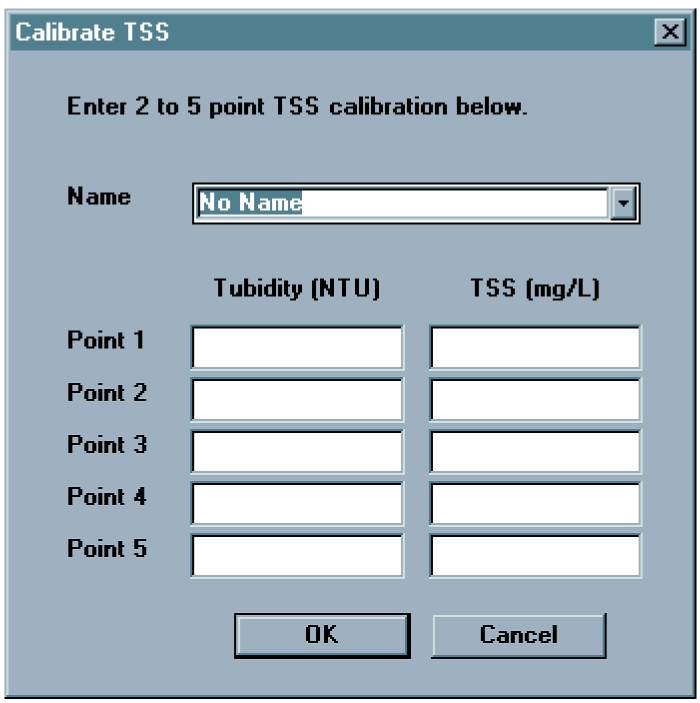
Change name
This command takes you to the **Define Parameter Name** dialog box where you may change the default names of the parameters.

This dialog is intended to make changes like "degrees Celsius" to "degrees C". If you change "degrees Celsius" to "degrees Fahrenheit", then the data displayed will be in degrees Celsius even though the graph says "degrees Fahrenheit." To change the units for that parameter, use the **Change Parameter Units** dialog box.



Calibrate TSS

TSS is an abbreviation for Total Suspended Solids. TSS is a unit derived from a Turbidity (NTU) measurement and correlated TSS-NTU measurements. The Calibrate TSS feature is only used if the TSS parameter has been added to the current data file using **Add/Remove Parameters**. This command opens the TSS Calibration window and allows calibration adjustment.



How do I add TSS to my data file?

You must have a data set that includes Turbidity data points.

It is also common to use a 0 to 0 correlation as a base point in these measurements. This can be used as the first correlation point. You need to establish a correlation between your Turbidity reading and a TSS value. This is done by taking a sample and noting its Turbidity in NTU's. Then run a lab analysis to obtain a total suspended solids reading. You have now determined one correlation point.

Once you have at least two correlation points, you have established a linear correlation between the two measurements. EcoWatch allows you to enter up to five correlation points. The more correlation points you have, the higher that your accuracy will be.

To add the TSS parameter to your data file, go to the **Setup** menu. Choose **Parameters**, then **Add/Remove**. Select the **TSS** parameter and click the **Add** button. The Calibrate TSS window will appear.

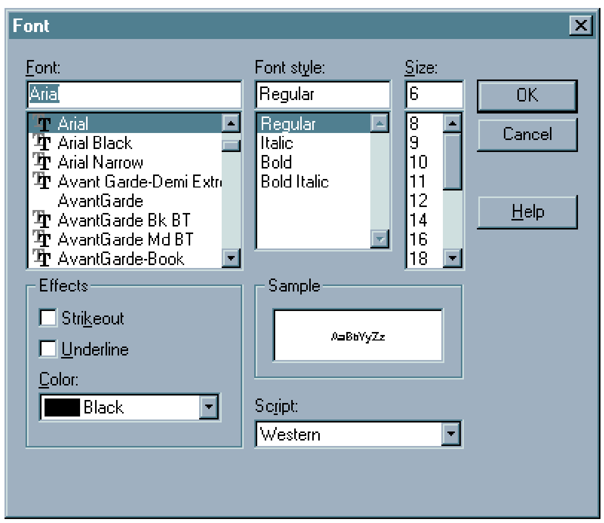
Name the file for identification in the future. Multiple calibration files may be created. Any previously created calibration files will be located in the drop-down name list box.

Once you have entered the desired number of correlation points, click **OK**. EcoWatch will calculate the TSS values by doing a linear interpolation of the Turbidity (NTU) data and the correlation chart .

GRAPH

The **Setup** menu, **Graph** submenu has the following commands:

Font/Color
Goes to the **Font Dialog Box** where you can change the font and color of text that appears in the graph.



- **Font**
  Type or select a font name. EcoWatch lists the fonts available with the current printer driver and additional fonts installed in your system.

- **Font Style**
  Select a font style. To use the default type style for a given font, select Regular.

- **Size**
  Type or select a font size. The sizes available depend on the printer and the selected font. If the size you type is not available on the current printer, EcoWatch chooses the closest available size.

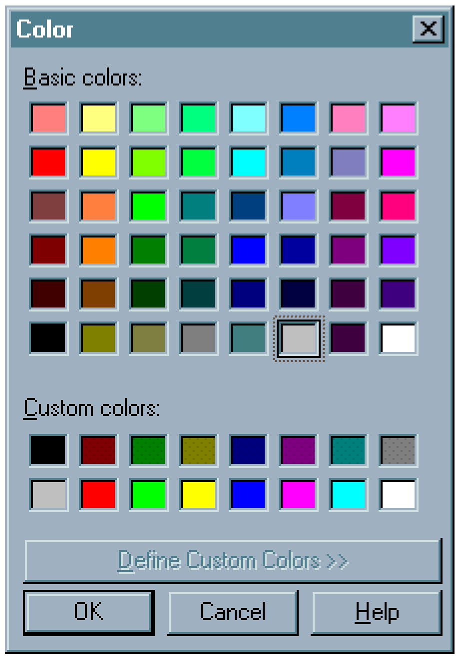
- **Effects**
  Choosing **Strikeout** will draw a line through all text in the table. Choosing underline will underline the text.

- **Color**
  Type or select one of the 16 predefined colors. To display color, you must have a color monitor; to print color, you must have a color plotter or a color printer.

- **Sample**
  Shows the effects of the formatting you specify before you apply it to the document.

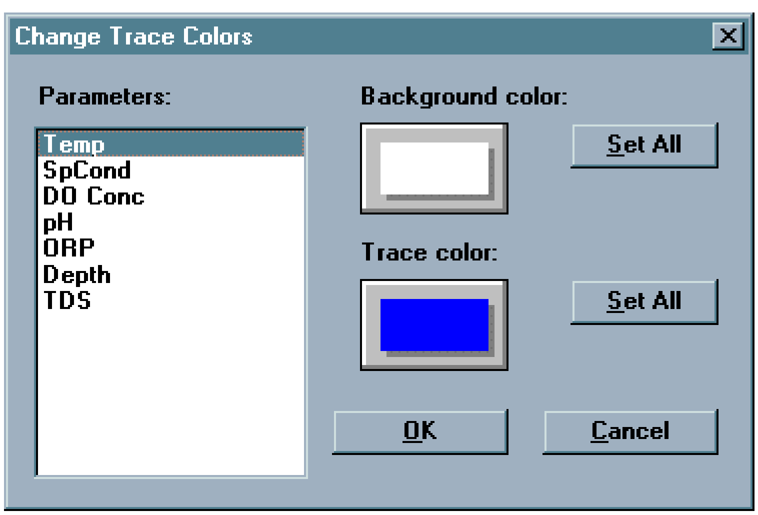
Page Color

Goes to the **Color Dialog Box** where you can change the color of the graph page. This is the background for all of the graphs rather than the background for each individual graph that is set with the next command.



Trace Color

Goes to the **Change Trace Color** dialog box where you can change the color of the trace and the background for each of the individual graphs. For setting the background color for all graphs, see the previous command.

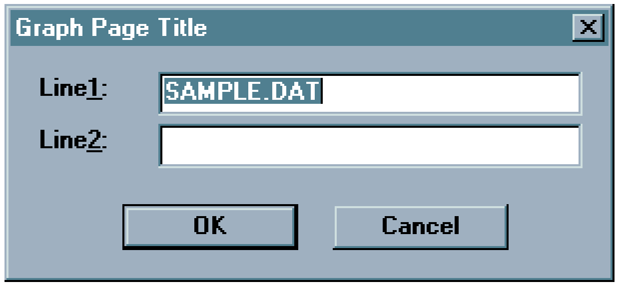


Note that there are two color buttons, one for the trace color and the other for the background color. Clicking on either of these buttons will take you to the **Color** dialog box where you can change the color.

Use the **Set All buttons** to quickly set all traces or backgrounds to the same color.

Page Title

This is where you can enter a title for the graph. The title may have one or two lines.



1 Trace per Graph

Choose this to have just one parameter on each graph.

2 Traces per Graph

Choose this to have two parameters on each graph.

TABLE

If there is no table, then the commands on this submenu will be unavailable. The Table submenu offers the following commands:

Font/Color

Goes to the Font Dialog Box where you can change the font and color of text that appears in the table.

Page Color

Goes to the Color Dialog Box where you can change the color of the table background color. That is the part of the table where the readings appear.

Highlight Color

Goes to the Color Dialog Box where you can change the color of the table highlight color. That is the part of the table where the reading units appear.

SET DEFAULT TEMPLATE

This option allows you to select display parameters for your data when you initially open a file in EcoWatch. Display parameters include background and trace colors on your graph, which parameters are displayed, parameter ordering, parameter units, and scaling of those parameters (either manual or automatic). The first time you use EcoWatch with a data file, graphing will proceed according to the default settings present in EcoWatch. For example, graph backgrounds will all be black, traces will be plotted each with a different color, all parameters will be auto-scaled, and if your sonde measures conductivity and dissolved oxygen, EcoWatch will display specific conductance in mS/cm and dissolved oxygen in mg/L. You can change the default settings by using **Set Default Template.**

1 - Open a data file and observe the presentation of the data in graphic and tabular form.

2 - You can change the background and trace colors by going into the **Graph** and/or **Table submenus** of the **Setup Menu**.

3 - You can add or remove parameters by going into the **Parameter submenu** of the **Setup Menu**.

4 - You can change the units of the displayed parameters by going into the Parameter submenu of the Setup Menu.

5 - You can change the order of the parameters by going into the **Add/Remove Parameters dialog box** in the **Parameter submenu** of the **Setup Menu**.

6 - You can set the scaling options for your data by double-clicking on the Y-axis of the graph and using the **Graph Y-Axis dialog box** to set the scales.

7 - After setting the display parameters enter the **Setup Menu** and choose **Set Default Template**. Now every data file that you initially open will use the display parameters that you have chosen. If you want to delete your template, enter the **Setup Menu** and choose **Clear Default Template**.

CLEAR DEFAULT TEMPLATE

This command will eliminate a default template that has been saved. With no default template, all new EcoWatch files open in whatever form they were saved in.

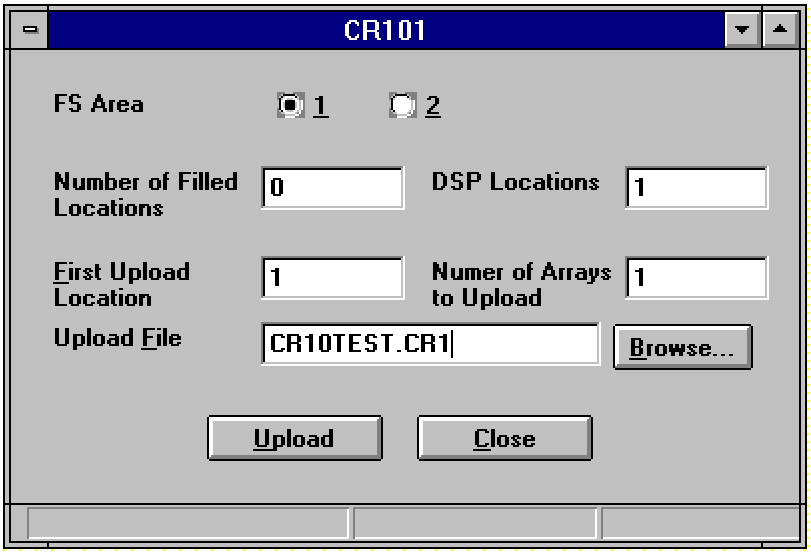
4.3.8 APPL(ICATIONS)

The **Appl** menu is the link to other Application programs that can be used with EcoWatch.
For Help using a GIS software, consult the menu that came with the GIS system.

To upload from a Campbell Scientific CR10 Logger, first connect the logger to a COM port using a Campbell Scientific SC32A Adapter. Set the port for 9600 Baud, 8 data bits, no parity and Xon/Xoff handshaking. Then from the EcoWatch **Appl** menu, select **CR10 Upload.** The dialog box below will appear.

The items Number of Filled Locations and DSP Locations are information from the logger that you cannot change. FS Area, First Upload Location, and Number of Arrays to Upload are fields that you must enter. Refer to your CR10 manual for instructions.

Select a destination file (under Upload File; use the Browse button as needed) and click Upload.



4.3.9 WINDOW

The Window menu offers the following commands that enable you to arrange multiple views of multiple documents in the application window:

CASCADE

Use this command to arrange multiple opened windows in an overlapped fashion

TILE HORIZONTAL

Use this command to vertically arrange multiple opened windows in non-overlapped horizontal tiles.

TILE VERTICAL

Use this command to arrange multiple opened windows side by side.

ARRANGE ICONS

Use this command to arrange the icons for minimized windows at the bottom of the main EcoWatch window. If there is an open document window at the bottom of the main window, then some or all of the icons may not be visible because they will be underneath this document window.

WINDOW 1, 2...

EcoWatch displays a list of currently open document windows at the bottom of the Window menu. A check mark appears in front of the document name of the active window. Choose a document from this list to make its window active.

4.3.10 HELP

The Help menu offers the following commands, which provide you assistance with this application:

CONTENTS

Offers you a list of the available Help topics.

USING HELP

Use this command for instructions about using Help.

TECHNICAL SUPPORT

YSI Technical support phone number.

ABOUT

Displays the version number of this application.

SECTION 5 PRINCIPLES OF OPERATION

5.1 CONDUCTIVITY

The sondes utilize a cell with four pure nickel electrodes for the measurement of solution conductance. Two of the electrodes are current driven, and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value in milli-Siemens (millimhos). To convert this value to a conductivity value in milli-Siemens per cm (mS/cm), the conductance is multiplied by the cell constant that has units of reciprocal cm (cm^{-1}). The cell constant for the sonde conductivity cell is approximately 5.0/cm. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed. Solutions with conductivities of 1.00, 10.0, 50.0, and 100.0 mS/cm, which have been prepared in accordance with recommendation 56-1981 of the Organization International De Metrologie Legale (OIML), are available from YSI. The instrument output is in mS/cm or uS/cm for both conductivity and specific conductance. The multiplication of cell constant times conductance is carried out automatically by the software.

CALIBRATION AND EFFECT OF TEMPERATURE

The conductivity of solutions of ionic species is highly dependent on temperature, varying as much as 3% for each change of one degree Celsius (temperature coefficient = 3%/°C). In addition, the temperature coefficient itself varies with the nature of the ionic species present.

Because the exact composition of a natural media is usually not known, it is best to report a conductivity at a particular temperature, e.g. 20.2 mS/cm at 14 ^{o}C. However, in many cases, it is also useful to compensate for the temperature dependence in order to determine at a glance if gross changes are occurring in the ionic content of the medium over time. For this reason, the sonde software also allows the user to output conductivity data in either raw or temperature compensated form. If Conductivity is selected, values of conductivity that are *NOT* compensated for temperature are output to the report. If Specific Conductance is selected, the sonde uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to 25°C. The calculation is carried out as in equation (1) below, using a temperature coefficient of 1.91%/°C (TC = 0.0191):

$$\text{Specific Conductance } (25^{o}\text{C}) = \frac{\text{Conductivity}}{1 + TC * (T - 25)}$$

As noted above, unless the solution being measured consists of pure KCl in water, this temperature compensated value will be somewhat inaccurate, but the equation with a value of TC = 0.0191 will provide a close approximation for seawater and for solutions of many common salts such as NaCl and NH_4Cl.

MEASUREMENT AND CALIBRATION PRECAUTIONS

1 - When filling the calibration vessel prior to performing the calibration procedure, make certain that the level of calibrant standard is high enough in the calibration cup or beaker to cover the entire conductivity cell.

2 - After placing the sonde in the calibration solution, agitate the sonde to remove any bubbles in the conductivity cell.

3 - During calibration, allow the sensors time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration protocol. The readings after calibration are only as good as the calibration itself.

4 - Perform sensor calibration at a temperature as close to 25°C as possible. This will minimize any temperature compensation error.

5- The 6560 YSI 6-series conductivity system is extremely linear and therefore the sensor will be accurate within its 0.5% accuracy specification when calibrated anywhere in the range. Thus, there is normally no need to calibrate with low conductivity standards when making measurements in fresh water or high conductivity standards when making measurements in brackish or sea water. Low conductivity standards are very susceptible to contamination and their use is not recommended unless extra care is taken to rinse the calibration vessel and probe compartment with the standard prior to actually calibrating. For most applications, YSI recommends calibration using a mid-range calibration standard of approximately 10,000 uS/cm such as YSI 3163 Calibrator Solution which is available in quart bottles. For special applications or for users who insist on calibrating at values near that of the water to be monitored, YSI does offer standards of higher and lower conductivities – see **Appendix C Accessories and Calibration Reagents**.

5.2 SALINITY

Salinity is determined automatically from the sonde conductivity and temperature readings according to algorithms found in *Standard Methods for the Examination of Water and Wastewater (ed. 1989).* The use of the Practical Salinity Scale results in values that are unitless, since the measurements are carried out in reference to the conductivity of standard seawater at 15 °C. However, the unitless salinity values are very close to those determined by the previously used method where the mass of dissolved salts in a given mass of water (parts per thousand) was reported. Hence, the designation "ppt" is reported by the instrument to provide a more conventional output.

5.3 TOTAL DISSOLVED SOLIDS (TDS)

The electrical conductivity of environmental water is due to the presence of dissolved ionic species. Thus, the magnitude of the conductivity (or specific conductance) value can be used as a <u>rough</u> estimate of amount (in g/L) of these ionic compounds which are present. The 6-series software provides a conversion from specific conductance to total dissolved solids (TDS) by the use of a simple multiplier. However, this multiplier is highly dependent on the nature of the ionic species present. <u>To be assured of even moderate accuracy for the conversion, the user must determine this multiplier for the water at the site of interest</u>. Use the following protocol to determine the conversion factor:

1. Determine the specific conductance of a water sample from the site;
2. Filter a portion of water from the site;
3. Completely evaporate the water from a carefully measured volume of the filtered sample to yield a dry solid;
4. Accurately weigh the remaining solid;
5. Divide the weight of the solid (in grams) by the volume of water used (in liters) to yield the TDS value in g/L for this site; Divide the TDS value in g/L by the specific conductance of the water in mS/cm to yield the conversion multiplier. Be certain to use the correct units.
6. Enter the determined constant into the sonde software from the Advanced|Sensor menu to view the correct TDS values from a computer/sonde interface.

CAUTION: The default value (0.65) for conversion of specific conductance in mS/cm to TDS in g/L which is resident in the Advanced|Sensor menu of the software is only useful for a gross estimate of the TDS. As noted above, to attain any degree of accuracy for TDS, the user must determine the conversion factor empirically. Even then, if the nature of the ionic species at the site changes during an unattended study or between sampling studies, the TDS values will be in error. It is important to recognize that, generally speaking, TDS cannot be calculated accurately from specific conductance unless the make-up of the chemical species in the water remains constant.

NOTE: EcoWatch for Windows contains a conversion factor of 0.65 for conversion of specific conductance in mS/cm to TDS in g/L. However, unlike the sonde software, this constant cannot be varied in EcoWatch. Thus, to calculate TDS from data resident in an EcoWatch file, the user should export the specific conductance readings to a spreadsheet and carry out the calculation there using the formula:

TDS in g/L = (Sp. Cond in mS/cm) x (User-Derived Constant)

5.4 OXIDATION REDUCTION POTENTIAL (ORP)

The sondes determine the Oxidation Reduction Potential (ORP) of the media by measuring the difference in potential between an electrode which is relatively chemically inert and a reference electrode. To measure ORP with a sonde, a combination pH/ORP probe must be in place in the sonde bulkhead and ORP must be accessed via the ISE2 channel of the sonde. The ORP sensor consists of a platinum button found on the tip of the probe. The potential associated with this metal is read versus the Ag/AgCl reference electrode of the combination sensor that utilizes gelled electrolyte. ORP values are presented in millivolts and are not compensated for temperature.

CALIBRATION AND EFFECT OF TEMPERATURE

Calibration may not be required for the ORP sensor of the sonde when it is new. However, older probes that have been deployed extensively may show some deviation from the theoretical ORP value. This deviation is usually due to a change in the concentration of the KCl in the reference electrode gel. To determine whether the sensor is functioning correctly, place the ORP probe in 3682 Zobell solution and monitor the millivolt reading. If the probe is functioning within specifications, the ORP reading should be within the range of 221-241 at normal ambient temperature. If the reading is outside of this range, the probe can be calibrated to the correct value (231 mV at 25°C) using the calibration procedure outlined in **Section 2.6.1, Calibration.**

ORP readings for the same solution can vary up to 100 mv depending on the temperature. However, no standard compensation algorithms exist for this parameter. Be sure to take this factor into account when reporting ORP values and checking sensor calibration. For Zobell solution, consult the following chart:

TEMPERATURE, CELSIUS	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

MEASUREMENT AND CALIBRATION PRECAUTIONS

1 - Instructions for preparation of ORP calibrator solutions (including Zobell reagent) can be found in Section 2580 A. of *Standard Methods for the Examination of Water and Wastewater.* Alternatively, the Zobell solution is available from YSI.

2 – Reagants to confirm ORP sensitivity are available. Contact YSI Technical Support for ordering information.

3 - ORP readings usually stabilize much more rapidly in standards (e.g., Zobell solution) than in most environmental water. Be certain to consider this factor when determining ORP in field studies.

4 - Clean and store the pH/ORP sensor by following the instructions in **Section 2.10, Care, Maintenance and Storage** of this manual.

5.5 pH

The sondes employ a field replaceable pH electrode for the determination of hydrogen ion concentration. The probe is a combination electrode consisting of a proton selective glass reservoir filled with buffer at approximately pH 7 and a Ag/AgCl reference electrode that utilizes electrolyte that is gelled. A silver wire coated with AgCl is immersed in the buffer reservoir. Protons (H^+ ions) on both sides of the glass (media and buffer reservoir) selectively interact with the glass, setting up a potential gradient across the glass membrane. Since the hydrogen ion concentration in the internal buffer solution is invariant, this potential difference, determined relative to the Ag/AgCl reference electrode, is proportional to the pH of the media. The pH system of the 600R utilizes individual glass sensing and reference electrodes, but the operating principle is the same.

YSI offers three styles of pH and pH/ORP relative to the glass portion of the probe – flat-, bulb-, and hemisphere-type. The bulb-type sensors (6561, 6565, and 6566) use lower impedance glass and therefore are more stable in laboratory applications and calibration when in the presence of static. The flat-type sensors have higher impedance glass and so may show some jumpiness during laboratory operations, including calibration, unless the user avoids touching the sonde and stays out of close proximity to the instrument. The advantages of the flat-type glass sensors are that (a) they are much less susceptible to breakage than their bulb-type analogs and (b) they are more readily cleaned in long term field studies when using the auxiliary brush of the 6600EDS V2-2 sonde. Users should consider these factors when deciding which YSI pH or pH/ORP sensor to purchase.

Our testing of the 6561, 6561FG, 6565, 6565FG, 6566 pH or pH/ORP sensors, 6569 pH/ORP, 6579 pH, and the 600R/600QS pH/ORP system indicates that they should provide long life, good response time, and accurate readings in most environmental waters, including freshwater of low ionic strength. Thus, no special sensor is required (nor offered) for water of low conductivity.

CALIBRATION AND EFFECT OF TEMPERATURE

The software of the sondes calculates pH from the established linear relationship between pH and the millivolt output as defined by a variation of the Nernst equation:

$$E = E_o + \frac{2.3RT}{nF} * pH$$ where E = millivolts output

E_o = a constant associated with the reference electrode
T = temperature of measurement in degrees Kelvin
R, n, and F are invariant constants

Thus, in simplified ***y = mx + b*** form, it is (mv output) = (slope)x(pH) + (intercept). In order to quantify this simple relationship, the instrument must be calibrated properly using commercially available buffers of known pH values. In this procedure, the millivolt values for two standard buffer solutions are experimentally established and used by the sonde software to calculate the slope and intercept of the plot of millivolts vs. pH. Once this calibration procedure has been carried out, the millivolt output of the probe in any media can readily be converted by the sonde software into a pH value, *as long as the calibration and the reading are carried out at the same temperature.* This last qualifier is almost never met in actual environmental measurements since temperatures can vary several degrees during a deployment simply from a diurnal cycle. Thus, a mechanism must be in place to compensate for temperature or, in other words, to accurately convert the slope and intercept of the plot of pH vs. millivolts established at T_c (temperature of calibration) into a slope and intercept at T_m (temperature of measurement). Fortunately, the Nernst equation provides a basis for this conversion.

According to the Nernst equation as shown above, the slope of the plot of pH vs. millivolts is *directly proportional* to the absolute temperature in degrees Kelvin. Thus, if the slope of the plot is experimentally determined to be 59 mv/pH unit at 298 K (25 C), then the slope of the plot at 313 K (40 C) must be (313/298) * 59 = 62 mv/pH unit. At 283 K (10 C), the slope is calculated to be 56 mv/pH unit ((283/298) * 59). Determination of the slope of pH vs. mv plots at temperatures different from T_c is thus relatively simple. In order to establish the intercept of the new plot, the point where plots of pH vs. mv at different temperatures intersect (the isopotential point) must be known. Using standard pH determination protocol, the sonde software assigns the isopotential point as the mv reading at pH 7 and then calculates the intercept using this assumption. Once the slope and intercept to the plot of pH vs. mv are assigned at the new temperature, the calculation of pH under the new temperature conditions is straightforward, and is automatically carried out by the sonde software.

MEASUREMENT AND CALIBRATION PRECAUTIONS

1- The 6561FG and 6565FG sensors are characterized by a flat glass pH sensor which is more rugged than the glass in traditional bulb-type pH sensors. Users should note, however, that the flat glass sensors are characterized by significantly higher impedance which makes them somewhat more susceptible to static interference when users are handling or are in close proximity to the sonde during calibration or other laboratory activities. The static interference can sometimes cause the pH readings observed during Discrete Sample studies or sensor calibration to be very jumpy. If this jumpiness is observed during calibration or use of a flat glass pH probe, users should simply avoid touching the sonde and should maintain a distance away from the sonde of at least 2 feet until the calibration has been confirmed. The static interference is particularly noticeable during winter when the air is drier.

2- When filling the calibration cup prior to performing the calibration procedure, make certain that the level of calibrant buffers is high enough in the calibration/storage cup to cover at least ½ inch of the pH probe and the temperature sensor of the 6560 probe.

3 - Rinse the sensors with deionized water between changes of calibration buffer solutions.

4 - During pH calibration, allow the sensors time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration protocol. The pH readings after calibration are only as good as the calibration itself.

5- The true pH values of commercially-available buffers are slightly temperature dependent with the actual pH values at various temperatures usually shown on the bottle. For example, the actual pH of YSI “pH 7 buffer” at 20 C is 7.02 rather than the value of 7.00 at 25 C. Users who wish to obtain the maximum accuracy from their pH sensors should first determine the temperature of their buffers and then enter the proper pH reading for that temperature (from the bottle label) when carrying out calibration of pH.

6 - Clean and store the probe according to the instructions found in **Section 2.10, Care, Maintenance and Storage** of this manual.

5.6 DEPTH AND LEVEL

The sondes can be equipped with either depth or level sensors. In fact, both sensors measure depth, but by YSI convention, level refers to vented measurements and depth refers to non-vented measurements. Both measurements use a differential strain gauge transducer to measure pressure with one side of the transducer exposed to the water.

For depth measurements, the other side of the transducer is exposed to a vacuum. The transducer measures the pressure of the water column plus the atmospheric pressure above the water. Depth must be calculated from the pressure exerted by the water column alone; therefore, when depth is calibrated in air, the software records the atmospheric pressure and subtracts it from all subsequent measurements. This method of compensating for atmospheric pressure introduces a small error. Because the software uses the atmospheric pressure at the time of calibration, changes in atmospheric pressure between calibrations appear as changes in depth. The error is equal to 0.045 feet for every 1mm Hg change in atmospheric pressure. In sampling applications, frequent calibrations eliminate the error. Considering typical changes in barometer during long-term monitoring, errors of ± 0.6 feet (0.2m) would be common. In applications where this error is significant, we recommend using a level sensor in place of the depth sensor.

As with depth measurements, level uses a differential transducer with one side exposed to the water. However, the other side of the transducer is vented to the atmosphere. In this case, the transducer measures only the pressure exerted by the water column. Atmospheric pressure is ignored and changes in atmospheric pressure do not affect the reading at all.

The voltage output of the transducer is directly proportional to the pressure. The sonde software converts this voltage to a depth reading in feet or meters via calibration parameters that are factory installed. Readings are automatically compensated for the temperature and for the density of the environmental medium that is estimated from the measured salinity.

For more additional information on measuring level, see **Appendix G, Using Vented Level.**

CALIBRATION AND EFFECT OF TEMPERATURE

The depth sensor must be zeroed prior to deployment to account for atmospheric pressure. Level sensors may also require a small adjustment prior to their first use. This procedure is carried out by following the calibration menu instructions with the sonde in air only (do not submerge). The sensors can also be set to any known depth via the calibration routine after they are immersed. The temperature dependence of the sensor is automatically taken into account by the sonde software based on input from factory calibration.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) Be certain that the sonde is not immersed in water during the calibration procedure unless you know the exact distance between the sensor and the water surface. Calibration (zeroing) in air is usually the recommended method.

(2) Remember that the depth sensors for the sonde are not vented. In practical terms, this means that changes in barometric pressure after the sensor is calibrated will appear as changes in depth. This effect is significant, particularly for the 0-30 ft option of the depth probe. For example, a change of 1 mm of Hg in barometric pressure will change the apparent depth by approximately 0.045 feet (0.012 m). As noted above, this error is eliminated for level sensors because they are vented to the atmosphere.

5.7 TEMPERATURE

The sondes utilize a thermistor of sintered metallic oxide that changes predictably in resistance with temperature variation. The algorithm for conversion of resistance to temperature is built into the sonde software, and accurate temperature readings in degrees Celsius, Kelvin, or Fahrenheit are provided automatically. No calibration or maintenance of the temperature sensor is required.

5.8 DISSOLVED OXYGEN – 6562 RAPID PULSE POLAROGRAPHIC

The sondes employ the patented YSI Rapid Pulse system for the measurement of dissolved oxygen (DO). Use of this technology provides major advantages for the *monitoring* of DO without significantly compromising the accuracy of *sampling* applications. Standard electrochemical detectors of DO are highly flow-dependent and therefore require external stirring of the medium being evaluated. This stirring must be supplied either by an auxiliary stirrer (which can consume much of the battery reserve in a portable system) or by manually agitating the sonde when carrying out spot sampling applications (which can be inconvenient). These disadvantages are overcome by the Rapid Pulse dissolved oxygen technology that is associated with the sonde because it needs no stirring to yield accurate readings. In addition, because of the nature of the technology, some effects of fouling of the sensor are minimized.

The Rapid Pulse system utilizes a Clark-type sensor that is similar to other membrane-covered steady-state dissolved oxygen probes. The system still measures the current associated with the reduction of oxygen which diffuses through a Teflon membrane, and this current is still proportional to the partial pressure (not the concentration) of oxygen in the solution being evaluated. The membrane isolates the electrodes necessary for this reduction from the external media, encloses the thin layer of electrolyte required for current flow, and prevents other non-gaseous, electrochemically active species from interfering with the measurement. However, as the user will note from examination of the 6562 probe, the sensor consists of three electrodes (a cathode, anode, and reference electrode) while steady state Clark probes usually have only two electrodes (a cathode and a combined anode-reference electrode). In addition, the geometry of the sensor is novel, consisting of a thin linear gold cathode placed between two silver rectangles which serve as anode and reference electrodes. These sensor changes were required to implement the Rapid Pulse method for DO measurement as described in the following section.

METHOD OF OPERATION

Standard Clark dissolved oxygen sensors, which are marketed by YSI and other manufacturers, are continuously polarized at a voltage sufficiently negative to cause oxygen to be reduced to hydroxide ion at the cathode and silver metal to be oxidized to silver chloride at the anode. The oxygen diffuses through the

Teflon membrane. The current associated with this process is proportional to the oxygen present in the solution outside the membrane. However, as this electrochemical reaction proceeds, oxygen is consumed (or depleted) in the medium, resulting in a decrease in measured current (and apparent oxygen content) if the external solution is not stirred rapidly. To minimize this oxygen depletion, the probe electrodes in the YSI Rapid Pulse system are rapidly and reproducibly polarized (on) and depolarized (off) during a measurement sequence. The Rapid Pulse system thus measures the charge or coulombs (current summed over a specific time period) associated with the reduction of oxygen during a carefully controlled time interval. The coulombs due to charging of the cathode (capacitance), but not to reduction of oxygen, are subtracted during integration after the cathode has been turned off. The net charge, like the steady state current in a standard system, is proportional to the oxygen partial pressure in the medium. Because oxygen is only being reduced 1/100th of the total measurement time, even if the probe is pulsed in this manner continuously, oxygen consumption outside the membrane is kept to a minimum, and the stirring dependence of the system is greatly reduced.

One key to the practicality of Rapid Pulse oxygen system is the fact that the "on time" is very short. This allows the "off time" to also be relatively short and still maintain the off to on ratio of 100 which is necessary to obtain relatively flow independent measurements. The second important aspect of the Rapid Pulse technology is the integration (summing of the current) over the total pulse (on and off). Because the charging current of the electrodes is subtracted in this process, the net signal is due only to the reduction of oxygen. From a practical point of view, this means that when there is zero oxygen partial pressure outside the membrane, the Rapid Pulse signal will also be zero; this in turn allows the system to be calibrated with a single medium (air or water) of known oxygen pressure.

CALIBRATION AND EFFECT OF TEMPERATURE

The sonde Rapid Pulse system is calibrated using the same basic methods employed for steady state oxygen sensors. However, the software that controls the calibration protocol is somewhat different depending on whether the unit will be used in sampling or deployment studies. For sampling studies using either a 650 MDS display unit or a laptop computer, the Rapid Pulse system is allowed to run continuously when the Calibration mode is activated if "Autosleep" is turned off. Under these software conditions, the user views the DO readings in real time and confirms the calibration manually after the readings have stabilized.

For studies in which the sonde is deployed and readings are saved less frequently (5 – 60 minutes) to sonde memory, a computer or data collection platform, an appropriate warm up time is selected for the system in the **Advanced|Sensor** menu. Usually 40 seconds is adequate for this parameter, but, in some cases, larger values may result in more accurate results. Most importantly for deployment studies, "Autosleep" should be activated. With these software entries in place, the user will input the calibration value (concentration or barometric pressure), and the unit will automatically calibrate after the selected warm up time.

The description below is designed around deployment applications with "Autosleep" activated.

The two general calibration methods possible with the sonde are "DO mg/L" and "DO %". The former method is designed for calibration in solution while the latter utilizes water-saturated air as the medium. Since the percent saturation (DO %) and concentration (DO mg/L) values are related, calibration by either method results in correct outputs in both units.

If the mg/L method is selected from the sonde Calibrate menu, the oxygen concentration of an aqueous solution may be determined by several methods:

- Winkler titration
- Aerating the solution and assuming that it is saturated, or
- Measurement with another instrument.

If this calibration method is employed, place the sonde into this known-value solution and wait 5-10 minutes for equilibration to occur. Then input the value (in mg/L) into the sonde software and begin the calibration protocol according to the instructions. The calibration will occur automatically at the end of the specified warm-up time.

If the Percent Saturation method is selected, the sonde is simply placed in a calibration cup that contains a small quantity of water or a damp sponge. ***The probe sensor should not be in the water for this calibration procedure.*** The sonde should be left under these conditions for 10-15 minutes to allow temperature and humidity equilibration to occur. Then input the true barometric pressure into the sonde software and begin the calibration protocol according to the instructions. The calibration will occur automatically at the end of the specified warm-up time.
NOTE: Remember that control of the calibration will be manual rather than automatic if the unit is set up properly for spot sampling applications ("Autosleep" deactivated).

The DO readings of steady state oxygen systems are greatly affected by temperature (approximately 3% per degree Celsius) due to the effect of temperature on the diffusion of oxygen through the membrane. The Rapid Pulse system exhibits a greatly reduced effect of temperature (approximately 1% per degree Celsius), but this factor still must be accounted for if DO readings acquired at temperatures different from that at calibration are to be accurate. The sonde software automatically carries out this compensation.

In addition, the relationship between the measured partial pressure of oxygen (percent saturation) and the solubility of oxygen in mg/L is very temperature dependent. For example, air saturated water (DOsat % = 100) contains 9.09 mg/L at 20 ^{o}C, but only 7.65 mg/L at 30 ^{o}C. The sonde software compensates for both of these temperature-related factors after instrument calibration. The temperature compensation for the percent saturation reading is empirically derived, while the conversion from percent saturation and temperature to solubility in mg/L is carried out automatically by the sonde software using formulae available in *Standard Methods for the Examination of Water and Wastewater (ed. 1989).* See **Appendix D, Solubility and Pressure/Altitude Tables** for dissolved oxygen solubility tables as a function of salinity and temperature.

FLOW DEPENDENCE

As noted above, oxygen readings acquired using the Rapid Pulse technology are much less affected by sample flow than steady state probes. However, there is a finite stirring dependence exhibited by the Rapid Pulse system if measurements are taken when the probe is being pulsed continuously. Our tests indicate that, under these sampling conditions, observed dissolved oxygen readings can be 2-3 percent lower than the true readings in very still water. Minimal movement of the water (which occurs during most environmental measurements) removes this effect.

This small flow dependence of the sensor is greatly reduced in longer term monitoring deployments where the sampling interval is longer, e.g. 15 minutes. Under these conditions, the sensor is pulsed for only approximately 40 seconds every 15 minutes, and normal diffusion of oxygen in the medium re-establishes the oxygen which has been depleted in the previous warm-up/read sequence.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) If water-saturated air is used as the calibrating medium, make certain that *both the DO reading and the temperature* have stabilized (10-15 minutes) before starting the calibration sequence. A wet thermistor can indicate artificially low temperature readings due to evaporation and this situation will result in poor temperature compensation and inaccurate readings.

(2) For calibrations in water-saturated air, ensure that the calibration cup being used is vented or pressure released.

(3) If air-saturated water is used as the calibrating medium, make certain that the water is truly saturated by sparging it for at least 1 hour with an aquarium air-pump and air-stone.

(4) For short term storage (2 weeks or less), keep the probe moist when not in use, either by immersing in water or by placing a damp sponge in the calibration vessel. For longer-term storage, remove the probe from the sonde and store it in water with a membrane and electrolyte in place. If the membrane appears to be damaged or has dried out, be sure to replace it prior to calibration and deployment.

(65 Before you install a new membrane, make sure that the O-ring groove and the probe tip are clean and smooth. If the KCl electrolyte solution leaks from the probe surface during monitoring studies, the accuracy of the readings will be compromised.

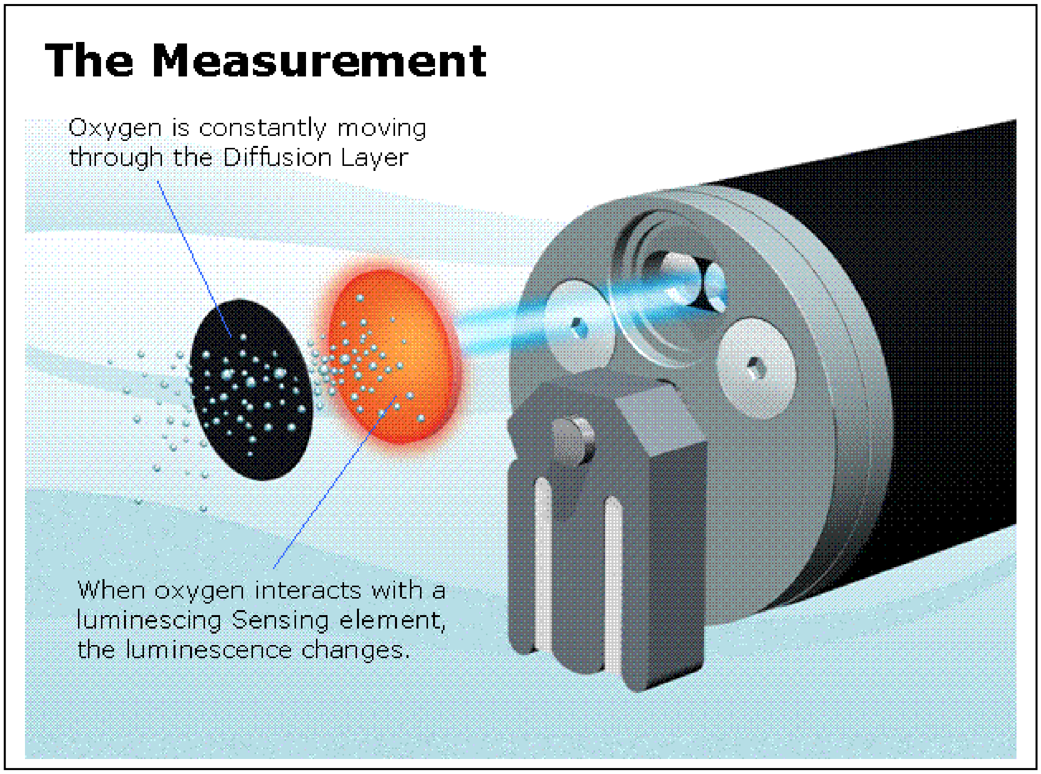
5.9 DISSOLVED OXYGEN – 6150 ROX OPTICAL

In general, optical dissolved oxygen sensors from a variety of manufacturers are based on the well-documented principle that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with carefully-chosen chemical dyes. The 6150 sensor operates by shining a blue light of the proper wavelength on this luminescent dye which is immobilized in a matrix and formed into a disk about 0.5 inches in diameter. This dye-containing disk will be evident on inspection of the sensor face. The blue light causes the immobilized dye to luminesce and the lifetime of this dye luminescence is measured via a photodiode in the probe. To increase the accuracy and stability of the technique, the dye is also irradiated with red light during part of the measurement cycle to act as a reference in the determination of the luminescence lifetime.

When there is no oxygen present, the lifetime of the signal is maximal; as oxygen is introduced to the membrane surface of the sensor, the lifetime becomes shorter. Thus, the lifetime of the luminescence is inversely proportional to the amount of oxygen present and the relationship between the oxygen pressure outside the sensor and the lifetime can be quantified by the Stern-Volmer equation. For most lifetime-based optical DO sensors (including the YSI 6150), this Stern-Volmer relationship (((Tzero/T) – 1)) versus O_2 pressure) is not strictly linear (particularly at higher oxygen pressures) and the data must be processed using analysis by polynomial non-linear regression rather than the simple linear regression used for most polarographic oxygen sensors. Fortunately, the non-linearity does not change significantly with time so that, as long as each sensor is characterized with regard to its response to changing oxygen pressure, the curvature in the relationship does not affect the ability of the sensor to accurately measure oxygen for an extended period of time. The 6150 probe is warranted for 2 years and sensor modules are warranted for 1 year by YSI.

Each YSI sensor module (the assembly which is attached to the face of the probe by three screws) is factory-calibrated over a range of 0-100 percent oxygen to quantify the relationship of its luminescence lifetime as a function of oxygen pressure. The Stern-Vollmer parameters from this data are then fit to a third order regression equation ($ax^3 + bx^2 + cx$) and values of a, b, and c determined. These coefficients, along with the luminescence lifetime at zero oxygen pressure (Tzero), are provided to the user in coded form with each sensor membrane module or probe/sensor module combination. If you install a replacement sensor membrane assembly (YSI 6155) on your existing probe, you will be required to enter these coded constants into the sonde as described in the instructions which come with the 6155 prior to the use of the sensor. If you have purchased a probe/membrane combination, i.e. a new 6150 Optical DO sensor, the constants are already stored in your probe and will automatically be transferred to your sonde when the sensor is installed.

A schematic representation of the 6150 ROX Optical DO sensor is shown in the picture below:



EFFECT OF TEMPERATURE AND SALINITY

In terms of the determination of dissolved oxygen in environmental water, the 6150 is similar to standard membrane-covered dissolved oxygen probes in that its measured parameter is proportional to the partial pressure (not the concentration) of oxygen in the solution being evaluated. This partial pressure value is reported as "Percent Air Saturation". The signal from the 6150 system is affected by temperature (approximately 1.32% per degree Celsius), and this factor must be accounted for if DO readings acquired at temperatures different from that at calibration are to be accurate. The sonde automatically carries out this compensation. In addition, the relationship between the measured partial pressure of oxygen (percent saturation) and the solubility of oxygen in mg/L is very temperature dependent. For example, air-saturated fresh water contains 9.09 mg/L at 20 ^{o}C, but only 7.65 mg/L at 30 ^{o}C. The sonde compensates for both of these temperature-related factors after instrument calibration. The temperature compensation for the percent saturation reading is empirically derived, while the conversion from percent saturation and temperature to solubility in mg/L is automatically carried out using formulae available in *Standard Methods for the Examination of Water and Wastewater (ed. 1989).* See **Appendix D, Solubility and Pressure/Altitude Tables** of the manual supplied with your 6-series sonde for dissolved oxygen solubility tables as a function of salinity and temperature.

While the measured partial pressure of air-saturated water is not a function of the salinity (or solids content) of the water, the concentration of oxygen at a given partial pressure changes significantly with salinity. Thus, air-saturated freshwater (salinity = 0) at 20 ^{o}C contains 9.09 mg/L of oxygen while air-saturated sea water (salinity = 35) contains only 7.35 mg/L. This effect is automatically accounted for when the firmware in your 6-series sonde calculates DO mg/L, as long as the conductivity sensor is active and properly calibrated.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) If water-saturated air is used as the calibrating medium, make certain that *both the DO reading and the temperature* have stabilized (10-15 minutes) before starting the calibration sequence. A wet thermistor can indicate artificially low temperature readings due to evaporation and this situation will result in poor temperature compensation and inaccurate readings.

(2) If air-saturated water is used as the calibrating medium, make certain that the water is truly air-saturated by sparging with an aquarium air-stone for at least 1 hour prior to implementing the calibration procedure.

(3) If calibrating in water-saturated air, insure that the calibration cup being used is vented or pressure released.

(4) When not in use, you MUST keep the probe moist, either by immersing in water or by covering the membrane on the probe tip with the plastic cap/moist sponge which was in place on the sensor when it was received.

(5) If you inadvertently leave your sensor exposed to ambient air for a period of more than approximately 2 hours, you can rehydrate the membrane by the following method: (1) Place approximately 400 mL of water in a 600 mL beaker or other similar glass vessel – do NOT use plastic vessels – and heat the water on a thermostatted hotplate or in an oven so that a consistent temperature of 50+/- 5 C is realized. Place the probe tip containing the sensor membrane in the warm water and leave it at the elevated temperature for approximately 24 hours. Cover the vessel if possible to minimize evaporation. After rehydration is complete, store the probe in either water or water-saturated air prior to calibration and deployment. **CAUTION: MAKE CERTAIN THAT THE WATER IN THE VESSEL DOES NOT COMPLETELY EVAPORATE DURING THE REHYDRATION STEP.**

(6) To assure that the best possible accuracy for the ROX Optical DO sensor, YSI recommends that the membrane assembly be replaced after 1 year. The 6155 Optical DO Membrane Replacement Kit can be ordered from YSI Technical Support.

For more information on the practical aspects of using the 6150 ROX dissolved oxygen sensor, see **Appendix M** of this manual.

5.10 NITRATE

The sonde nitrate probe consists of a silver/silver chloride wire electrode in a custom filling solution. The internal solution is separated from the sample medium by a polymer membrane, which selectively interacts with nitrate ions. When the probe is immersed in water, a potential is established across the membrane that depends on the relative amounts of nitrate in the sample and the internal filling solution. This potential is read relative to the Ag/AgCl reference electrode of the sonde pH probe. As for all ISEs, the linear relationship between the logarithm of the nitrate activity (or concentration in dilute solution) and the observed voltage, as predicted by the Nernst equation, is the basis for the determination.

Under ideal conditions, the Nernst equation predicts a response of 59 mV for every 10-fold rise in nitrate activity at 25°C. However, in practice, empirical calibration of the electrode is necessary to establish the slope of the response. Typical slopes are 53-58 mV per decade for YSI sensors. This slope value is determined by calibration with two solutions of known nitrate concentration (typically 1 mg/L and 100 mg/L NO_3-N). The slope of the plot of log (nitrate) vs. voltage is also a function of temperature, changing from its value at calibration by a factor of the ratio of the absolute temperatures at calibration to that at measurement. The point where this new plot of log (nitrate) vs. voltage intersects the calibration plot is called the isopotential point, that is, the nitrate concentration at which changes in temperature cause no change in voltage. Our experience with ISEs indicates that for best accuracy, the isopotential point should be determined empirically. To do so, the user employs a third calibration point where the voltage of the lower concentration standard is determined at a temperature at least 10°C different from the first two calibration points. The slope, offset, and isopotential point drift slowly, and you should recalibrate the probe periodically.

All ion selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. For example, chloride ion binds in this way to the nitrate membrane and produces positive nitrate readings even when no nitrate is present in the medium. Fortunately, most fresh water does not usually contain significant quantities of ions that produce a large interference on the nitrate reading, such as azide, perchlorate, and nitrite. It usually does contain some chloride and carbonate ions, but the interference from these ions is relatively small. For example, if the all of the ionic content of water with a conductivity of 1.2 mS/cm (Sal = 0.6) were due to the presence of sodium chloride, the nitrate reading would be erroneously high by about 1.6 mg/L. If the conductivity in this sample were all due to sodium bicarbonate, the sensor output would indicate the presence of only 0.2 mg/L of non-existent nitrate from the interference.

Even though the interference from chloride is relatively small and thus tolerable at low salinity, the large quantity of this species in salt or brackish water creates interference so great as to make the sensor unsuitable for these media.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all-interfering species produce an artificially high nitrate reading. Thus, if the sonde indicates the presence of only small quantities of nitrate, it is unlikely that the reading is erroneously low because of interference. Unusually high nitrate readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Ion selective electrodes have the greatest tendency to exhibit calibration drift over time of all the sensors available on the sonde. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if a nitrate sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few “grab samples” during the course of the deployment for analysis in the laboratory by chemical means or with another nitrate sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

CALIBRATION AND EFFECT OF TEMPERATURE

The nitrate sensor should be calibrated using solutions of known nitrate-nitrogen content according to the procedures detailed in **Sections 2.6.1 and 2.9.2**. If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different from ambient laboratory temperatures.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) The temperature response of ion selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the probe. This will provide a default setting for the effect of temperature on your particular sensor. After this initial calibration, you can

use the less time-consuming 2 point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

(2) Ion selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

(3) Ion selective electrodes generally drift more than pH sensors. To check for this drift, place the sonde in one of your standards at the end of each deployment.

(4) Nitrate standards are good growth media for a variety of organisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each deployment, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

(5) Remember that the nitrate sensor will take longer to stabilize after exposure to pH buffers. To accelerate this process, soak the sensor in 100 mg/L standard for a few minutes after performing a pH calibration. In addition, be particularly careful that readings are stable during nitrate calibration after exposure to buffers.

CAUTION**:** *The nitrate membrane module is for use only at depths less than 50 feet (15.2 meters). Use of the probe at greater depths is likely to permanently damage the sensor***.**

5.11 AMMONIUM AND AMMONIA

The sonde ammonium probe employs a silver/silver chloride (Ag/AgCl) wire electrode in a custom filling solution. Nonactin membrane separates the internal solution from the sample medium and this membrane selectively interacts with ammonium ions. When the probe is immersed in water, a potential is established across the membrane that depends on the relative amounts of ammonium in the sample and the internal filling solution. This potential is read relative to the reference electrode of the sonde pH probe. As for all ISEs, there is a linear relationship between the logarithm of the ammonium activity (or concentration in dilute solution) and the observed voltage. The Nernst equation describes this relationship.

Under ideal conditions, the Nernst equation predicts a response of 59 mV for every 10-fold rise in ammonium activity at 25°C. In practice, however, empirical calibration of the electrode is necessary to establish an accurate slope of the response. Typical empirical slopes are 53-58 mV per decade for YSI sensors. This slope value is determined by calibration with two solutions of known ammonium concentration (typically 1 mg/L and 100 mg/L NH_4^+-N).

The slope of the plot of log (ammonium) vs. voltage is also a function of temperature. The slope changes by a factor that is the ratio of the absolute temperature of calibration to absolute temperature of measurement. The point where this new plot of log (ammonium) vs. voltage intersects the calibration plot is called the isopotential point, that is, the ammonium concentration at which changes in temperature cause no change in voltage. Our experience with ISEs indicates that for best accuracy, the isopotential point should be determined empirically. To do so, use a third calibration point where the voltage of the lower concentration standard is determined at a temperature at least 10°C different from the first two calibration points. The slope, offset, and isopotential point drift slowly, and the probe should be recalibrated periodically.

All ion selective electrodes are subject to interference from ions, which are similar in nature to the analyte. For example, sodium and potassium ions bind to the ammonium membrane and produce positive readings even when no ammonium is present. Fortunately, fresh water does not usually contain enough interfering ions to produce large errors. For example, a common conductivity for freshwater is about 1.2 mS/cm (Sal

= 0.6). Even if the ionic content were due to sodium chloride, the ammonium reading would be erroneously high, about 0.4 mg/L.

However, brackish or seawater has enough sodium and potassium to cause interference so great as to make the sensor unsuitable for these media.

The sensor used in the sonde detects only ammonium ions (NH_4^+), the predominant form of total ammonium nitrogen in most environmental samples. However, using the concurrently determined values of pH, temperature, and conductivity, the sonde software can also provide the user with the concentration of free ammonia (NH_3) in the sample under investigation.

Ammonium ions and free ammonia are in equilibrium in any solution according to the following equation:

$$NH_4^+ \rightleftharpoons NH_3 + H^+$$

The value of the equilibrium constant associated with this reaction, $K = [NH_3][H^+]/[NH_4^+]$, and its variation with temperature and salinity, is well known. This information allows the free ammonia concentration $[NH_3]$ to be automatically calculated by the sonde software and displayed if this parameter is activated.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high ammonium reading. Thus, if the sonde indicates the presence of only small quantities of ammonium, it is unlikely that the reading is erroneously low because of interference. Unusually high ammonium readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if an ammonium sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few “grab samples” during the course of the deployment for analysis in the laboratory by chemical means or with another ammonium sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

CALIBRATION AND EFFECT OF TEMPERATURE

The ammonium sensor should be calibrated using solutions of known total ammonium-nitrogen content according to the procedures detailed in **Sections 2.6.1 and 2.9.2**. If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different ambient laboratory temperatures.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) The temperature response of ion selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the probe. This will provide a default setting for the effect of temperature on your particular sensor. After this initial calibration, you can use the less time consuming 2 point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

(2) Ion selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

(3) Ion selective electrodes generally drift more than pH sensors. To check for this drift, place the sonde in one of your standards at the end of each deployment.

(4) Ammonium standards are good growth media for a variety of organisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each deployment, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

(5) Remember that the ammonium sensor will take longer to stabilize after exposure to buffers in a sonde pH calibration. To accelerate this process, soak the sensor in 100 mg/L standard for a few minutes after performing a pH calibration. In addition, be particularly careful that readings are stable during ammonium calibration after exposure to buffers.

***CAUTION*:** *The ammonium membrane module is for use only at depths less than 50 feet (15.2 meters). Use of the probe at greater depths is likely to permanently damage the sensor.*

5.12 CHLORIDE

The sonde chloride probe employs a solid state membrane attached to a conductive wire. When the probe is immersed in water, a potential is established across the membrane that depends on the amount of chloride in the medium. This potential is read relative to the reference electrode of the sonde pH probe. As for all ISEs, there is a linear relationship between the logarithm of the chloride activity (or concentration in dilute solution) and the observed voltage. The Nernst equation describes this relationship.

Under ideal conditions, the Nernst equation predicts a response of 59 mV for every 10-fold rise in chloride activity at 25°C. However, in practice, empirical calibration of the electrode is necessary to establish the slope of the response. Typical slopes are 45-55 mV per decade for YSI sensors. This slope value is determined by calibration with two solutions of known chloride concentration (typically 10 mg/L and 1000 mg/L Cl^-).

The slope of the plot of log (chloride) vs. voltage is also a function of temperature, changing from its value at calibration by a factor of the ratio of the absolute temperatures at calibration to that at measurement. The point where this new plot of log (chloride) vs. voltage intersects the calibration plot is called the isopotential point, that is, the chloride concentration at which changes in temperature cause no change in voltage. Our experience with ISEs indicates that for best accuracy, the isopotential point should be determined empirically. To do so, the user employs a third calibration point where the voltage of the lower concentration standard is determined at a temperature at least 10°C different from the first two calibration points. The slope, offset and isopotential point drift slowly, and the probe should be recalibrated periodically.

All ion selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. These interfering species thus include other halide ions (fluoride, bromide, and iodide) as well as other anions.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high chloride reading. Thus, if the sonde indicates the presence of only small quantities of chloride, it is unlikely that the reading is erroneously low because of interference. Unusually high chloride readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if a chloride sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another chloride sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 15 % of the reading or 5 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

CALIBRATION AND EFFECT OF TEMPERATURE

The chloride sensor should be calibrated using solutions of known chloride content according to the procedures detailed in **Sections 2.6.1 and 2.9.2**. If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different ambient laboratory temperatures.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) The temperature response of ion selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the probe. This will provide a default setting for the effect of temperature on your particular sensor. After this initial calibration, you can use the less time-consuming 2 point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

(2) Ion selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

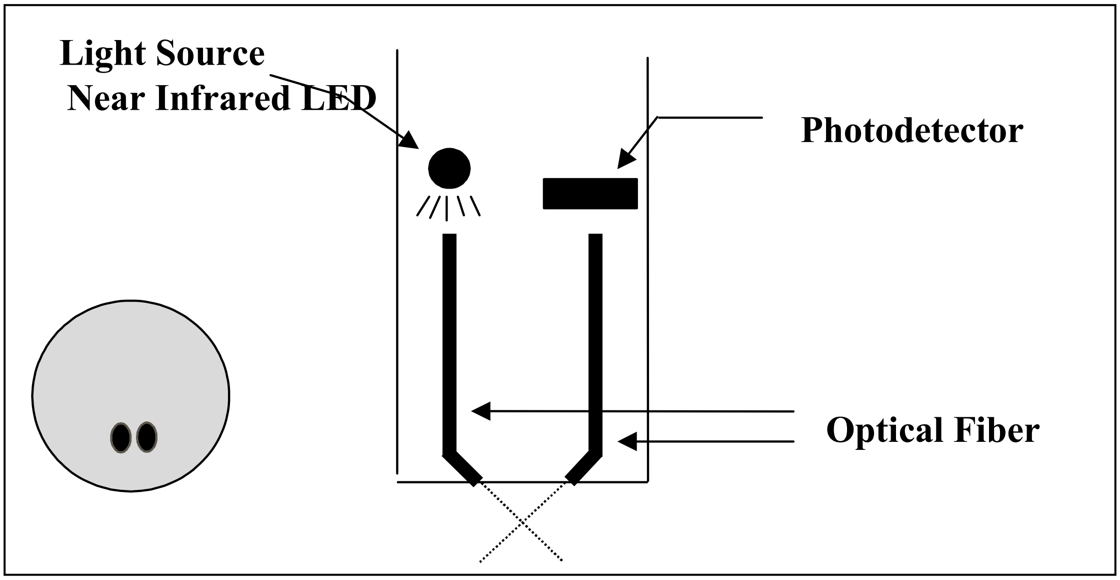
(3) Ion selective electrodes generally drift more than pH sensors. Be sure to check for this drift by placing the sonde in a standard at the end of each deployment.

(4) Remember that the chloride sensor will take longer to stabilize after exposure to pH buffers. To accelerate this process, soak the sensor in 1000 mg/L standard for a few minutes after performing a pH calibration. In addition, be particularly careful that readings are stable during chloride calibration after exposure to buffers.

5.13 TURBIDITY

Turbidity is the measurement of the content of suspended solids (cloudiness) in water and is typically determined by shining a light beam into the sample solution and then measuring the light that is scattered off of the particles which are present. For turbidity systems capable of field deployment, the usual light source is a light emitting diode (LED) which produces radiation in the near infrared region of the spectrum. The detector is usually a photodiode of high sensitivity. The angle between the emitted and detected light varies (usually between 90 and 180 degrees) depending on the probe used. The International Standards Organization (ISO) recommends the use of a light source with a wavelength between 830 and 890 nm and an angle of 90 degrees between the emitted and detected radiation (ISO 7027).

The turbidity system available as an option for use with YSI 6-series sondes consists of a probe which conforms to the above ISO recommendations. The output of the sonde turbidity sensor is processed via the sonde software to provide readings in nephelometric turbidity units (NTUs). A schematic of a YSI turbidity sensor is shown in the following picture.



Two turbidity probes have been available for use with YSI 6-series sondes – the 6026 and the 6136. The 6026 probe is no longer available from YSI, but since a large number of this probe type are still in use, a description of the sensor will be included in this section. The probes are detailed briefly below; both are equipped with a mechanical wiper to periodically clean the sensor either by manual or automatic activation. These wiper systems make the probe ideal for long term monitoring, but they also work well for spot sampling applications.

- The Model 6026 probe was offered by YSI from 1995 to approximately 2002 and is characterized by relatively small optics, a factor that results in minimal penetration of the light beam into the sample and thus allows the use of shorter probe guards on the sonde in which it is installed. If a 6026 sensor is selected in the Sensor menu of the sonde, the turbidity will automatically be reported in the units "turbid NTU".

- The Model 6136 has been the only turbidity probe sold by YSI since 2002 and it is characterized by relatively large optics compared to the 6026. Since these larger optics result in deeper penetration of the light beam into the sample, the use of a longer probe guard is required, a slight disadvantage. However, the larger optical cell volume of the sensor has two significant advantages: (1) There is less background noise associated with the turbidity readings and (2) the absolute values of the readings are significantly closer to those from typical laboratory turbidimeters (such as the Hach 2100AN) which use a large cell volume. If a 6136 sensor is selected in the Sensor menu of the sonde, the turbidity will automatically be reported in the units "turbid+ NTU".

In the primary standard formazin, the two turbidity sensors (6026 and 6136) will show effectively identical behavior. In addition, AEPA-AMCO polymer beads (supplied by YSI as Model 6073) can also be used with one important qualification. You will need to remember that the 6026 and 6136 sensors, which read the same in formazin suspensions, will have different responses in the suspensions of the AEPA-AMCO beads. This effect is due to the larger optical cell volume of the 6136. Thus, as noted on the label of the turbidity standards supplied by YSI, the value of the standard is **100 NTU when used for calibration of the 6026 sensor, but 126 NTU when used to calibrate the 6136.**

In environmental water that contains suspended particles of varying size and density, the readings for the two probes will also differ after calibration with either formazin or polymer beads, with the 6026 almost always showing higher readings and the extent of the difference generally being proportional to the overall turbidity. For example, if both probes are calibrated at 0 and 100 NTU and then placed in a turbid river, the 6026 might read 400 NTU while the 6136 would read 300 NTU. The absolute difference in the sensor readings would shrink as the turbidity dropped. Thus, if the 6026 read 30 NTU, the 6136 would likely read approximately 21 NTU.

Note that the sonde software labels the output of the two sensors with slightly different units of turbidity ("turbid NTU" for the 6026 and "turbid+ NTU" for the 6136) so that the user will readily be able to determine which sensor was used in a particular study during later data analysis.

No matter whether the 6026 or 6136 is installed in your sonde, it is important to remember that field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can generally be removed in short term sampling applications by simply agitating the sonde manually. However, for studies longer than a few hours where the user is not present at the site, the quality of the turbidity data obtained with a turbidity sensor that has no capability of mechanical cleaning is likely to be poor. However, as noted above, both the 6026 and the 6136 probes are equipped with a mechanical wiper that makes them ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically during long term unattended sampling studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde software. Generally one movement is sufficient for most environmental applications, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

CALIBRATION AND EFFECT OF TEMPERATURE

The sonde software offers the option of 1-point, 2-point, or 3-point calibrations procedures. For most applications, a 2-point calibration at 0 and approximately 100 NTU is sufficient for either the 6026 or the 6136 sensor. However, a user might wish to carry out a 3-point calibration at values of approximately 0, 100 and 1000 NTU to provide maximum accuracy over the entire normally encountered environmental turbidity range (0-1000 NTU). If the range of turbidity in the environmental sample is well known, standards of other turbidity values can be utilized (in either 3 point or 2 point routines). However, in all calibration procedures, one of the standards must be 0 NTU and this should be the first calibration point.

NOTE: Before calibrating your 6026 or 6136 turbidity sensor, pay particular attention to the following cautions:

- For all calibration procedures, you MUST use standards that are based on either formazin or AMCO-AEPA styrene divinylbenzene beads as described in *Standard Methods for the Examination of Water and Wastewater* and have been prepared either by Hach (formazin based) or AMCO-AEPA based standards prepared by YSI or an approved YSI vendor listed on the YSI website (www.ysi.com). THE USE OF STANDARDS FROM OTHER VENDORS AND/OR THOSE PREPARDED FROM MATERIALS OTHER THAN FORMAZIN OR AMCO-AEPA POLYMER BEADS WILL RESULT IN BOTH CALIBRATION ERRORS AND INACCURATE FIELD READINGS.

- For AMCO-AEPA standards, the value entered by the user during the calibration protocol is DIFFERENT depending on which sensor (6026 or 6136) is being calibrated. This reflects the empirically determined fact that the 6026 and 6136 sensors which have been calibrated to the same value in the primary standard formazin will have different responses in the suspensions of the AEPA-AMCO beads. This effect is likely due to the larger optical cell volume of the 6136. Thus, for example, the label of the YSI 6073 turbidity standard bottle indicates that the value of the standard is **100 NTU when used for calibration of the 6026 sensor, but 126 NTU when used to calibrate the 6136.** Note that the phenomenon of a sensor-specific formazin/AEPA-AMCO ratio is well known for sensors other than the 6026 and 6136.

YSI and its approved vendors offer easy-to use AMCO-AEPA turbidity standards which can also be quantitatively diluted with turbidity-free water to provide calibrant suspensions of lower values. Hach also offers relatively inexpensive formazin suspensions at various NTU values up to 1000 NTU under the Stablcal™ designation which will provide accurate calibration of either the 6026 or 6136 sensors as long as the user is willing to exercise the proper safety precautions as outlined in the MSDS associated with formazin. The primary advantage of the Hach formazin standards is their cost; their primary disadvantage is that the suspended matter settles out fairly rapidly. Although the AMCO-AEPA standards are somewhat more expensive, they do not settle out, making them significantly easier to use.

While the effect of temperature on the turbidity sensor is small, this factor is automatically taken into account by the sonde software providing temperature compensated readings. Temperature coefficients of 0.3%/degree C and 0.6%/degree C are automatically activated for the 6026 and 6136, respectively, when these sensors are activated in the **Sensor** menu.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) For best results, use only freshly prepared or purchased turbidity standards. Degradation of standards can occur on standing, particularly formazin prepared from dilution of concentrated suspensions such as Hach 4000 NTU standard.

(2) If unusually high or jumpy readings are observed during the calibration protocol, it is likely that there are bubbles on the optics. Manually activating the wiper of the 6026 or 6136 from a computer or 650 MDS keypad removes these bubbles.

(3) When calibrating the 6136 sensor, be aware of the fact that precautions must be taken to avoid interference of the bottom of the calibration vessel. Instructions for two methods of calibrating the 6136 sensor are provided in Section 2.6.1 of this manual. Unless these precautions are taken, field turbidity readings can exhibit an offset of approximately 1.5 NTU. For example, a field reading of 2.5 NTU would really be 4.0 NTU. The offset is not magnified at higher turbidity (for example, a reading of 100 NTU would really be 101.5 NTU) and thus, the effect is much more important in water of low turbidity.

(4) The output of turbidity sensors is susceptible not only to the overall cloudiness of the environmental medium, but also to the particle size of the suspended solids which pass across the optics on the probe face. Thus, although the turbidity of an environmental sample may appear to the eye to be relatively stable, the displayed turbidity can vary significantly depending on the nature of the particles in the optical path at the instant of measurement. For example, if individual readings are taken every 4 seconds in a discrete sample study of environmental water, variations of 0.5-1.0 NTU are common between readings. In long term, unattended studies this effect can be even more exaggerated with spikes of up to 10 NTU sometimes observed. This apparent jumpiness is not observed for freshly prepared turbidity standards, since the particle size in these suspensions is homogeneous.

The sonde turbidity system allows the user to either observe these real turbidity events (while obtaining somewhat jumpy readings) or to apply a mathematical filter to the raw data so that the NTU output may be more reflective of the overall cloudiness of the environmental sample. From the **Advanced|Data Filter** menu of the sonde software, the user can activate the data filter that is specific to turbidity and "fine tune" its performance. For typical sampling and monitoring applications, YSI recommends that the Data Filter settings be selected as follows: Enabled -- On; Wait for Filter -- Off; Time Constant = 12; Threshold = 0.010.

For most unattended sampling applications, selection of the above filter settings should also be appropriate. However, an additional capability is also available which enhances the elimination of spurious single point spikes from the logged data and thus allows for a better presentation of the average turbidity during the deployment. This "**Turb Spike Filter**" is activated/deactivated in the **Advanced|Sensor** menu. Its capability is further described in **Section 2.9.8, Advanced**. YSI recommends the use of this feature for all unattended studies. The user should determine from experience whether its activation is also appropriate for spot sampling studies at particular sites.

See **Appendix E, Turbidity Measurements** for additional practical information on the measurement of turbidity with 6-series sondes.

5.14 CHLOROPHYLL

INTRODUCTION

Chlorophyll, in various forms, is bound within the living cells of algae, phytoplankton, and other plant matter found in environmental water. Chlorophyll is a key biochemical component in the molecular apparatus that is responsible for photosynthesis, the critical process in which the energy from sunlight is used to produce life-sustaining oxygen. In general, the amount of chlorophyll in a collected water sample is used as a measure of the concentration of suspended phytoplankton, the magnitude of which can significantly affect the overall quality of the water.

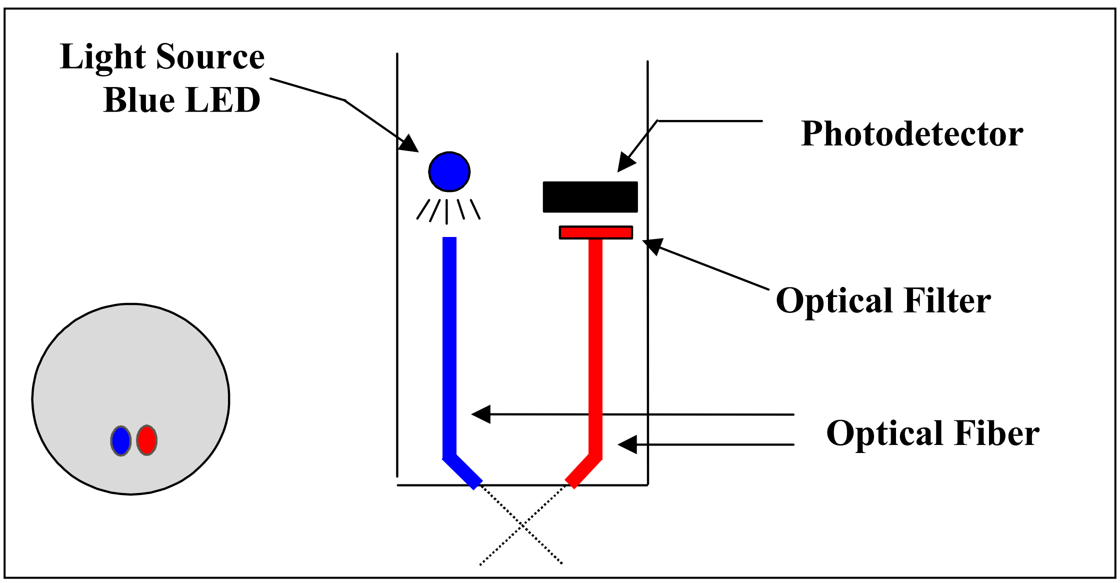
The use of the measurement of phytoplankton as an indicator of water quality is described in Section 10200 A. of *Standard Methods for the Examination of Water and Wastewater*. The classical method of determining the quantity of chlorophyll at a particular site is to collect a fairly large water sample and analyze it in the laboratory. The procedure involves filtration of the sample to concentrate the chlorophyll containing organisms, mechanical rupturing of the collected cells, and extraction of the chlorophyll from the disrupted cells into the organic solvent, acetone. The extract is then analyzed by either a spectrophotometric method using the known optical properties of chlorophyll or by high performance liquid chromatography (HPLC). This general method is detailed in Section 10200 H. *of Standard Method* and has been shown to be accurate in multiple tests and applications as long as a competent laboratory analyst carries out the protocol. The procedure is generally accepted for reporting in scientific literature. The method is time-consuming, however, and usually requires an experienced, efficient analyst to generate consistently accurate and reproducible results. It also does not lend itself readily to continuous monitoring of chlorophyll, and thus phytoplankton, since the collection of samples at reasonable time intervals, e.g., every hour, would be extremely tedious.

YSI has developed the YSI 6025 chlorophyll sensor for the determination of chlorophyll in spot sampling and continuous monitoring applications. It is based on an alternative method for the measurement of chlorophyll which overcomes these disadvantages, albeit with the potential loss of accuracy. In this procedure, chlorophyll is determined *in vivo,* i.e., without disrupting the cells as in the extractive analysis. The YSI 6025 chlorophyll sensor is designed for these *in vivo* applications and its use allows the facile collection of large quantities of chlorophyll data in either spot sampling or continuous monitoring applications. It is important to remember, however, that the results of *in vivo* analysis will not be as accurate as those from the certified extractive analysis procedure.

The limitations of the *in vivo* method are outlined below and should be carefully considered before making chlorophyll determinations with your YSI sonde and sensor. Some of the sources of inaccuracy can be minimized by combining the data from the YSI 6025 with data from extractive analysis of a few samples acquired during a sampling or monitoring study. However, the *in vivo* studies will never replace the standard procedure. Rather, the <u>estimates</u> of chlorophyll concentration from the easy-to-use YSI chlorophyll system are designed to complement the more accurate (but more difficult to obtain) results from more traditional methods of chlorophyll determination.

MEASUREMENT OF CHLOROPHYLL *IN VIVO*

One key characteristic of chlorophyll is that it fluoresces, that is, when irradiated with light of a particular wavelength, it emits light of a higher wavelength (or lower energy). The ability of chlorophyll to fluoresce is the basis for all commercial fluorometers capable of measuring the analyte *in vivo*. Fluorometers of this type have been in use for some time. These instruments induce chlorophyll to fluoresce by shining a beam of light of the proper wavelength into the sample, and then measuring the higher wavelength light which is emitted as a result of the fluorescence process. Most chlorophyll systems use a light emitting diode (LED) as the source of the irradiating light that has a peak wavelength of approximately 470 nm. LEDs with this specification produce radiation in the visible region of the spectrum with the light appearing blue to the eye. On irradiation with this blue light, chlorophyll resident in whole cells emits light in the 650-700 nm region of the spectrum. To quantify the fluorescence the system detector is usually a photodiode of high sensitivity that is screened by an optical filter that restricts the detected light. The filter prevents the 470 nm exciting light from being detected when it is backscattered off of particles in the water. Without the filter, turbid (cloudy) water would appear to contain fluorescent phytoplankton, even though none were present. The following diagram can be used to better understand the principles of the YSI system.



Most commercial fluorometers fit into two categories. In the first category are benchtop instruments that generally have superior optical flexibility and capability but are relatively expensive and are often difficult to use in the field. In the second category are sonde-type fluorometers that have a fixed optical configuration, but are less expensive, can be more easily used in the field, and are usually compatible with data collection platforms. The use of a pump is recommended for some sonde fluorometers and this can result in the need for large capacity batteries for field use.

The unique YSI chlorophyll system available as an option for use with YSI sondes consists of a probe which is similar in concept to the sonde-type fluorometers, but is much smaller, making it compatible with the probe ports of the YSI 6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 600 OMSV2-1, 6600V2-2, 6600EDS V2-2, and 6600V2-4 sondes. The output of the sensor is automatically processed via the sonde software to provide readings in either relative fluorescence units (Chl RFU) or µg/L of chlorophyll. No pump is required for the YSI system allowing the sensor to operate off of either the sonde internal batteries or the batteries in the YSI 650 MDS display/logger. Like the YSI 6026 and 6136 turbidity probes, the YSI

6025 chlorophyll probe is equipped with a mechanical wiper to periodically clean the optical face either by manual or automatic activation. With these features, the YSI chlorophyll sensor provides the same level of performance as the sonde fluorometers, but is much easier to use and can be deployed in environmental water for several weeks without the need for service. In addition, the probe will be a component in sondes that can acquire up to ten other parameters simultaneously with chlorophyll, rather just providing the single parameter.

CALIBRATION METHODS -- GENERAL

As described in **Section** 2 of this manual, the sonde software offers the option of performing 1-point, 2-point, or 3-point calibration procedures in µg/L of chlorophyll. The 1-point calibration is designed only to zero the sensor in chlorophyll-free water and is sufficient for most field applications as described below. Performing a 1-point calibration also zeroes the relative fluorescence unit (RFU) parameter. The 2-point calibration will normally be used for checking the stability of the sensor during deployment by using a dye solution to set the relative sensitivity of the sensor as described below. The 3-point calibration routine is only for special applications and seldom improves the accuracy of the sensor.

For calibration of the YSI chlorophyll system, **only one type of standard will assure accurate field readings: a suspension of phytoplankton of known chlorophyll content**. The chlorophyll content of this suspension should be determined by the extractive analysis procedure described in *Standard Methods*. Most users will not have this analyzed plankton suspension available prior to field studies for use in the 2-point calibration protocol resident in the sonde software. Thus, the best "calibration" method usually comprises the following steps:

1. Prior to use in the field, place the sensor in clean water and perform a 1-point calibration at 0 ug/L.
2. Immerse the sonde in a dye standard (see below) and record the reading. Note that you are not "calibrating" to the dye reading, only checking its value relative to the default sensitivity of the sensor.
3. While making your field readings (sampling or unattended studies), collect a few grab samples and record the date/time and location where they were acquired.
4. On return to the laboratory, perform extractive analyses for chlorophyll on the grab samples and record the results for later use.
5. After the study is complete, place your YSI chlorophyll data in the column of a spreadsheet and place your laboratory data in an adjacent column for comparison. Calculate ratios of field to laboratory results for each grab sample point and then average the results to produce a ratio for adjustment (or „postcalibration") of your field results into accurate chlorophyll readings (relative to extractive analysis).
6. Use the calculating power of the spreadsheet to multiply all of your field readings by the correction ratio to obtain the best possible accuracy for your 6025 data.

A variation of this method is to perform a 2-point calibration prior to deployment using clear water and a dye standard, setting apparent chlorophyll equivalent of the dye standard to the value shown in the tables below. However, it must be emphasized that this technique does not increase the accuracy of the chlorophyll sensor significantly over the simple 1-point calibration recommended above – the user still must collect grab sample and perform laboratory analysis to be assured of meaningful chlorophyll values. The primary utility of the dye is to check for sensor drift during deployment by reanalyzing the dye solution after sonde recovery. The use of the 2-point dye calibration procedure may make it easier to quantify the predeployment dye value and, if so, may be preferable. Remember, however, that no real enhancement of sensor accuracy is attained by using the dye as a calibrant.

PREPARATION OF DYE SOLUTIONS FOR CHECKING SENSOR DRIFT

RHODAMINE WT STANDARD SOLUTION

CAUTION: Be certain to read and follow all the safety instructions and MSDS documentation which is supplied with the dye before proceeding. Remember that only trained personnel should handle chemicals.

Use the following procedure to prepare a Rhodamine WT solution for use as a sensor stability check reagent.

1. Rhodamine WT dye is usually purchased in solution form and can vary somewhat in nominal concentration. YSI uses Rhodamine WT from the supplier noted below and recommends that the user purchase this exact item if possible. The solution is approximately 2 % in Rhodamine WT.

   Fluorescent FWT Red Dye (Item 106023)
   Kingscote Chemicals
   3334 South Tech Blvd.
   Miamisburg, OH 45342
   1-800-394-0678
   Fax: 937-886-9300

2. Accurately transfer 5.0 mL of the Rhodamine WT solution into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water and mix well to produce a solution that is approximately 100 mg/L of Rhodamine WT. Transfer this standard to a glass bottle and retain it for future use.

3. Accurately transfer 5.0 mL of the solution prepared in the above step to a 1000 mL volumetric flask and then fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution, which is 0.5 mg/L in water (a 200:1dilution of the concentrated solution).

4. Store the concentrated standard solution produced in (2) above in a glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 24 hours of its preparation.

When Rhodamine standards are required in the future, perform another dilution of the concentrated Rhodamine solution after warming it to ambient temperature. Our experience has indicated that the concentrated solution that has been kept at cold temperatures is much more stable than the dilute solution stored at room temperature.

It is well known that the intensity of the fluorescence of many dyes shows an inverse relationship with temperature. The effect must also be accounted for when “calibrating” the YSI chlorophyll sensor with Rhodamine WT. Enter the calibration value from the table below corresponding to the temperature of the standard.

WARNING: The “Chl Tempco” factor in the Advanced|Sensor menu, MUST BE SET TO ZERO, when calibrating with Rhodamine WT.

Table. Approximate algal chlorophyll equivalent of 0.5 mg/L Rhodamine WT as a function of temperature.

T, C	ug/L Chl to Enter	T, C	Ug/L Chl to Enter
30	100	18	122
28	103	16	126
26	106	14	131
24	110	12	136
22	113	10	140
20	118	8	144

REMEMBER: The use of Rhodamine WT for "calibration with Rhodamine WT is only an approximation. To assure accurate readings from the 6025 sensor, the user must relate the field fluorescence readings to data from extractive analysis samples as described above. YSI does not provide an accuracy specification for chlorophyll due to these limitations.

EFFECT OF TEMPERATURE ON READINGS

While the effect of temperature on the chlorophyll sensor itself is very small, YSI experiments have indicated that the fluorescence of phytoplankton suspensions can show significant temperature dependence. For example, the apparent chlorophyll content of our laboratory test samples of algae increased from 185 to 226 µg/L when the temperature was dropped from 21 °C to 1 °C even though no change in phytoplankton content took place. In the absence of compensation, this effect would obviously result in errors in field chlorophyll readings if the site temperature were significantly different from the calibration temperature. This temperature error can be reduced by employing a chlorophyll temperature compensation routine ("Chl tempco") resident in the sonde software under the **Advanced|Sensor** menu.

From our studies, it appears that entry of a value of 1 to 2 % per degree C for "Chl tempco" is appropriate to partially account for changes in the fluorescence of environmental phytoplankton with temperature. This value can be estimated in the above example as follows:

Change in Temperature = 21–1 = 20 °C
Change in Fluorescence = 226-185 = 41 µg/L
% Change in Fluorescence = (41/185) x 100 = 22.1
Chl Tempco Factor = 22.1/20 = 1.11 % per degree °C

Note that the use of this empirically derived compensation does not guarantee accurate field readings since each species of phytoplankton is likely to be unique with regard to the temperature dependence of its fluorescence. Changes in fluorescence with temperature are a key limitation of the *in vivo* fluorometric method (see below) which can only be reduced, not eliminated, by this compensation. In general, the best way to minimize errors is to calibrate with phytoplankton standards of known chlorophyll content that are as close as possible in temperature to that of the environmental water under investigation.

EFFECT OF FOULING ON CHLOROPHYLL MEASUREMENTS

Field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can sometimes be removed in short term sampling applications by simply agitating the sonde manually. For studies longer than a few hours where the user is not present at the site, the quality of the chlorophyll data obtained with a fluorescence sensor that has no capability of mechanical cleaning is likely to be compromised. The YSI 6025 probe is equipped with a mechanical wiper that makes it ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically just before each sample is taken during long term unattended monitoring studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde software. Generally, one wiper movement is sufficient for most environmental applications, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

EFFECT OF TURBIDITY ON CHLOROPHYLL READINGS

As described above, the filters in front of the photodiode in the YSI 6025 chlorophyll probe prevent most of the 470 nm light which is used to excite the chlorophyll molecules from reaching the detector after being backscattered off of non-fluorescent particles (turbidity) in environmental water. However, the filter system is not perfect and a minor interference on chlorophyll readings from suspended solids may result. Laboratory experiments indicate that a suspension of typical soil measured with a YSI turbidity sensor will have a turbidity interference characterized by a factor of about 0.03 µg/L per NTU. For example, the turbidity of the water must be above 100 NTU to produce an apparent chlorophyll reading equal to 3 µg/L. In very cloudy water, the user may wish to use the independently-determined turbidity value and the above compensation factor to correct measured chlorophyll values using, for example, a spreadsheet.

LIMITATIONS OF *IN VIVO CHLOROPHYLL* MEASUREMENTS

As noted above, the measurement of chlorophyll from *in vivo* fluorescence measurements will always be less reliable than determinations made on molecular chlorophyll that has been extracted from the cells using the procedures described in *Standard Methods*. This section describes some of the known problems with *in vivo* chlorophyll measurement.

INTERFERENCES FROM OTHER FLUORESCENT SPECIES: The analytical methods described in *Standard Methods* for chlorophyll involve disruption of the living organisms present in suspension, followed by extraction of molecular chlorophyll into a homogeneous solution in an organic solvent. Acidification of the extract helps to minimize the interferences caused by a number of other, non-chlorophyll species. In addition, readings can be taken at various wavelengths on a spectrophotometer to differentiate between the various forms of chlorophyll (a, b, c) and pheophytin a.

In contrast to this fairly controlled situation, all *in vivo* sensors operate under whole-cell, heterogeneous conditions where the sensor will measure, at least to some degree, everything which fluoresces in the region of the spectrum above 630 nm when irradiated with 470 nm light. Therefore, the sensor is really quantifying overall fluorescence under these optical conditions, rather than chlorophyll specifically. While it is probable that most of the fluorescence is due to suspended plant and algal matter and that much of the fluorescence from this biomass is due to chlorophyll, it is impossible to exclude interferences from other fluorescent species using the approach described above.

Note that *in vivo* fluorometers usually cannot differentiate between the different forms of chlorophyll.

LACK OF CALIBRATION REAGENTS: The usual reagents which are used for the calibration of fluorometric measurements for chlorophyll after extraction into organic solvents are purchased as "purified chlorophyll a" from chemical supply vendors such as Sigma. These standards are not soluble in aqueous media and, even if they were, their fluorescence is unlikely to be the same as when the chlorophyll is present in the whole living cell. Therefore, for even a semiquantitative calibration, the user needs a "substitute" standard such as Rhodamine WT (see above) to provide a method for estimating the sensitivity of the sensor. Field readings based on this type of calibration will provide only an estimate of chlorophyll in environmental water where the measurement is taken on whole cell suspensions *in vivo*. The calibration standard that provides the best measure of accuracy for *in vivo* chlorophyll sensors is a portion of a phytoplankton suspension that has been analyzed for chlorophyll by the extractive procedure. We recommend the use of this procedure and further recommend that the phytoplankton suspension be taken from the site being monitored so that the species producing the fluorescence in the standard are as close as possible to the field organisms. To truly assess data reliability in a long term monitoring study, grab samples should be taken periodically, e.g. weekly, and analyzed in the laboratory as the study progresses. These data can then be used to "postcalibrate" the readings logged to the instrument during the study, perhaps using a spreadsheet for the simple mathematical treatment. In any case, getting quantitative chlorophyll data from any *in vivo* fluorometric sensor is much more difficult than with most other environmental sensors. For this reason, it is difficult to provide an accuracy specification for chlorophyll measurement made with *in vivo* fluorometers and therefore no accuracy specification is quoted for the YSI 6025.

EFFECT OF CELL STRUCTURE, PARTICLE SIZE, AND ORGANISM TYPE ON *IN VIVO* READINGS: Even if the only fluorescent species present for *in vivo* measurements were chlorophyll, and reliable calibration standards were available, its absolute quantification would probably still be difficult because samples are not homogeneous. Differing species of algae with differing shape and size will likely fluoresce differently even if the type and concentration of chlorophyll are identical and this significantly limits the accuracy of *in vivo* measurements.

EFFECT OF TEMPERATURE ON PHYTOPLANKTON FLUORESCENCE: As noted above, YSI experiments indicate that phytoplankton fluorescence increases as temperature decreases. Thus, readings taken on a phytoplankton suspension at cold temperature would erroneously indicate the presence of more phytoplankton than when the suspension is read at room temperature. Unless this effect is taken into account, most field readings will be somewhat in error, since the field temperature will differ from the temperature of calibration. The use of the "Chl Tempco" factor found in the Advanced|Sensor menu will help to reduce this error, but must be used with caution since each species of phytoplankton is likely to have a slightly different temperature dependence.

EFFECT OF LIGHT ON PHYTOPLANKTON FLUORESCENCE: It is well documented in the literature that the fluorescence of chlorophyll resident in phytoplankton can be inhibited by light. This "photoinhibition" is confirmed by empirical data which indicate that, at constant phytoplankton level, the fluorescent signal can change significantly on a diurnal schedule, showing less fluorescence during the day and more fluorescence at night. Data showing this diurnal cycle is shown in **Appendix I, Chlorophyll Measurements**. It is clear that this effect would produce errors in the absolute values of chlorophyll unless it were accounted for by the user.

The chlorophyll section of Standard Methods substantiates these limitations along with application notes that are offered by current fluorometer manufacturers. The limitations result in the realization that any *in vivo* "chlorophyll" sensor will be much less quantitative than any of the other sensors offered for use with our sondes.

MEASUREMENT AND CALIBRATION TIPS

1. For best results, analyze field samples to be used for "calibration" of the sensor as soon as possible after collection.

2. If unusually high or jumpy readings are observed during calibration, it is likely that there are bubbles on the optics. The surface should be cleaned by manually activating the wiper before confirming the calibration.

3. The output of the YSI fluorescence sensor is susceptible not only to the overall phytoplankton concentration in the environmental medium, but also to the size and rate of movement of the suspended particles that pass across the optics on the probe face. Thus, although the phytoplankton

content of an environmental sample may appear to the eye to be relatively stable, the displayed chlorophyll reading can vary significantly depending on the nature of the particles in the optical path at the instant of measurement. In a discrete sample study of environmental water, for example, the variability of the output can be significant. This apparent jumpiness is not observed in dye standards, since these are homogeneous solutions containing no suspended matter.

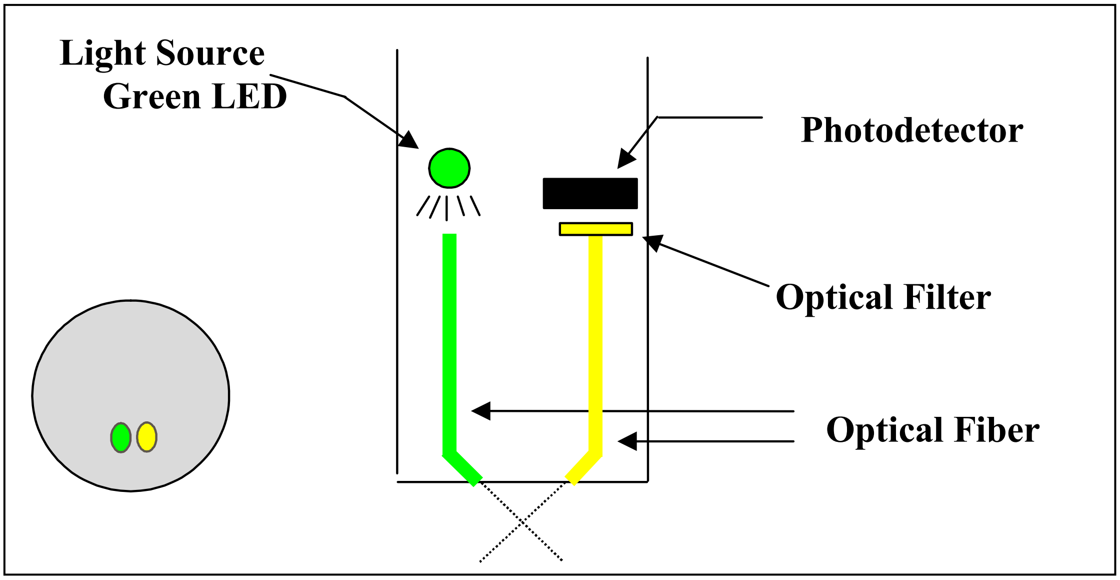
The sonde chlorophyll system allows the user to apply a mathematical filter to the raw data so that the sensor output may be more representative of the average phytoplankton content of the environmental sample. From the **Advanced|Sensor** menu of the sonde software, the user can activate the data filter and adjust its performance. For typical sampling and monitoring applications, YSI recommends that the Data Filter settings for chlorophyll be selected as follows: Enabled -- On; Wait for Filter -- Off; Chlorophyll Time Constant = 12; Chlorophyll Threshold = 1. The advantage of the filter is a more stable display of chlorophyll readings.

5.15 RHODAMINE WT

INTRODUCTION AND PRINCIPLE OF OPERATION

Rhodamine WT is a red dye that is commonly used in stream flow studies. The amount of the species at various points (horizontal and vertical) in the water under examination is determined by utilizing the fact that Rhodamine WT fluoresces when irradiated with the proper wavelength of light and thus the YSI 6130 Rhodamine WT sensor works on the same principles as described above for the 6025 chlorophyll sensor.

As for chlorophyll, Rhodamine WT fluoresces, that is, when irradiated with light of a particular wavelength, it emits light of a higher wavelength (or lower energy). The ability of Rhodamine WT to fluoresce is the basis for all commercial fluorometers capable of measuring the analyte *in situ*. Fluorometers of this type have been in use for some time. These instruments induce Rhodamine WT to fluoresce by shining a beam of light of the proper wavelength into the sample, and then measuring the higher wavelength light which is emitted as a result of the fluorescence process. Most Rhodamine systems use a light emitting diode (LED) as the source of the irradiating light that has a peak wavelength of approximately 540 nm. LEDs with this specification produce radiation in the visible region of the spectrum with the light appearing green to the eye. On irradiation with this green light, Rhodamine WT in the water emits visible light with a higher wavelength than that of the exciting beam, i.e. the Rhodamine fluoresces. To quantify this fluorescence, the system detector is usually a photodiode of high sensitivity that is screened by an optical filter that restricts the detected light. The filter minimizes (a) the exciting light being detected when it is backscattered off of particles in the water and (b) the interference from other fluorescent species such the chlorophyll in phytoplankton. Without the filter, turbid (cloudy) water or water with high levels of phytoplankton would appear to contain Rhodamine WT, even though none were present. The following diagram can be used to better understand the principles of the YSI Rhodamine WT system.



Field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can generally be removed in short term sampling application by simply agitating the sonde manually. However, for studies longer than a few hours where the user is not present at the site, the quality of the data obtained with a Rhodamine WT sensor that has no capability of mechanical cleaning may be compromised. Like all YSI optical probes described above, the 6130 Rhodamine WT probe is equipped with a mechanical wiper that makes it ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically during long term unattended sampling studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde software. Generally one movement is sufficient for most environmental application, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

CALIBRATION AND EFFECT OF TEMPERATURE

The sonde software offers the option of 1 point, 2 point, or 3 point calibrations procedures. For most applications, a 2-point calibration at 0 and 100 ug/L is sufficient. However, for maximum accuracy over the entire 0-200 ug/L range of the sensor, a 3-point calibration procedure can slightly enhance the accuracy of the sensor. Note that YSI does not offer Rhodamine WT standards, but does suggest a vendor for user-production of standards and, later in this section, provides instructions for preparing a solution which is 100 ug/L in Rhodamine WT.

While the effect of temperature on the Rhodamine sensor and electronics is small, the fluorescence of Rhodamine WT changes significantly with temperature. The combination of the two factors is automatically taken into account by the sonde software providing temperature compensated readings.

RHODAMINE WT STANDARD SOLUTION – PREPARATION AND USE

***CAUTION*: Before using concentrated Rhodamine WT solution to prepare standards, be certain to read the safety instructions provided by the supplier with this chemical. Remember that only trained personnel should handle chemicals.**

PREPARATION

Use the following procedure to prepare a 100 ug/L solution that can be used to calibrate your Rhodamine WT sensor for field use:

1. We recommend that Rhodamine WT concentrate be purchased from Keystone Aniline Corporation, 2501 W. Fulton Street, Chicago, IL 60612 (Telephone: 312-666-2015) under the name KEYACID RHODAMINE WT LIQUID (Part # 70301027). As purchased, the solution is approximately 20 % Rhodamine WT by weight, i.e., 200 g/L.

2. Accurately weigh 0.500 g of the 20 % Rhodamine concentrate, quantitatively transfer the viscous liquid to a 1000-mL volumetric flask and fill the flask to the top graduation. This solution contains 100 mg of Rhodamine WT per 1000 mL of water.

3. Accurately transfer 1.0 mL of the solution prepared in the above step to a 1000 mL volumetric and then fill the flask to the top graduation with purified water. Mix well to obtain a solution that is 100 ug/L (0.10 mg/L) in water (a 1000:1 dilution of the concentrated solution).

4. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of its preparation.

When Rhodamine WT standards are required in the future, perform another dilution of the concentrated dye solution after warming it to ambient temperature. Our experience has indicated that the concentrated solution that has been kept at cold temperatures is much more stable than the dilute solution stored at room temperature.

EFFECT OF TURBIDITY ON RHODAMINE WT READINGS

As described above, the filters in front of the photodiode in the YSI 6130 Rhodamine probe prevent most of the green light which is used to excite the Rhodamine molecules from reaching the detector after being backscattered off of non-fluorescent particles (turbidity) in environmental water. However, the filter system is not perfect and a minor interference on Rhodamine WT readings from suspended solids may result. Laboratory experiments indicate that a suspension of typical soil measured with a turbidity sensor will have turbidity interference characterized by a factor of about 0.03 µg/L per NTU. For example, the turbidity of the water must be above 100 NTU to produce an apparent Rhodamine WT reading equal to 3 µg/L. In very cloudy water, the user may wish to use the independently-determined turbidity value and the above compensation factor to correct measured chlorophyll values using, for example, a spreadsheet.

EFFECT OF CHLOROPHYLL ON RHODAMINE WT READINGS

While the green LED used in the Rhodamine WT sensor is not ideal for excitation of the chlorophyll in phytoplankton, some fluorescence of environmental chlorophyll will always be induced by the Rhodamine sensor. Because the filter system for the Rhodamine photodiode is not perfect in excluding chlorophyll fluorescence, a minor interference on Rhodamine WT readings from phytoplankton may result. Laboratory experiments indicate that a suspension of phytoplankton measured with a YSI 6025 sensor will have chlorophyll interference characterized by a factor of about 0.10 µg/L Rhodamine WT per ug/L of chlorophyll. For example, the chlorophyll content of the water must be above 30 ug/L chlorophyll to produce an apparent Rhodamine WT reading equal to 3 µg/L. In water with a high algal content, the user may wish to use the independently-determined chlorophyll value and the above compensation factor to correct measured Rhodamine values using, for example, a spreadsheet.

5.16 PHYCOCYANIN-CONTAINING BLUE-GREEN ALGAE

Introduction

Blue-green algae (BGA), also known as cyanobacteria, are common forms of photosynthetic bacteria present in most freshwater and marine environments. BGA contain a unique set of accessory pigments of the phycobiliprotein family that serve a variety of roles for the organism. The primary phycobilin pigments are phycocyanin (PC) and phycoerythrin (PE) and both happen to have strong fluorescent signatures that do not interfere significantly with the fluorescence of the chlorophylls. This allows for the *in vivo* detection of cyanobacteria with minimal interference from other groups of algae. BGA with the PC phycobilin pigment can be found in both fresh and brackish water environments while BGA with the PE phycobilin pigment is usually found only in brackish or marine environments.

The monitoring of BGA is of growing interest in a number of research and monitoring fields and of particular interest is the monitoring of BGA as a public health risk in freshwater and estuarine areas. As the rates of eutrophication accelerate due to human impacts on aquatic ecosystems, algal blooms are becoming a more common problem. In the case of BGA blooms, some species can produce toxins generally referred to as cyanotoxins that can cause health risks to humans and animals. The real-time monitoring of BGA through fluorometry can serve as an early warning system for potentially hazardous conditions. In addition to potential toxin production, BGA blooms can also result in water with an unpleasant appearance, and in the case of drinking water, an unpleasant taste and odor. These problems adversely affect water quality and diminish the water's recreational utility. Also of concern are high cell concentrations causing an increase in filter run times in drinking water plants. Thus, monitoring the BGA population and distribution in lakes, reservoirs and estuarine areas is extremely important for basic research, resource protection, and public health and safety.

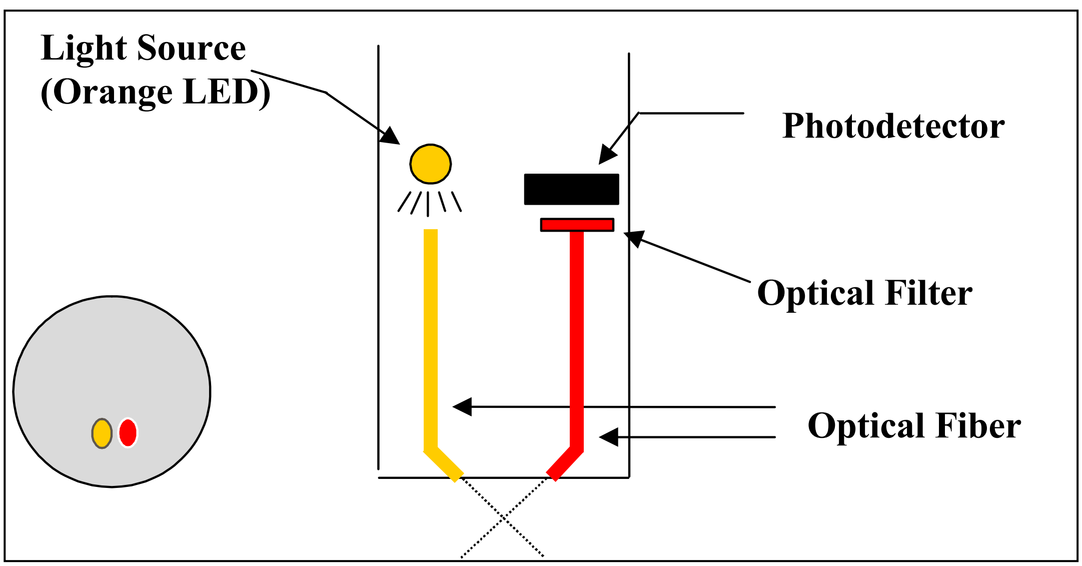
The YSI 6131 sensor, when used in conjunction with YSI 6-series multiparameter sondes, is designed to detect and monitor the presence of PC-containing BGA in order to eliminate, or at least reduce, their public health risks and their general effects on drinking water purification.

The determination of BGA as an indicator of water quality has historically been carried out using either (a) extraction of BGA samples followed by analysis of the extracts by fluorometry, HPLC, or a combination of the two techniques or (b) the automated or manual counting of actual BGA cells in the known volume of sample water. While accurate, these types of analytical techniques usually are done as part of a “spot sampling” protocol and almost never yield continuous data with regard to BGA content. The methods are time-consuming and usually require an experienced, efficient analyst to generate consistently accurate and reproducible results. Most importantly, the methods do not lend themselves readily to continuous monitoring of PC-containing BGA, since the analysis of a collection of samples taken at reasonable time intervals, e.g., every hour, would be extremely tedious.

YSI has developed the YSI 6131 sensor for the determination of PC-containing BGA in spot sampling and continuous monitoring applications. It is based on an alternative method for the measurement of BGA which overcomes the disadvantages of discrete laboratory methods outlined above, albeit with the potential loss of accuracy. In this procedure, PC-containing BGA are measured *in vivo,* i.e., without either disrupting the cells as in the laboratory extractive analysis procedure or using cell counting techniques as described above. The YSI 6131 sensor is designed for these *in vivo* applications and its use allows the facile collection of large quantities of data in either spot sampling or continuous monitoring applications. It is important to remember, however, that the results of *in vivo* analysis will almost certainly not be as accurate as those from the certified extractive analytical or cell counting procedures.

The limitations of the *in vivo* method are outlined below and should be carefully considered before making BGA determinations with your YSI sonde and sensor. Some of the sources of inaccuracy can be minimized by combining the data from the YSI 6131 with data from standard laboratory analysis of a few samples acquired during a sampling or monitoring study. However, the *in vivo* studies will never replace the standard procedure. Rather, the estimates of BGA concentration from the easy-to-use YSI Phycocyanin Probe are designed to complement the more accurate (but more difficult to obtain) results from more traditional methods of BGA determination. The YSI 6131 sensor is ideally suited for the monitoring the relative changes (temporally or spatially) in the PC-containing BGA population.

Measurement of PC-containing BGA *In Vivo*
One key characteristic of phycocyanin-containing BGA is that the cells fluoresce, that is, when irradiated with light of a particular wavelength, they emit light of a higher wavelength (or lower energy). The ability of phycocyanin to fluoresce while present in whole BGA cells is the basis for all commercial fluorometers capable of measuring the analyte *in vivo*. These instruments induce phycocyanin to fluoresce by shining a beam of light of the proper wavelength into the sample, and then measuring the longer wavelength light which is emitted as a result of the fluorescence process. The YSI 6131 Phycocyanin Probe uses an orange light emitting diode (LED) for the excitation process. On irradiation with this orange light, phycocyanin molecules resident in whole cells emit light in the 600-700 nm region of the spectrum. To quantify the fluorescence, the system detector is a photodiode of high sensitivity that is screened by an optical filter that restricts the detected light. The filter prevents the orange exciting light from being detected when it is backscattered off of particles in the water. Without the filter, turbid (cloudy) water would appear to contain significant amounts of PC-containing BGA, even though none were present. The following diagram can be used to better understand the principles of the YSI system.



The unique YSI 6131 BGA system consists of a probe which is compatible with the optical probe ports of all YSI 6-series sondes. The output of the sensor is automatically processed via the sonde firmware to provide readings in either generic fluorescence units (RFU) or cells/mL of PC-containing BGA. Like all YSI optical probes, the 6131is equipped with a mechanical wiper to periodically clean the optical face either by manual or automatic activation. With this feature, the YSI 6131 sensor can be deployed in environmental water for several weeks without the need for service and is ideal for providing continuous monitoring of potentially-hazardous PC-containing BGA.

CALIBRATION METHODS

For calibration of the YSI BBA-PC Probe, **only one type of standard will assure the best possible accuracy for field readings: a suspension of known PC-containing BGA cells**. The BGA concentration of this suspension should be determined by either cell counting or a pigment extraction of PC . However, most users may not have cultures of BGA available prior to field studies for use in the 2-point calibration protocol resident in the sonde firmware and thus the best "calibration" method usually comprises the following steps:

1. Prior to use in the field, place the sensor in clean water and perform a 1-point calibration at 0 cells/mL
2. Immerse the sonde in a dye standard (see below) and record the reading. Note that you are not "calibrating" to the dye reading, only checking its value relative to the default sensitivity of the sensor.
3. While making your field readings (sampling or unattended studies), collect a few grab samples and record the date/time and location where they were acquired.
4. Collect and transport your field sample according to Standard Methods to ensure the BGA cells contained in the sample are not damaged or significantly changed since the time of collection.
5. On return to the laboratory, analyze the grab samples for the amount of PC-containing BGA and record the results for later use.
6. After the study is complete, place your YSI BGA-PC data in the column of a spreadsheet and place your laboratory data in an adjacent column for comparison. Calculate ratios of field to laboratory results for each grab sample point and then average the results to produce a ratio for adjustment (or „postcalibration") of your field results into more accurate values.
7. Use the calculating power of the spreadsheet to multiply all of your field readings by the correction ratio to obtain the best possible accuracy for your 6131 data.

A variation of this method is to perform a 2-point calibration prior to deployment using a clear water and a dye standard, setting the apparent PC-containing BGA equivalent of the dye standard to the value shown in the table in the next section . However, it must be emphasized that this technique does not increase the accuracy of the PC sensor significantly over the simple 1-point calibration recommended above – the user still must collect grab samples and perform laboratory analysis to be assured of meaningful BGA-PC values. The primary utility of the dye is to check for sensor drift during deployment by reanalyzing the dye solution after sonde recovery. The use of the 2-point dye calibration procedure may make it easier to quantify the predeployment dye value and, if so, may be preferable. Remember, however, that no real enhancement of sensor accuracy is attained by using the dye as a calibrant.

PREPARATION OF RHODAMINE WT SOLUTIONS FOR CHECKING SENSOR DRIFT

***CAUTION*: Before using concentrated Rhodamine WT solution to prepare standards, be certain to read the safety instructions provided by the supplier with this chemical. Remember that only trained personnel should handle chemicals.**

Use the following procedure to prepare a 100 ug/L solution that can be used to "calibrate" your YSI 6131 Phycocyanin Probe for field use:

1. We recommend that Rhodamine WT concentrate be purchased from Keystone Aniline Corporation, 2501 W. Fulton Street, Chicago, IL 60612 (Telephone: 312-666-2015) under the name KEYACID RHODAMINE WT LIQUID (Part # 70301027). As purchased, the solution is approximately 20 % Rhodamine WT by weight, i.e., 200 g/L.

2. Accurately weigh 0.500 g of the 20 % Rhodamine concentrate, quantitatively transfer the viscous liquid to a 1000-mL volumetric flask and fill the flask to the top graduation. Mix well. This solution contains 100 mg of Rhodamine WT per 1000 mL of water.

3. Accurately transfer 1.0 mL of the solution prepared in the above step to a 1000 mL volumetric and then fill the flask to the top graduation with purified water. Mix well to obtain a solution that is 100 ug/L (0.10 mg/L) in water (a 1000:1 dilution of the concentrated solution).

4. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of its preparation.

When Rhodamine WT standards are required in the future, perform another dilution of the concentrated dye solution after warming it to ambient temperature. Our experience has indicated that the concentrated solution that has been kept at cold temperatures is much more stable than the dilute solution stored at room temperature.

It is well known that the intensity of the fluorescence of many dyes shows an inverse relationship with temperature. The effect must also be accounted for when "calibrating" the YSI PC sensor with Rhodamine WT. Enter the calibration value from the table below corresponding to the temperature of the standard.

WARNING: The "PC tempco" factor in the Advanced|Sensor menu MUST BE SET TO ZERO, when calibrating with Rhodamine WT.

Table. Approximate PC-containing equivalent of 100 ug/L Rhodamine WT as a function of temperature.

T, C	**Cells/mL to Enter**	**T, C**	**Cells/mL to Enter**
30	44940	18	76580
28	49700	16	83580
26	54600	14	91420
24	58940	12	98140
22	64120	10	107940
20	70000	8	113540

REMEMBER: The use of Rhodamine WT for "calibration" of the Phycocyanin Probe is only an approximation. To assure the maximum accuracy for the 6131 sensor, the user must relate the field fluorescence readings to data from actual BGA samples as described above. YSI does not provide an accuracy specification for the sensor due to the limitations described above and below.

EFFECT OF TURBIDITY ON BGA-PC READINGS

As described above, the filters in front of the photodiode in the YSI 6131 Phycocyanin Probe prevent most of the orange light which is used to excite the Rhodamine molecules from reaching the detector after being backscattered off of non-fluorescent particles (turbidity) in environmental water. However, the filter system is not perfect and a minor interference on PC-containing BGA readings from suspended solids will result. Laboratory experiments indicate that a YSI 6131 sensor will have a turbidity interference characterized by a factor of about 21 cells/mL of PC-containing BGA per NTU of turbidity. For example, at a turbidity of 100 NTU, a PC-containing BGA reading of 2100 cell/mL will be observed over and above the reading actually due to the presence of BGA. Users may wish to use the independently-determined turbidity value and the above compensation factor to correct measured PC-containing BGA values using, for example, a spreadsheet.

EFFECT OF CHLOROPHYLL ON BGA-PC READINGS

While the orange LED used in the 6131 Phycocyanin Probe is not ideal for excitation of the chlorophyll in non-BGA phytoplankton, some fluorescence of environmental chlorophyll will always be induced by the Phycocyanin Probe. Because the filter system for the 6131photodiode is not perfect in excluding chlorophyll fluorescence, a minor interference on PC-containing BGA readings from chlorophyll-containing phytoplankton will result. Laboratory experiments indicate that a suspension of phytoplankton from *Scenedesmus quadricauda* which had its chlorophyll content measured using a YSI 6025 sensor will have chlorophyll interference characterized by a factor of about 77 cells/mL of PC-containing BGA per ug/L of chlorophyll. For example, at a chlorophyll value of 30 ug/L from *Scenedesmus quadricauda,* a PC-containing BGA reading of 2310 cell/mL will be observed over and above the reading actually due to the presence of BGA. Note, however, that the chlorophyll interferences from other algae species are likely to be significantly different from that used in the test, and so the quoted value of 77 cells/mL per ug/L of chlorophyll is only a gross approximation.

EFFECT OF TEMPERATURE ON BGA-PC READINGS

YSI experiments have indicated that the fluorescence of phytoplankton suspensions can show significant temperature dependence, both due to a change in BGA fluorescence and to a change in probe output. In the absence of compensation, this effect would obviously result in errors in field PC-containing BGA readings if the site temperature were significantly different from the calibration temperature. This temperature error can be reduced by employing a phycocyanin temperature compensation routine ("PC tempco") resident in the sonde firmware under the **Advanced|Sensor** menu where the factor in "% per degree C" can be input by the user.

The value of this factor can be estimated as follows using a single suspension of PC-containing BGA under laboratory conditions. In the experiment, the cells/mL value of the suspension is measured at both ambient temperature and then at a much colder temperature by cooling the suspension in a refrigerator.

Change in Temperature = 21 C at ambient temperature – 2 C in refrigerator = 19 C temperature change
Change in Fluorescence = 100,000 cells/mL at 21 C – 120,000 cells/ml at 2 C = 20,000 cells/mL change
% Change in Fluorescence = (20,000/100,000) x 100 = 20%
PC Tempco Factor = 20%/19 C = 1.05 % per degree °C

CAUTION: This example is hypothetical only. Actual tempco factor values must be determined by the user.

Note that the use of this empirically derived compensation does not guarantee accurate field readings since each species of PC-containing BGA is likely to be unique with regard to the temperature dependence of its fluorescence. Changes in fluorescence with temperature are a key limitation of the *in vivo* fluorometric method (see below) which can only be reduced, not eliminated, by this compensation. In general, the best way to minimize errors is to calibrate with standards of known BGA composition that are as close as possible in temperature to that of the environmental water under investigation.

EFFECT OF FOULING ON BGA-PC READINGS

Field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can sometimes be removed in short term sampling applications by simply agitating the sonde or by manually activating the wiper. For studies longer than a few hours where the user is not present at the site, the quality of the PC data obtained with a fluorescence sensor that has no capability of mechanical cleaning is likely to be compromised. The YSI 6131 probe is equipped with a mechanical wiper that makes it ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically just before each sample is taken during long term unattended monitoring studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde firmware. Generally, one wiper movement is sufficient for most environmental applications, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

LIMITATIONS OF ACCURACY FOR THE BGA-PC SENSOR

As mentioned above, the measurement of PC-containing BGA from *in vivo* fluorescence measurements will almost always be less accurate than determinations made using either cell counting or spectrofluorometric quantitation of molecular phycocyanin after its extraction from cells. Some of the reasons for this accuracy limitation with *in vivo* BGA-PC measurement include the following:

- Interferences from other microbiological species such as chlorophyll-containing phytoplankton
- Interference from sample turbidity.
- Differences in the general fluorescence intensity of different PC-containing BGA species
- Differences in the effect of temperature on the fluorescence intensity of different PC-containing BGA species
- Effect of the variation in ambient light conditions on BGA fluorescence and differences in this effect between different PC-containing BGA species.

In addition, when present in high concentrations, colonies of BGA can often be seen with the naked eye and may resemble fine grass cutting or take the form of small irregular clumps or pinhead-sized spheres. When BGA colonize into these forms, the sensitivity of the YSI sensor in terms of the fluorescence per cell of BGA is reduced because it has been designed to detect microscopic, free-floating cells and not large, macroscopic floating particles. Thus, the sensor is likely to underestimate the total amount of BGA present in the water when clumps are present.

Users should take careful note that these limitations mean that any *in vivo* sensors such as BGA-PC and chlorophyll will be significantly less quantitative than any of the other sensors offered for use with YSI 6-series sondes and make it impossible for YSI to provide an actual accuracy specification in cells/mL for the 6131 Phycocyanin Probe.

ESTIMATION OF THE BGA-PC RANGE IN CELLS/ML

As noted in the above section, the use of *in vivo* phycocyanin fluorescence to estimate the cell content of PC-containing algae has significant limitations. These limitations also make the designation of a range (or full scale sensor reading) for any PC-BGA sensor less than quantitative. The range estimate for the YSI 6131 sensor is based on the fact that its reading in an empirical sample of PC-containing algae is about 40% less than that of the industry standard fluorometer from Turner Designs which is configured for PC-BGA. In the estimation experiment, a Turner Cyclops sensor was fixed on its middle range and then its voltage reading in a PC-BGA culture (*Microcystis aeruginosa*) was determined. The YSI 6131 sensor was placed in the same culture and its sensitivity found to be about 40% less in terms of the percent of full scale deflection relative to the Turner sensor on its middle range. Since Turner Designs has designated the middle range of its sensor as 0-200,000 cells/mL, the YSI sensor is estimated to have a range of about 40% more or 280,000 cells/mL. Naturally, this range is only an estimation for both the YSI and Turner sensors because of the general limitations of *in vivo* fluorescence measurements described above.

5.17 PHYCOERYTHRIN-CONTAINING BLUE-GREEN ALGAE

Introduction

Blue-green algae (BGA), also known as cyanobacteria, are common forms of photosynthetic bacteria present in most freshwater and marine systems. BGA contain a unique set of accessory pigments of the phycobiliprotein family that serve a variety of roles for the organism. The primary phycobilin pigments are phycocyanin (PC) and phycoerythrin (PE) and both happen to have strong fluorescent signatures that do not interfere significantly with the fluorescence of the chlorophylls. This allows for the *in vivo* detection of BGA with minimal interference from other groups of algae. BGA with the PC phycobilin pigment can be found in both fresh and brackish water environments while BGA with the PE phycobilin pigment is usually found only in brackish or marine environments.

The monitoring of BGA is of growing interest in a number of research and monitoring fields and of particular interest is the monitoring of BGA as a public health risk in coastal areas and as an important primary producer is some oceanic environments. As the rates of eutrophication accelerate due to human impacts on aquatic ecosystems, harmful algal blooms (HABs) are becoming a more common problem. In the case of cyanobacterial blooms, some species can produce toxins generally referred to as cyanotoxins that can cause health risks to humans and animals.

The YSI 6132 sensor, when used in conjunction with YSI 6-series multiparameter sondes, is designed to detect and monitor the presence of PE-containing BGA in order provide an early warning system for potentially hazardous conditions as well as thoroughly characterize aquatic environments where PE-containing BGA exist.

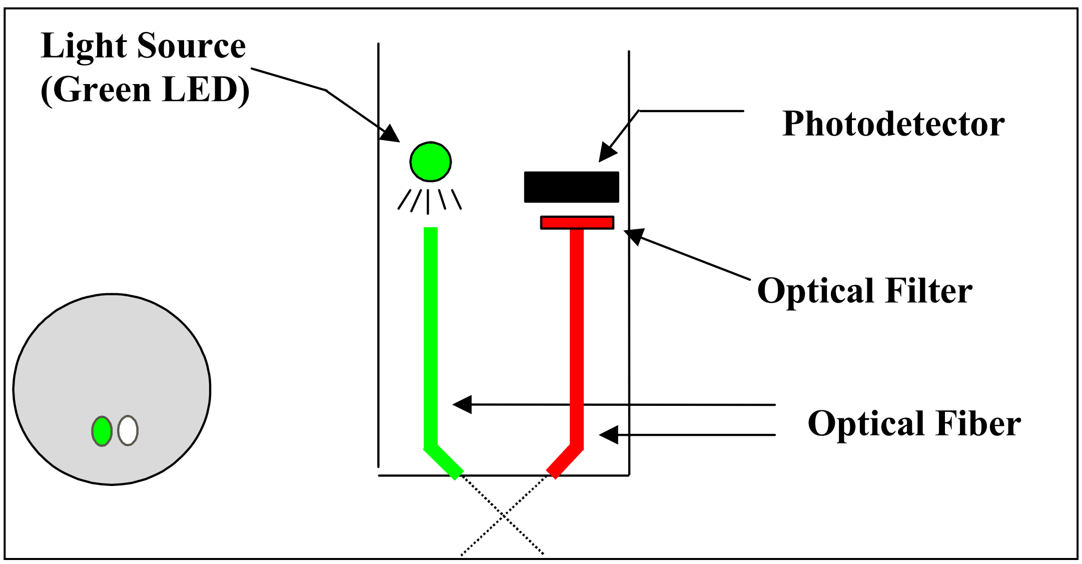
The determination of BGA as an indicator of water quality has historically been carried out using either (a) extraction of BGA samples followed by analysis of the extracts by fluorometry, HPLC, or a combination of the two techniques or (b) the automated or manual counting of actual BGA cells in the known volume of sample water. While accurate, these types of analytical techniques usually are done as part of a "spot sampling" protocol and almost never yield continuous data with regard to BGA content. The methods are time-consuming and usually require an experienced, efficient analyst to generate consistently accurate and reproducible results. Most importantly, the methods do not lend themselves readily to continuous monitoring of PE-containing BGA, since the analysis of a collection of samples taken at reasonable time intervals, e.g., every hour, would be extremely tedious.

YSI has developed the YSI 6132 sensor for the determination of PE-containing BGA in spot sampling and continuous monitoring applications. It is based on an alternative method for the measurement of BGA in general which overcomes the disadvantages of discrete laboratory methods outlined above, albeit with the potential loss of accuracy. In this procedure, PE-containing BGA are measured *in vivo,* i.e., without either disrupting the cells as in the laboratory extractive analysis procedure or using cell counting techniques as described above. The YSI 6132 sensor is designed for these *in vivo* applications and its use allows the facile collection of large quantities of data in either spot sampling or continuous monitoring applications. It is important to remember, however, that the results of *in vivo* analysis will almost certainly not be as accurate as those from the certified extractive analytical or cell counting procedures.

The limitations of the *in vivo* method are outlined below and should be carefully considered before making BGA determinations with your YSI sonde and sensor. Some of the sources of inaccuracy can be minimized by combining the data from the YSI 6132 with data from standard laboratory analysis of a few samples acquired during a sampling or monitoring study. However, the *in vivo* studies will never replace the standard procedure. Rather, the estimates of BGA concentration from the easy-to-use YSI PE Probe are designed to complement the more accurate (but more difficult to obtain) results from more traditional methods of BGA determination. The YSI 6132 sensor is ideally suited for the monitoring the relative changes (temporally or spatially) in the PE-containing BGA population.

Measurement of PE-containing BGA *In Vivo*

One key characteristic of phycoerythrin-containing BGA is that the cells fluoresce, that is, when irradiated with light of a particular wavelength, they emit light of a higher wavelength (or lower energy). The ability of PE to fluoresce while present in whole BGA cells is the basis for all commercial fluorometers capable of measuring the analyte *in vivo*. These instruments induce PE to fluoresce by shining a beam of light of the proper wavelength into the sample, and then measuring the longer wavelength light which is emitted as a result of the fluorescence process. The YSI 6132 PE Probe uses a green light emitting diode (LED) for the excitation process. On irradiation with this green light, PE molecules resident in whole cells emit light in the 565-610 nm region of the spectrum. To quantify the fluorescence, the system detector is usually a photodiode of high sensitivity that is screened by an optical filter that restricts the detected light. The filter prevents the green exciting light from being detected when it is backscattered off of particles in the water. Without the filter, turbid (cloudy) water would appear to contain significant amounts of PE-containing BGA, even though none were present. The following diagram can be used to better understand the principles of the YSI system.



The unique YSI 6132 BGA system consists of a probe which is compatible with the optical probe ports of all YSI 6-series sondes. The output of the sensor is automatically processed via the sonde firmware to provide readings in either generic fluorescence units (RFU) or cells/mL of PE-containing BGA. Like all YSI optical probes, the 6132 is equipped with a mechanical wiper to periodically clean the optical face either by manual or automatic activation. With this feature, the YSI 6132 sensor can be deployed in environmental water for several weeks without the need for service and is ideal for providing continuous monitoring of potentially-hazardous PE-containing BGA.

CALIBRATION METHODS

For calibration of the YSI BGA-PE Probe, **only one type of standard will assure the best possible accuracy for field readings: a suspension of known PE-containing BGA cells**. The BGA concentration of this suspension should be determined by either cell counting or a pigment extraction of PE. However, most users may not have cultures of BGA available prior to field studies for use in the 2-point calibration protocol resident in the sonde firmware and thus the best "calibration" method usually comprises the following steps:

8. Prior to use in the field, place the sensor in clean water and perform a 1-point calibration at 0 cells/mL
9. Immerse the sonde in a dye standard (see below) and record the reading. Note that you are not "calibrating" to the dye reading, only checking its value relative to the default sensitivity of the sensor.
10. While making your field readings (sampling or unattended studies), collect a few grab samples and record the date/time and location where they were acquired.
11. Collect and transport your field sample according to Standard Methods to ensure the BGA cells contained in the sample are not damaged or significantly changed since the time of collection.
12. On return to the laboratory, analyze the grab samples for the amount of PE-containing BGA and record the results for later use.
13. After the study is complete, place your YSI BGA-PE data in the column of a spreadsheet and place your laboratory data in an adjacent column for comparison. Calculate ratios of field to laboratory results for each grab sample point and then average the results to produce a ratio for adjustment (or „postcalibration") of your field results into more accurate values.
14. Use the calculating power of the spreadsheet to multiply all of your field readings by the correction ratio to obtain the best possible accuracy for your 6132 data.

A variation of this method is to perform a 2-point calibration prior to deployment using a clear water and a dye standard, setting the apparent PE-containing BGA equivalent of the dye standard to the value shown in the table in the next section . However, it must be emphasized that this technique does not increase the accuracy of the PE sensor significantly over the simple 1-point calibration recommended above – the user still must collect grab samples and perform laboratory analysis to be assured of meaningful BGA-PE values. The primary utility of the dye is to check for sensor drift during deployment by reanalyzing the dye solution after sonde recovery. The use of the 2-point dye calibration procedure may make it easier to quantify the predeployment dye value and, if so, may be preferable. Remember, however, that no real enhancement of sensor accuracy is attained by using the dye as a calibrant.

PREPARATION OF RHODAMINE WT SOLUTIONS FOR CHECKING SENSOR DRIFT

***CAUTION*: Before using concentrated Rhodamine WT solution to prepare standards, be certain to read the safety instructions provided by the supplier with this chemical. Remember that only trained personnel should handle chemicals.**

Use the following procedure to prepare an 8 ug/L solution that can be used to "calibrate" your YSI 6132 PE Probe for field use:

1. We recommend that Rhodamine WT concentrate be purchased from Keystone Aniline Corporation, 2501 W. Fulton Street, Chicago, IL 60612 (Telephone: 312-666-2015) under the name KEYACID RHODAMINE WT LIQUID (Part # 70301027). As purchased, the solution is approximately 20 % Rhodamine WT by weight, i.e., 200 g/L.

2. Accurately weigh 0.500 g of the 20 % Rhodamine concentrate, quantitatively transfer the viscous liquid to a 1000-mL volumetric flask and fill the flask to the top graduation. Mix well. This solution contains 100 mg of Rhodamine WT per 1000 mL of water.

3. Accurately transfer 80 uL of the solution prepared in the above step to a 1000 mL volumetric and then fill the flask to the top graduation with purified water. Mix well to obtain a solution that is 8 ug/L (0.008 mg/L) in water.

4. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of its preparation.

When Rhodamine WT standards are required in the future, perform another dilution of the concentrated dye solution after warming it to ambient temperature. Our experience has indicated that the concentrated solution that has been kept at cold temperatures is much more stable than the dilute solution stored at room temperature.

It is well known that the intensity of the fluorescence of many dyes shows an inverse relationship with temperature. The effect must also be accounted for when "calibrating" the YSI BGA-PE sensor with Rhodamine WT. Enter the calibration value from the table below corresponding to the temperature of the standard.

WARNING: The "PE tempco" factor in the Advanced|Sensor menu MUST BE SET TO ZERO, when calibrating with Rhodamine WT.

Table. Approximate PE-containing equivalent of 8 ug/L Rhodamine WT as a function of temperature.

T, C	**Cells/mL to Enter**	**T, C**	**Cells/mL to Enter**
30	156,000	18	210,000
28	164,000	16	220,000
26	174,000	14	230,000
24	181,000	12	240,000
22	189,000	10	247,000
20	200,000	8	254,000

REMEMBER: The use of Rhodamine WT for "calibration" of the PE Probe is only an approximation. To assure the maximum accuracy for the 6132 sensor, the user must relate the field fluorescence readings to data from actual BGA samples as described above. YSI does not provide an accuracy specification for the sensor due to the limitations described above and below.

EFFECT OF TURBIDITY ON BGA-PE READINGS

As described above, the filters in front of the photodiode in the YSI 6132 PE Probe prevent most of the orange light which is used to excite the Rhodamine molecules from reaching the detector after being backscattered off of non-fluorescent particles (turbidity) in environmental water. However, the filter system is not perfect and a minor interference on PE-containing BGA readings from suspended solids will result. Laboratory experiments indicate that a YSI 6132 sensor will have a turbidity interference characterized by a factor of about 140 cells/mL of PC-containing BGA per NTU of turbidity. For example, at a turbidity of 100 NTU, a PE-containing BGA reading of 14000 cell/mL will be observed over and above the reading actually due to the presence of BGA. Users may wish to use the independently-determined turbidity value and the above compensation factor to correct measured PE-containing BGA values using, for example, a spreadsheet.

EFFECT OF CHLOROPHYLL ON BGA-PE READINGS

While the orange LED used in the 6132 PE Probe is not ideal for excitation of the chlorophyll in non-BGA phytoplankton, some fluorescence of environmental chlorophyll will always be induced by the `PE Probe. Because the filter system for the 6132 photodiode is not perfect in excluding chlorophyll fluorescence, a minor interference on PE-containing BGA readings from chlorophyll-containing phytoplankton will result. Laboratory experiments indicate that a suspension of phytoplankton from *Scenedesmus quadricauda* which had its chlorophyll content measured with a YSI 6025 sensor will have chlorophyll interference characterized by a factor of about 20 cells/mL of PC-containing BGA per ug/L of chlorophyll. For example, at a chlorophyll value of 30 ug/L from *Scenedesmus quadricauda,* a PC-containing BGA reading of 600 cells/mL will be observed over and above the reading actually due to the presence of BGA. Note, however, that the chlorophyll interferences from other algae species are likely to be significantly different from that used in the test, and so the quoted value of 20 cells/mL per ug/L of chlorophyll is only a gross approximation.

EFFECT OF TEMPERATURE ON BGA-PE READINGS

YSI experiments have indicated that the fluorescence of phytoplankton suspensions can show significant temperature dependence, both due to a change in BGA fluorescence and to a change in probe output. In the absence of compensation, this effect would obviously result in errors in field PE-containing BGA readings if the site temperature were significantly different from the calibration temperature. This temperature error can be reduced by employing a PE temperature compensation routine ("PE tempco") resident in the sonde firmware under the **Advanced|Sensor** menu where the factor in "% per degree C" can be input by the user.

The value of this factor can be estimated as follows using a single suspension of PE-containing BGA under laboratory conditions. In the experiment, the cells/mL value of the suspension is measured at both ambient temperature and then at a much colder temperature by cooling the suspension in a refrigerator.

Change in Temperature = 21 C at ambient temperature – 2 C in refrigerator = 19 C temperature change
Change in Fluorescence = 100,000 cells/mL at 21 C – 120,000 cells/ml at 2 C = 20,000 cells/mL change
% Change in Fluorescence = (20,000/100,000) x 100 = 20%
PE Tempco Factor = 20%/19 C = 1.05 % per degree °C

CAUTION: This example is hypothetical only. Actual tempco factor values must be determined by the user.

Note that the use of this empirically derived compensation does not guarantee accurate field readings since each species of PE-containing BGA is likely to be unique with regard to the temperature dependence of its fluorescence. Changes in fluorescence with temperature are a key limitation of the *in vivo* fluorometric method (see below) which can only be reduced, not eliminated, by this compensation. In general, the best way to minimize errors is to calibrate with standards of known BGA composition that are as close as possible in temperature to that of the environmental water under investigation.

EFFECT OF FOULING ON BGA-PE READINGS

Field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can sometimes be removed in short term sampling applications by simply agitating the sonde or by manually activating the wiper. For studies longer than a few hours where the user is not present at the site, the quality of the PE data obtained with a fluorescence sensor that has no capability of mechanical cleaning is likely to be compromised. The YSI 6132 probe is equipped with a mechanical wiper that makes it ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically just before each sample is taken during long term unattended monitoring studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde firmware. Generally, one wiper movement is sufficient for most environmental applications, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

LIMITATIONS OF ACCURACY FOR THE BGA-PE SENSOR

As mentioned above, the measurement of PE-containing BGA from *in vivo* fluorescence measurements will almost always be less accurate than determinations made using either cell counting or spectrofluorometric quantitation of molecular PE after its extraction from cells. Some of the reasons for this accuracy limitation with *in vivo* BGA-PE measurement include the following:

- Interferences from other microbiological species such as chlorophyll-containing phytoplankton
- Interference from sample turbidity.
- Differences in the general fluorescence intensity of different PE-containing BGA species
- Differences in the effect of temperature on the fluorescence intensity of different PE-containing BGA species
- Effect of the variation in ambient light conditions on BGA fluorescence and differences in this effect between different PE-containing BGA species.

In addition, when present in high concentrations, colonies of BGA can often be seen with the naked eye and may resemble fine grass cutting or take the form of small irregular clumps or pinhead-sized spheres. When BGA colonize into these forms, the sensitivity of the YSI sensor in terms of the fluorescence per cell of BGA is reduced because it has been designed to detect microscopic, free-floating cells and not large, macroscopic floating particles. Thus, the sensor is likely to underestimate the total amount of BGA present in the water when clumps are present.

Users should take careful note that these limitations mean that any *in vivo* sensors such as BGA-PE and chlorophyll will be significantly less quantitative than any of the other sensors offered for use with YSI sondes and make it impossible for YSI to provide an actual accuracy specification in cells/mL for the 6132 PE Probe.

ESTIMATION OF THE BGA-PE RANGE IN CELLS/ML

As noted in the above section, the use of *in vivo* phycoerythrin fluorescence to estimate the cell content of PE-containing algae has significant limitations. These limitations also make the designation of a range (or full scale sensor reading) for any BGA-PE sensor less than quantitative. The range estimate for the YSI 6132 sensor is based on the fact that its reading in an empirical sample of PE-containing algae is very similar to that of the industry standard fluorometer from Turner Designs which is configured for BGA-PE. In the estimation experiment, the Turner Cyclops was fixed on its middle range and then its voltage reading in a BGA-PE culture (a *Synechococcus* sp.) was determined. The YSI 6132 sensor was placed in the same culture and its sensitivity adjusted to show the same percent of full scale deflection as the Turner sensor on its middle range. Since Turner Designs has designated the middle range of its sensor as 0-200,000 cells/mL, the YSI sensor is estimated to have the same range. Naturally, this range is only an estimation for both the YSI and Turner sensors because of the general limitations of *in vivo* fluorescence measurements described above.

5.18 FLOW

Flow is a calculated value. Whenever there is a one to one relationship between the level of water in an open channel and the flow of water through it, then flow can be calculated from a level measurement. YSI sondes that are equipped with shallow vented level can calculate flow based on several different methods.

Flow is only available in the Sensors menu on those sondes that have shallow vented level. The **Flow Setup** menu only appears when **Flow** is enabled in the **Sensors** menu.

Note: In this manual we describe how to use our sondes to calculate flow from vented level. While weirs, flumes and the Manning equation are described briefly in this manual, it is not a complete treatment of the subject. We make no claims on the accuracy or appropriateness of any of these techniques for any particular application.

WEIR AND FLUME

Many devices have been designed for the determination of flow in an open channel. For example, a weir is a dam of specific geometry that restricts the flow of water while giving a very repeatable and accurate relationship between level and flow. There are several varieties of weirs; each designed for a specific application. Similarly, a flume also restricts flow producing a repeatable and accurate flow/level curve by forcing the flow not over a dam, but through a narrower portion of the channel. The flow is gradually narrowed, passed through a throat in the channel, and then gradually expanded back to the original channel width. As with weirs, there are several varieties of flumes, each designed for a specific application.

The weir or flume is referred to as the primary measuring device, and the level meter is referred to as the secondary measurement device. There are commonly 3 types of weirs and 7 types of flumes. Most of these are available in a number of sizes. Flow/level curves for common types and sizes are already programmed in the sonde so that it is only necessary to describe the primary measuring device to get flow readings. If you have a primary measuring device that is not already programmed, you have the option of entering either an equation or a table that defines the flow/level curve for your device. The table can also be used to calculate the flow of water in stream for which the flow/level data is available.

MANNING EQUATION

YSI sondes with shallow vented level can be used with the Manning equation. In an open channel without any restriction built explicitly for measuring flow, the Manning Equation can sometimes be used to calculate flow. Under the right conditions the channel itself is the primary measurement device and flow can be calculated from the level of water in the channel. Careful use of the Manning equation under ideal conditions can be accurate to 10%. Less careful use under worse conditions can give errors of 50% or more. The formula is:

$$\frac{Q = K \bullet A \bullet R^{\frac{2}{3}} \bullet S^{\frac{1}{2}}}{n}$$

Where: Q = Flow rate
A = Cross sectional area of flow
R = Hydraulic radius
S = slope
n = Manning coefficient of roughness
K = constant dependent on units

The Manning roughness coefficient n is an index of the frictional resistance to flow on the surface of the channel. Values of n are published for different materials. However, in the field, determination of n is perhaps the largest source of error. For example, n for a concrete channel can vary from 0.011 to 0.020 depending upon how the surface of the concrete was finished during construction. Occasional debris or vegetation in the channel also affects the value of n, and in most applications the value changes depending upon the depth of water in the channel.

Other uncertainties can also make the measurement inaccurate. Best results are obtained at the end of a straight channel 1000 feet (300 meters) long. However, in reality it is difficult to find channels that are very long, and very straight, and with constant slope, and with uniform roughness.

Even with all these uncertainties, the Manning equation can yield useful results as long as the user is aware of its limitations.

EQUATION

The YSI sondes that are equipped with shallow vented level can also calculate flow based on an equation. The equation must be of the form:

$$Q = K_1 \bullet H^{P_1} + K_2 \bullet H^{P_2}$$

This allows the use of primary measuring devices other than the standard ones already programmed. Users may enter values for K_1, P_1, K_2, and P_2 and the sonde will calculate flow. Note: if you do not need the second term in the equation, simply enter 0 for K_2.

TABLE

YSI sondes that are equipped with shallow vented level can also calculate flow based on a table. Users can enter up to 50 pairs of (level, flow) data. The sonde will then calculate flow from the resulting table, linearly interpolating between points when necessary. This feature can be used with non-standard primary measuring devices for which there is a table rather than an equation. This data is often available for rivers and streams so that flow can be calculated from the level in a river at the proper location.

See Appendix F, Flow for additional practical information on the calculation of flow with a sonde.

SECTION 6 TROUBLESHOOTING

This section contains troubleshooting tables that will be helpful to identify the causes of the most common difficulties that may occur while operating the YSI 6-Series Sondes. The **Symptom** column describes the type of difficulty that you might experience. The **Possible cause** column describes the conditions that might cause the stated symptom. The **Action** column provides simple steps that can be followed to correct for the "possible cause" and cure the "symptom" being experienced. The column entitled **Ref** is the number of the reference section and subsection in the manual where you may find additional information.

Troubleshooting problems have been categorized into four general areas.

- Calibration Error Messages
- Sonde Communication
- Sensor Performance

If you need assistance that this Troubleshooting section can not provide, please contact YSI Technical Support.

6.1 CALIBRATION ERRORS

There are three main Calibration Error messages that are possible and are listed below, instead of in the troubleshooting table. Only two of the error messages are related to sensor performance.

High DO Charge: This message indicates a malfunction in the Rapid Pulse DO sensor that is generally due to the roughness of the electrodes on the surface of the probe face. The charge associated with the DO sensor must be below 75 or the error message will appear when calibration is attempted. If this error message is encountered, remove the DO probe from the sonde and resurface it according to the instructions in **Section 2.10, Care, Maintenance and Storage**. After resurfacing the probe, activate the DO charge parameter in the Report setup section of the sonde software and confirm that the value is within the acceptable range of 50 ± 25. After resurfacing, allow the sensor to pulse in the Run mode for at least 5 minutes, during which time the DO charge may be expected to drop in value if the sensor is still functional. If resurfacing according to the instructions in **Section 2.10, Care, Maintenance and Storage** does not result in a lowering of the charge, contact YSI Technical Support for additional help.

Out of Range: This message indicates that the output of the sensor being calibrated does not conform to the normal range for this parameter. This problem could be due to either a malfunctioning sensor or to a calibration solution that is out of specification. If this error message is encountered, first insure that your standards for pH, ORP, ammonium, nitrate, chloride, conductivity, and turbidity have not been contaminated and that your DO sensor is in air (DO % Cal) or in a solution of known dissolved oxygen concentration (DO mg/L). Also be certain that you have entered the correct value for the calibration solution. If the calibration error message continues to occur, contact YSI Technical Support to determine whether the sensor in question needs to be factory-serviced or replaced.

Bad Input: This message simply indicates that your keyboard input does not conform to the accepted format for this parameter. For example, you may have entered the “letter O” instead of “zero” for a calibration value. Return to the desired parameter in the Calibrate menu and repeat the calibration entry being certain to enter only numbers.

The following troubleshooting tables can help you if you encounter problems with software, communication protocol, or sensor malfunctions other than calibration errors.

6.2 SONDE COMMUNICATION PROBLEMS

SYMPTOM	POSSIBLE CAUSE	ACTION	REF
Cannot communicate with sonde	Sonde not powered	Check 12 vdc source	2.3.3
	Cable connection is loose	Check both ends of cable; secure connectors	2.3.4
	Damaged connectors	Check pins at both ends; insure they are straight, dry and clean.	
	Com port not selected	Change to other com port, other peripheral on the same port (Internal mouse). Try other PC, 650 display/logger or dumb terminal	2.4.3
Scrambled data	Unmatched baud rate between host and sonde	Match the baud rate	2.4.3
	Host is too slow	Use faster computer	
	Interface cable failure	Check cable for damage. If necessary, return for service	2.3.4
	Internal failure	Return sonde for service	9

6.3 SENSOR PERFORMANCE PROBLEMS

SYMPTOMS	POSSIBLE CAUSE	ACTION	REF
Rapid Pulse dissolved Oxygen reading unstable or inaccurate	Probe not properly calibrated	Follow DO cal procedures	2.6.1
	Membrane not properly installed or may be punctured	Follow 6562 setup procedure	2.3.1
	DO probe electrodes require cleaning	Follow DO cleaning procedure. Use 6035 maint. kit	2.10.2
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Algae or other contaminant clinging to DO probe	Rinse DO probe with clean water	2.10.2
	Barometric pressure entry is incorrect	Repeat DO cal procedure	2.6.1
	Cal at extreme temperature	Recal at (or near) sample temperature	2.6.1
	DO Charge too high (>75) 1. Anodes polarized (tarnished) 2. Probe left on continuously	Enable DO charge parameter in the Sonde report menu. Run sonde, if charge is over 100, recondition probe with 6035 Maintenance Kit. Follow DO cleaning procedure.	2.10.2
	DO Charge too low (<25) Insufficient electrolyte.	Replace electrolyte and membrane.	2.3.1
	DO probe has been damaged	Replace 6562 probe	9
	Internal failure	Return sonde for service	9
ROX dissolved Oxygen reading unstable or inaccurate	Probe not properly calibrated	Follow DO cal procedures	2.6.1
	Membrane assembly not properly installed or may be punctured	Follow instructions for proper membrane assembly replacement	2.10.2
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Algae or other contaminant clinging to DO probe	Rinse DO probe with clean water	2.10.2
	Barometric pressure entry is incorrect	Repeat DO cal procedure	2.6.1
	Membrane assembly is more than 1 year old	Replace membrane assembly (6155 Optical DO Membrane Replacement Kit)	9
	Wiper is not parking correctly	Make certain that setscrew is tight. If problem persists, return probe for service.	9
	DO probe has been damaged	Replace 6150 probe	9
pH, ORP, chloride, ammonium, or nitrate readings are unstable or inaccurate. Error messages appear during calibration.	Probe requires cleaning,	Follow probe cleaning procedure	2.10.2
	Probe requires calibration	Follow cal procedures	2.6.1
	pH probe reference junction has dried out from improper storage.	Soak probe in tap water or buffer until readings become stable	2.10.2

	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Probe has been damaged	Replace probe	9
	Calibration solutions out of spec or contaminated with other solution	Use new calibration solutions	C
	ORP fails Zobell check	Take into account temperature dependence of Zobell solution readings	5.4
	Internal failure	Return sonde for service	9

Depth unstable or inaccurate	Depth sensor has not been zeroed	Follow depth zero procedure	2.6.1
	Depth sensor access hole is obstructed	Follow depth cleaning procedure	2.10.2
	Depth sensor has been damaged	Return sonde for service	9
	Internal failure	Return sonde for service	9
Conductivity unstable or inaccurate. Error messages appear during calibration.	Conductivity improperly calibrated.	Follow cal procedure	2.6.1
	Conductivity probe requires cleaning	Follow cleaning procedure	2.10.2
	Conductivity probe damaged	Replace probe	9
	Calibration solution out of spec or contaminated	Use new calibration solution	C
	Internal failure	Return sonde for service	8
	Calibration solution or sample does not cover entire sensor.	Immerse sensor fully.	2.6.1
Installed probe has no reading	The sensor has been disabled	Enable sensor	2.9.7
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Probe has been damaged	Replace the 6560 probe	9
	Report output improperly set up	Set up report output	2.9.6
	Internal failure	Return sonde for service.	9
Temperature, unstable or inaccurate	Water in connector	Dry connector; reinstall probe	2.3.2
	Probe has been damaged	Replace the 6560 probe	9
Optical probe (turbidity, chlorophyll, rhodamine WT, BGA-PC, or BGA-PE) unstable or inaccurate. Error messages appear during calibration	Probe requires cleaning.	Follow probe cleaning procedure	2.10.2
	Probe requires calibration	Follow cal procedures	2.6.1
	Probe has been damaged	Replace probe	9
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Calibration solutions out of spec	Use new calibration solutions	C
	Wiper is not turning or is not synchronized.	Activate wiper. Assure rotation. Make sure setscrew is tight.	2.10.2
	Wiper is fouled or damaged.	Clean or replace wiper.	2.10.2
	Internal failure.	Return probe for service.	9

SECTION 7 COMMUNICATION

This section describes the communication protocols that the Sondes use to communicate with the host system. **Section 7.1** gives a brief overview of the communication ability of the Sondes. The remaining sections describe available hardware and software features.

7.1 OVERVIEW

The sondes communicate via a serial port that can be configured as either a SDI-12, or a 3-wire RS-232 interface. The normal mode of operation for the sonde is RS-232, with the following configurations:

Baud rate: 300, 600, 1200, 2400, 4800, 9600
Data Bit: 8
Parity: None
Handshake: None

For further detail into the sondes RS-232 and SDI-12 implementations, see S**ections 7.3 and 7.4** respectively.

With these configurations, the Sonde is capable of interfacing to a variety of devices from a “dumb” terminal to numerous data collection platforms.

7.2 HARDWARE INTERFACE

Connection from the Sonde to the host computer is provided using the YSI 6095B MS-8 to DB-9 female adapter. This 6095B then connects to the standard DB-9 male connector on the host computer. The Sonde PC interface cable is wired for direct connection to a DTE device. The following table defines the interface circuits. The signals and their directions are defined with respect to use of the Sonde with the 6095B adapter.

Wire Color	Pin Description	DB-9	MS-4	MS-8
Yellow	RS232 TX	2	----	C
Orange	RS232 RX	3	----	D
Green	Alarm	----	----	E
Grey	RTS	----	----	G
Blue	CTS	----	----	H
Red	+ 12V DC	9	A	A
Black	GND	5	C	B
Purple	SDI-12	----	B	F
Bare	Shield	----	----	B

7.3 RS-232 INTERFACE

The sonde has an auto-baud feature that allows the instrument to automatically adjust to the terminal baud rate. If the sonde is set to a baud rate of 4800 and a 9600 baud terminal is attached to it, after a few carriage returns are entered, the sonde will recognize the communication mismatch and attempt to change its own internal baud rate to match the terminals.

7.4 SDI-12 INTERFACE

SDI-12 is an industry-standard serial digital interface bus. The bus was designed to allow compatibility between data collection devices and sensors of various manufacturers. The description below applies specifically to the Sonde implementation of SDI-12 interface. For complete SDI-12 technical specifications please contact:

Campbell Scientific, Inc.
P.O. Box 551
Logan, Utah 84321 USA
(801) 753-2342

SDI-12 is a single master multi-drop bus and command protocol. As many as 10 sensors can be connected to the bus at a time. Each sensor is pre-assigned a unique address from 0 to 9. Each Sonde is factory-set to address 0. The address can be changed in the System menu, **see Section 2.9.5, System menu** for details.

Running the sonde in SDI-12 mode requires it to be connected to a SDI-12 master device. An example of such a device is the YSI 6200 or units from Campbell Scientific or Handar Instruments. These instruments provide the commands necessary to communicate with the sonde in SDI-12 mode. In addition, the sonde also supports the following commands which are entered from the command line at the # prompt:

SDI12

This command activates SDI-12 mode. This is the only mode in which the Sonde will respond to any SDI-12 command. To exit to command line, press any key from the terminal connected to the RS-232 port.

The Sonde implements the basic SDI-12 command set. Below are the descriptions of each command and their responses.

The following notations are used:

a	Sonde SDI-12 address (ASCII '0' to '9')
[CR]	Carriage return (ASCII 13)
[LF]	Line feed (ASCII 10)
Master	Any SDI-12 compatible data collection device

```
Master:        aM!       Initiate a measurement.
Sonde:     atttn[CR][LF]
```

`ttt` - Maximum time in seconds the Sonde will take to complete the measurement.

`n` - Number of data that will be available when the measurement is completed. This number is the same as the number of output parameters set in the Report menu, as described in **Section 2.9.6, Report**. For ten or more parameters, the sonde returns ":", ";", "<", "=", ">", "?", "@", "A", "B",…etc.

After finishing the measurement, the Sonde will usually send a service request "a[CR][LF]" to the bus master. The bus master can then retrieve the measurement result by "D0" to "D9" commands (see below). If the Sonde does not send a service request within the specified maximum time, the measurement is canceled. The bus master can then restart with another "M" command.

```
Master:         aI!       Send identification.

Sonde:     allccccccccmmmmmmvvvxxx...xxx[CR][LF]
```

`l` - 2 character SDI-12 level number.

`c` - 8 character manufacturer identification. This field always contains "YSIIWQSG" (YSI Inc., Water Quality Systems Group).

`m` - 6 character model number. This field always contains "EM600_" or "EM 6920" (Environmental Monitoring System Sonde) depending on the sonde.

`v` - 3 character version number. This field holds the sonde's software version number ("100" for version 1.00).

```
Master:         aD0! to aD9!
Retrieve measurement/verifying data

Sonde:     a<values>[CR][LF]
```

<**`values`**>- 33 characters or less. This field holds one or more values resulting from a measurement or verifying sequence. A value contains between 1 to 7 digits with an optional radix mark (period '.' or comma ','). Each value must be preceded by its sign (either '+' or '-') since the sign is also used to delimit multiple values.

If the number of values returned by the "D0" command is less than the number specified in the previous response to "M" commands, the rest of the data can be retrieved by using "D1" to "D9" commands. The "D" commands are non-destructive. Thus if the same "D" command is issued multiple times before the next "M" command, it will return the same data. If the response to the "D0" command is "a[CR][LF]" then either no "M" command was received before the first "D" command or the "M" command was canceled.

Example: Here is an example SDI-12 transaction. Here SDI-12 master will issue an Identify command followed by a Measure command. The sonde is configured with a report output of Temperature, Specific conductance, DO %, DO mg/L, pH (ISE1), ORP (ISE2), and Depth, a DO warm up time of 60 seconds, and an SDI-12 address of 1.

Master: 1I!

Sonde: 110YSIIWQSGEM600_107[CR][LF]

The bus master asked for identification and the Sonde returned data showing the following.

SDI-12 level: 1.0

Manufacturer:	YSIIWQSG
Model:	EMS600_
Version:	1.07

Master: 1M!

Sonde: 10617[CR][LF]

The bus master sent a measurement command. The Sonde will take a maximum of 61 seconds to finish the measurement. Upon completion, it will have 7 sensor data available.

Sonde: 1[CR][LF]

Master: 1D0!

Sonde: 1+17.5+12.05+98.7+8.25+6.45[CR][LF]

Master: 1D1!

Sonde: 1-325+10[CR][LF]

After finishing the measurement, the Sonde sent a service request to indicate completion. The bus master then sent the "D0" command to retrieve the data. There were 5 data returned. Since 7 readings should be available, the master continued with "D1" command and received the remaining data. The responses from "D0" and "D1" commands are:

Temperature:	17.5
Specific conductance:	12.05
DO %:	98.7
DO mg/L:	8.25
pH (ISE1):	6.45
ORP (ISE2):	-325
Depth:	10

SECTION 8 UPGRADING SONDE FIRMWARE

YSI periodically makes changes in the firmware which is resident in the sonde and controls its functions. These changes can be made to allow the use of new sensors, to improve the overall capability of the instrument, or to fix problems which have arisen in the existing firmware. New versions of 6-series firmware can easily be installed in the sonde without returning the instrument to the factory. Upgrades are performed from the YSI Website and should be carried according to the following instructions.

- Connect your sonde to the serial port of a PC with access to the Internet using the proper cable as described in Section 2 of the manual.

- Make sure that the sonde is powered with either internal batteries or a suitable power supply.

- Access the YSI Environmental Software Downloads page at www.ysi.com/edownloads or go to main page at www.ysi.com and click on Support button in green bar.

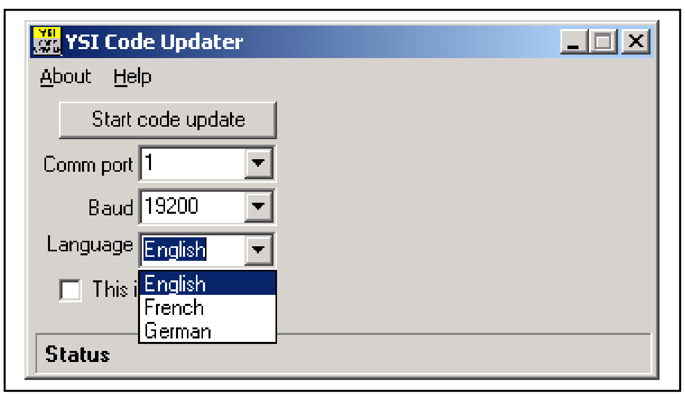
- Log in, or if a first time user, fill out the registration form and wait for a login password via return E-mail.

- Click on the **Software** folder under the Software Downloads section.

- Inside the folder, click on the file *6-Series & 556MPS Code Updater, M-DD-YYYY* and save the file to a temporary directory on your computer.

- 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 Technical Support for advice.

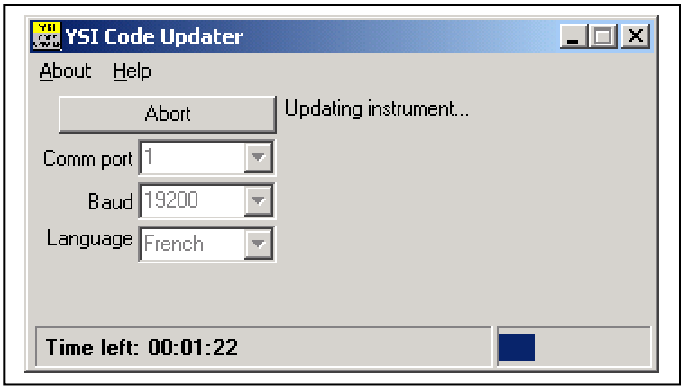
- Run the YSI Code Updater software that you just installed on your computer. The following window will be displayed:



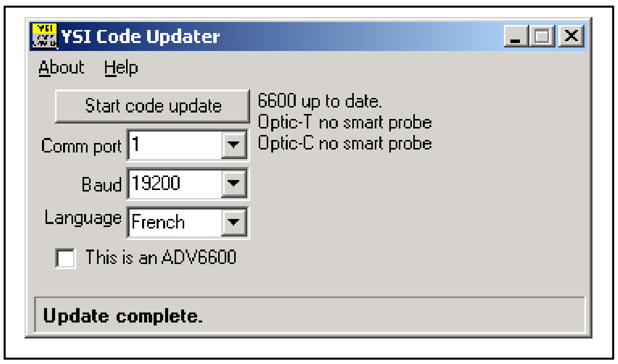
- Set the Comm port number to match the port to which you connected the sonde cable and make sure that the "This is an ADV6600" selection is NOT checked. Next, select the language (English, French, or German) which will be used in the menus of your sonde.

  NOTE CAREFULLY: With versions of 6-series sonde firmware greater than 3.00, you will NOT be able to switch languages in the System Menu of your sonde as in past versions. If you decide to use your sonde with the menus in a different language than that selected at the time of the sonde upgrade, you MUST rerun the YSI Code Updater Software and select the language via the Updater.

- Then click on the Start Code Update button. An indicator bar will show the progress of the upgrade as shown below.



- When the update is finished (indicated on the PC screen as shown below), close the YSI Code Updater window (on the PC) by clicking on the "X" in the upper right corner of the window.



SECTION 9 WARRANTY AND SERVICE INFORMATION

The sondes are warranted for two years and the 650 MDS for three years against defects in workmanship and materials when used for their intended purposes and maintained according to instructions. All cables are warranted for one year. The warranty periods for probes are as follows:

- All ROX DO optical probes manufactured on or after January 2012 are covered under a flat two year warranty. ROX membrane assembly is warranted for 1 year.
- All non-DO (Turbidity, Chlorophyll, Rhodamine WT, Blue-green Algae – Phycocyanin, and Blue-green Algae – Phycoerythrin) optical probes manufactured on or after January 2012 are covered under a flat two year warranty.
- Depth, Rapid Pulse dissolved oxygen, temperature/conductivity, pH, pH/ORP, and chloride probes are warranted for 1 year. Ammonium and nitrate probes are warranted for six months.

Due to the dynamic nature of the shaft seal used on the optical probes, we strongly recommend probes be returned to a YSI repair center every two years for servicing. The dynamic shaft seal replacement and lubrication can only be performed at authorized service centers, and helps extend the operational life of the probe.

Please register your products online at www.ysi.com/warranty

This warranty does not include batteries or damage resulting from defective batteries. As documented in the Care and Maintenance Section of this manual, batteries should be removed from all sondes and the 650 MDS when the product is not in use. Since many battery manufacturers will repair or replace any equipment that has been damaged by their batteries, it is essential that leaky or defective batteries be retained with the damaged product until the manufacturer has evaluated the claim. Please contact the YSI Technical Support Group if you have any questions.

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 Technical Support 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.

9.1 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.

9.2 AUTHORIZED SERVICE CENTERS

YSI has several authorized Service Centers in the United States and around the world. Please refer to the YSI website (ysi.com) for you nearest authorized Service Center.

9.3 CLEANING INSTRUCTIONS

NOTE: Before they can be serviced, equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected. 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 YSI, the following steps must be taken to insure the safety of our 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 are 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.

9.4 PACKING INSTRUCTIONS

- ☞ Clean and decontaminate items to insure the safety of the handler.
- ☞ Complete and include the Product Return Form which is on the next page of this section.
- ☞ 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.

9.5 PRODUCT RETURN FORM

Product Return Form

If known, please provide your:

YSI Customer # ____________________

Service Request # ____________________

Step 1: Provide your billing and shipping information

Bill To	Ship To	Return Shipping
		Via (circle one)
		DHL FedEx UPS
		Account #:
		Please note: Shipping is prepaid and add.
Contact:	Contact:	Method (circle one)
Phone: ( )	Phone: ( )	Ground / Next Day AM
Fax: ( )	Fax: ( )	2 Day / Next Day PM
Email:	Email:	Other:

Step 2: Provide information on your equipment

Model Number:	Serial Number:
Please describe the problem(s):	

Step 3: Provide your method of payment

Payment Method
For faster service, specify 'Pre-approval', provide the amount and payment method

☐ Pre-approval with Purchase Order (please attach)
Amount: ____________________
PO Number: ____________________

☐ Credit Card
To ensure security, all credit card information must be processed via phone. Please call the service center handling your repair with card information.
We accept VISA, MasterCard and American Express.

☐ Prepayment

☐ Quote Required

Please note: There is an estimate fee of approximately $35 to $80 (product dependent) which is waived if service is approved.

Step 4: Fill out the Cleaning Certificate

Cleaning Certificate

Model Number:

Lot/Serial Number:

Contaminants (if known):

Cleaning Agents used:

☐ Radioactive Decontamination Certified
(check only if product has been exposed to radiation and successfully decontaminated.)

Cleaning Certified by:
Signature:
X ____________________
Date: ____________________

Ship to one of the following locations:

YSI Service Center
1725 Brannum Lane
Yellow Springs, OH 45387
+1 937 767 7241
environmental@ysi.com

YSI Service Center
12231 Industriplex Blvd, Suite A
Baton Rouge, LA 70809
+1 225 753 2650
gulfcoast@ysi.com

For more information contact your service center or visit www.ysi.com.

1007 Rev E

APPENDIX A HEALTH AND SAFETY

NOTE: For additional health, safety, and disposal information about YSI reagents, download the MSDS documents for the chemical in question from the YSI webpage (ysi.com).

YSI Conductivity solutions: 3161, 3163, 3165, 3167, 3168, and 3169

INGREDIENTS:
- Iodine
- Potassium Chloride
- Water

Inhalation:
Inhalation of mist or splashes of iodine solution can cause severe irritation, with potential destruction of respiratory tissues, spasms, and edema (choking) in throat and lungs, depending on frequency and degree of exposure. Other reported potential effects are coughing, burning sensation, laryngitis, headache, and nausea.

Use a NIOSH approved respirator for liquid mists and/or splashes. Get supplier recommendations. Provide adequate ventilation. Avoid conditions that cause misting or splashing.

Remove to fresh air. Give artificial respiration and get medical attention as needed.

Skin:
May cause irritation with repeated exposure.
Wear water-resistant gloves as needed.
Wash exposed areas with soap and water for 15 minutes. Remove contaminated clothing, and wash before re-using.

Eyes:
Can cause irritation and potential eye damage with repeated exposure.
Wear splash-proof water-resistant goggles. Have convenient eyewash stations.
Flush with water for 15 minutes.

Ingestion
Can cause irritation of mouth, throat, and an upset stomach.
Wear a mouth cover or face shield when there is splashing.
Do not swallow. Rinse mouth. If swallowed, do not induce vomiting. Get prompt medical attention.

(No chronic effects reported)

IN ALL CASES: GET MEDICAL ATTENTION IF EFFECTS PERSIST.

Most likely routes of entry: skin, eyes, ingestion.

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 quantities of water. Do not induce vomiting. 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.

YSI Ammonium Standard Solutions: 3841, 3842, and 3843

INGREDIENTS:

- Ammonium Chloride
- Lithium Acetate Dihydrate
- Sodium Azide (trace)
- Hydrochloric acid

CAUTION **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

May be harmful by ingestion or skin absorption. May cause eye and skin irritation. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities of lithium salts can affect the central nervous system producing symptoms ranging from dizziness to collapse. It may also cause kidney damage, nausea, and anorexia. Note that the ingestion of harmful quantities form the solutions is considered unlikely given the low concentration of lithium and the volumes likely to be handled.

FIRST AID:

INHALATION - Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes).

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 - Immediately rinse out mouth with large quantities of water. If reagent was swallowed, give 2 glasses of water and seek medical attention immediately.

YSI Nitrate Standard Solutions: 3885, 3886, and 3887

INGREDIENTS

θ Potassium Nitrate
θ Magnesium Sulfate
θ Gentamycin Sulfate (Trace)

CAUTION **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION.**

May be harmful by ingestion or skin absorption. May cause eye and skin irritation. The chemical, physical, and toxicological properties have not been thoroughly investigated.

FIRST AID:

INHALATION - Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes).

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 - Immediately rinse out mouth with large quantities of water. If irritation occurs or reagent was swallowed, seek medical attention immediately.

YSI Turbidity Standard: 6073

INGREDIENTS

θ Styrene divinylbenzene copolymer spheres

The material is not volatile and has no known ill effects on skin, eyes, or on ingestion. Therefore, no special precautions are required when using the standards. General precautions should be adopted as required with all materials to minimize unnecessary contact. Note, however, that the chemical, physical, and toxicological properties have not been thoroughly investigated.

FIRST AID:

SKIN CONTACT - Remove contaminated clothing. Wash affected area with soap or mild detergent and water.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. If irritation occurs, seek medical attention immediately.

INGESTION - Rinse out mouth with large quantities of water. If irritation occurs or reagent was swallowed, seek medical attention as a precaution.

YSI Replacement Desiccant 065802

INGREDIENTS

θ Calcium Sulfate and Calcium Chloride

CAUTION **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

FIRST AID:

SKIN CONTACT - Flush with water.

EYE CONTACT - Flush with water. If irritation continues, obtain medical attention.

INGESTION - If patient is conscious, induce vomiting. Obtain medical attention.

APPENDIX B REQUIRED 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:

θ Reorient the receiving antenna

θ Relocate the computer with respect to the receiver

θ Move the computer away from the receiver

θ 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.

APPENDIX C ACCESSORIES AND CALIBRATION STANDARDS

STANDARD EQUIPMENT WITH YSI SONDES

θ 600R, 600QS, 600XL, 600XLM, 600 OMS V2-1, 600LS, 6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, and 6600V2-4 Sondes with Calibration Cup and Probe Guard
θ EcoWatch for Windows Software
θ Operations Manual
θ Guard for Probe Compartment
θ 6570 Maintenance Kit (all sondes except 600R and 600QS)
θ 6583 Maintenance Kit (600R and 600QS)
θ 6560 Conductivity/Temperature Probe (not supplied with the 600R, 600QS, 600LS, or 600 OMSV2-1 because of integral conductivity sensors)

PROBES FOR THE SONDES

(See Appendix M, Sonde Specifications for the probes that your sonde supports)
θ 6560 Conductivity/Temperature Probe
θ 6561 pH Probe
θ 6561FG Flat Glass pH Probe
θ 6562 Rapid Pulse DO Probe
θ 6150 ROX Optical DO Probe
θ 6565 Combination pH/ORP Probe
θ 6565FG Flat Glass Combination pH/ORP Probe
θ 6566 Combination pH/ORP Probe, Fouling Resistant
θ 6025 Chlorophyll Probe, wiped
θ 6130 Rhodamine WT Probe, wiped
θ 6131 Phycocyanin Probe, wiped
θ 6132 Phycoerythrin Probe, wiped
θ 6136 Turbidity Probe, wiped
θ 6882 Chloride Probe
θ 6883 Ammonium Probe
θ 6884 Nitrate Probe
θ 6580 Reference Electrode Replacement for 600R Sonde

OPTIONAL ACCESSORIES FOR THE SONDES

θ 062781 PC6000 Software (Available at no cost)
θ 655423 Spare Probe Installation Tool
θ 6155 Replacement Membrane Kit for ROX Optical DO Probe
θ 6627 Turbidity Wiper Kit, White
θ 6624 Chlorophyll and Rhodamine WT Fluorescent Wiper Kit for 6025 and 6130, Orange
θ 6625 ROX Optical DO and BGA Wiper Kit for 6150, 6131, and 6132, Black
θ 6144 Optical Wiper Pad Kit for 6027, 6627, 6024, and 6624 Wiper Assemblies

- θ 6628 Wiper Kit for 6600EDS V2-2 Sonde, White
- θ 6630 Wiper Kit for 6600EDS V2-2 Sonde, Black
- θ 6035 Probe Reconditioning Kit for 6562 Dissolved Oxygen Probe
- θ 6038 12 VDC Power Supply with 110 VAC input
- θ 6651 12 VDC Power Supply with 90 to 264 VAC input
- θ 6100 External Power Connector, attaches to 6095B Field Cable
- θ 6101 Power Pack, 12 VDC, MS-4
- θ 6570 Maintenance Kit
- θ 5775 Membrane Kit
- θ 690 Replacement Sonde Weight for 600 series sondes, Small
- θ 691 Replacement Sonde Weight for 600 series sondes, Large
- θ 6885 Sonde Weight Kit for 6820 and 6920 series sondes
- θ 6044 Sonde Weight for 6600 series sondes
- θ 6182 Zinc Anode Kit
- θ 6108 Desiccant Cartridge Kit
- θ 6109 Desiccant Canister Kit
- θ 065802 Replacement Desiccant
- θ 6120 6-Series Operations Manual, Spanish
- θ 6121 6-Series Operations Manual, German
- θ 116275 Extended Length Calibration Cup Assembly for 6600V2-2, 6600EDS V2-2, and 6600V2-4 Sondes
- θ 655488 Extended Length Calibration Cup Sleeve for 6820V2-1, 6820V2-2, 6920V2-1, and 6920V2-2 Sondes
- θ 066267 Decreased Length Calibration Cup Sleeve for 6600V2-4 Sonde

FLOW CELLS FOR THE SONDES

- θ 6601 Flow Cell for 6600V2-2 Sonde
- θ 131041460 (Endeco Part #) Flow Cell for 6600EDS V2-2 and 6600V2-4 Sondes
- θ 5083 Flow Cell for 600XL and 600XLM
- θ 6160 Flow Cell for 6820V2-1, 6820V2-2 , 6920V2-1, and 6920V2-2 Sondes
- θ 696 Flow Cell for 600R

CABLES FOR THE SONDES

- θ 6093 Field Cable, 100 ft (30 m)
- θ 6092 Field Cable, 50 ft (15 m)
- θ 6091 Field Cable, 25 ft (7.5 m)
- θ 6090 Field Cable, 8 ft (2.4 m)
- θ 6191 Field Cable, Vented, 25 ft (7.5 m)
- θ 6192 Field Cable, Vented, 50 ft (15 m)
- θ 6067 Low Cost Calibration Cable, Dry use only; 10 ft (3m)
- θ 6077 CE Calibration Cable, 10 ft. (3m)
- θ SP6093-L Special field cables available in 25 ft(7.6 m) increments; Maximum 1000 ft (305m)
- θ 6096 MS-8 to Flying Lead (wire) adapter, 15 ft (5m)
- θ 6095 Field Cable to Female DB-9 (PC Serial with Power Connector)
- θ 6103 MS-8 Dust Cover (caps connector when not in use)

CONDUCTIVITY REAGENTS

- θ 3161 Calibrator Solution, 1,000 uS/cm (quart)
- θ 3163 Calibrator Solution, 10,000 uS/cm (quart)
- θ 3165 Calibrator Solution, 100,000 uS/cm (quart)
- θ 3167 Calibrator Solution, 1,000 uS/cm (box of 8 pints)
- θ 3168 Calibrator Solution, 10,000 uS/cm (box of 8 pints)
- θ 3169 Calibrator Solution, 50,000 uS/cm (box of 8 pints)

pH REAGENTS

- θ 3821 pH 4 Buffer (box of 6 pints)
- θ 3822 pH 7 Buffer (box of 6 pints)
- θ 3823 pH 10 Buffer (box of 6 pints)
- θ 3824 Assorted Buffers (2 bottles of pH 4, pH7, and pH 10 Buffers)

ORP REAGENTS

- θ 3682 Zobell Solution (125 ml)

AMMONIUM REAGENTS

- θ 3841 1 mg/L ammonium-nitrogen standard solution
- θ 3842 10 mg/L ammonium-nitrogen standard solution
- θ 3843 100 mg/L ammonium-nitrogen standard solution

NITRATE REAGENTS

- θ 3885 1 mg/L nitrate-nitrogen standard solution
- θ 3886 10 mg/L nitrate-nitrogen standard solution
- θ 3887 100 mg/L nitrate-nitrogen standard solution

TURBIDITY REAGENTS

- θ 6073 126 NTU standard suspension, 1 pint
- θ 6073G 126 NTU standard suspension, 1 gallon
- θ 6072 12.7 NTU standard suspension, 1 gallon
- θ 6074 1000 NTU standard suspension, 1 gallon
- θ 6080 0 NTU turbidity-free water, 1 gallon

DISPLAYS, LOGGERS, AND ACCESSORIES

- θ 650-01 – Low memory with no barometer
- θ 650-02 – High memory with no barometer
- θ 650-03 – Low memory with barometer

- θ 650-04 – High memory with barometer
- θ 6112 PC Interface Cable. PC to 650 MDS.
- θ 6113 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6114 110 volt wall charger, and 6117 battery pack included
- θ 6126 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6123 universal charger, European power cable, British power cable, and 6117 battery pack included
- θ 6127 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6123 universal charger, China/Australia power cord, and 6117 battery pack included
- θ 4654 Tripod
- θ 614 Ultra Clamp
- θ 5085 Hands Free Harness
- θ 5065 Form-fitting Case
- θ 6930 Hard-sided Case
- θ 6655 Soft-sided Case
- θ 6124 Backpack
- θ 6117 Extra Rechargeable Battery Pack for 650 MDS
- θ 6115 GPS Cable for interface with user-supplied GPS unit
- θ 616 Cigarette Lighter Charger

LOGGER/TELEMETRY

- θ 6200 Data Acquisition System (6200 DAS) and Accessories. Contact YSI Massachusetts (1-800-363-3269) for options and ordering information.

SOFTWARE

- θ 6075 EcoWatch for Windows for use with 6-series applications; also available at no cost from the ysi.com website.
- θ Software upgrades for sondes and 650 – See ysi.com website

ANTI-FOULING

- θ 6145-AF Sonde Guard Kit, 6600
- θ 6151-AF Port Plug Kit, Large
- θ 6161-AF Port Plug Kit, Small
- θ 6171-AF Port Plug Kit, ISE
- θ 6176-AF Sonde Guard Kit, 6820/6920
- θ 6189-AF Copper Tape Kit
- θ 6445-AF Wiper Brush Kit, 6600V2
- θ 6625-AF Wiper Kit, Optical
- θ 6630-AF Wiper Brush Kit, EDS

APPENDIX D SOLUBILITY AND PRESSURE/ALTITUDE TABLES

Table 1: Solubility of Oxygen (mg/L) in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure.

Salinity = Measure of quantity of dissolved salts in water.
Chlorinity = Measure of chloride content, by mass, of water.
$S(^0/_{00}) = 1.80655 \times \text{Chlorinity } (^0/_{00})$

Temp °C	Chlorinity 0 Salinity: 0	5.0 ppt 9.0 ppt	10.0 ppt 18.1 ppt	15.0 ppt 27.1 ppt	20.0 ppt 36.1 ppt	25.0 ppt 45.2 ppt
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
τ						τ

τ						τ
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.72	6.39
26.0	8.11	7.71	7.33	6.96	6.62	6.28
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.96	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	3.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.98	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

Table 2: Calibration Values for Various Atmospheric Pressures and Altitudes

PRESSURE			ALTITUDE		CALIBRATION VALUE
Inches Hg	mm Hg	Millibars	Feet	Meters	Percent Saturation
30.23	768	1023	-276	-84	101
29.92	760	1013	0	0	100
29.61	752	1003	278	85	99
29.33	745	993	558	170	98
29.02	737	983	841	256	97
28.74	730	973	1126	343	96
28.43	722	963	1413	431	95
28.11	714	952	1703	519	94
27.83	707	942	1995	608	93
27.52	699	932	2290	698	92
27.24	692	922	2587	789	91
26.93	684	912	2887	880	90
26.61	676	902	3190	972	89
26.34	669	892	3496	1066	88
26.02	661	882	3804	1160	87
25.75	654	871	4115	1254	86
25.43	646	861	4430	1350	85
25.12	638	851	4747	1447	84
24.84	631	841	5067	1544	83
24.53	623	831	5391	1643	82
24.25	616	821	5717	1743	81
23.94	608	811	6047	1843	80
23.62	600	800	6381	1945	79
23.35	593	790	6717	2047	78
23.03	585	780	7058	2151	77
22.76	578	770	7401	2256	76
22.44	570	760	7749	2362	75
22.13	562	750	8100	2469	74
21.85	555	740	8455	2577	73
21.54	547	730	8815	2687	72
21.26	540	719	9178	2797	71
20.94	532	709	9545	2909	70
20.63	524	699	9917	3023	69
20.35	517	689	10293	3137	68
20.04	509	679	10673	3253	67
19.76	502	669	11058	3371	66

Table 3. Conversion Factors for Feet/Meters, Celsius/Fahrenheit, mg/L/ppm

TO CONVERT FROM	TO	EQUATION
Feet	Meters	Multiply by 0.305
Meters	Feet	Multiply by 3.28
Degrees Celsius	Degrees Fahrenheit	$5/9\times(^{o}F-32)$
Degrees Fahrenheit	Degrees Celsius	$9/5\times(^{o}C)+32$
Milligrams per liter (mg/L)	Parts per million (ppm)	Multiply by 1

Table 4. Conversion Factors for Common Units of Pressure

	kilo Pascals	mm Hg	millibars	inches H_20	PSI	inches Hg
1 atm	101.325	760.000	1013.25	406.795	14.6960	29.921
1 kiloPascal	1.00000	7.50062	10.0000	4.01475	0.145038	0.2953
1 mmHg	0.133322	1.00000	1.33322	0.535257	0.0193368	0.03937
1 millibar	0.100000	0.750062	1.00000	0.401475	0.0145038	0.02953
1 inch H_20	0.249081	1.86826	2.49081	1.00000	.0361	0.07355
1 PSI	6.89473	51.7148	68.9473	27.6807	1.00000	2.0360
1 inch Hg	3.38642	25.4002	33.8642	13.5956	0.49116	1.00000
1 hectoPascal	0.100000	0.75006	1.00000	0.401475	0.0145038	0.02953
1 cm H_20	0.09806	0.7355	9.8×10^{-7}	0.3937	0.014223	0.02896

APPENDIX E TURBIDITY MEASUREMENTS

This appendix is in the format of "frequently asked questions, is designed to allow users to optimize the performance and trouble-shooting problems for your YSI 6136 turbidity probe by supplementing the discussion of turbidity that is provided in the other sections of this manual (Getting Started, Basic Operation, Principles of Operation, and Maintenance).

Where should I get my turbidity standards?

To properly calibrate YSI turbidity sensors, you MUST use standards that have been prepared according to details in *Standard Methods for the Treatment of Water and Wastewater (Section 2130 B)*. Acceptable standards include (a) formazin prepared according to *Standard Methods*; (b) dilutions of 4000 NTU formazin concentrate purchased from Hach; (c) Hach StabCal^{TM} standards in various NTU denominations; and (d) AMCO-AEPA standards prepared specifically for the 6136 by either YSI or an approved YSI vendor as listed on YSI website (www.ysi.com). STANDARDS FROM OTHER VENDORS OTHER THAN HACH, YSI, OR YSI-APPROVED ARE NOT ACCEPTABLE FOR USE WITH THE YSI TURBIDITY SYSTEM AND THEIR USE WILL LIKELY RESULT IN BOTH CALIBRATION ERRORS AND INCORRECT FIELD READINGS.

For the best combination of accuracy and ease of use, we recommend that you use standards that have been prepared from AMCO-AEPA polymer beads by either YSI or a YSI-approved vendor. This material is listed as a secondary turbidity standard by *Standard Methods for the Examination of Water and Wastewater.* These standards have been certified to be the proper value in NTUs by comparison of their turbidity outputs with those of freshly prepared formazin, the latter being the most accepted primary standard for turbidity. The polymer standards can be linearly diluted with turbidity free water to generate standards that are lower in value and which can then also be used as calibrants. For example, diluting 50 mL of 100 NTU standard to a total volume of 500 mL will yield a 10 NTU standard.

You can also use formazin as your source for turbidity standards. The formazin can be generated by the procedure found in *Standard Methods for the Examination of Water and Wastewater,* or it can be purchased from Hach as a 4000 NTU suspension that can be linearly diluted to form lower NTU standards. In addition, Hach offers formazin turbidity standards in a variety of NTU values under the StablCal^{TM} designation and these standards may prove useful for the calibration of your YSI turbidity sensor. The advantage of the use of formazin is its cost; the primary disadvantage is that it is a somewhat hazardous reagent for which care must be taken in handling and disposal. In addition, formazin settles out much more rapidly than the AMCO-AEPA polymer and may be less stable to degradation in dilute form. If you use formazin, we recommend that you purchase from Hach either the 4000 NTU concentrate and dilute it or the StablCal^{TM} standards in the proper turbidity concentrations for your application, rather than generating the reagent from the chemical reaction described in *Standard Methods for the Examination of Water and Wastewater.* Whatever your source of formazin, be very safety conscious if you use it and be sure to follow the manufacturer's instructions with regard to its handling and disposal.

Remember that is imperative that you do **NOT** use standards that are based on suspended materials other than formazin or AMCO-AEPA polymer or have been prepared by vendors other than YSI, YSI-approved suppliers, or Hach. These standards will **NOT** read correctly when measured with the YSI turbidity systems. If you have any doubts about the composition of your standards, consult your supplier and be certain that they are based on either formazin or AMCO-AEPA materials and were prepared by the proper method.

Do I have to buy turbidity-free water for the 0 NTU calibration?

For most applications, purified water of any kind (distilled, deionized or filtered) will be acceptable for the 0 NTU standard. This water can be obtained from a laboratory or can be purchased at a local supermarket. It is not recommend that you use tap water as the 0 NTU standard. For maximum accuracy at very low NTU values (below the specification of the instrument), you may want to purchase turbidity-free water from YSI or another vendor.

Should I carry out a 1-point, 2-point, or 3-point turbidity calibration, and what values should I use?

Even though the default calibration value in your sonde is reasonably appropriate for the “average” 6136 sensor, you need to carry out some multi-point calibration (2- or 3-point) prior to your first usage. This will make certain that your system meets the YSI accuracy specifications provided in the operations manual. For the accuracy required in most environmental applications, a 2-point calibration is sufficient, and it is recommended that the two points be 0 and approximately 100 NTU – YSI offers a 126 NTU standard. Only if you desire extreme accuracy in, for example, the 100-1000 NTU range, should you carry out a 3-point calibration at 0, ca. 100, and ca. 1000 NTU. Note, however, that the effect on accuracy may be too small to overcome the inconvenience of using the 3-point routine and the cost of the 1000 NTU standard.

Once the initial multi-point calibration of the 6136 sensor has been carried out, we recommend that the accuracy of the sensor at low NTU be checked (or reset) by performing a **1-point** calibration at 0 NTU before each usage.

How often should I perform additional multi-point calibrations?

Your frequency of calibration will depend on the conditions under which your sonde is used and on the degree of accuracy required in your application. Periodic calibration also confirms that the sensor is performing properly with regard to its sensitivity and general function.

Our empirical testing has indicated that the optical system of the 6136 probe is very stable and likely to require only infrequent calibration. However, you should initially confirm the stability of the sensor for your typical sampling or monitoring application by frequently checking the sensor reading in a standard other than 0 NTU prior to increasing the time between multi-point calibrations.

What color wiper should be used with my 6136 turbidity sensor?

The optimal wiper color for the 6136 depends on the software which is installed in the sonde. For versions of 6-series software prior to 3.00, a white wiper should be used. For versions of software after 3.00, a black wiper should be used. The difference exists due to an improvement in the wiper parking algorithm which was implemented with Version 3.00 of software. If your sonde software version is pre-3.00, YSI strongly recommends that you upgrade the software via the YSI Website and then use black wipers.

How do I purchase new wipers for the 6136 turbidity sensor?

Entire wiper assemblies, complete with installed pad, can be purchased from YSI in the 6627 Wiper Replacement Kit (White) or the 6625 Wiper Kit (Black). If you wish to just change the pad on your old wiper assemblies, you can purchase the 6144 Wiper Pad Kit from YSI.

What about data filter and spike rejection settings for processing turbidity data from the YSI turbidity system?

As described in **Section 5, Principles of Operation**, some processing of raw turbidity data is usually beneficial in terms of outputting values that reflect the “average” turbidity at the site. Filter options designed to optimize this data processing are located in the sonde menu structure under both the **3-Sensor** and the **4-Data Filter** selections in the **6-Advanced** submenu.

For most applications involving both spot sampling and monitoring, the following settings are recommended with regard to data processing:

- In **3-Sensor**, activate the “Turb Spike Filter”
- In **4-Data Filter**, “Enable” the filter.
- In **4-Data Filter**, “Disable” the “Wait for Filter” selection.
- In **4-Data Filter** for turbidity, set the Time Constant to 12
- In **4-Data Filter** for turbidity, set the Threshold to 0.010

These settings will normally produce data that is reflective of the “average” turbidity without having any significant effect on the response times of the other sensors. Increasing the values of the time constant, threshold, or both can further smooth the turbidity values, but also are likely to increase the apparent response time of the sensor.

How do I set up 6-series sondes for logging turbidity data to internal memory?

First, as outlined above, set the data filter and turbidity spike filter settings as recommended in the previous question/answer. Second, access **2-Setup** in the **Advanced** submenu and make certain that the “Turb Wipes” entry is set to “1”. Finally, in the same submenu, set the “Twipe Int” parameter (in minutes) to the same value as the sample interval for which data will be transmitted to the logging device. For example, if **Sample Interval** is set to” 900 seconds” (15 minutes) in the Discrete Sample Run menu or “15 minutes” in the Unattended mode, set “Twipe Int” to “15”. Under these conditions, the turbidity wiper will be activated in a single bi-directional cleaning motion every 15 minutes to clean bubbles and fouling from the optics of the probe and minimize the chance of corrupted readings due to these factors. Note, however, that for Unattended applications with the sonde where data is being logged to internal sonde memory and “Autosleep RS232” is activated, it is only necessary that the value of Twipe Int be less than that of the sample interval selected for the Unattended study. Thus, if Twipe Int is set to 5 minutes and the Unattended sample interval is set to 15 minutes, the sensor will only be cleaned every 15 minutes. For this reason, if you use your sonde primarily for Unattended monitoring, it is recommended that you leave Twipe Int at the default setting of “5”, even though this is different from your sample interval. As outlined in the manual, in sites where fouling is more prevalent, it may be necessary to set “Turb Wipes” to a higher value, but a setting of “1” will be adequate for most water.

After sonde software setup is complete as outlined above, attach the sonde to a computer or a 650 MDS and calibrate all sensors (including turbidity). Then set up an Unattended study at your desired sample interval and deploy the sonde without cable connections for later data upload and analysis.

How do I set up 6-series sondes with turbidity for use with a Data Collection Platform (DCP?

If your 6-series sonde with a turbidity sensor will be attached to a data collection platform, you should calibrate the sensors (including turbidity) prior to DCP connection. You should also make sure that the “SDI12/M” factor which is found in the Advanced|Sensor menu is set to a value of “1” to ensure proper wiping of the turbidity probe during deployment on the DCP. Then connect the sonde to the data collection platform using the proper cable/adapter and begin sampling according to the instruction manual.

How do I manually activate the turbidity wiper on a 6136 turbidity probe when the sonde is sampling?

If you are using the sonde with a 650, highlight the “Clean Optics” entry in the upper right logging box and press **Enter** to activate the wiper. If the sonde is connected to a computer (sequential lines of data are present on the screen), press the “3” key to activate the wiper.

What precautions should I take when using the sonde turbidity system with a 650 MDS display/logger in sampling applications where the user is present?

Prior to observing or logging turbidity readings, you should always activate the wiper manually for the 650 keypad to remove bubbles/and or fouling.

What are the things most likely to give me problems when measuring turbidity with the 6136 probe and YSI 6-series sondes?

The turbidity system has been designed to be easy to calibrate, easy to use in both sampling and deployment applications, and trouble-free in normal usage. However, during our empirical testing, we have observed occasional problems in calibration and in field applications. These difficulties are likely to be experienced only infrequently by users. In fact, most of these problems are not due to any malfunction in the turbidity system itself, but instead occur because of contaminated calibration solutions or the presence of bubbles on the optics of the probe. However, we have gained experience in separating problems which can be easily solved by the user from those which involve sensor malfunction and must be dealt with by YSI Technical Support and Product Repair. This section is intended to pass this experience along to the user.

You might see calibration errors. This problem could be due to bubbles on the optical surface, contamination of your 0 NTU standard, or a higher calibration standard which has not been prepared properly or has been contaminated or diluted inadvertently. The problem could also be due to an internal malfunction of the probe optical system. To troubleshoot the problem, do **not** override the cal error, return to the Main menu and activate Discrete Sampling in the Run mode. Remove the sonde guard and place your thumb or finger over the optics of the probe while observing the data display. A high (>1000 NTU) reading should be observed if the probe is responding correctly from an optical standpoint. If no response is noted, the probe must be returned to YSI Product Service for repair or replacement. CAUTION: DO NOT ATTEMPT TO DISASSEMBLE THE PROBE YOURSELF. If the probe is functioning properly, replace the probe guard and place the sonde back into 0 NTU water. Activate the wiper manually and enter the calibration routine of choice (1-, 2-, or 3-point) from the **Calibrate** menu. Observe the readings for the 0 NTU standard. If values higher than about 5 NTU are observed, it is possible that your 0 NTU standard has been contaminated from debris that was retained on the sonde and probes from the previous field usage. Discard the water, rinse the sonde, and replace in new 0 NTU standard. After agitation, check the reading to see if it has been reduced. If so, proceed with the second calibration point. If not, contact YSI Technical Support for further assistance. If a calibration error occurs on the second point, use a new source of standard and try again. If an error still occurs, contact YSI Technical Support for further assistance.

You might observe slightly negative readings in very clear water. This effect is usually due to one of two causes:

1. The “zero” turbidity standard which you have used is not really 0 NTU because of inadvertent contamination. This contamination usually occurs when the fouling from a sonde just taken from the field contaminates the turbidity-free water used for the zero point. To overcome the problem, be sure to clean the sonde as well as possible prior to recalibration of the turbidity sensor and then assure that the zero reading is as low as possible by changing the turbidity-free water until no further lowering of the reading is noted.

2. The probe is experiencing “interference” from the calibration cup bottom during the zero point calibration. This “interference” can due to (a) improperly using a calibration cup with a gray (rather than black) bottom; (b) using a calibration cup with a black bottom which has been contaminated with impurities; or (c) having the probe too close to a the calibration cup bottom. To overcome (a), be sure to use install the black bottom that came with your 6136 into your calibration cup. To overcome (b) be sure that the black bottom of the calibration cup is clean before performing a calibration. To overcome (c), make certain that you engage only ONE THREAD when screwing the calibration cup onto the sonde in order to keep the turbidity probe face as far as possible from the calibration cup bottom to avoid interference. To completely overcome the “interference” problem, use the extended length calibration cup (#116275 for 6600-style sondes and #069310 for 6820/6920-style sondes). Note, however, the longer calibration cups will require larger volumes of calibration standard.

You might observe readings during sampling which appear unreasonable from visual inspection of the water. Bubbles on the optics of the sensor usually cause the problem. Activate the wiper to remove the bubbles. If the readings are still unreasonable, remove the sonde completely from the water and then replace in the water. If problems are still evident, remove the sonde guard and check general probe function by placing your finger or thumb over the optics as described above. If the probe does not respond, contact YSI Technical Support.

You might see readings during sampling that you think are too jumpy. If this occurs, the water may be non-homogeneous with regard to the size of the suspended particles. The jumpiness that you are observing is probably real. However, if you want to smooth it out, you can incrementally increase the Time Constant and Threshold settings in the Data Filter menu to obtain the noise level which you desire.

You might observe single point spikes in data from deployment applications. These high readings may be real turbidity events caused by large particles passing over the optical surface at the time of measurement. As long as the spiking occurs only occasionally, there is no reason to believe that the turbidity system is malfunctioning. Depending on the site, these spikes may be a normal occurrence.

You might see a lot of unreasonable high spikes in data from deployment applications. This symptom usually results from improper activation or parking of the wiper assembly. If it occurs with a new wiper assembly, make certain that the wiper rotates and parks correctly (opposite the optical surface) in 0 NTU standard. If the wiper does not rotate at all, be certain that the setscrew of the assembly is contacting the flat part of the shaft and that the screw is securely tightened using the small hex key that is supplied with the wiper assembly. If the wiper still will not rotate on manual activation, contact YSI Technical Support. If the problem occurs with a wiper assembly which has been in the field for some time and is discolored or abraded, install a replacement wiper with a new pad, assure function and correct parking in 0 NTU standard, and redeploy. If a high frequency of spikes still occurs in the deployment data, contact YSI Technical Support for further assistance.

APPENDIX F FLOW

Flow is only available in the **Sensors** menu on sondes that have vented level. The **Flow Setup** menu only appears when **Flow** is enabled in the **Sensors** menu.

Note: In this manual we describe how to use YSI's sondes to calculate flow from vented level. While weirs, flumes and the Manning equation are described briefly here, this manual is not a complete treatment of the subject. We make no claims on the accuracy or appropriateness of any of these techniques for any particular application.

Flow is a calculated value. Whenever there is a one to one relationship between the level of water in an open channel and the flow of water through it, then flow can be calculated from a level measurement. Many devices are designed to be placed in an open channel to improve the determination of flow. For example, a weir is a dam of specific geometry that restricts the flow of water while giving a very repeatable and accurate relationship between level and flow. There are several varieties of weirs, each designed for a specific application. Similarly, a flume also restricts flow producing a repeatable and accurate flow/level curve by forcing the flow not over a dam, but through a narrower portion of the channel. The flow is gradually narrowed, passed through a throat in the flume, and then gradually expanded back to the original channel width. As with weirs, there are several varieties of flumes each designed for a specific application.

The weir or flume is referred to as the primary measuring device, and the level meter is referred to as the secondary measurement device. There are three common types of weirs and seven types of flumes. Most of these are available in a number of sizes. Flow/level curves for common types and sizes are already programmed in the sonde so that it is only necessary to describe the primary measuring device to get flow readings. If you have a primary measuring device that is not already programmed, you have the option of entering either an equation or a table that defines the flow/level curve for your device. The table can also be used to calculate the flow of water in stream for which the flow/level data is available.

The Manning Equation is also available to calculate flow in an open channel without any restriction built explicitly for measuring flow. In this case the channel itself is the primary measuring device.

SETTING UP YOUR SONDE

WEIR OR FLUME

Getting your sonde ready to calculate flow for a weir or a flume can be summarized in the following simple steps. Using EcoWatch or a 650 MDS display/logger to communicate with the sonde:

1. Enable **Flow** in the **Sensors** menu.
2. Go to **Flow Setup** menu in the **Advanced|Sensor** menu**.**
3. Choose a method (flume or weir), then a type (V-notch, rectangular, Parshall, etc.).
4. Choose a size.
5. Verify proper setup, choosing preferred units.
6. Choose preferred units in the **Report** menu.

The **Flow Setup** menu only appears when **Flow** is enabled in the **Sensors** menu. Once in the **Flow Setup** menu you must define your primary measuring device by **Method, Type**, and **Size**. Note that the menus change depending upon your selection.

For example, after choosing **Flume** for your method, only types of flume are shown. So it is important to choose first the method, then the type, and finally the size. The following chart lists the primary devices that are programmed in the sonde.

Method	Type	Size
Weir	V-Notch	22½°, 30°, 45°, 60°, 90°, 120°
	Rectangular w/ End Contractions	Any size
	Rectangular w/o End Contractions	Any size
	Cipolletti	Any size
Flume	Parshall	1”, 2”, 3”, 6”, 9” 12”, 18”, 2’, 3’, 4’, 5’, 6’, 8’, 10’, 12’
	Palmer-Bowlus	4”, 6”, 8”, 10”, 12”, 15”, 18”, 21”, 24”, 27”, 30”
	Leopold-Lagco	4”, 6”, 8”, 10”, 12”, 15”, 18”, 21”, 24”, 30”
	Trapezoidal	Large 60° V, X-large 60° V, 2” 45° WSC, 12” 45° SRCRC
	Hs	0.4ft, 0.6ft, 0.8ft, 1ft,
	H	0.5ft, 0.75ft, 1 ft, 1.5ft, 2ft, 2.5ft, 3 ft, 4.5 ft
	HL	4 ft

After selecting the method, type and size of primary device, YSI strongly recommends that you verify that the sonde is set up properly. Find a chart that lists head versus flow for your primary measuring device. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units that are on your chart. Enter a few values for **Test Head** and compare the resulting **Test Flow** values against those found in the chart. Note that there may be minor differences in the least significant digit between the published values and the values given by the sonde. The difference is generally much less than the overall tolerance of the weir or flume being used.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

MANNING EQUATION

Once in the **Flow Setup** menu, choose **Manning** for the Method and then choose which type of channel the measurement is to be done in: closed pipe, U- channel, rectangular, or trapezoidal. Then choose the units for the equation. It is very important that the units chosen match the coefficients for the equation. Finally choose **Setup Manning** and define the width of the channel, its roughness and slope. Roughness is given in many fluid hydraulics texts and other engineering references as the Manning coefficient, n. Empirical values for n are given in the same references for most commonly found materials used in open channel construction. Slope is the ratio of rise to run. For example, if a channel drops one foot every one hundred feet, the value of the slope would be 0.01.

After setting up the **Manning Equation**, we strongly recommend that you verify that the sonde is set up properly. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units that you prefer. Enter a few values for **Test Head** and judge whether the resulting **Test Flow** values are reasonable. You might even want to try doing the calculation yourself.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

EQUATION

Equation is used to calculate flow with primary measuring devices other than the ones already programmed in the sonde. (**Table** is also sometimes useful for this purpose.)

Once in the **Flow Setup** menu you must define the equation. First choose the units for the equation. It is very important that the units chosen match the coefficients for the equation. The equation is of the form:

$$Q = K_1 \bullet H^{P_1} + K_2 \bullet H^{P_2}$$

Enter values for **K1, P1, K2,** and **P2.** Note: if you do not need the second term in the equation, simply enter zero for **K2**.

After setting up the **Equation**, we strongly recommend that you verify that the sonde is set up properly. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units that you prefer. Enter a few values for **Test Head** and compare the resulting **Test Flow** values against values that you have calculated.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

TABLE

Table is used to calculate flow with primary measuring devices other than the ones already programmed in the sonde (**Equation** is also sometimes useful for this purpose). **Table** can also be used to calculate flow in streams for which there is data relating flow to level.

Once in the **Flow Setup** menu you must define your **Table**. Do this by entering up to 50 pairs of **Head** and **Flow** data points. Choose **Setup Table**. Be sure to choose the units that match the data in your table. Then enter each pair of points one by one. It is not necessary to enter the points in order. The software will put them in order. There are items on the menu to edit the next point or the previous point, to enter a new point, to delete a point or to delete the entire table. Later, when the sonde is measuring level and calculating flow, it will linearly interpolate between points in the table.

After setting up the **Table**, we strongly recommend that you verify that the sonde is set up properly. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units used in the table. Enter a few values for **Test Head** and compare the resulting **Test Flow** values against values in the original table.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

DEPLOYING YOUR SONDE

WEIR

Deployment of the sonde in a weir is normally very simple.   Generally the point of level measurement is recommended to be at a distance upstream of the weir equal to 3 to 4 times the maximum level expected; however, do not deploy the sonde without knowing the design measurement point for the weir you are using. If flow is overly turbulent and readings are jumpy, then it may be necessary to install a stilling well for the sonde. If other water quality measurements are of interest (DO, pH, etc,) then take care that the stilling well does not overly isolate the sonde from the water in the channel.

Deploy the sonde so that the pressure sensor on the side of the sonde is slightly below the lowest level expected. Be sure the sonde is installed so that it cannot move during measurement.

Normally, a staff gauge is installed with a weir. After the sonde is installed, calibrate depth to the value read off the staff gauge.

Be sure also to follow the instructions printed in Appendix G, **Using Vented Level**.

FLUME

Generally there is a staff gauge installed in a flume at the point where the level should be measured. Be certain that you know the location of the measurement for the flume you are using. Some flumes are built with a stilling well outside of the flume. Deploying the sonde in the stilling well will give accurate level readings, but readings of other parameters like DO and pH may not be equivalent to those in the main flow of the flume. Also be aware that many flumes are not much bigger than the sonde. Installing the sonde in the flume may change the way the flume behaves, thus causing errors in flow readings. An ideal deployment would include a flume with a recess for the sonde that locates the pressure sensor properly, allows the other sensors to measure the water flowing through the flume, and does not significantly alter the geometry of the flume. In a flume this means deploying the sonde horizontally. If possible, deploy the sonde so that the pressure sensor on the side of the sonde is slightly below the lowest level expected. Also be aware that the pressure sensor in the sonde is along the side of the sonde and not at its very tip. If a sonde is deployed vertically in the flume, then it may not be able to make measurements when the water level is low. Be sure the sonde is installed so that it cannot move during measurement.

Normally, a staff gauge is installed with a flume. After the sonde is installed, calibrate depth to the value read off the staff gauge.

Be sure to follow the instructions printed in Appendix G, **Using Vented Level**.

USING THE MANNING EQUATION IN AN OPEN CHANNEL

The channel should be large enough that the sonde does not significantly alter the flow of water. Most deployments will require the sonde to be in the channel horizontally so that the pressure sensor remains submerged at all times. Be sure that the sonde cannot move during the measurement. After installation measure the depth of water in the channel with a ruler and use that measurement to calibrate depth on the sonde.

Be sure to follow the instructions printed in Appendix G, **Using Vented Level**.

APPENDIX G USING VENTED LEVEL

Sondes that are equipped with level sensors use vented cables. The vented level option eliminates errors due to changes in barometric pressure. This is accomplished by using a special sensor that has been vented to the outside atmosphere by way of a tube that runs up through the sonde and cable. The tube must remain open and vented to the outside atmosphere to function. All storage caps must be removed and no foreign matter can block the openings. Never expose the sonde or the cable to the atmosphere for more than a few minutes without an active desiccant system in place. This prevents moisture from entering the vent tube.

Special field cables are used for the vented level. These cables have a vent tube that runs up the middle of the cable. Your sonde has a stainless steel connector on the top of it. In the center of this connector is the vent hole. When the cable is removed from the sonde, seal the sonde with the pressure cap provided with the sonde, to keep it clean and dry. The field cable should also be stored in a sealed plastic bag with some desiccant to keep it dry.

At the instrument end of every vented cable is a barbed fitting. This is to provide an attachment for a desiccant system. One of the two desiccant systems should always be attached to the sonde while exposed to the atmosphere to prevent moisture buildup in the vent tube. When dry and active, the desiccant is a distinct blue color. When exhausted it turns to a rose red or pink color. The desiccant can be regenerated in an oven. See **Section 2.10, Care, Maintenance and Storage** for the proper procedure.

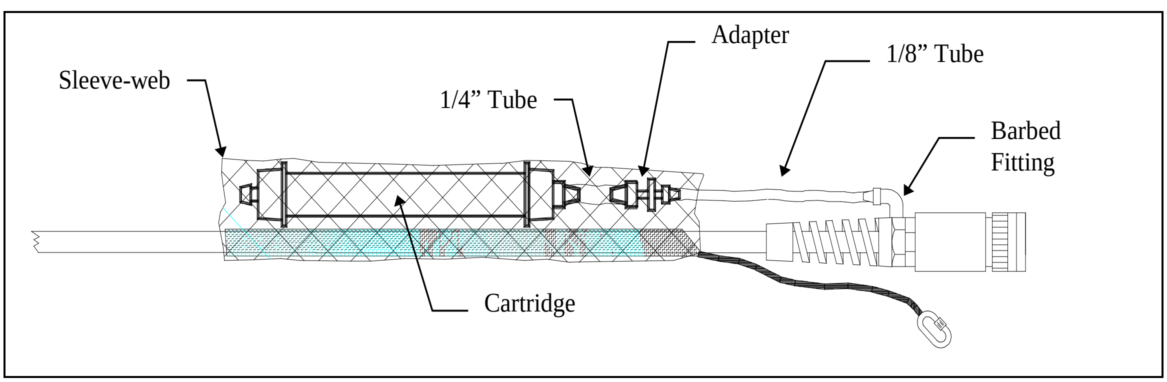
Avoid bending the cables sharply to prevent the vent tube from kinking.

Two desiccant systems are available, a cartridge kit (YSI 6108) and a canister kit (YSI 6109). Either will keep moisture from entering the vent tube. The desiccant cartridge kit mounts directly to the cable and is intended for short-term applications. The desiccant canister contains a larger amount of desiccant and is intended for long term deployment. The desiccant canister kit contains mounting brackets for mounting the canister to a nearby structure. The length of time that the desiccant remains active depends on several factors including heat and humidity.

When using vented level, you must enter altitude and latitude. From the sonde **Main** menu, select **Advanced**, then **3-Sensor**. Enter the altitude in feet and the latitude in degrees of the measurement site. These values need to be accurate within 500 feet and 1 degree, respectively.

For best performance of depth measurements, users should ensure that the sonde's orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

INSTALLING THE CARTRIDGE KIT



1. Place the short length of 1/4” tubing onto the 1/4” side of the 1/8” to 1/4” adapter fitting. Seat firmly.

2. Place the length of 1/8” tubing onto the 1/8” side of the adapter fitting. Seat firmly.

3. Remove one of the plugs from the end of the desiccant cartridge and place the open end of the short length of 1/4” tubing onto the open end of the desiccant cartridge. Seat firmly.

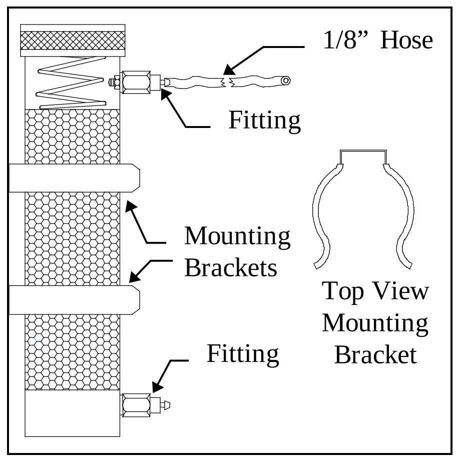
4. Remove the plug from the barbed fitting on the end of the cable and place the open end of the 1/8” tubing onto the cable fitting. Seat firmly.

5. Slide the sleeve-web over the end of the cable and the bail. Work the sleeve-web down the cable and over the cartridge taking care not to unplug the hose that connects the cartridge to the cable.

Optional: Using one of the tie-wraps, secure the hose to the cable taking care not to close off the hose.

The vent end of the cartridge should remain plugged until the sonde is ready for use. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

INSTALLING THE CANISTER KIT



1. Remove the 1/8” NPT plugs from the stainless steel fittings on the canister.

2. Install the 1/8” NPT to 1/8” hose fittings into the stainless steel fittings located on the side of the desiccant canister. ***CAUTION***: Do not over-tighten!

3. Place the plugs over the fittings on the canister until you are ready to use the canister.

4. Using suitable screws fasten the canister mounting brackets to an appropriate support structure. The spacing between the brackets must accommodate the length of the canister. The canister must be located within a few feet of the cable end.

5. Remove the plug from the top fitting of the canister. Remove the plug from the barbed fitting on the end of the cable. Using the tubing provided in the kit, connect the canister to the fitting on the end of the cable. Remember to remove the remaining plug from the canister when ready to begin sampling. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

APPENDIX H EMC PERFORMANCE

When using the YSI 6-Series sondes in a European Community (CE) country, please be aware that electromagnetic compatibility (EMC) performance issues may occur under certain conditions, such as when the sonde is exposed to certain radio frequency fields.

If you are concerned with these issues, consult the Declaration of Conformity (page H-2). Specific conditions where temporary sensor problems may occur are listed in this document.

If you are unable to locate the Declaration of Conformity that was shipped with your instrument, contact your local YSI representative, or YSI Technical Support in Yellow Springs, Ohio for a copy of the document. See **Section 9, Warranty and Service Information** for contact information.

DECLARATION OF CONFORMITY

Manufacturer:	YSI Incorporated 1725 Brannum Lane P.O. Box 279 Yellow Springs, OH 45387 USA
Product Name:	6-Series Multi-parameter Water Quality Monitors (Sondes)
Model Numbers:	600R, 600XL, 600XLM, 6820, 6920, 6600, 6600EDS, 600OMS, 600LS, 600DW-B, 6920DW, 6820V2, 6920V2, 6600V2
Conforms to the following:	
Directives:	EMC Directive 2004/108/EC
Applied Standards:	EN 61326-1:2006 CISPR 11:2010
Harmonized Standards:	EN55011:2009, A1:2010 Class B equipment EN61000-4-2 (ESD) EN61000-4-3 (RF radiated immunity) EN61000-4-4 (EFT) EN61000-4-6 (rf conducted immunity) EN61000-4-8 (50 Hz Radiated Susceptibility) FCC Part 15, Subpart B, Sections 15.107a & 15.109a, Class B

Supplementary information:
This device complies with the requirements of the EMC Directive 2004/108/CE and carries the CE mark accordingly.

All performance met class A immunity criteria with the following exceptions:

- Diminished performance may be observed during laboratory procedures, when interfacing to PC, during ESD events that occur directly at the sensors. Permanent diminished performance in sensor performance may occur as a result of severe ESD events that occur at the sensors.
- Diminished performance may be observed with Chlorophyll measurements whenever the dry sonde is subject to radio-frequency fields approaching 3 Volts/meter. Fields nearing 10 Volts/meter can adversely affect measurements of Temperature, Dissolved Oxygen, Chlorophyll, Turbidity, Battery Volts, Ammonium, Nitrate, & Chloride.

Lisa M. Abel
Director, Quality Assurance
Date: November 11, 2010

Authorized EU-representative: YSI Hydrodata Ltd
Unit 2 Focal Point
Lacerta Court
Works Road
Letchworth, Hertfordshire
SG6 1FJ

YSI Incorporated
Yellow Springs, Ohio 45387 USA•Phone 937-767-7241•800-765-4974•Fax 937-767-9353

APPENDIX I CHLOROPHYLL MEASUREMENTS

This is a question and answer guide that will help you optimize performance and trouble-shoot problems. While the YSI 6025 chlorophyll sensor provides a simple and convenient way to estimate phytoplankton concentration in the field, there are significant limitations associated with its use that the user should appreciate fully before beginning field studies. In addition, the chlorophyll systems of YSI 6-series sondes are characterized by a great deal of flexibility from the point of view of the user. Some examples are shown below.

- The data from the chlorophyll sensor can be processed via a sophisticated filtering algorithm that has variable parameters that are input by the user.
- The chlorophyll system can be used in spot sampling applications with a YSI 650 MDS display/logger or a portable computer.
- The chlorophyll system can be used on all sondes for long term deployment applications using cable attachment to a data collection platform.
- The chlorophyll system can be used for long-term deployment applications with the YSI 6-series sondes which contain internal batteries by logging readings directly to sonde memory since they contain 'on board' power.
- A number of calibration options are offered with the YSI chlorophyll system.

This section is designed to help the user attain the maximum possible benefit from the YSI 6025 chlorophyll system by supplementing the discussions of chlorophyll provided in other sections of this manual. (**Section 2.1 --Getting Started, Section 5 - Principles of Operation, and Section 2.10 - Care, Maintenance and Storage**). These are questions that may be asked by a typical user of 6-series sondes with the YSI 6025 chlorophyll sensors. It does not deal with specific instructions for operation of the sondes at the level presented elsewhere in the manual.

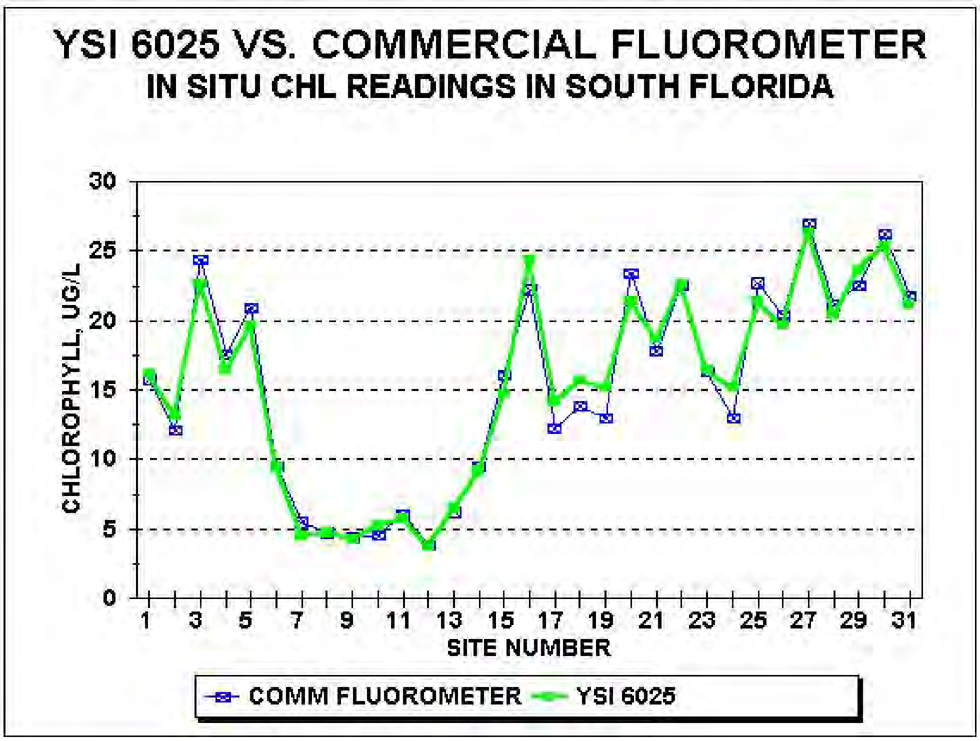
What is the YSI 6025 chlorophyll probe designed to measure?

The YSI sensor is designed to estimate the phytoplankton content of environmental water. Phytoplankton concentrations can be useful in predicting detrimental algal blooms and, indirectly, in determining nutrient loading in environmental applications. The phytoplankton content is estimated by detecting the fluorescence from the chlorophyll in these species *in vivo*, i.e., without disrupting the living cells. Note, however, that the sensor directly measures the fluorescence of all species in the water sample that occurs when they are irradiated with blue light (centered at about 470 nm). Usually most of the fluorescence is due to the chlorophyll in the phytoplankton, but it is important to remember that any compounds which are present in the water sample (either in chemical or biological form), and fluoresce under the optical constraints of the sensor, will contribute to the readings.

What level of accuracy can be expected in my chlorophyll determinations with the YSI 6025?

YSI feels that the user will attain about the same accuracy with the YSI 6025 as with other commercial fluorometers that are designed to carry out *in vivo* determinations of environmental chlorophyll. As for all measurements of this type, the accuracy will be less than that attained if the user collects water samples and analyzes them in the laboratory by disrupting cells and quantifying by spectrophotometric or HPLC analysis of the extracted molecular chlorophyll as described in *Standard Methods*. The relative accuracy of the *in vivo* measurement will be completely dependent on the method of calibration which the user employs (see next question). No matter what calibration technique is used, however, the readings from the YSI

6025 should approximately track the chlorophyll trends in the environmental water being analyzed. For example, if the user deploys the sensor and acquires readings over time at a standard sampling interval (e.g., every 15 minutes), the changes in the chlorophyll data will usually reflect increases or decreases in the phytoplankton content at the site over a long period of time. If the user makes horizontal or vertical profiling spot readings in the same body of water, then the sensor output will usually indicate the presence of more or less phytoplankton at the various sampling sites. The figure below shows the tracking of the chlorophyll content at various sites by both the YSI 6025 and a good quality single parameter commercial fluorometer.

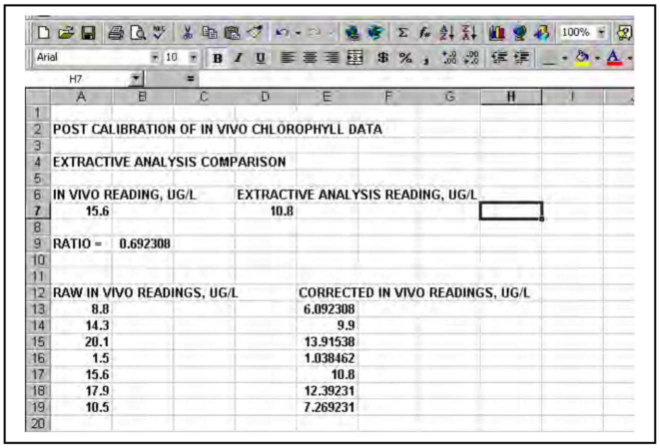


It is important for the user to remember that, because of the limitations defined in this appendix and in **Section 5, Principles of Operation**, YSI is unable to quote an accuracy specification for the *in vivo* measurement of chlorophyll.

What calibration methods are available for the YSI 6025?

There is only one real method of calibration for the 6025 sensor if accuracy is to be assured versus the true chlorophyll content of the water: The sensor must be calibrated with a phytoplankton suspension for which the chlorophyll content is known from extractive analysis in the laboratory. This methodology requires the user to collect water samples of the environmental water in question during sampling or monitoring studies, analyze the samples in the laboratory after cell disruption, and use the chlorophyll values determined by this method to adjust the data acquired with the YSI 6025. Discrete steps for this procedure are found in **Section 5. Principles of Operation**.

Using this method, the field data must be adjusted, either manually or in a spreadsheet, according to the laboratory value. For example, if the YSI 6025 value for a particular site is15.6 ug/L chlorophyll and the laboratory value is 10.8 ug/L, then all of the values for the study should be multiplied by .69 (10.8/15.6). This can easily be done in a spreadsheet, such as Excel, as shown below.



POST CALIBRATION OF IN VIVO CHLOROPHYLL DATA					
EXTRACTIVE ANALYSIS COMPARISON					
IN VIVO READING, UG/L			EXTRACTIVE ANALYSIS READING, UG/L		
15.6			10.8		
RATIO =	0.692308				
RAW IN VIVO READINGS, UG/L				CORRECTED IN VIVO READINGS, UG/L	
8.8				6.092308	
14.3				9.9	
20.1				13.91538	
1.5				1.038462	
15.6				10.8	
17.9				12.39231	
10.5				7.269231	

Note: Be sure to carry out1-point calibration of the sensor before the study, using deionized water to make certain that the sensor reads zero in chlorophyll-free water.

If the sensor is post-calibrated using the values from laboratory analysis of grab samples, will my field data be totally accurate?

No. They will <u>only be as accurate as possible within the limitations of the fluorometry method.</u> The limitations for all *in vivo* chlorophyll determinations described in **Section 5, Principles of Operation** will almost certainly compromise the accuracy of your data even if you employ the best calibration method possible. For example, different phytoplankton species are likely to fluoresce differently *in vivo* even if the actual chlorophyll content is the same. Thus, unless the biological species are perfectly homogeneous with regard to site in a sampling study and with regard to time in a monitoring study, inaccuracy will occur if only a single phytoplankton calibration is performed. In addition, the fluorescence intensity of many phytoplankton types shows a diurnal cycle even though the same amount of material is present. Under this limitation, the time of day at which calibration samples are taken would have to be identical to the time of field measurement for the chlorophyll values determined by the two methods to agree consistently. This level of synchronization is usually not practical.

The key point to remember is that *in vivo* chlorophyll determinations made with any fluorometer are likely to be less accurate than those measured by laboratory analysis of individual samples. The advantages of the *in vivo* method are its convenience and ability to continuously track changes in relative phytoplankton values via indirect fluorescence readings

Can I use a dye standard to calibrate my 6025 chlorophyll sensor to increase the accuracy?

The use of the dye solutions described in the **Principles of Operation** section above will usually not significantly enhance the accuracy of your field readings relative to extractive analysis of grab samples. The primary utility of the dye is to check for sensor drift during deployment by reanalyzing the dye solution after sonde recovery. The use of the 2-point dye calibration procedure may make it easier to quantify the predeployment dye value and, if so, may be preferable. Remember, however, that no real enhancement of sensor accuracy is attained by using the dye as a calibrant.

Will the chlorophyll values determined *in vivo* with the YSI 6025 be reportable for compliance purposes?

Probably not. Because of the limitations on the method outlined above and in the **Section 5, Principles of Operation**, there is always inaccuracy in the *in vivo* method. It might be possible to work with a particular regulatory agency to develop specific correlation protocols between *in vivo* and laboratory-determined chlorophyll values for a particular site, but generation of this methodology is left to the user.

I have seen molecular chlorophyll standards advertised. Can these be used to calibrate the YSI 6025 sensor?

Probably not. The standards are usually only soluble in organic solvents such as acetone that would cause serious damage to the materials used in the YSI 6025 probe. Even if molecular chlorophyll standards that are soluble in aqueous media were available, their fluorescence is not likely to emulate *in vivo* chlorophyll fluorescence any better than the dye standard described above.

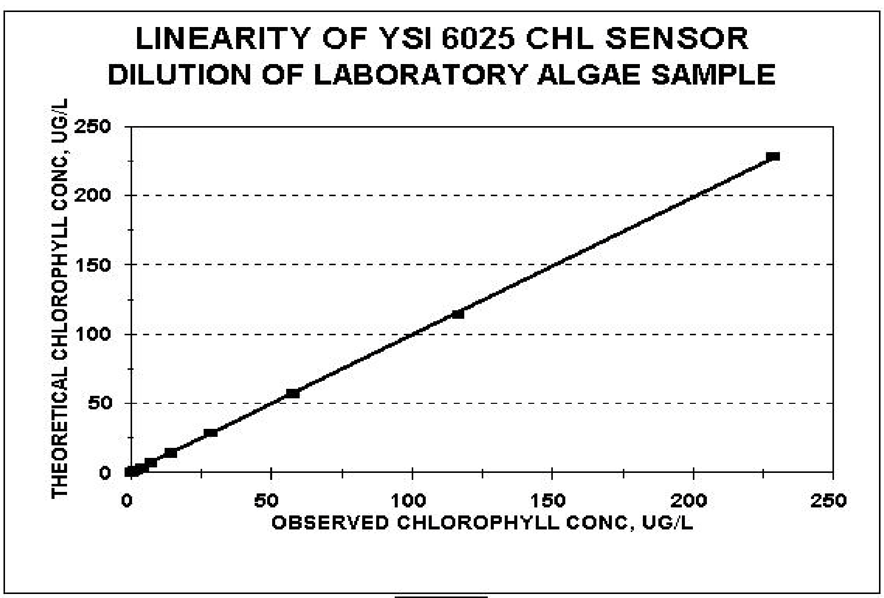
***Caution*:** Do not expose the YSI 6025 to calibrant solutions involving any solvent other than water or very dilute aqueous acid mixtures. Damage to the sensor under these conditions will not be covered under warranty.

The Standard Methods procedure generates values designated as "chlorophyll a". Is this species the reporting unit for the YSI 6025?

No. The different types of chlorophyll cannot be differentiated by the YSI 6025, or by virtually any *in vivo* fluorometer. The values from the YSI 6025 should be reported either as relative fluorescence units or in ug/L of general chlorophyll as long as the method of determination (and its limitations) is specified.

Is the YSI 6025 sensor linear with regard to changes in phytoplankton content?

Yes. The sensor is very linear as evidenced by the following plot that shows the results of a serial dilution of a laboratory algae sample. This linearity on a particular algal species maximizes the ability of the sensor to track relative phytoplankton changes from site to site or during a monitoring study.



What Data Filter settings should I use to obtain the best possible field chlorophyll readings?

As described in **Section 5, Principles of Operation**, some processing of raw chlorophyll data is usually beneficial in terms of outputting values that reflect the "average" chlorophyll at the site. Filter options designed to optimize this data processing are located in the sonde menu structure under both the **3-Sensor** and the **4-Data** Filter selections in the **Advanced** submenu.

For most applications involving both spot sampling and monitoring, the following settings are recommended with regard to data processing:

- In **3-Sensor**, Disable the "Chl Spike Filter" if present
- In **4-Data Filter**, "Enable" the filter.
- In **4-Data Filter**, "Disable" the "Wait for Filter" selection.
- In **4-Data Filter** for chlorophyll, set the Time Constant to 12
- In **4-Data Filter** for chlorophyll, set the Threshold to 1

These default settings will normally produce data that is reflective of the "average" chlorophyll without significantly slowing the response time of the sensor for either sampling or monitoring applications. Increasing the values of the time constant, threshold, or both can further smooth the chlorophyll values. Variation in the default settings should be based on empirical data taken at your particular site.

How often should I calibrate my YSI 6025 sensor?

You should always perform a zero point calibration in deionized water before each use of the YSI 6025 sensor.

Testing at YSI has indicated that the overall sensitivity of the optical system of the YSI 6025 is very stable and is unlikely to show significant drift over time. Thus, if you are using the dye "calibration" method (with its limitations), you may only have to carry out the routine very infrequently (Remember that it is basically only useful as a drift check anyway). In general, you should perform periodic 2-point calibrations using a dye sample more frequently during your initial studies with the YSI 6025 to empirically determine its drift rate and use these results to set up your calibration frequency.

If you are post-calibrating the sensor with phytoplankton suspensions to obtain accurate readings relative to chlorophyll as determined by laboratory extractive analysis, then you will effectively be performing a 2-point calibration for every sampling or monitoring study.

Are there precautions that I should take when acquiring samples for laboratory analysis?

Yes. The key is to obtain a sample which is representative of the water being measured by the YSI 6025 *in vivo*. The mistake most often made is to simply immerse an open bottle in the environmental water. Under these conditions, any macroscopic surface plant or algal matter (which also contains chlorophyll) will also be introduced into the sample even though it is not present in the subsurface zone where the probe is measuring fluorescence. If this happens, your laboratory analysis will always be erroneously high relative to the *in vivo* chlorophyll data from the YSI 6025.

For surface sampling you can minimize this effect greatly by placing the sealed bottle a foot or more below the water surface and only then removing the cap and allowing the container to fill. The cap should then be reinstalled before removing the bottle from the water. A better technique is to acquire commercially available water sampling devices that are designed specifically to acquire a representative sample at a particular depth.

You should also take precautions to stabilize your samples for transport back to the laboratory. The samples should be kept cool and in the dark (e.g., in an ice chest) until the analytical procedure has begun. Some users prefer to filter the sample in the field and keep the filter pads on ice in the dark during transport.

My environmental sites have a lot of visible floating algae, but my YSI 6025 chlorophyll sensor shows very low readings. What is causing this paradox?

The YSI 6025 is not designed to measure macroscopic algal or plant material that floats on the surface. Rather it measures the fluorescence from the microscopic phytoplankton that is suspended below the surface of the water. It is fairly common to see mats of floating algae on environmental water that has low subsurface phytoplankton concentrations.

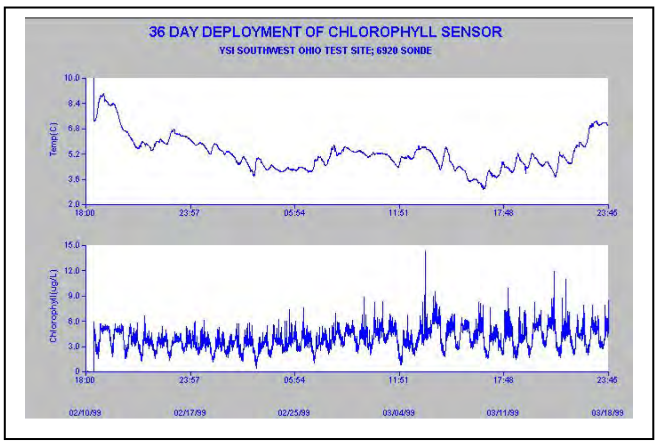
What can I do to obtain the best possible data from my YSI 6025 sensor in sampling studies?

Two factors are most important. The first is to make certain that the readings are stable before manually recording them or logging them to a computer or YSI 650 MDS display/logger. You should visually monitor the readings for at least 1-2 minutes to assure stability after the sonde is immersed. The second factor is that you should always manually activate the mechanical wiper on the sensor after sonde immersion but before beginning the visual monitoring of the readings. The cleaning cycle is necessary to remove bubbles from the optical face, which are certain to cause erroneous readings. If the observed readings appear unusual after the first cleaning cycle, activate the wiper repeatedly to assure that all bubbles are removed. Manual activation of the wiper mechanism is easily accomplished from the Run screen of the 650 MDS.

You should also allow adequate time for the sonde to acclimate to the temperature of the water at the site.

What sort of "noise" level is expected for unattended monitoring studies?

All environmental water is somewhat heterogeneous with regard to phytoplankton content and this factor will cause some noise or jumpiness in long term monitoring studies for chlorophyll. The extent of the noise will be dependent on your site. The data from a typical 36-day deployment at a YSI test site (lake in southwestern Ohio) is shown in the figure below as a reference. Note the diurnal cycle in the data which is likely due to the photoinhibition of chlorophyll fluorescence as discussed in **Section 5, Principles of Operation.**

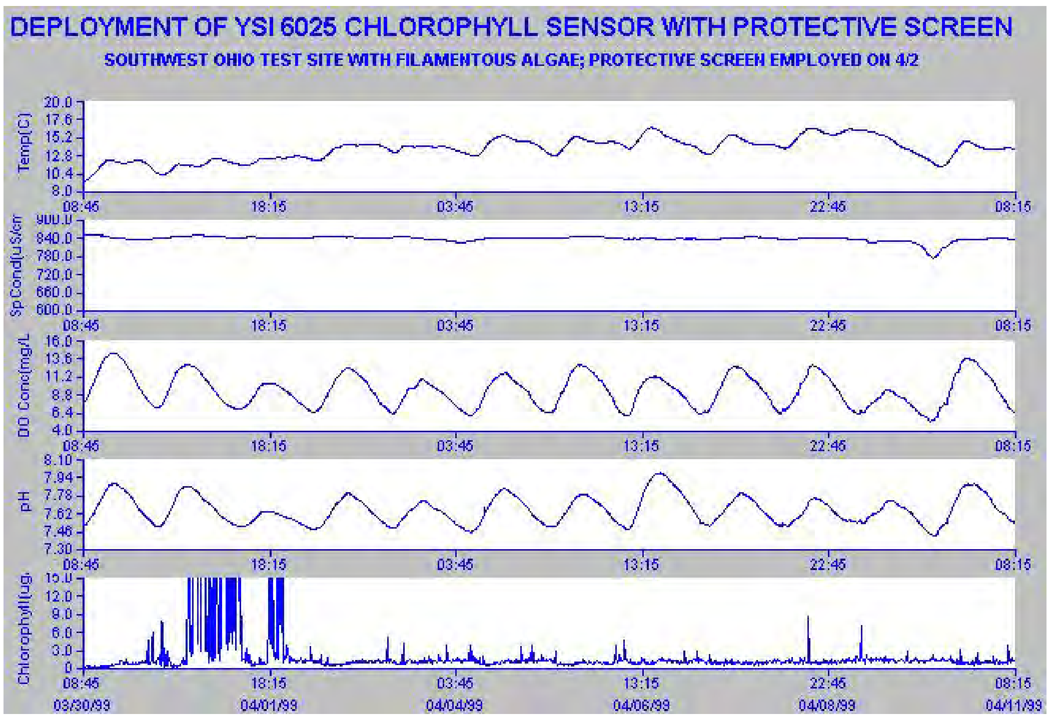


Note also that your may observe less or more noise at your site with no compromise in sensor performance. Occasional spikes during a monitoring study are normal and usually simply indicate the transient passage of a large phytoplankton particle over the optical face during the time of sampling.

If you consistently observe periods in your monitoring study where the data is clearly unreliable due to a large number of very high spikes, then you may have to take additional precautions to minimize the effect (see next question).

My unattended monitoring data shows a large number of chlorophyll spikes that clearly do not reflect the average phytoplankton content of the water. What is causing this effect and is there anything I can do to minimize it?

This effect, shown in the initial chlorophyll readings in the figure below, can be caused by the presence of subsurface macroscopic filamentous algae.



The flexible algal strands can become attached to the wiper arm and sometimes are resident on the probe optics even after a cleaning cycle. The key to decreasing the spiking effect is to minimize the free algae, which is present in the probe compartment of the sonde. This can sometimes be accomplished by encasing the sonde guard in standard fiberglass window screen wire which is available at most hardware stores and then anchoring the screen with rubber bands as shown in the picture below.

Note the significant improvement in the overall noise level of the readings after the screen was installed on 4/2/99. However, there is no guarantee that this solution will completely solve spiking problems caused by macro algal species. In some applications, it may be necessary to clean the sonde and probes at a frequent interval to minimize the number of erroneous readings.

CAUTION: If the installed screen becomes completely clogged with algal filaments, it can create an isolated environment within the probe compartment which does not accurately reflect the water quality readings of the overall water at the site. Users should periodically remove the screen and check for immediate changes in parameters such as dissolved oxygen and pH. If gross changes appear in the data after removal of the screen, then the screen is likely to be retarding water flow to the sensors and should be cleaned at more frequent intervals.

Another factor that can contribute to repeated spikes in the user's chlorophyll data is wiper malfunction so that the wiper assembly parks over the probe optics. This problem is usually due to the edges of the fluorescent wiper becoming coated with nonfluorescent material such as sediment that, in turn, prevents the sonde software from detecting the wiper movement. If the spikes are due to this factor, then the problem will be corrected by manually cleaning the wiper edges so that the fluorescent surface is restored.

How often should I change my mechanical wiper?

For sampling and monitoring studies, YSI recommends periodic inspection of the wiper to assure that it is not fouled with silt or biological material. If any of these symptoms is noted, debris should be removed from the wiper, particularly the edges where the pad meets the wiper assembly. If the wiper pad is abraded or damaged in anyway, the wiper assembly should be changed immediately. YSI also recommends that the wiper be changed as a precaution prior to each long term monitoring study. Spare wipers are available in the YSI 6024 Wiper Kit. In addition, users who wish to replace only the pad of the wiper assembly can purchase the YSI 6144 Optical Wiper Pad Kit.

***Caution*:** When replacing the wiper, be sure that you do not rotate the wiper arm after it is tightened to the shaft. This may damage the internal motor/gearbox mechanism and could void your warranty.

Do I have to worry about the effect of variable temperature on my field readings?

This factor is definitely a consideration depending on the level of reliability you require if the water at your site is at a significantly different temperature from that of calibration. YSI studies show that, while the optics and electronics of the sensor show very little temperature effect, the fluorescence of phytoplankton samples does vary significantly with temperature. Generally, the chlorophyll in biological samples shows increased fluorescence at lower temperatures with a factor of 1-2 % per degree Celsius. In practice, this means that if, for example, the calibration temperature is 25 C and the water temperature at the site is 10 C, the observed chlorophyll readings will be erroneously high by 15-30 %. The "Chl Tempco" factor in the **Advanced|Sensor** menu can be used to partially compensate for this error, if the user has some knowledge of the temperature effect on the particular phytoplankton at the site. The factor can be empirically determined by bringing a sample of the environmental water to the laboratory and determining its fluorescence at ambient temperature and low temperature. (Simply cool the sample in a refrigerator for the latter reading.) The calculated factor can then be entered into the sonde software. See the example in **Section 5, Principles of Operation**.

I suspect that my YSI 6025 chlorophyll sensor is not performing properly. What should I do before contacting YSI Technical Support to facilitate resolving the problem?

You should perform two diagnostic tests to help YSI personnel determine if the YSI 6025 is malfunctioning.

First, determine whether the wiper system of the probe is working by interfacing the sonde containing the sensor to a computer on a 650 MDS display/logger, beginning a **Discrete Sample** study, and manually activating the wiper. Determine if the wiper turns at all, and, if it does, whether it reverses direction and parks approximately 180 degrees from the optical face.

Second, determine the sensitivity of the probe by measuring its sensitivity under factory default conditions in a dye solution prepared as described in **Section 5, Principles of Operation**. Place the sonde containing the probe in question into the dye solution. Enter the Calibrate menu and then the Chlorophyll submenu and choose a "1-point Chl ug/L" protocol. Instead of entering a value at the prompt, type the work "uncal" and press **Enter**. This returns the sonde software to the factory default sensitivity. Begin a **Discrete Sample** study and record the chlorophyll ug/L reading displayed. Finally, place the sonde in deionized water and record the chlorophyll ug/L reading displayed in **Discrete Sample**.

Record the results of these two tests and report them, along with any other symptoms, to a YSI Technical Support Group representative.

APPENDIX J PERCENT AIR SATURATION

The term “Percent Air Saturation” (abbreviated in many applications to “Percent Saturation”) is a common parameter for expressing the state of the oxygenation of environmental water and is widely used by YSI and other manufacturers during the calibration of oxygen sensors. Basically the "Percent Saturation" value is simply a surrogate for the partial pressure of oxygen in the medium (air or water) being measured. In this light, it is important to understand that, to our knowledge, all environmental oxygen sensors (either electrochemical or optical) directly measure the pressure of oxygen – not the concentration. Thus, the “Percent Saturation” value from an environmental instrument reflects the directly measured parameter for the system, with the concentration in mg/L being easily calculated from known equations involving Percent Saturation, Temperature, and Salinity.

Because the “Percent Saturation” parameter can be expressed by two different conventions, there can be confusion around the use of the term. This section is designed to minimize that confusion by defining each of these conventions and to provide instructions for configuring your 6-series sonde so that you will have a choice as to which of the conventions is used. **It is very important to note, however, that no matter which of the conventions is employed (in YSI or competitive instrumentation), the values of dissolved oxygen in mg/L, the units usually reported, will be identical and unaffected by the choice of DO % convention.**

Note also that the discussion below applies equally to data obtained from both the YSI Rapid Pulse membrane-covered polarographic oxygen sensor and the YSI ROX optical dissolved oxygen sensor.

The “DOsat %” Convention

In the first convention, used for many years in YSI handheld and laboratory instruments and in 6-series sondes, the "% saturation" value at the time of calibration in air reflects the value of the barometer that was input in the calibration protocol. If the parameter “DOsat %” is active in your 6-series Report menu, then this convention is being used. Effectively, this convention provides a value of water oxygenation that can be carried out by air exposure, with the value referenced to having the air at exactly 1 atmosphere (760 mm Hg or 101.3 kPa). A “DOsat %” value of 89 means that the water contains 89 % of the oxygen that could be dissolved if the water was sparged with air that had a total pressure of 1 atm. For example, for an air calibration in the mountains at a typical barometric pressure of 630 mm Hg, the YSI “DOsat %" value at calibration would read 82.9 % (630/760 * 100). If the sensor did not drift electrochemically and the sonde was taken to a location where the atmospheric pressure was exactly 760 mm Hg (e.g., sea level), then the “DOsat %” reading in air (or air-saturated water) would change to 100 % (760/760 *100) because there is more total oxygen in the air at the lower elevation. (Note that the ratio of oxygen to other gases in the air is effectively independent of the barometer or altitude, but the absolute amount of oxygen changes with barometer or altitude.) If the water at both sites is assumed to have a temperature of 20 C (where water exposed to water-saturated air at exactly 760 mm Hg is 9.09 mg/L), then the mg/L value would be 7.54 mg/L (0.829 * 9.09) in the mountains and 9.09 mg/L (1.00 * 9.09) at sea level. Thus, to calculate mg/L values at any site after calibration using this convention, the observed “DOsat %” value is simply multiplied by the Standard Methods or ISO table values that correspond to 100 % at various temperatures and salinities.

The "DOsat %Local" Convention

In the second convention, used for many years by other multiparameter instrument companies and by many European handheld instrument manufacturers, the "% saturation" value is always set to exactly 100 % at the time of calibration regardless of the barometer value that was input. The software of the instrument "remembers" the barometric pressure input at the time of calibration for use in later calculation of the DO concentration in mg/L. Effectively, this convention provides a value of water oxygenation that can be carried out by air exposure with the value referenced to the local air pressure. The 100 % value at calibration for this convention basically reflects the fact that this is the most oxygen that can be dissolved in water for this location at the time of calibration. In late 2001 (Version 2.13 of 6-series code), this dissolved oxygen convention was added to the YSI 6-series software through the use of the parameter "DOsat %Local". For example, for an air calibration in the mountains at a typical barometric pressure of 630 mm Hg, the "DOsat %Local" value at calibration would read 100.0 % and the value of 630 mm would be stored in instrument memory. If the sensor did not drift electrochemically and the sonde was taken to a location where the atmospheric pressure was exactly 760 mm Hg (e.g., sea level), then the "DOsat %Local" reading in air (or air-saturated water) would change to 120.6 % (760/630 * 100) because there is more total oxygen in the air at the lower elevation.

The mg/L value for water saturated air or air-saturated water assuming a temperature of 20 C at both sites would change from 7.54 mg/L (1.00 * 630/760 * 9.09) in the mountains to 9.09 mg/L (1.206 * 630/760 * 9.09) at sea level. Thus, to calculate mg/L values at any site after calibration using this convention, the "DOsat %Local" value is multiplied by the ratio of the barometric pressure at calibration to 1 atm (table conditions) and then by the table value as shown above. Note that the same mg/L values are obtained at both sites for the "DOsat %" and "DOsat %Local" conventions even though the "percent saturation" values are significantly different.

It is important to note that the convention specified for "% saturation" by the British (and EU) standard REQUIRES that the local barometric pressure be read for every DO data point taken after calibration. Under this convention, a sensor should ALWAYS read 100 % saturation when in water-saturated air or air-saturated water. Since the software of most instruments does not "know" the barometer at any time after calibration, **neither of the conventions described above complies with the British standard.**

Calibrating Using the mg/L Mode

When the user performs a mg/L calibration, no barometer input will be required. Instead, values of "DOsat %Local" reported after the calibration will be based on the barometer reading input by the user at the time of the last "DO %" calibration. If the user requires the best possible accuracy for "DOsat %Local" values after calibration then a "DO %" calibration (with correct barometer input) should be performed immediately before the "DO mg/L" calibration. If a "DO %" calibration has never been carried out, then the software will assume that the barometer at the last calibration was exactly 760 mm Hg.

When the user performs a mg/L calibration, values of "DOsat %" will be calculated as they are in the current software, i.e., the input mg/L value will be divided by the theoretical mg/L value at 1 atmosphere (found in the Std. Methods Table) to yield the reported "DOsat %" value. For example, if a value of 7 mg/L is entered at a temperature value of 21 C (where 100 % saturation at 1 atmosphere is 8.915), the "DOsat %" value will be (7/8.915) or 78.5. DO % readings for field readings are carried out in exactly the same way – find the Table value in mg/L which corresponds to the environmental salinity and temperature and divide the environmental DO mg/L by it.

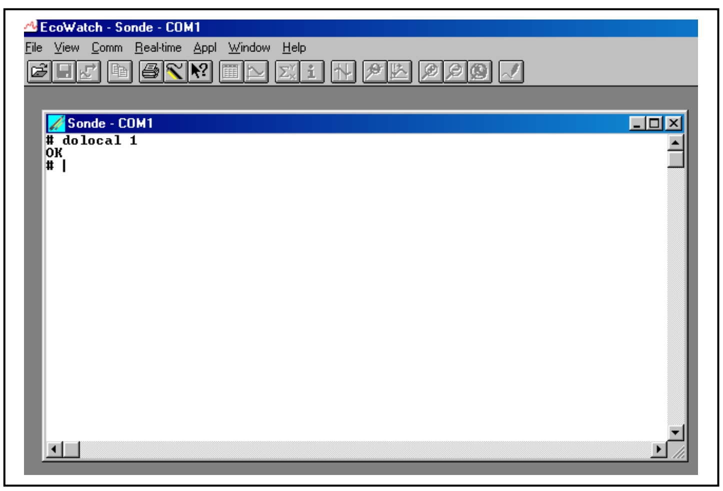
If the user performs a mg/L calibration and "DOsat %Local" is active in the Report, the software will, as noted in above, assume that the barometer reading at calibration is the same as that at the last "DOsat %" calibration. Thus, after the calibration procedure is complete "DOsat %" values calculated as described above are then multiplied (in the software) by a factor of (760/BP) to yield the corresponding "DOsat

%Local" values. For example, assume that the temperature of the calibration standard is 21 C (where air saturation at 760 mm Hg is 8.915 mg/L) and that the oxygen content of the solution has been determined to be 7 mg/L by Winkler titration. Assume also that the local barometric pressure was entered as 700 mm at the last "DOsat %" calibration. After the new "DO mg/L" calibration, the "DO mg/L" value will be set to 7.00, the "DOsat %" value will be set to (7/8.915)*100 = 78.5, and the "DOsat %Local" will be set to (760/700)*78.5 = 85.2.

NOTE: As pointed out above, it is important to realize that UNLESS THE BAROMETRIC PRESSURE IS KNOWN FOR EVERY DO READING AFTER CALIBRATION, the values of "DOsat %" and "DOsat %Local" will be incorrect if the barometric pressure has changed since calibration. Thus, even if the barometer had been input at the time of a mg/L calibration (a method used by some instrument manufacturers, the values of "DOsat %Local" will still not be exactly accurate after calibration.

Activation of the "DOsat %Local" or "ODOsat %Local" Parameter

On receipt of your sonde or after upgrading your 6-series software to Version 2.13 or higher, the "DOsat %Local" or "ODOsat %Local" parameter will NOT appear in your Report menu. To activate the parameter, it is necessary to exit the menu structure of the sonde software to the command line prompt ("#"). The "#" sign appears after you press **Esc** from the Main menu and then answer "Y" to the question, "Exit menu (Y/N)"? Once the "#" prompt is shown on the display, type "dolocal 1" as shown in the display below and press **Enter**. The screen will show "OK" to indicate that the action was successful and return another "#" sign as shown. Then type "menu" at the second "# sign and press **Enter** to return to the sonde software menu structure.

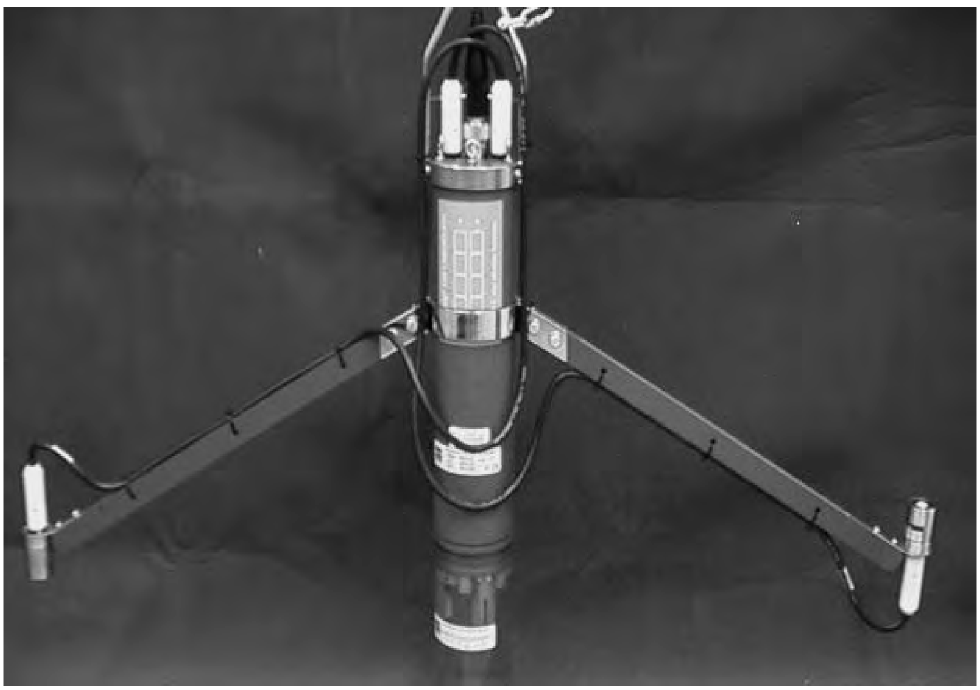


After taking the above action the parameter "DOsat %Local" or "ODOsat %Local", depending on the type of DO sensor used in your sonde, will be present in your Report menu. If you want to remove the parameter, return to the "#" prompt, type "dolocal 0", and press **Enter.**

APPENDIX K PAR SENSOR

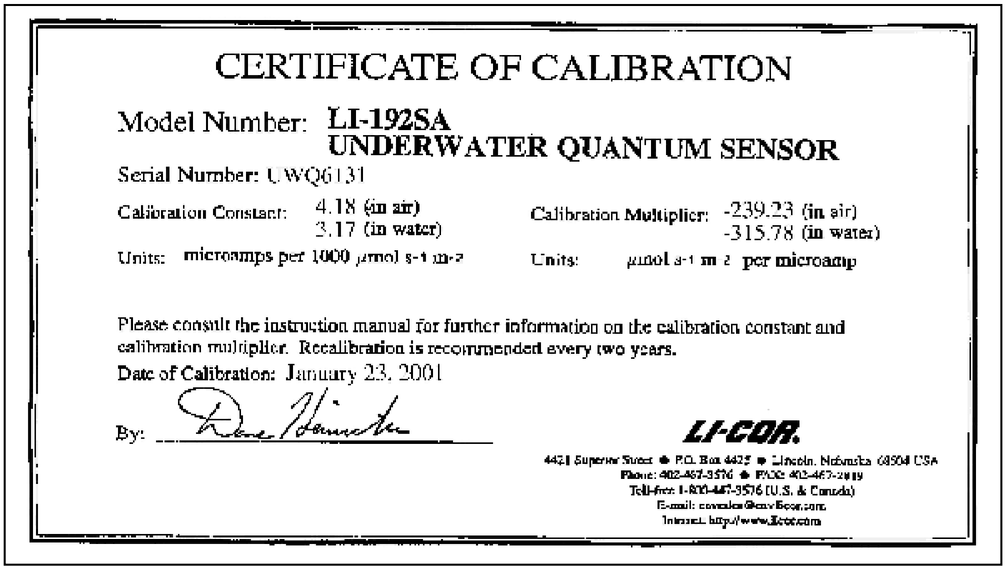
Some users of the YSI 6600-style sonde (6600V2-2, 6600EDS V2-2, and 6600V2-4) may wish to incorporate a photosynthetically active radiation (PAR) sensor into their field monitoring equipment. This sensor can be added to the 6600 in the form of a special product engineered by Endeco/YSI. This section is designed to give potential users of this type of system an idea of how it is configured and the steps necessary to acquire and log PAR data with the modified sonde.

Li-Cor PAR sensors are required for the 6600 modification and these can either be supplied to Endeco/YSI by the user or can be purchased from Endeco/YSI as part of the system cost. These sensors are then attached to “arms” which extend from the sonde and their output cables are connected to the sonde PCB through the top of the sonde as shown in the following picture. The picture shows the installation of two sensors (one pointing up, the other pointing down), but it is also possible to use a single PAR sensor if the user prefers that configuration.



Each Li-Cor PAR sensor can be individually configured by Endeco/YSI with an internal circuit to have variable sensitivities: high (usually employed for “upwell” or downward pointing sensors) or low (usually employed for “downwell” or upward pointing sensors). After sensitivity configuration, the outputs of the sensors are fed into the main sonde PCB thorough ISE ports ISE3 and ISE4. The ports can, in turn, be configured in the **Sensor** and **Report** menus to show the presence of the PAR sensors (PAR1 for ISE3) and PAR2 for ISE4), allowing the user to view or internally log their data during profiling or unattended monitoring studies.

If the default settings of the sonde software are accepted, the PAR outputs will simply be in millivolts. However, it is also possible to enter the calibration constants provided by Li-Cor into the sonde software through the **Advanced|Sensor** menu. If these constants are entered then the units viewed or logged from the PAR sensors will be shown as “Photosynthetic Photon Flux Density” with units of umoles/second/m^2. A typical Certificate of Calibration as supplied by Li-Cor is shown below:



CERTIFICATE OF CALIBRATION

Model Number: **LI-192SA**
UNDERWATER QUANTUM SENSOR

Serial Number: UWQ6131

Calibration Constant: 4.18 (in air)
3.17 (in water)

Units: microamps per 1000 μmol s-1 m-2

Calibration Multiplier: -239.23 (in air)
-315.78 (in water)

Units: μmol s-1 m-2 per microamp

Please consult the instruction manual for further information on the calibration constant and calibration multiplier. Recalibration is recommended every two years.

Date of Calibration: January 23, 2001

By: ____________

LI-COR.
4421 Superior Street ◆ P.O. Box 4425 ◆ Lincoln, Nebraska 68504 USA
Phone: 402-467-3576 ◆ FAX: [illegible]
Toll-free: 1-800-447-3576 (U.S. & Canada)
E-mail: [illegible]
Internet: [illegible]

To set up your special PAR 6600-style sonde, follow the steps below in the sonde menu structure:

Enter the **Sensor** menu and then press the proper number for ISE3. Then choose PAR1 from the submenu and press **Esc** to return to the Sensor menu. If you have two PAR sensors, repeat the process to activate PAR2 for the ISE4 port.

```
------------Sensors enabled---------
1-(*)Time           7-( )ISE3 NONE
2-(*)Temperature    8-( )ISE4 NONE
3-(*)Conductivity   9-( )ISE5 NONE
4-(*)Dissolved Oxy  A-(*)Turbidity
5-(*)ISE1 pH        B-(*)Chlorophyll
6-(*)ISE2 Orp       C-(*)Battery

Select option (0 for previous menu): 7
```

```
--------------Select type-------------
-
1-( )ISE3 NH4+
2-( )ISE3 NO3-
3-( )ISE3 Cl-
4-( )ISE3 PAR1

Select option (0 for previous menu): 4
```

After activating the sensors, enter the **Report** menu and make certain that the PAR selections are active as shown below:

```
-------------Report setup-------------
1-(*)Date            C-( )DOchrg
2-(*)Time hh:mm:ss   D-(*)pH
3-(*)Temp C          E-( )pH mV
4-(*)SpCond uS/cm    F-(*)Orp mV
5-( )Cond            G-(*)PAR1
6-( )Resist          H-(*)PAR2
7-( )TDS             I-(*)Turbid NTU
8-(*)Sal ppt         J-(*)Chl ug/L
9-(*)DOsat %         K-( )Fluor %FS
A-( )DOsat %Local    L-(*)Battery volts
B-( )DO mg/L

Select option (0 for previous menu): 0
```

Finally, if you want to present your PAR data in photon flux density (umoles/second/m^2), enter the **Advanced|Sensor** menu as shown below and enter values for the PAR gain settings after consulting the Certificate of Calibration obtained from Li-Cor for each sensor.

```
------------Advanced sensor------------
1-TDS constant=0.65
2-Pres psi=0
3-DO temp co %/C=1.1
4-DO warm up sec=40
5-( )Wait for DO
6-Wipes=1
7-Wipe interval=5
8-SDI12-M/wipe=1
9-Turb temp co %/C=0.3
A-(*)Turb spike filter
B-Chl temp co %/C=0
C-( )Chl spike filter
D-PAR1 gain=1
E-PAR2 gain=1

Select option (0 for previous menu):
```

The number that should be entered is derived from the Calibration Multiplier in the Certificate of Calibration supplied with each sensor, but the exact entry requires some modification of the Certificate value. First, the Calibration Multiplier “in water” should be selected. Second, the negative sign should be dropped from the number prior to entry. Finally, the number should be divided by either 100 (Low Sensitivity Hardware) or 1000 (High Sensitivity Hardware) prior to entry. Thus, if the two identical sensors characterized by the above Certificate were present in the sonde, but were configured for both low sensitivity (PAR1) and high sensitivity (PAR2), the entered gain numbers should be 3.1578 for PAR1 and 0.31578 for PAR2, with both numbers derived from the –315.78 value on the Certificate. As noted above, once these entries are made, the viewed and logged PAR values will be in umoles/second/m^2 of Photon Flux Density.

```
------------Advanced sensor------------
1-TDS constant=0.65
2-Pres psi=0
3-DO temp co %/C=1.1
4-DO warm up sec=40
5-( )Wait for DO
6-Wipes=1
7-Wipe interval=5
8-SDI12-M/wipe=1
9-Turb temp co %/C=0.3
A-(*)Turb spike filter
B-Chl temp co %/C=0
C-( )Chl spike filter
D-PAR1 gain= 3.1578
E-PAR2 gain=0.31578

Select option (0 for previous menu):
```

For additional information about modification of you 6600 to include a PAR sensor configuration, contact Endeco/YSI (1-800-363-3269).

APPENDIX L PROTECTIVE ZINC ANODE

Shipbuilders have used the concept of the "sacrificial anode" for decades to minimize corrosion damage to all metallic parts of ships. Elemental zinc is commonly used as the sacrificial anode because it is more easily oxidized than most other metals. Thus, a replaceable block of zinc is installed in electrical contact to other metals on the ship which are susceptible to salt water corrosion and the zinc is preferentially oxidized (or corroded), preventing damage to the ship hull and other metal components.

The concept of the sacrificial anode can also be utilized for 6-series sondes which are deployed in corrosive media – particularly seawater or brackish estuarine water. In this case, the zinc anode is used to prevent corrosion of the stainless steel connector found on the top of most 6-series sondes. The instructions below outline the installation procedures for the zinc anode offered by YSI as Model 6182 Kit. The anode enclosed in the kit is divided into two C-shaped sections as shown in Figure 1 below. Note that each section has a flat on one end.

Figure 1

Installing the Zinc Anode on 600R, 600XL, 6820V2-1, and 6820V2-2 Sondes

NOTE: Before beginning the installation, be sure to clean the sonde connector of mud, sediment sediments, barnacles, etc. It is important for the surface to be clean in order to make good electrical contact to the zinc anode.

Figure 2

Figure 3

1. Using a large regular blade screwdriver, bend the bracket outward to the angle shown in Figure 2.
2. Position the zinc anode flat towards the bracket and squeeze together with pliers if necessary as shown in Figure 3.
3. Use the screwdriver to bend the bracket back to vertical.
4. Secure zinc halves with the cable tie.

Installing the Zinc Anode on 6000upg, 6600V2-2, 6600EDS V2-2, 6600V2-4, 6920V2-1, 6920V2-2, 600XLM, and 600 OMS V2-1 Sondes:

NOTE: Before beginning the installation, be sure to clean the sonde connector of mud, sediment sediments, barnacles, etc. It is important for the surface to be clean in order to make good electrical contact to the zinc anode.

Figure 4

For the 6600-style sondes, first remove the pressure-relief battery lid and set it aside for later installation. The position the zinc anode onto the sonde connector as shown in Figure 4 above, leaving a small gap between the bottom of the anode and the top of the sonde. Make sure that the flat sides of the anode parts are next to the battery lid as shown.

Figure 5

For 6920-style sondes, make certain that fresh batteries have been installed and that the battery lid is in place. Then position the zinc anode on the connector making certain that the flat is toward the bail hardware (Figure 5 above) and that the anode is installed below the threads on the connector.

Figure 6

For the 600XLM and 600 OMS V2-1 sondes, the user will be required to manually cut a second flat on the other end of the C-shaped anode sections. Then make certain that fresh batteries have been installed in the sonde. Finally, with the battery lid in place, install the anode sections on the connector being certain that the flats are on the sides where the bail attaches to the battery cover and that the assembly is below the threads of the connector. The proper installation is shown in Figure 6 above.

For all sondes, after the sections of the anode have been put in place, squeeze the halves together, using pliers if necessary for a tight fit.

Finally secure the anode to the connector using a cable tie which is included in the Model 6182 kit.

NOTE: The zinc anode collar must be removed before you can replace the batteries for 600XLM, 600 OMS V2-1, and 6920-style sondes. A new plastic cable tie will be needed to re-secure the zinc.

WARNING: The zinc anode must not interfere with the ability to properly attach of the pressure cap to the sonde connector – the cap MUST be threaded all the way down to prevent leaks into the connector. Therefore, the anode must also NOT be placed over the threads of the connector.

APPENDIX M ROX OPTICAL DO SENSOR

This appendix is in the format of "frequently asked questions", is designed to allow users to optimize the performance and the trouble-shooting of problems for your YSI 6150 ROX Optical dissolved oxygen probe by supplementing the discussion of optical dissolved oxygen measurement that is provided in the other sections of this manual (**Getting Started, Basic Operation, Principles of Operation, and Maintenance**).

How does the ROX Optical DO Sensor work?

In general, optical dissolved oxygen sensors from a variety of manufacturers are based on the well-documented principle that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with carefully-chosen chemical dyes. The 6150 sensor operates by shining a blue light of the proper wavelength on this luminescent dye which is immobilized in a matrix and formed into a disk about 0.5 inches in diameter. This dye-containing disk will be evident on inspection of the sensor face. The blue light causes the immobilized dye to luminesce and the lifetime of this dye luminescence is measured via a photodiode in the probe. To increase the accuracy and stability of the technique, the dye is also irradiated with red light during part of the measurement cycle to act as a reference in the determination of the luminescence lifetime.

When there is no oxygen present, the lifetime of the signal is maximal; as oxygen is introduced to the membrane surface of the sensor, the lifetime becomes shorter. Thus, the lifetime of the luminescence is inversely proportional to the amount of oxygen present and the relationship between the oxygen pressure outside the sensor and the lifetime can be quantified by the Stern-Volmer equation. For most lifetime-based optical DO sensors (including the YSI 6150), this Stern-Volmer relationship (((Tzero/T) – 1)) versus O_2 pressure) is not strictly linear (particularly at higher oxygen pressures) and the data must be processed using analysis by polynomial non-linear regression rather than the simple linear regression used for most polarographic oxygen sensors. Fortunately, the non-linearity does not change significantly with time so that, as long as each sensor is characterized with regard to its response to changing oxygen pressure, the curvature in the relationship does not affect the ability of the sensor to accurately measure oxygen for an extended period of time.

Each YSI sensor module (the assembly which is attached to the face of the probe by three screws) is factory-calibrated over a range of 0-100 percent oxygen to quantify the relationship of its luminescence lifetime as a function of oxygen pressure. The Stern-Volmer parameters from this data are then fit to a third order regression equation ($ax^3 + bx^2 + cx$) and values of a, b, and c determined. These coefficients, along with the luminescence lifetime at zero oxygen pressure (Tzero), are provided to the user in coded form with each sensor membrane module or probe/sensor module combination. If you install a replacement sensor membrane assembly (YSI 6155) on your existing probe, you will be required to enter these coded constants into the sonde as described in the instructions which come with the 6155 prior to the use of the sensor. If you have purchased a probe/membrane combination, i.e. a new 6150 Optical DO sensor, the constants are already stored in your probe and will automatically be transferred to your sonde when the sensor is installed.

What are the key advantages of the ROX sensor over membrane-covered polarographic sensors?

The ROX dissolved oxygen sensor has three key advantages over the YSI Rapid Pulse sensor:

1. The set-up and maintenance of the ROX sensor is much easier since there is no membrane or electrolyte to be changed by the user.

2. Testing indicates that the ROX sensor is significantly less susceptible to field drift.

3. The ROX sensor is automatically wiped during field studies to eliminate effects of fouling. The Rapid Pulse sensor can be wiped, but only if a 6600EDS V2-2 sonde is used.

In addition, the ROX DO sensor has NO flow dependence, giving it a large advantage over systems which utilize steady-state membrane covered polarographic oxygen sensors. This advantage is minimal relative to the YSI Rapid Pulse technology which is effectively flow-independent in monitoring studies and shows only minimal flow dependence (ca. 3%) in continuous-on sampling studies.

What is the warranty period for the ROX DO Sensor?

The probe is warranted for 2 years and the sensor membrane assembly is warranted for 1 year. See **Section 9** of this manual for details of the YSI warranty policy.

What sondes can use the ROX DO Sensor?

The ROX Sensor can be used with any existing or new YSI 6-series sonde which contains an optical port. Currently available sondes which support the use of the ROX sensor are 600 OMS V2-1, 6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, and 6600V2-4 which were manufactured after June 1999. If you have an older sonde with an optical port and want to determine whether it will support the use of the ROX sensor, contact YSI Technical Support. They will be able to evaluate the compatibility of your sonde with the ROX sensor by giving you a few simple software commands to issue at the "#" sign of your sonde.

If I want to use the new ROX DO Sensor with my existing sonde, what else do I have to do?

In order to use the ROX technology on an existing YSI 6-series sonde, you must do the following:

- Upgrade the firmware in your sonde from the YSI Website (ysi.com) to Version 3.00 or higher.
- Upgrade your EcoWatch for Windows PC software from the YSI Website to Version 3.18 or higher.
- Upgrade the firmware in your 650 MDS Display/Logger from the YSI Website to Version 1.18 or higher.

Note if your sonde was manufactured after June 1999, there is no need to return your existing sonde to YSI. After carrying out the software upgrades described in detail in the instruction sheet shipped with the 6150 Probe, you will be able to simply install the ROX sensor in your optical port and begin taking readings. If your sonde was manufactured prior to June 1999, then you should contact YSI Technical Support to determine if it is compatible with the ROX sensor

Can I measure dissolved oxygen with both ROX Optical and Rapid Pulse Polarographic sensors in the same sonde?

No. If you try to activate both the ROX and Rapid Pulse sensors in the sonde **Sensor** menu, only the last sensor activated will be functional.

What are the key differences between the ROX Optical and Rapid Pulse DO sensors?

The key differences between the sensors are as follows:

- The 6150 optical sensor has no flow dependence even in continuous operation during spot sampling studies while the 6562 polarographic sensor can exhibit up to 3% flow dependence.

- For the 6562 polarographic sensor, users must calibrate the sensor by different methods for sampling (Discrete Sample) and monitoring (Unattended Sample) by activating or deactivating the "Autosleep RS-232" feature found in the **Advanced|Setup** menu. The calibration of the 6150 optical sensor is the same for both sampling and monitoring applications and no changes in the "Autosleep RS-232" feature are required.

- It is possible to calibrate the 6562 polarographic sensor ONLY in oxygen-containing media at a single point. The 6150 optical sensor can be calibrated at either a single point in oxygen-containing media OR at two points, a zero-oxygen medium and an oxygen-containing medium. This allows users to maximize the accuracy of the 6150 sensor at low oxygen levels if they feel it to be necessary.

Is the ROX DO Sensor calibrated at YSI prior to shipment to the customer?

Yes. Factory calibration is required because, unlike all other sensors for YSI 6-series sondes, the response of the ROX Optical DO sensor is not linear relative to the species being measured. This non-linearity requires that the sensor be factory-calibrated at a number of oxygen values and the data fit to a third-order regression. The three constants and the sensor value at zero dissolved oxygen which define this regression analysis are automatically stored in the sensor at the time of factory-calibration. It is important to note that these constants are a function of the sensor membrane installed on the 6150 probe and NOT a function of the probe, i.e., the constants reflect the characteristics of the sensor membrane and NOT the probe. When a 6150 probe is purchased from YSI, it already has a sensor membrane installed and the constants of that membrane are transferred automatically to the sonde PCB when the sensor is run for the first time. After transfer, the constants can be viewed by accessing the **Advanced|Cal Constants** menu as described below in a separate question/answer.

Note, however, that, even with the factory calibration, the user still should perform a calibration after receipt of the sensor as described below in order to assure that the typical accuracy specification is met.

How do I calibrate my ROX DO sensor?

The ROX DO sensor is typically calibrated in the same way as the YSI Rapid Pulse sensor – a single point calibration in either air-saturated water, water saturated air, or a solution whose oxygen content has been determined by Winkler titration. Like the Rapid Pulse sensor, the ROX sensor can be calibrated in either the air-saturation mode (requiring a local barometer value input) or in concentration mode (requiring an input of oxygen content in mg/L).

It is also possible to carry out a 2-point calibration of the ROX sensor with the other point being zero oxygen content. NOTE, HOWEVER, THAT YSI DOES NOT RECOMMEND THE 2-POINT CALIBRATION UNLESS (A) YOU ARE CERTAIN THAT THE SENSOR DOES NOT MEET YOUR ACCURACY REQUIREMENTS AT LOW DO VALUES AND (B) YOU ARE OPERATING UNDER CONDITIONS WHERE YOU ARE CERTAIN TO BE ABLE TO GENERATE A MEDIUM WHICH IS TRULY FREE OF OXYGEN.

The calibration methods and recommendations for the ROX sensor are provided in detail in Section 2 of this manual and in the instruction sheet which you received with the ROX probe. The key is to remember that the single point calibration option will provide data of acceptable accuracy for the vast majority of users and it should be used in most cases.

Should I calibrate my ROX sensor in water-saturated air or air-saturated water?

Studies at YSI have shown that the sensor shows effectively the same reading in air-saturated water and water-saturated air. Thus, if the calibration is carried out properly, either medium can be used with confidence. The advantage of air-saturated water is the quick equilibration of the sonde sensors relative to thermal and humidity factors; the disadvantages are that you will require an aquarium pump, an air-stone, a large vessel to immerse the sonde in the air-saturated water, and you must sparge the water for at least 1 hour prior to calibration to assure that it is air-saturated. The advantage of using water-saturated air is that the calibration can be carried out in the cup supplied with the sonde and it can be done somewhat faster than the air-saturated water method. Note, however, that if you use water-saturated air as the calibration method, you should still wait at least 15 minutes after placing the sensors in the calibration vessel to assure thermal equilibration between the temperature and ROX DO sensors.

The bottom line is that either method will give good results as long as the considerations above are followed. The air-saturated water method may be slightly preferable if you have the equipment because of the assured equilibration, but the advantage is slight.

If I want to perform a 2-point calibration, how do I generate a zero-oxygen medium?

Two methods are generally used to provide a zero-oxygen environment:

1. Place the ROX sensor in a vessel which is filled with a flowing inert gas such as nitrogen gas

2. Place the ROX sensor in an aqueous solution of sodium sulfite at a concentration of approximately 2 g/L)

The following qualifiers apply to the zero point calibration methods:

- If you use nitrogen gas for the zero point calibration, you should make certain that the vessel you use has a SMALL exit port to prevent back diffusion of air and that you have completely purged the vessel before confirming the calibration.

- If you use sodium sulfite solution for the zero point calibration, you should make up the solution at least 2 hours prior to use and keep it sealed in a bottle which does not allow diffusion of oxygen through the sides of the container. You should also transfer the sodium sulfite solution rapidly from its container to the sonde calibration cup, fill the cup as full as possible with solution to minimize head space, and seal the calibration cup to the sonde to prevent diffusion of air into the vessel.

Whichever method you use, it is very important that you wait at least 10-12 minutes and until the readings are stable for at least 2 minutes before confirming the zero point calibration entry.

If I make a mistake in a 2-point calibration, will my sensor always be inaccurate?

No. You can either perform a new 2-point calibration with better control of the conditions or you can return to the factory default calibration by using the “uncal” command as described below.

- Select **Calibrate** from the **Main** menu, then **Optic T Dissolved Oxy**, and then run any of the ODOsat % or ODO mg/L options.

- When prompted for the input of a barometer or a concentration value, type the word "uncal" and press **Enter** if your sonde is attached to a computer. If your sonde is attached to a 650 MDS, when prompted for input, hold down the **Enter** key and press the **Esc** key.

Either procedure will reset your 6150 calibration constants to the previously input values associated with your sensor membrane.

How often should I calibrate my ROX sensor?

Our experience is that, even though the drift of the ROX sensor is minimal, it is prudent to calibrate the sensor in air-saturated water or water-saturated air prior to each deployment or field sampling study. The calibration takes very little time and should be carried out to (a) maintain the best possible accuracy for the sensor and (b) to assure that the sensor is working properly prior to proceeding to the field.

I notice that, during Discrete Sample studies, there is a lag between when I begin the sampling and when ROX DO readings actually appear on the display. What is causing this effect?

The lag between starting the study and actually seeing data is due to the fact that the readings of all optical sensors, including ROX DO, are frozen during the sensor wiping sequence. If the sonde has not been used for more than a minute, it will be in the "sleep" mode and, under these conditions, all optical sensors will automatically wipe the first time a Discrete Sample command is issued. The extent of the lag varies depending on how many optical sensors are present in the sonde and will be about 15 seconds per optical sensor. Thus, lag will be about 15 seconds for a sonde with two optical sensors and about 1 minute for a sonde with four optical sensors.

How does the ROX sensor deal with fouling in field studies?

The ROX sensor has a wiper similar to those used on all YSI optical sensors (turbidity, chlorophyll, rhodamine WT, and blue-green algae) which removes fouling from the sensor membrane. The wiper activates just prior to each measurement point in a long term study. In addition, the wiper can be activated manually from a PC keyboard or from a 650 MDS handheld logger to remove bubbles from the sensor membrane prior to spot sampling measurements.

What color wiper should be used with the ROX DO sensor?

Because the probe is digital, you can use any color wipers with the 6150 ROX sensor. In fact, if you are using the ROX sensor in the "T" port of a 6600EDS V2-2 sonde, you should use the white EDS wiper for the application. However, just to be consistent, YSI recommends that you use black wipers for the ROX sensor like those supplied with the probe for all 7non-EDS applications. The wiper is a wear item and a spare is provided with each probe along with a 0.05" hex key to loosen/tighten the wiper set screw. Black wiper packs, YSI 6625, can be ordered from YSI Technical Support or Customer Service. Alternatively, users who choose to change only the wiper pad can purchase the YSI 6144 Optical Wiper Pad Kit.

What is the response time of the ROX DO sensor?

On transfer to field water, typically the ROX sensor will reach 90% of its final value in less than 30 seconds – slightly faster than the YSI Rapid Pulse sensor. Note, however, that the response time of the ROX probes varies slightly from sensor module to sensor module.

How often should I change my ROX sensor membrane assembly?

YSI recommends that you change your membrane assembly every 12 months. The membrane assembly is simple to install and can be purchased from YSI Technical Support as the YSI 6155 Optical DO Sensor Replacement Kit.

Since the sensor is non-linear and the non-linearity is not identical for all sensors, how do I take this factor into account when I replace the sensor membrane assembly?

As described in the instruction sheet for the 6155 Optical DO Sensor Replacement Kit, you will be required to enter coded constants which are provided with the new membrane assembly into the sonde software. The process takes only a few minutes as briefly described below.

Locate the Calibration Code Label which is attached at the end of the instruction sheet provided and note the five numbers which are listed as K1 through K4 and C on the sticker. These five numbers contain the calibration code for this particular sensor membrane.

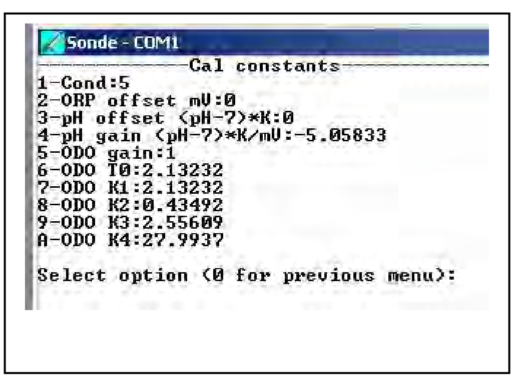
From the **Main** sonde menu, select **Calibrate|Optic T- Dissolved Oxy a**nd then select the "**3-Enter Cal Sheet**" entry. You will be prompted to enter the K1 value from the sticker. After carefully entering K1, press **Enter** to confirm the entry and then you will be prompted to enter the value of the next number. Values of K2-K4 and C should be entered in similar fashion to K1, pressing **Enter** to confirm each entry. If no error message is encountered after confirming the C value, then you have made all entries correctly and the proper constants will be transferred automatically into the sensor system for correct calculation of dissolved oxygen. If an error message is displayed after entry of C, then you have made an error (or errors) in entering the code. Following the error message you will be returned to the **Calibrate** menu from which you should again enter the K1-K4 and C numbers until the entries have been made correctly

Note that it is good idea to place the instruction sheet which contains the calibration information IN A SAFE PLACE in the unlikely event that you need to reenter it later.

How can I be sure that my calibration coefficients have been entered correctly and confirm that they are being read correctly by the sonde software?

One of the five constants (C) which you entered in coded form is a check sum value associated with the values of K1-K4 and will prevent acceptance of the constants if typographical errors are made in their entry by the user. Thus, it is not possible to make an incorrect entry of the coded constants.

After entry of the coded constants in the **Calibrate** menu, the actual constants associated with the regression fit of your particular membrane can be viewed by accessing the **Advanced|Cal Constants** menu as shown below – the regression constants are ODO K2-ODO K4 and the value at zero oxygen is K1 as shown below. Note that these constants will not appear at this location until the sonde has been run for the first time with the 6150 ROX sensor installed.



How should I store my ROX sensor when it is not in use?

When the 6150 sensor is not in field use, it MUST BE STORED IN A MOIST ENVIRONMENT, i.e., either in water or in water-saturated air with storage in water being preferable. If the sensor membrane is allowed to dry out by exposure to ambient air, it is likely to drift slightly at the beginning of your next deployment unless it is rehydrated. Thus, to make the use of the sensor as simple as possible, remember to store it WET whenever possible. The easiest storage method is to use the protective plastic cap (and enclosed sponge) which was on the probe at receipt. If you have retained this cap/sponge, then simply soak the sponge in water and replace the cap on the probe tip. Inspect the sponge every 30 days to make sure it is still moist. Alternatively, you can remove the probe from the sonde and place it directly in water (making sure that the water does not evaporate over time or leave the probe in the sonde and make certain that the calibration cup has an atmosphere which is water-saturated by placing approximately ½ inch of water in the bottom of the cup and then sealing it snugly to the sonde.

If I have inadvertently allowed my ROX sensor membrane to dry out for several days, is it ruined?

No. The sensor membrane can easily be rehydrated using the following basic procedure:

> Place approximately 400 mL of water in a 600 mL beaker or other similar glass vessel – do NOT use plastic vessels – and heat the water on a thermostatted hotplate or in an oven so that a consistent temperature of 50+/- 5 C is realized. Place the probe tip containing the sensor membrane in the warm water and leave it at the elevated temperature for approximately 24 hours. Cover the vessel if possible to minimize evaporation. After rehydration is complete, store the probe in either water or water-saturated air prior to calibration and deployment.

Once the rehydration has been performed, the sensor should be returned to its original performance specification.

Can I use alcohol or other organic solvents to clean my sensor membrane?

Absolutely NOT**.** Alcohol will dissolve the outer paint layer of the membrane assembly and other organic solvents will likely dissolve the dye itself. Under NO circumstances should you use organic solvents to clean your sensor membrane. The best method of cleaning the membrane is just to gently wipe away any fouling with a piece of lens cleaning tissue which has been moistened with water only.

I have a few pinholes in the outer paint layer of my sensor membrane so that I can see small spots of light from the probe. Will this light leakage affect the performance of my ROX sensor?

No. A few small pinholes in the outer paint layer will have no discernable effect on sensor performance. However, if there are a lot of holes or if they are relatively large (1 mm or greater in diameter), then there might be a minor compromise of sensor accuracy relative to the factory calibration. Under these latter conditions, YSI would recommend replacing the membrane assembly.

Is there any effect of ambient light on the readings from the ROX DO sensor?

Under all normal operating conditions, the ROX sensor is unaffected by ambient light, even if there are a few minor scrapes or pinholes in the protective paint layer of the sensor membrane. These conditions include exposure to room lighting during calibration and set-up and deployments in all clarities of water as long as the ROX sensor is pointed down or on its side. Our studies indicate that only if the ROX sensor is exposed directly to bright sunlight with the probe pointed upward will the readings be affected significantly. Thus, there is no reason to worry about the effect of ambient light unless your deployment sight is very unusual and requires that the sensor be pointed directly upward in shallow water with no probe guard. It is also important to note that if the membrane is exposed to bright sunlight for extended periods, i.e., more than 60 minutes, the life of the membrane may be reduced due to photo-bleaching of the dye. Thus, make certain that you protect the membrane from bright sunlight during any storage and/or transportation to your deployment site.

Is there any effect of wiping the sensor membrane on the ROX DO readings?

Yes, there is a minor effect. Typically the optical DO reading will drop by about 1.5 % immediately after a wipe which is activated during Discrete Sample studies. After 12 seconds, the reading has typically returned to within 0.7 % of the final reading. It takes about 30 seconds for complete recovery of the ROX optical DO reading after the sensor membrane is wiped. This effect is due to the physical contact of the wiper pad with the membrane since it is not observed when the wiper assembly is removed and only the wiper shaft turns when a wipe command is issued.

Will this wiping effect cause inaccuracy in my Unattended study readings with the ROX DO sensor since I will be calibrating without wiping, but logging readings after the ROX sensor has been wiped?

The error will be minor in any case, but will vary depending on what other optical probes you have installed in your sonde. Since the effect is physical as described in the previous question, the longer it takes to log a reading after the ROX sensor has wiped, the less error there will be relative to the calibration. Under the worst case scenario, the user has ONLY a ROX sensor present with an ODO Time Constant setting of 12 seconds as set in **Advanced|Data Filter**. This set-up means that readings will be logged internally 12 seconds after the wipe has terminated and, under these conditions, there will be a typical error of 0.7 % of the reading – within the sensor specification of 1 % of the reading. This error will be further reduced if other optical probes are present since the time for them to be wiped plus their time constants will further increase the time between the wiping of the ROX sensor and the time a point is logged to internal memory. (Note that the ROX sensor is ALWAYS WIPED FIRST, no matter what optical port it is installed in as long as you have Version 3.04 or later of firmware installed in your sonde.) The extent of the error would thus be greatest with a 6920V2-1 running ROX DO only, less with a 6600-type or 6920V2-2 sonde running ROX DO and turbidity, still less with a 6600-type sonde running ROX DO and chlorophyll or BGA (since the time constant these other optical sensors is 24 seconds) and least for a 6600V2-4 sonde containing ROX DO and 3 other optical sensors. Typical errors in Unattended readings from this wiping effect are 0.7% for a sonde with only a ROX sensor and 0.3% for a sonde with a ROX and one other optical sensor. There is no discernible error for a 6600V2-4 sonde with a ROX and three other optical sensors.

Can I reduce the small error from the wiping effect?

Yes. By increasing the Time Constant value for ODO in the **Advanced|Data Filter** menu, the error will definitely be reduced. For example, with a ROX DO probe as its only optical sensor, typically your error would be reduced from 0.7% to 0.3% by increasing the ODO Time Constant from 12 to 24 seconds. Naturally, however, this will have an adverse effect on the battery life of your sonde for deployments so you should balance this factor relative to the small DO error which will be observed if you leave the Time Constant at 12 seconds.

I will be installing a ROX sensor in my 6600EDS V2-2 sonde along with another optical probe. Does it matter in which optical port I place the ROX sensor?

Yes. You should always install the ROX probe in the center (T) port of the 6600EDS V2-2 sonde and substitute the special EDS wiper for the black wiper that came with the ROX probe. The other optical probe should be installed in the outer optical port (c) with a standard wiper assembly. This installation protocol will prevent the stiff EDS auxiliary brush which cleans the pH or pH/ORP sensor from abrading the outer paint layer of the ROX membrane. There should be no problem with the EDS wiper parking correctly even though it is white (rather than the standard black wiper supplied with the probe) since an internal Hall Effect device controls the parking in the ROX sensor.

How can I tell if my ROX sensor is not functioning is not functioning properly?

There are two factors which would indicate that your sensor is not operating up to specifications. The first is that you are observing software errors when you attempt to calibrate the ROX probe. The second is that your data (either in Discrete Sample or Unattended Sample studies becomes jumpier than normal. In addition, if your membrane surface has suffered major damage as evidenced by loss of more than 10% of the outer paint layer, then, even if the readings are stable and you do not see calibration errors, it is probably time to change your membrane assembly.

What should I do if I don't think that my ROX sensor is functioning properly?

The first step is to remove the membrane assembly from the probe face as shown in Section 2.10.2 of this manual and make certain that there is no moisture present under the membrane assembly. If moisture is present, gently remove it with lens cleaning tissue and, if possible, by a compressed air stream. Make certain that the O-ring which seals the membrane assembly to the probe face is in the groove and undamaged. Then replace the membrane assembly and evaluate the probe performance. If the performance has not improved, consult YSI Technical Support for advice on how to proceed next.

APPENDIX N NMEA APPLICATIONS

6-series sondes can be configured to output NMEA formatted strings (National Marine Electronics Association). Some equipment manufactures in the marine industry use this as their native method of communication. This appendix is designed to help personnel who are already trained in NMEA applications implement this specialized protocol for their sondes.

NMEA APPLICATIONS SET UP

There are two ways to get NMEA strings from the sonde:

1. Send the NMEA command from the command prompt.
2. Enable start up to NMEA in the advanced setup menu.

Once the sonde is outputting NMEA strings you can return to the command prompt by sending an <ESC> character. Note that if you enabled start up to NMEA, the sonde will revert back to outputting NMEA strings after you reset or power cycle the sonde.

The format of the NEMA string is:

$YSI,Code #1,Value #1,Code #2,Value #2,...*XX

Code is the YSI defined parameter code. (See table below)
Value is the value of the parameter.
XX is a check computed by a bitwise "exclusive or" (xor) of all characters between $ and *, non inclusive. The XX value is sent as 2 hexadecimal nibbles, most significant nibble first.

Here's an example:

$YSI,1,4.44,7,10,18,7.00*4E

In this case we have:
Temp C 4.44
SpCond uS/cm 10
pH 7.00

PARAMETER CODES

The list below shows all possible parameters that can be output from a 6-series sonde. Note that depending on the sonde type you have, some parameters may not be available. In addition, some parameters are for internal testing only and will not be available, but are listed for completeness.

```
Code Name and units
---- --------------
 51, Date d/m/y
 52, Date m/d/y
 53, Date y/m/d
153, Date
 54, Time hh:mm:ss
  1, Temp C
  2, Temp F
  3, Temp K
  6, SpCond mS/cm
```

```
  7, SpCond uS/cm
  4, Cond mS/cm
  5, Cond uS/cm
  9, Resist MOhm*cm
  8, Resist KOhm*cm
 94, Resist Ohm*cm
 10, TDS g/L
 95, TDS Kg/L
 12, Sal ppt
 14, DOsat %
200, DOsat %Local
 15, DO mg/L
 96, DOchrg
209, Cl2 mg/L
210, Cl2chrg
 20, Press psia
104, Press psir
 21, Press psig
111, Press psi
 22, Depth meters
 23, Depth feet
118, Flow ft3/sec
166, Flow ft3/min
167, Flow ft3/hour
168, Flow ft3/day
164, Flow gal/sec
119, Flow gal/min
165, Flow gal/hour
120, Flow Mgal/day
121, Flow m3/sec
169, Flow m3/min
170, Flow m3/hour
171, Flow m3/day
122, Flow L/s
172, Flow AF/day
123, Volume ft3
124, Volume gal
173, Volume Mgal
125, Volume m3
126, Volume L
174, Volume acre*ft
 18, pH
 17, pH mV
 19, Orp mV
 48, NH4+ N mg/L
108, NH4+ N mV
 47, NH3 N mg/L
106, NO3- N mg/L
101, NO3- N mV
112, Cl- mg/L
145, Cl- mV
201, PAR1
202, PAR2
 37, Turbid NTU
203, Turbid+ NTU
193, Chl ug/L
194, Chl RFU
```

```
204, Rhodamine ug/L
211, ODOsat %
214, ODOsat %Local
212, ODO mg/L
215, BGA-PC cells/mL
216, BGA-PC RFU
217, BGA-PE cells/mL
218, BGA-PE RFU
 98, Gnd Hz
 99, Scale Hz
100, Prescmp
 32, Density kg/m3
 28, Battery volts
```

APPENDIX O SPECIFICATIONS

SONDE SPECIFICATIONS

6600V2-2 SONDE

Available Sensors Temperature, Conductivity, Rapid Pulse Dissolved Oxygen, pH, ORP, Ammonium, Nitrate, Chloride, and Depth (shallow, medium, deep, shallow vented). Two total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, BGA-PE). Note that Rapid Pulse and ROX DO sensors cannot be activated simultaneously.

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 656 feet (200 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors
-10 to +60 °C for pH, pH/ORP, ISE, and optical sensors

Material: PVC, Stainless Steel

Diameter: 3.5 inches (8.9 cm)
Length: 19.6 inches (49.8 cm) with no depth, 21.6 inches (54.9 cm) with depth
Weight: 7 pounds (3.18 kg) with depth and batteries but no added bottom weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 C-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 75 days at 20 C at a 15 minute logging interval, and temperature, conductivity, pH/ORP, Rapid Pulse DO with a 60-second DO warm up time, and two optical probes other than ROX DO active. Approximately 70 days at 20 C at a 15 minute logging interval, with temperature, conductivity, pH/ORP, ROX Optical DO, and one other optical probe active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6600EDS V2-2 SONDE

Available Sensors Temperature, Conductivity, Rapid Pulse Dissolved Oxygen, pH, ORP, and Depth (shallow, medium, deep, shallow vented). Two total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, and BGA-PE). Note that Rapid Pulse and ROX DO sensors cannot be activated simultaneously.

Operating Environment Medium: fresh, sea, or polluted water

Temperature: -5 to +50 °C for most sensors
Depth: 0 to 656 feet (200 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, and optical sensors
-10 to +60 °C for pH, pH/ORP, and optical sensors

Material: PVC, Stainless Steel

Diameter: 3.5 inches (8.9 cm)
Length: 19.6 inches (49.8 cm) with no depth, 21.6 inches (54.9 cm) with depth
Weight: Approximately 7 pounds (3.18 kg) with depth and batteries but no added bottom weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 C-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 75 days at 20 C at a 15 minute logging interval, and temperature, conductivity, pH/ORP, Rapid Pulse DO with a 60-second DO warm up time, and two optical probes other than ROX Optical DO active. Approximately 70 days at 20 C at a 15 minute logging interval, with temperature, conductivity, pH/ORP, ROX Optical DO, and one other optical probe active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6600V2-4 SONDE

Available Sensors Temperature, Conductivity, Dissolved Oxygen (ROX Optical), pH, ORP, and Depth (shallow, medium, deep, shallow vented). Four total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE).

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 656 feet (200 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, and optical sensors
-10 to +60 °C for pH, pH/ORP, and optical sensors

Material: PVC, Stainless Steel

Diameter: 3.5 inches (8.9 cm)
Length: 19.6 inches (49.8 cm) with no depth, 21.6 inches (54.9 cm) with depth
Weight: Approximately 7 pounds (3.18 kg) with depth and batteries but no added bottom weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 C-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 55 days at 20 C at a 15 minute logging interval, and temperature, conductivity, pH/ORP, ROX Optical DO, Turbidity, Chlorophyll, and BGA-PC (or BGA-PE) sensors active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6920V2-1 SONDE

Available Sensors Temperature, Conductivity, Rapid Pulse Dissolved Oxygen, pH, ORP, three ion selective electrodes (ammonium, nitrate, chloride), and Depth (shallow, medium, shallow vented). One total optical sensor (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE). Note that Rapid Pulse and ROX DO sensors cannot be activated simultaneously.

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors
-10 to +60 °C for pH, pH/ORP, ISE, and optical sensors

Material: Polyurethane, PVC, Stainless Steel

Diameter: 2.9 inches (7.4 cm)
Length: Approximately 18.25 inches (46.4 cm) with no depth.

Weight: Approximately 3.74 pounds (1.7 kg).

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 AA-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 30 days at 20 °C at 15 minute logging interval with temperature, conductivity, pH/ORP, and Rapid Pulse DO with a 40-second DO warm up time, and one optical probe other than ROX optical DO active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6920V2-2 SONDE

Available Sensors	Temperature, Conductivity, pH, ORP, one ion selective electrode (ammonium, nitrate, or chloride), and Depth (shallow, medium, shallow vented). Two total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE).
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 feet (61 meters)
Storage Temperature:	-40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors -10 to +60 °C for pH, pH/ORP, ISE, and optical sensors
Material:	Polyurethane, PVC, Stainless Steel
Diameter:	2.9 inches (7.4 cm)
Length:	Approximately 18.25 inches (46.4 cm) with no depth, 19.63 inches (49.9 cm) with depth
Weight:	Approximately 3.74 pounds (1.7 kg)
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	8 AA-size Alkaline Batteries or External 12 VDC
Battery Life:	Approximately 32 days at 20 C at a 15 minute logging interval with ROX Optical DO, another optical sensor (turbidity, chlorophyll, Rhodamine WT, BGA-BC, or BGA-PE), temperature, conductivity, and pH active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6820V2-1 SONDE

Available Sensors	Temperature, Conductivity, Rapid Pulse Dissolved Oxygen, pH, ORP, three ion selective electrodes (ammonium, nitrate, chloride), and Depth (shallow, medium, shallow vented). One total optical sensor (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE). Note that Rapid Pulse and ROX DO sensors cannot be activated simultaneously.
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors
-10 to +60 °C for pH, pH/ORP, ISE, and optical sensors

Material: PVC, Stainless Steel

Diameter: 2.9 inches (7.4 cm)
Length: Approximately 16.82 inches (42.7 cm) with no depth; 18.2 inches (46.2 cm) with depth
Weight: Approximately 3.4 pounds (1.5 kg)

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Computer Interface: RS-232C, SDI-12
Power: External 12 VDC (8 to 13.8 VDC)

6820V2-2 SONDE

Available Sensors Temperature, Conductivity, pH, ORP, one ion selective electrode (ammonium, nitrate, or chloride), and Depth (shallow, medium, shallow vented). Two total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE).

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors
-10 to +60 °C for pH, pH/ORP, ISE, and optical sensors

Material: Polyurethane, PVC, Stainless Steel

Diameter: Approximately 2.9 inches (7.4 cm)
2.9 inches (7.4 cm)
Length: Approximately 16.82 inches (42.7 cm) with no depth; 18.2 inches (46.2 cm) with depth
Weight: Approximately 3.4 pounds (1.5 kg)**.**

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: External 12 VDC (8 to 13.8 VDC)

600XLM SONDE

Available Sensors Temperature, Conductivity, Dissolved Oxygen (Rapid Pulse Polarographic Only) pH, ORP, Depth (shallow, medium, shallow vented).

Operating Environment Medium: fresh, sea, or polluted water
Temperature :-5 to +50 °C for most sensors
Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH and pH/ORP
-10 to +60 °C for pH and pH/ORP sensors

Material: PVC, Stainless Steel

Diameter: 1.65 inches (4.2 cm)
Length: 21.3 inches (54.1 cm) with no depth; 23.3 inches (59.2 cm) with depth
Weight: 1.48 pounds (0.67 kg) (with batteries, without bottom weight)

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 4 AA-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 30 days at 20 C at a 15 minute logging interval with temperature, conductivity, pH/ORP, and Rapid Pulse DO with a 60-second DO warm up time active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

600XL SONDE

Available Sensors Temperature, Conductivity, Dissolved Oxygen (Rapid Pulse Polarographic Only), pH, ORP, Depth (shallow, medium, shallow vented)

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH and pH/ORP
-10 to +60 °C for pH and pH/ORP sensors

Material: PVC, Stainless Steel

Diameter: 1.65 inches (4.2 cm)
Length: 15.25 inches (38.7 cm) from bottom of probe guard to top of connector with no depth and no weight. Add 2 inches (5.1 cm) for depth; add 0.75 inches (1.9 cm) for bottom weight)
Weight: 1.07 pounds (0.49 kg) (without bottom weight)

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Computer Interface: RS-232C, SDI-12

Power: External 12 VDC (8 to 13.8 VDC)

600R SONDE

Available Sensors Temperature, Conductivity, Dissolved Oxygen (Rapid Pulse Polarographic Only), pH, ORP

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 200 (61 meters)

Storage Temperature: -40 to +60 °C (without pH installed)
-10 to +60 ° C (with pH installed)

Material: PVC, Stainless Steel

Diameter: 1.65 inches (4.2 cm)

Length: 14.75 inches (37.5 cm)) from bottom of probe guard to top of connector with no depth and no weight. Add 2 inches (5.1 cm) for depth; add 0.75 inches (1.9 cm) for bottom weight)

Weight: 1.1 pounds (0.50 kg) without weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: External 12 VDC (8 to 13.8 VDC)

600QS SONDE

Available Sensors Temperature, Conductivity, Dissolved Oxygen (Rapid Pulse Polarographic Only), pH, ORP, Depth (medium)

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 200 (61 meters)

Storage Temperature: -40 to +60 °C (without pH installed)
-10 to +60 ° C (with pH installed)

Material: PVC, Stainless Steel

Diameter: 1.65 inches (4.2 cm)
Length: 14.75 inches (36.20 cm) from bottom of probe guard to top of connector with no depth. Add 2 inches (5.1 cm) for depth; add 0.75 inches (1.9 cm) for bottom weight)

Weight: 1.1 pounds (0.65 kg) without weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: External 12 VDC (8 to 13.8 VDC)

600 OMS V2-1 SONDE

Available Sensors Temperature, Conductivity, and Depth (shallow, medium, shallow vented). One total optical sensor (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE)

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C (without optical sensor installed)
-10 to +60 °C (with optical sensor installed)

Material: PVC, Stainless Steel

Diameter: 1.65 inches (4.2 cm)
Length: 21.25 inches (54.0 cm) from top of connector to bottom of probe guard without depth, bottom weight, and battery option. Add 3.75 inches (9.5 cm) for battery option. Add 2.0 inches (5.1 cm) for depth. Add 0.75 inches (1.9 cm) for weight
Weight: 1.78 pounds (0.81 kg) with depth and batteries but without bottom weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 4 AA-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 30 days at 20 C with a 15 minute logging interval and temperature, conductivity, and ROX Optical DO active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

600LS SONDE

Available Sensors	Temperature, Conductivity, and shallow vented depth.
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C Depth: 0 to 30 feet (15 meters)
Storage Temperature:	-40 to +60 °C
Material:	PVC, Stainless Steel
Diameter:	1.65 inches (4.2 cm)
Length:	Approximately 15 inches (38.0 cm) from top of connector to bottom of probe guard, bottom weight, and battery option. Add 0.75 inches (1.9 cm) for weight
Weight:	Approximately1.10 pounds (0.50 kg)
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	4 AA-size Alkaline Batteries or External 12 VDC
Battery Life:	Approximately 180 days at 20 C with a 30 minute sample interval. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

SENSOR SPECIFICATIONS

The following are typical performance specifications for each sensor.

Non-Vented Level – Deep

Sensor Type...........Stainless steel strain gauge
Range.....................0 to 656 feet (200 m)
Accuracy................+/- 1 ft (0.3 m)
Resolution..............0.001 ft (0.001 m)
Temperature Range -5 to 45 C

Non-Vented Level - Medium

Sensor Type...........Stainless steel strain gauge
Range.....................0 to 200 ft (61 m)
Accuracy................+/- 0.4 ft (0.12 m)
Resolution..............0.001 ft (0.001 m)
Temperature Range -5 to 45 C

Non-Vented Level - Shallow
Sensor Type.............Stainless steel strain gauge
Range.......................0 to 30 ft (9.1 m)
Accuracy .... +/- 0.06 ft (0.018 m)
Resolution................0.001 ft (0.001 m)
Temperature Range -5 to 45 C

Vented Level - Shallow
Sensor Type.............Stainless steel strain gauge
Range.......................0 to 30 ft (9.1 m)
Accuracy, 0-30ft ......+/- 0.01 ft (0.003 m)
Resolution................0.001 ft (0.001 m)
Temperature Range -5 to 45 C

Temperature
Sensor Type...........Thermistor
Range.....................-5 to 50 °C
Accuracy................+/- 0.15 °C
Resolution.............0.01 °C
Depth……………200 meters

Rapid Pulse Dissolved Oxygen, % saturation
Sensor Type...........Rapid Pulse - Clark type, polarographic
Range.....................0 to 500 % air saturation
Accuracy................0-200 % air saturation, +/- 2 % of the reading or 2 % air saturation, whichever is greater
200-500 % air saturation, +/- 6 % of reading
Resolution.............0.1 % air saturation
Temperature Range -5 to 50 C
Depth……………200 meters

Rapid Pulse Dissolved Oxygen, mg/L (Calculated from % air saturation, temperature and salinity)
Sensor Type.......... Rapid Pulse - Clark type, polarographic
Range.....................0 to 50 mg/L
Accuracy................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.............0.01 mg/L
Temperature Range -5 to 50 C
Depth……………200 meters

ROX Optical Dissolved Oxygen, % saturation
Sensor Type...........Optical, Luminescence Lifetime
Range.....................0 to 500 % air saturation
Accuracy ....0-200 % air saturation, +/- 1 % of the reading or 1 % air saturation, whichever is greater
200-500 % air saturation, +/- 15 % of reading; Relative to Calibration Gases.
Resolution.............0.1 % air saturation
Temperature Range -5 to 50 C
Depth…………… 61 meters

ROX Optical Dissolved Oxygen, mg/L (Calculated from % air saturation, temperature and salinity)
Sensor Type.......... Optical, Luminescence Lifetime
Range.....................0 to 50 mg/L
Accuracy................0 to 20 mg/L, +/- 1 % of the reading or 0.1 mg/L, whichever is greater
20 to 50 mg/L, +/- 15 % of the reading; Relative to Calibration Gases.
Resolution.............0.01 mg/L
Temperature Range -5 to 50 C
Depth…………… 61 meters

pH
Sensor Type...........Glass combination electrode
Range.....................0 to 14 units
Accuracy................+/- 0.2 units
Resolution..............0.01 units
Temperature Range -5 to 50 C
Depth……………200 meters

ORP
Sensor type............ Platinum button
Range.....................-999 to +999 mV
Accuracy................+/-20 mV in redox standard solutions
Resolution...............0.1 mV
Temperature Range -5 to 60 C
Depth……………200 meters

Turbidity
Sensor type............ Optical, 90 ° scatter, with mechanical cleaning
Range..................... 0 to 1000 NTU
Accuracy................+/- 2% of the reading or 0.3 NTU (whichever is greater), in YSI AMCO-AEPA standards
Resolution...............0.1 NTU
Temperature Range -5 to 50 C
Depth…………… 61 meters

Chlorophyll
Sensor type............ Optical, fluorescence, with mechanical cleaning
Range..................... Approximately 0 to 400 µg/L Chl; 0-100 Relative Fluorescence Units (RFU)
Accuracy................ No specification provided
Linearity................ R2 > 0.9999 for serial dilution of Rhodamine WT solution from 0 to 500 ug/L
Detection Limit…..Approximately 0.1 ug/L Chl (determined using cultures of Isochrysis sp. and chlorophyll a concentration determined through extractions).
Resolution...............0.1 µg/L Chl; 0.1 RFU
Temperature Range -5 to 50 C
Depth…………… 61 meters

Phycocyanin-Blue-green Algae (BGA-PC)
Sensor type............ Optical, fluorescence, with mechanical cleaning
Range..................... Approximately 0 to 280,000 cells/mL of BGA (See **Principles of Operation** section for explanation of estimate); 0-100 Relative Fluorescence Units (RFU)
Accuracy................ No specification provided.
Linearity................ R2 > 0.9999 for serial dilution of Rhodamine WT solution from 0 to 400 ug/L
Detection Limit...... Approximately 220 cells/mL. Estimated from cultures of *Microcystis aeruginosa*
Resolution...............1 cell/mL; 0.1 RFU
Temperature Range -5 to 50 C
Depth…………… 61 meters

Phycoerythrin-Blue-green Algae (BGA-PE)
Sensor type............ Optical, fluorescence, with mechanical cleaning
Range..................... Approximately 0 to 200,000 cells/mL of BGA (See **Principles of Operation** section for explanation of estimate); 0-100 Relative Fluorescence Units (RFU)
Accuracy................ No specification provided.
Linearity................ R2 > 0.9999 for serial dilution of Rhodamine WT solution from 0 to 8 ug/L
Detection Limit...... Approximately 450 cells/mL. Estimated from cultures of a *Synechococcus* species.
Resolution...............1 cell/mL; 0.1 RFU
Temperature Range -5 to 50 C
Depth…………… 61 meters

Rhodamine WT
Sensor type............ Optical, fluorescence, with mechanical cleaning
Range..................... 0 to 200 µg/L Rhodamine WT
Accuracy................ +/- 5 % of the reading or 1 ug/L, whichever is greater
Resolution...............0.1 µg/L Rhodamine WT
Temperature Range -5 to 50C
Depth…………… 61 meters

Conductivity*
Sensor Type...........4 electrode cell with autoranging
Range.....................0 to 100 mS/cm
Accuracy................+/- 0.5% of reading + 0.001 mS/cm
Resolution..............0.001 mS/cm to 0.1 mS/cm (range dependent)
Temperature Range -5 to 60 C
Depth……………200 meters

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
Temperature Range -5 to 50 C
Depth……………...200 meters

Nitrate-Nitrogen
Sensor Type...........Ion-selective electrode
Range.....................0-200 mg/L-N
Accuracy................+/- 10% of reading or 2 mg/L (whichever is greater)
Resolution..............0.001 mg/L-N to 1 mg/L-N (range dependent)
Temperature Range -5 to 50 C
Depth……………15 meters

Ammonium-Nitrogen
Sensor Type...........Ion-selective electrode
Range.....................0-200 mg/L-N
Accuracy................+/- 10% of reading or 2 mg/L (whichever is greater)
Resolution..............0.001 mg/L-N to 1 mg/L-N (range dependent)
Temperature Range -5 to 50 C
Depth……………15 meters

* Report outputs of specific conductance (conductivity corrected to 25 C), resistivity, and total dissolved solids are also provided. These values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (Ed 1989).

Ammonia-Nitrogen
Sensor Type...........Calculated from ammonium, pH and temperature
Range.....................0-200 mg/L-N
Accuracy................+/- 10% of reading or 2 mg/L (whichever is greater)
Resolution.............0.001 mg/L-N to 1 mg/L-N (range dependent)
Temperature Range -5 to 50 C
Depth……………15 meters

Chloride
Sensor Type...........Solid state ion-selective electrode
Range.....................0-1000 mg/L
Accuracy................+/- 15% of reading or 5 mg/L (whichever is greater)
Resolution.............0.001 mg/L to 1 mg/L (range dependent)
Temperature Range -5 to 50 C
Depth……………15 meters

SOFTWARE SPECIFICATIONS

EcoWatch for Windows (included)

IBM PC compatible computer with CD ROM drive and with a 386 processor (or better) running Windows software. Compatible with Windows 3.1, Windows 95, Windows 98, Windows ME, Windows NT, Windows 2000, and Windows XP. Minimum RAM requirement: 4 megabytes

Y S I *i n c o r p o r a t e d*

1700/1725 Brannum Lane
Yellow Springs, Ohio 45387 USA
(800) 765-4974 (937) 767-7241
FAX: (937) 767-9320
Website: www.ysi.com
E-mail: environmental@ysi.com

Item # 069300
Drawing # A69300
Revision J
March 2012

SOP B.2 Decontamination of Personnel, Heavy Equipment, and Sampling Equipment

1.0 Purpose and Scope

The purpose and scope of this standard operating procedure is to provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

2.0 Equipment and Materials

- Distilled water
- Potable water
- Phosphate-free detergent (for example, Alconox or equivalent) solution (2.5 percent by weight)
- Isopropyl alcohol or methanol
- Plastic buckets, scrub brushes, spray bottles for Alconox or Liquinox solution, paper towels, water, plastic garbage bags, and plastic sheets
- Department of Transportation (DOT)-approved 55-gallon drum for disposal of waste
- Drum labels
- Disposable nitrile gloves
- Steam cleaner/high-pressure cleaner for large equipment
- Dedicated steam-cleaning pad (to be located in area designated by Field Team Leader)

3.0 Guidelines

3.1 Health and Safety

Prior to decontamination activities field personnel will don appropriate personal protective equipment (PPE) as defined in the health and safety plan. At a minimum, PPE will include disposable gloves, safety glasses, and steel-toed boots.

3.2 Drilling Rigs and Monitoring Well Materials

Heavy equipment and machinery including drilling rigs and drilling equipment will be steam cleaned in a designated area before the onset of drilling, after each borehole, before drilling through permanent isolation casing, and before leaving the site. The steam-cleaning area will be designed to contain decontamination waste and waste water and will be a high-density polyethylene-lined, bermed pad. A pumping system will be used to convey decontaminated water from the pad to drums.

3.3 Downhole Drilling Tools

Downhole tools will be steam cleaned before the onset of drilling, prior to drilling through permanent isolation casing, and between boreholes. This will include, but will not be 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 will 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 will be decontaminated following the procedures outlined in Section 4.3.

3.4 Field Equipment

Equipment used in sampling must be decontaminated prior to each use in order to prevent crossover contamination or contamination of a sample. Sampling equipment must be decontaminated as described in Section 4 unless manufacturer's instructions indicate otherwise.

3.5 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:

- Rinse with Alconox or Liquinox solution. If necessary, scrub using a brush to remove any residual material on the probe (for example, any oily residue encountered).
- Rinse with potable water.
- Rinse with distilled water.

3.5.1 Meters/Probes

Probes (for example, water-quality meters, pH or specific ion electrodes, flow-through cell, geophysical probes, or thermometers coming in direct contact with the sample) will be decontaminated using the procedures specified for water-level indicators unless manufacturer's instructions indicate otherwise. Devices that have been fouled by non-aqueous phase liquid should be alternately cleaned using isopropyl alcohol and Alconox solution. For probes that make no direct contact with the sample (for example, organic vapor monitoring equipment) the probe will be wiped with paper towels or cloth wetted with isopropyl alcohol.

4.0 Procedures

4.1 Personnel Decontamination

Personnel decontamination should be performed after the completion of field activities whenever potential for exposure to contamination exists.

1. Spray boots with Alconox solution and rinse with potable water. If disposable latex booties are worn over boots in the work area, rinse with Alconox solution, remove, and discard into DOT-approved 55-gallon drum.
2. Remove outer gloves and discard into DOT-approved 55-gallon drum.
3. Remove and discard Tyvek disposable coveralls into DOT-approved 55-gallon drum, if wearing.Remove respirator, if wearing.
4. Remove inner gloves and discard.
5. Shower entire body at the end of the work day, including hair, either at the work site or at home.
6. Sanitize respirator if worn.

4.2 Sampling Equipment Decontamination – Groundwater Sampling Pumps

If sampling pumps and tubing need to be decontaminated, the following steps should be followed:

1. Put on disposable gloves.
2. Spread plastic sheeting on the ground to keep hoses and tubing from touching the ground.
3. Remove pump from well and place pump in clean bucket, making sure that tubing does not touch the ground.
4. Pump 1 gallon of Alconox solution through the sampling pump.
5. Rinse with 1 gallon of potable water.
6. Rinse with 1 gallon of distilled water or triple rinse with potable water.
7. Keep decontaminated pump in clean bucket or remove and wrap in clean plastic sheeting or a clean garbage bag.
8. Dispose of all rinsate in a DOT-approved 55-gallon drum.
9. Dispose of decontamination materials (for example, plastic sheeting, tubing, etc.) in DOT-approved 55-gallon drum.

4.3 Sampling Equipment Decontamination – Other Equipment

Reusable sampling equipment (for example, water-level meters, water-quality meters) should be decontaminated after each use as follows:

1. Put on disposable gloves.
2. Spray and scrub all equipment surfaces that have contacted the potentially contaminated soil or water with Alconox solution.
3. Rinse with potable water.
4. Rinse with distilled water or triple rinse with potable water.
5. Air dry.
6. Completely air dry and wrap exposed areas with clean plastic sheeting or clean plastic garbage bag for transport if transporting equipment.
7. Dispose of all rinsate in a DOT-approved 55-gallon drum.
8. Dispose of decontamination materials (for example, plastic sheeting, tubing, etc.) in DOT-approved 55-gallon drum.

4.4 Sample Container Decontamination

If the outside of sample bottles or containers come into contact with contaminated materials the containers may need to be decontaminated prior to being packed for shipment or handled by personnel without protective gloves. The procedure is as follows:

1. Don appropriate PPE prior to handling sample containers.
2. Seal the sampling container after samples are collected.
3. Wipe the container with a paper towel dampened with Alconox™ solution. Take care not to remove or damage sample label.
4. Dispose of all contaminated paper towels and gloves in a DOT-approved 55-gallon drum.

4.5 Heavy Equipment and Tools

Heavy equipment (for example, drilling rigs, drilling rods/tools, backhoe) will be decontaminated prior to arrival at the site and between locations as follows:

1. The subcontractor will set up a decontamination pad in an area designated by the Field Team Leader.
2. Steam clean heavy equipment until no visible signs of soil is observed.
3. Observe the guidelines outlined in Section 3

5.0 Quality Control

Equipment blanks will be collected by pouring distilled water into or over the decontaminated sampling equipment or vessel and then transferring the water to the appropriate sample containers. Field personnel will use the same preservation methods, packaging, and sealing procedures as used during the collection of normal samples. General procedures for the collection of normal water samples are described in SOP B.9, *Low-flow Groundwater Sampling from Monitoring Wells.*

SOP B.3 Field Documentation

1.0 Purpose and Scope

This standard operating procedure (SOP) describes the protocol for documenting field activities for the Operable Unit 2 remedial investigation.

2.0 Equipment and Materials

- Bound and pre-numbered field logbook
- Hardcopy field forms (included as Appendix A of the Field Sampling Plan)
- Pen with waterproof ink
- Digital camera (if taking photographs)

3.0 Procedures

3.1 Daily Field Activities

The field representative will record all daily field activities in the field logbook for each day of fieldwork. The field team leader will keep the master field logbook and will document field activities. Documentation will include the following:

- Project identification
- Date
- General description of any soil or water testing conducted or samples collected
- Location of field activities/samples collected
- Field personnel responsible for sample collection
- Time on job (beginning and ending time)
- Weather conditions
- Activity description
- List of personnel and visitors onsite
- Safety equipment used and monitoring performed
- Photographic log, if appropriate
- Waste storage inventory (if any)
- Chronological record of activities and events
- Approximate duration and purpose for downtime, if applicable
- Contents of telephone conversations
- Signature or initials of field representative (for each daily entry)

Additional information relevant to groundwater and soil sampling events are listed below. Note that if the information below is included in the appropriate field form it does not need to be duplicated in the field logbook.

- Sampling location and description
- Date and time of sample collection
- Sample, blanks, and quality control sample identification numbers
- Sample analyses
- Condition of well-being sampled, if applicable
- Serial number and calibration of field instruments

- Field measurements
- Field observations (for example, odor, color)
- Sample packaging and shipment information

The field representative will complete, sign, and date all logs in waterproof ink. The field representative will make any corrections by crossing out the error with a single horizontal line, initialing and dating the correction, and entering the correct information. Crossed-out information should remain legible.

The field logbook will be used to document field activities that may not be specified on other field activity forms. Other activity-specific documentation requirements to be recorded are discussed in the SOP for each activity.

3.2 Field Forms

In addition to the field logbook, field personnel will complete specific field activity forms applicable to the field activities being conducted. Information that is captured in the appropriate field form does not need to be duplicated in the field logbook. Field forms included in Appendix A of the Field Sampling Plan include:

- Soil boring log
- Well construction logs
- Well development logs
- Groundwater sampling and water quality meter calibration log
- Monitoring well condition log
- Slug test data form
- Hydrologic testing log
- Photoionization detector monitoring and calibration log

3.3 Photographs

Photographs may be taken of site locations, general site conditions, soil core samples, or other samples collected during the remedial investigation. A photographic log will be kept to document any photographs taken and will include the following information:

- Project
- Date/time the photograph was taken
- Photographer
- Location
- Description
- Direction the photographer was facing (if applicable)

4.0 Documentation and Field Forms

Field forms are included in Appendix A of the Field Sampling Plan. All original hardcopy field forms will be filed with the appropriate project's records. Scans of original field logbook pages and field forms will be submitted to the Department of Veterans Affairs at the end of the task and included in technical memorandums/final reports that summarize field activities.

5.0 Quality Control

All completed field forms will be reviewed by the project manager or designated project reviewer within 1 week of the field task completion, scanned, and saved to the project file. Any necessary corrections will be made in pen with a single-line strikeout that is initialed and dated.

SOP B.4 Rotosonic Drilling and Monitoring Well Installation

1.0 Purpose and Scope

The purpose of this standard operating procedure (SOP) is to describe methods for the drilling and installation of groundwater monitoring wells and piezometers in unconsolidated or poorly consolidated materials using rotosonic (sonic) drilling techniques. This SOP also describes the procedures for groundwater and soil sampling during drilling and the procedure for abandoning monitoring wells.

2.0 Equipment and Materials

2.1 Drilling, Well Installation, Well Development, and Well Abandonment

- Truck or track-mounted drilling rig
- Rotosonic-drilling equipment including steel casing and core barrel
- Personal protective equipment (for example, disposable gloves, hard hat, safety glasses, steel-toed boots)
- Schedule 80 poly vinyl chloride (PVC) casing and screen
- Cement
- Bentonite
- Filter pack sand
- Bailer and cord
- Surge block
- Development pump
- Meter to monitor pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), specific conductance (SC), turbidity, and temperature (for example, YSI 6920 V2)
- Flow-through cell with inlet/outlet ports
- Water-level indicator
- Container for purge water
- Disposable nitrile gloves
- Plastic sheeting
- Calculator
- Cleaning detergent
- Distilled water
- Paper towels
- Plastic sheeting

- Well construction information
- Field form and/or logbook

2.2 Soil Bore Logging and Soil Sample Collection for Geotechnical Testing

The following equipment and supplies are necessary or useful for soil boring exploration and soil sample collection.

- Lath, flagging, orange spray paint, and lumber crayon
- 100-foot tape
- Brunton or Silva compass
- Global Positioning System unit
- Soil boring guideline – clipboard
- Engineer's pocket tape measure with tape lock
- Field logbook on all-weather paper
- Boring log forms (see Section 7.0 Attachments)
- Indelible marker
- Soil grain size chart
- Unified Soil Classification System reference guide
- Tools for cutting soil cores (for example, safety scissors, trowel)
- Munsell soil color chart
- Squirt bottle with water, spatula
- Hydrochloric acid, 10 percent solution
- Thin wall tube or Shelby Tube sampler and plastic end caps
- Impervious disks
- Wax plugs
- Shipping material (styrofoam plug)
- Xylene free permanent marker pen or indelible pen
- Chain-of-custody forms
- Sample labels
- Custody seals
- Sample identification register
- Cooler/esky
- Ice Packs/ice
- Nitrile gloves
- Jars with lids
- Resealable plastic bags
- Proctor analysis plastic bags
- 5-gallon buckets with lids
- Airtight tape (for example, electrical)
- Newspaper
- Pocket penetrometer
- Torvane
- Well sounder
- ½-inch steel rod
- Digital camera
- Hand lens
- Liquinox cleaning detergent
- Distilled water

- Brush
- Water-level indicator
- Rags
- Ear protectors
- Screwdrivers
- Hard hat
- Sunscreen
- Insect repellent

2.3 Push-Ahead Groundwater Sampling

The following equipment and supplies are necessary or useful for push-ahead groundwater sampling:

- Drilling equipment
- Push-ahead profiler
- Water-level indicator
- Stainless steel bailer or pump with tubing
- Meter to measure pH, ORP, DO, SC, turbidity, and temperature (for example, YSI 6920 V2).
- Disposable gloves
- Plastic sheeting
- Sample containers
- Sample labels
- Sharpie pen
- Cleaning detergent
- Distilled water
- Paper towels
- Shipping supplies (cooler, ice, plastic resealable bags, custody seals, chain-of-custody forms)
- Field form and/or logbook

3.0 Procedures

3.1 Rotosonic Drilling

Rotosonic drilling technology will be used for borehole drilling, core recovery, and monitoring well installation. For boreholes less than 100 feet deep, a smaller track-mounted remote-controlled Rotosonic drill rig (mini-Sonic) will likely be used; however, for boreholes approaching 500 feet deep, a larger truck-mounted Rotosonic drill rig will be required. Borehole sizes may range between 6-inch-diameter and 12-inch-diameter.

Drill casing with a minimum 6-inch inside diameter (ID) will be used to drill monitoring well boreholes. Continuous core soil samples (4-inch outside diameter) will be collected for lithologic classification and discreet intervals will be screened using a photoionization detector. Refer to Section 3.2 for geotechnical soil sampling procedures.

The use of water and drilling fluid to assist in sonic drilling for monitoring well installation will be minimized, unless required for lubricating and advancing the casing depending on the subsurface conditions.

Temporary outer casing, drill rods, core barrels, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location (SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*). Core barrels and other downhole soil sampling equipment will also be properly decontaminated before and after each use.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Field Sampling Plan and the Investigation-Derived Waste Management Plan.

3.2 Soil Bore Logging

These procedures establish the minimum standards for information that should be recorded in the field to adequately characterize recovered soil samples. In environmental work, there can be instances in which soil borings are advanced solely to collect soil or water samples for analytical results. The project manager and senior technical consultant should determine the level of soil logging required for a project and specify in the remedial investigation work plan. Because job requirements can vary widely, the minimum standards presented might need to be supplemented with additional technical descriptions or field test results.

The boring log should be completed in the field according to the instructions that follow. Forms should be filled out neatly and completely. Laboratory testing of samples collected from each borehole should be initiated immediately after borehole drilling is complete. For geotechnical projects, it is important to check field classifications against laboratory test results. Corrections should be noted, initialed, and dated on the field boring log.

The field form for soil boring logs is included in Section 7.0 and in Appendix A of the Field Sampling Plan. An example completed soil boring log is shown on Figure 1. The heading information should be completely filled out on each log sheet, and the technical items in each column must be addressed in the field. Field personnel should review completed logs for accuracy, clarity, and thoroughness. It is important that information be correctly recorded on both the sample container and the log sheets.

3.2.1 Heading Information

Project Number. Use the standard six-digit project number and appropriate point numbers.

Boring Number. Enter the boring number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring. If rock core log sheets are also used, continue the consecutive numbering.
Project. Fill in the name of the project or client.

Location. If stationing, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system by means of modifiers, such as *approximate* or *estimated*, as appropriate. If this information is not available, identify the client facility or the town and state.

Elevation. Enter the elevation. If it was estimated from a topographic map, or roughly determined using a hand level, use the modifier *approximate*. It is important to tie the boring elevation to a recoverable reference point (for example, fire hydrant or floor slab) if no other elevation data are available. Such points can be picked up later in a site survey, and boring elevations can be determined. Or, if no survey is done, at least the relative boring elevation with respect to pertinent project facilities or landmarks will be known.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit and casing size and type, drilling fluid (if used), and method of drilling (for example, sonic). In addition, enter information on the drilling equipment (for example, Sonic SDC200, Sonic SDC390, or Sonic SDC500).

Water Level and Date. Enter the depth below ground surface (bgs) to the static water level in the borehole, if encountered. If multiple water level measurements are taken for the boring, this field should list the last or most representative measurement. Frequent water measurements are recommended to capture differences between water-bearing zones and to measure the stable water level. Record the information in the Comments column. If free water is not encountered during drilling, or cannot be detected because of the drilling method, make note of this information. Generally, water levels should be measured each morning before resuming drilling if possible and at the completion of each boring. Record the date and time of day of each water level measurement.

Date of Start and Finish. Enter the dates the boring was started and completed. Add the time of day, if several borings are performed on the same day.

Logger. Enter the full name.

3.2.2 Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Draw horizontal lines at the top and bottom depth of each sample interval. These lines should extend to the soil description column. For a very short sample interval, the bottom line can be lowered after the interval column to provide room for writing the information (Figure 1). Enter the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. For instance, 1-S or SC 1 equals first sample, sonic core. Number samples consecutively, regardless of type. Enter a sample number, even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1 foot of soil sample recovered from the core barrel. Often, there will be some wash or caved material above the sample; try to estimate this amount of material and do not include the wash material in the measurement.

Soil Description. The soil classification should follow the format described in the following subsection, “Field Classification of Soil.”

Comments. Include all pertinent observations (changes in drilling rate, drilling chatter, rod bounce, as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). If casing was used, record the sizes and depths installed, and make a note if drilling fluid was added or changed. Instruct the driller to communicate any significant changes in drilling (changes in material, occurrence of boulders). Attribute such information to the driller and record it in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of hole caving or heaving
- Depth of change in material
- A notable change in drilling conditions
- The results of pocket penetrometer or torvane test reported as: “PP = _____ TSF” or “TV = _____ TSF,” respectively

Record the depth of piezometers and the results of in situ tests in the Comments column.

PROJECT NUMBER 464687 | **BORING NUMBER** U4-428 | SHEET 1 OF 2

SOIL BORING LOG

PROJECT: ~~OU8 SAI PHASE 2C~~ OU4 RD/RA Well Installation LOCATION: OU4 Hill AFB
ELEVATION: DRILLING CONTRACTOR: ~~VIRONEX~~ Major Drilling
WEATHER CONDITIONS: 69, 47 PC
DRILLING METHOD AND EQUIPMENT USED: Sonic 4x6 Geoprobe 8140 LS #137
WATER LEVELS: START: 10/11/16 END: LOGGER: J. Gecrsek

DEPTH BELOW SURFACE (FT)	SAMPLE: INTERVAL (FT)	SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY,	COMMENTS: STRUCTURE, SORTING, ODOR DEPTH OF CASING, DRILLING RATE, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole	VISUAL (%): GRAVEL	VISUAL (%): SAND	VISUAL (%): CLAY/SILT
	0-5		0		Silty sand w/gravel, 10 YR 5/4, loose, well graded gravel, poorly graded fine sand	HA to 5' bgs	10	80	10
5	5-9		4		lean clay w/gravel, 10 YR 3/3, dry, very stiff, med/low plasticity, high organic content		5	10	85
10	9-13		4		lean clay (w/sand ?), 10 YR 3/3, very (very) stiff, med plasticity, high organic content, white stringers, very occasional sand layers ~ 1/8" thick every 3-6"	gradational contact (to no more gravel)	~~0~~ 0	~~10~~ 5	~~90~~ 95
					color change to 7.5 YR 5/4 @ ~14'				
15	13-16		3		color change back to 10 YR 3/3, some gravel - cave in?				
					Silty sand w/gravel, 10 YR 3/3, dry, loose, some cobbles		25	50	25
	16-21		5		Sand with gravel + cobbles, 10 YR 4/6, becomes moist, loose, well graded gravel, poorly graded fine sand; color change to 10 YR 4/6 @ ~18' bgs	gradational contact	25	70	5
20									
	21-26		5		lean clay w/sand (gravel in top 1/2 foot) 10 YR 4/4, wet, stiff, med/low plasticity, 1/8-1/4" sand layer every 3-6" with some thicker layers	∇ 4" layer of silty sand w/gravel; 3" sand layer; 1" sand layer; 1" sand layer	10	10	80
							0	15	85
						2" sand layer; 1" sand layer			
					less sand layers 25-26'		0	5	95

Figure 1. Example of a Completed Soil Boring Log Form

3.2.3 Field Classification of Soil Procedures

This section describes the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488-09a, *Visual-Manual Procedure for Description and Identification of Soils*, which is available through ASTM.

The Unified Soil Classification System is based on numerical values of certain soil properties measured by laboratory tests (ASTM D 2487). It is possible, however, to estimate these values in the field reasonably accurately with visual-manual procedures (ASTM D 2488). Also, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field. Corrections and additions to the field classification can be provided, when necessary, through laboratory testing of the soil samples.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities between consecutive samples, rather than differences, should be stressed.

Soil descriptions must be recorded in the Soil Description column for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers
2. Group symbol
3. Relative density or consistency
4. Moisture content
5. Color
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in the U.S. Army Corps of Engineers contract. Examples of soil descriptions are provided in Table 1.

Soil Name

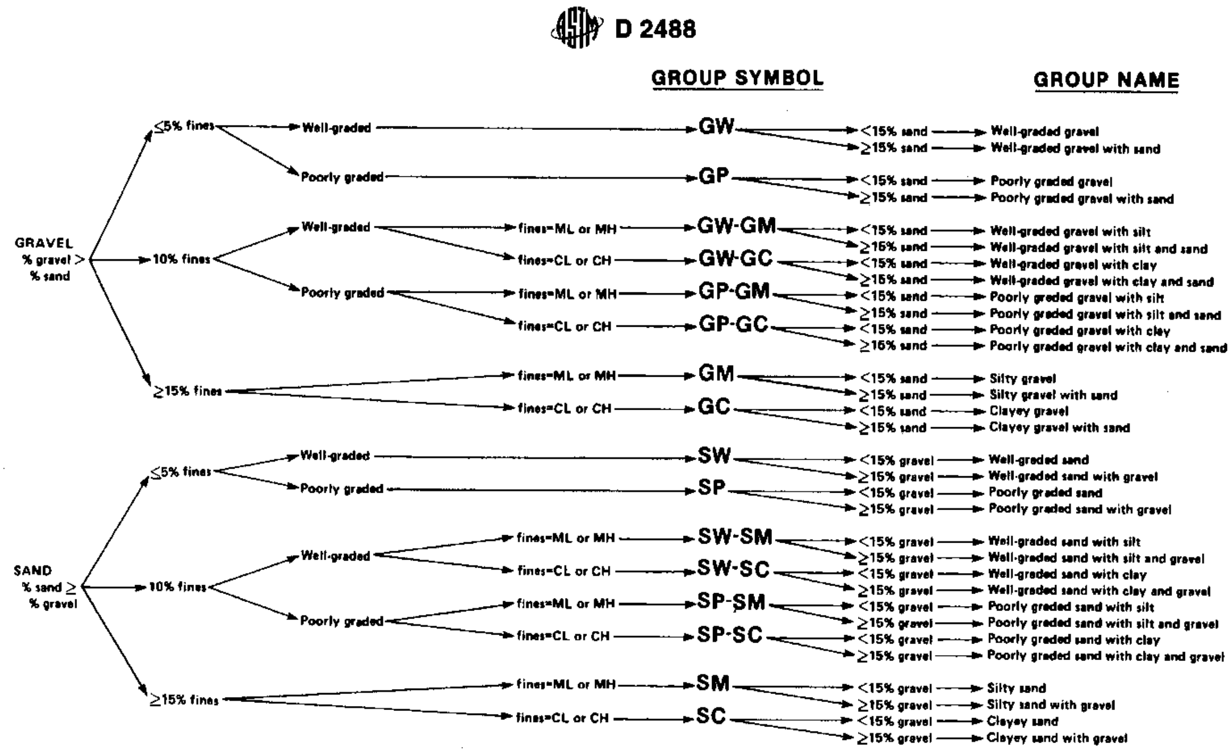
The basic name of a soil should be identical to the ASTM D 2488-84 Group Name, based on visual estimates of gradation and plasticity. The soil name should be capitalized. The only acceptable soil names are those listed on Figures 2 and 3, from ASTM D 2488-84.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

Table 1. Example Soil Descriptions

Soil Description Examples
POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size
FAT CLAY (CH), dark gray, moist, stiff
SILT (ML), light greenish gray, wet, very loose, some mica
WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, sub-angular gravel to 0.6-inch max
POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense
ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica
SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, sub-rounded gravel to 1.2 inches max
INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, non-plastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick
SILTY SAND WITH GRAVEL FILL(SM), light yellowish brown, moist, medium dense, weak gravel to 1.0-inch max, very few small particles of coal
SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation
LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff
WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0-inch max



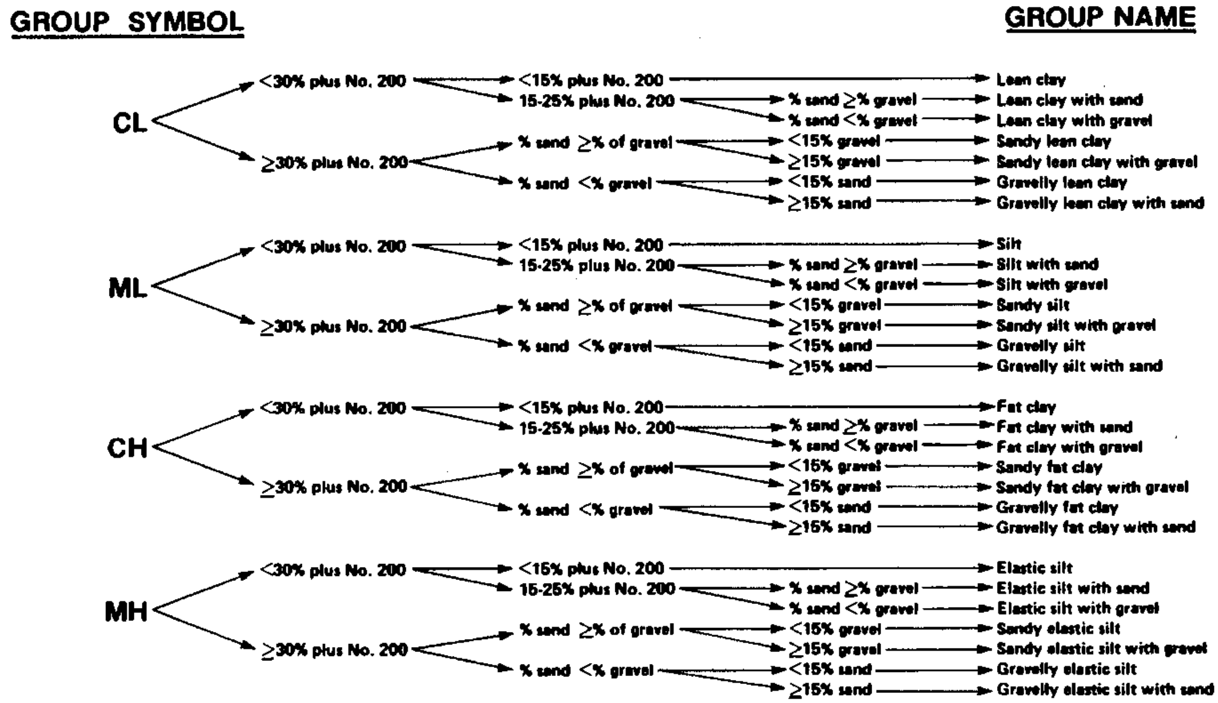
NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

Figure 2. Flow Chart for Identifying Coarse-grained Soils (less than 50% fines)

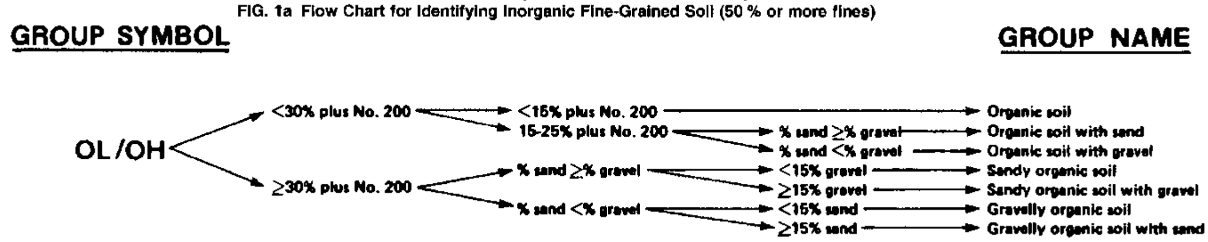
Source: ASTM, 1985

D 2488



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

Figure 3. Flow Chart for Identifying Inorganic Fine-grained Soils (50% or more fines)
Source: ASTM, 1985)

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488-84. For a coarse-grained soil, note whether the soil is well-graded or poorly graded. If poorly graded, note whether it is fine-, medium-, or coarse-graded. Also record the maximum size and angularity or roundedness of gravel and sand-sized particles. For fine-grained soil (50 percent or more passing the No. 200 sieve), modify the name by the appropriate plasticity/elasticity term, in accordance with ASTM D 2488-84.

For interlayered soils, describe each, starting with the predominant type. Use an introductory name, such as *Interlayered Sand and Silt*. Also indicate the relative proportion of each soil type and layer thickness (Table 1).

Where helpful, the evaluation of plasticity/elasticity can be justified (in the Comments section of the log) by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength, as described in ASTM D 2488-84.

Group Symbol

The appropriate group symbol from ASTM D 2488-84 (Figure 2) must be given after each soil name. Place the group symbol in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488-84, dual symbols (for example, GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (for example, GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. Borderline symbols should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

Fill is often encountered when drilling. Fill comprises any materials that people have placed on the naturally occurring ground surface. Fill material can be determined from historical information or from the discovery of human-made materials, such as concrete, brick, glass, plastic, and wood. If the soil being described is determined to be fill material, "fill" should be included in the soil description. If appropriate, provide additional details in the Comments column.

Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586; use the most current ASTM 1586 standard). If the presence of large gravel or disturbance of the sample makes determining the in situ relative density or consistency difficult, then omit this item from the description and explain it in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 2 and 3.

Table 2. Relative Density of Coarse-grained Soil

Blows/Ft	Relative Density	Field Test
0–4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5–10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11–30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb. hammer
31–50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb. hammer
50	Very Dense	Penetrated only a few inches with 12-in. steel rod driven with 5-lb. hammer

Developed from Sowers, 1979

Table 3. Consistency of Fine-grained Soil

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25–0.50	<0.12–0.25	Easily penetrated several inches by thumb
5–8	Firm	0.50–1.0	0.25–0.5	Can be penetrated several inches by thumb with moderate effort
9–15	Stiff	1.0–2.0	0.5–1.0	Readily indented by thumb, but penetrated only with great effort
16–30	Very stiff	2.0–4.0	1.0–2.0	Readily indented by thumbnail
30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

Developed from Sowers, 1979

Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed in Table 4.

Table 4. Criteria for Describing Moisture Conditions

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

Color

The basic color of a soil, such as brown, gray, or red, must be given. The color term can be modified, if necessary, by adjectives such as light, dark, or mottled. Especially note staining, iron staining, or mottling. This information might be useful for establishing water table fluctuations or contamination. As an alternative, consider using the Munsell soil color chart designation in addition to the color designation.

Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information should be recorded. Describe cementation, abundant mica, or unusual mineralogy, as well as other information, such as organic debris or odor.

Other descriptors can be included if they are relevant to the project or for describing the sample. These descriptors include particle size range and percentages, particular angularity, particle shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to hydrochloric acid (HCl), and cementation.

Residual soils have characteristics of both rock and soil and can be difficult to classify. Relict rock structure should be described and the parent rock identified, if possible.

Potentially Impacted Subsurface Media

Record observations of any potentially impacted subsurface media in the soil description or as comments. Make a note about odor, but do not try to guess what chemical you smell. Also describe nonaqueous phase liquids (NAPL) if they are present. Describe how they are present, such as sheen, staining along joints or root casts, residual, or free NAPL seeping from the sample. Do not try to guess what fluid is present. Use terms such as phase-separated hydrocarbons if you know a fluid is a fuel, but do not use terms such as diesel, unless you have tested and know that the fluid is diesel.

3.3 Soil Sample Collection for Geotechnical Testing

3.3.1 Bulk Soil Collection

Samples for geotechnical testing that can be collected from the cores collected in new plastic sleeves during sonic drilling include the following:

- Fraction of organic carbon
- Mineralogical analysis
- Hydrometer

- Particle density
- Moisture content
- USCS soil classification
- Sieve (particle size) analysis
- Atterberg Limits

These samples will be placed in plastic bags or 5-gallon buckets (according to laboratory sample size requirements), then labeled and stored according to the procedures outlined in Section 3.3.3 and SOP B.13, *Sample Handling and Shipping.*

3.3.2 Shelby Tube Sampling

Samples for geotechnical testing that require undisturbed fine-grained samples that will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) include the following:

- Total porosity
- Bulk density
- Unsaturated hydraulic conductivity
- Vertical permeability

Tubes will be 24 to 36 inches long and 3 to 4 inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends of the soil core will be sealed with beeswax and then the Shelby tube will be sealed with end caps and duct tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube will be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample.

3.3.3 Sample Labeling and Packaging

The samples recovered from the borehole are an important part of the boring record and must be properly packaged and labeled, if further testing is required. The following description outlines the minimum requirements for packaging and labeling the samples. Additional information is provided in SOP B.13, *Sample Handling and Shipping*.

1. Place disturbed samples in resealable plastic bags or jars. If you use jars, mark the jar lids and affix labels to the sides of the jars. Labels are usually available from the analytical laboratory. Mark the following information clearly on the bags or jars:

    a. Project number
    b. Boring number
    c. Analysis
    d. Preservative (if applicable)
    e. Sample number
    f. Sample depth
    g. Date

    Use a permanent marker. If moisture content tests are anticipated, use jars, which should be tightly sealed, then sent to the laboratory. Testing should be initiated as soon as possible (within 1 week).

2. Label boxes containing the jars, on top and on one end, with the following information:

    a. Project name
    b. Project number
    c. Boring number

d. Sample numbers
e. Sample depths
f. Date
g. Sampler name

It is helpful to start a new box for each new boring if the boxes are at least half full.

3. Clean Shelby tubes of mud and moisture. When they are dry, use a permanent marker to label them with the following information:

   a. Arrow indicating which way is up
   b. Project number
   c. Boring number
   d. Sample number
   e. Sample depth
   f. Amount of recovery
   g. Date

   Circumscribe the top and bottom of the sample on the outside of the tube with a marker.

Waxing of Shelby tubes is essential if sample testing is not to occur within a few days. In all cases, place lids on the ends and tape them with airtight tape. Be sure to seal the holes in the top of the tube. Pack the open portion of the tube above the sample to prevent shifting of the soil. Dampened newspaper is generally adequate for this purpose, but it should be separated from the soil sample with a wax seal or an inverted cap.

3.4 Push-Ahead Groundwater Sampling

When a groundwater sample is to be obtained from a specific depth, the Push-Ahead profiler will be threaded to the base of the drill string and its point will be advanced below the sonic casing into the undisturbed formation to the targeted groundwater sample interval. The Push-Ahead profiler is a heavy gauge steel point that is threaded to the base of a 3-inch drill rod. The point is perforated along the threaded portion allowing exposure to formation water at specific intervals. Once the point is at the specific interval, a water-level indicator will be lowered through the drill string to the base of the profiler to ensure there is no formation water accumulated inside the profiler and drill pipe. The threaded portion between the profiler and drill steel will then be partially unthreaded to expose the water ports and allow native formation water to enter the profiler. A groundwater sample will be obtained from the profiler using either a stainless-steel bailer or a pump with tubing.

Samples will be collected in bottles appropriate to the respective analysis. Sample labels will follow the naming convention identified in the SAP/QAPP and be applied to each sample container. Sample labels will include the following information:

- Sample name/number
- Time and date of sample collection
- Site name and location
- Project number
- Sample type and matrix
- Container
- Preservative
- Analysis method

The following information will be recorded on the field form prior to sample collection:

1. Site name and location
2. Weather conditions
3. Sample name/number
4. Sampler identity
5. Field observations and measurements
6. Date and time of sample collection
7. Number of sample containers and types of samples collected

Sample collection will proceed as follows:

1. Disposable gloves and eye protection should be worn at all times during sample collection. Gloves should be replaced if they are compromised or contaminated.
2. Samples collected for volatile organic compounds (VOCs) should be collected first.
3. Cap each sample container and label as described above. Pack samples in the cooler with ice immediately after sample collection.
4. Record results on field form.
5. Sample equipment should be decontaminated after sample collection per the procedures outlined in SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment* . Refer to SOP B.13, *Sample Handling and Shipping* for additional information on sample handling, storage, and shipping.

3.5 Well Installation and Completion

Monitoring wells will be constructed inside the temporary outer casing, once the borehole has been drilled 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 high-solids bentonite grout 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 designated 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. Centralizers, 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 (wells drilled to less than 100 feet bgs) will be made in the field by the Field Team Leader and/or Project Manager. It is expected that the range of commonly used filter pack materials (Rice Engineering, 2012) will be appropriate for this site.

Filter pack sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack and at a rate that limits the potential for bridging within the annulus. The temporary casing will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the temporary 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 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 sand pack may be installed for a minimum of 1 foot above the coarse sand pack. Depth intervals of the coarse and fine sand packs and bentonite seal may be modified in the field in response to subsurface conditions.

A bentonite seal at least 5 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 neat cement grout will be placed. The neat cement grout, with mixing ratio of water to 7 gallons per 94-pound sack of Type I/II Portland cement, will be installed continuously or in lifts (depending on the well depth) from the top of the bentonite seal to the ground surface (or top of the lift) 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 seal.

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 (that is, bollards) may be installed in high-traffic areas for additional protection. Four steel bollards will be installed around the protective casing, within the edges of the concrete pad. Bollards will be concrete-filled, at least 2 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above ground. The protective casing and bollards will be painted with an epoxy paint to prevent rust.

For monitoring wells with steel flush-mount completions, the top of the flush-mount cover will be positioned approximately at 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 flush-mount completion, and will slope uniformly downward to the adjacent grade. The flush-mount completion 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-inches 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, bollards, 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.

3.6 Monitoring Well Development

Each monitoring well will be developed no sooner than 48 hours and no later than 7 days after well construction is completed. Equipment used to develop monitoring wells will be determined based on the depth to groundwater, the amount of sediment present in the well, and the hydraulic conductivity of the aquifer at the well location. During well development, groundwater quality parameters of pH, specific conductivity, temperature, and turbidity will be monitored. The parameters will be measured at the beginning of well development and after evacuation of each borehole volume. A minimum of six water quality parameters will be made during well development.

Well development will continue until the following criteria are met:

- A minimum of five borehole volumes have been removed (assuming 30 percent porosity in the sand pack) in addition to the volume of potable water added during drilling OR two times the volume of potable water added during drilling, whichever is greater
- The final three consecutive water quality parameter measurements satisfy the following criteria:

Conductivity	=	±10%
pH	=	±10%
Temperature	=	±10%
Turbidity	=	<5 nephelometric turbidity units

The well development process is composed of:

- The application of sufficient energy in a monitoring well to create groundwater flow (surging) in and out of the well and the gravel pack to release and draw fines into the well.
- Pumping or bailing to draw any drilling fluids out of the borehole and adjacent natural formation, along with formation sediment from the well.
- Continue pumping until at least the quantity of potable water added and not previously removed during the drilling process has been purged, the parameters have stabilized, and the discharge water is visibly clear.

The general guidelines presented in this section are applicable to well development regardless of method.

3.6.1 Calculating Purge Volume

Before the development process begins, the minimum number of gallons to be removed will be calculated. The following information is needed to calculate purge volume:

- Total depth of well (TD)
- Measured static water level (WL)
- Screen length (SL)
- Well casing inner diameter (ID)
- Borehole Diameter (BD)
- Number of gallons of water used during well drilling/construction
- If the standing water column (SC) is longer than the screen length, the length of filter pack installed above the screen needs to be included in the borehole volume calculation.

The following procedure will be followed to determine the minimum volume of water to be removed during well development:

Total Purge Volume: $$V_t = 5\,(V_c + V_a n) \times 7.48 \text{ gal/ft}^3$$

where: V_t = Total Purge Volume (gallons)
V_c = Volume of water in well casing (cubic feet [ft^3])
$V_a n$ = Volume of water in well annulus (ft^3) Estimated porosity of sand pack (usually 30%)

$$\text{Casing Volume: } V_c = \pi\, r_1^2\, h_1$$

where: V_c = Casing Volume (ft^3)
r_1 = Inside radius of monitoring well casing (feet)
h_1 = Height of water column (feet) (that is, total well depth minus static water level depth)

$$\text{Annular Volume:} \quad V_a = \pi\, (r_2^2 - r_1^2)\, h_2$$

where: V_a = Annular volume (ft^3)
r_2 = Radius of borehole (feet)
r_1 = Outside radius of well casing (feet)
h_2 = Total vertical saturated thickness of sand pack (feet)

3.6.2 Bailing, Surging, and Pumping Procedures

In relatively clean, permeable formations where water flows freely into the borehole, a combination of surging, bailing, and pumping is an effective development technique. The following procedures will be followed when using this technique:

1. Tag the bottom of well to roughly estimate the amount of sand/silt within the well before and after surging.
2. Lower a bailer down the well to clean out any fines that may have settled on the bottom of the well.
3. Use a surge block to agitate the water, causing it to move in and out of the screen. Surging should be done in approximately 3- to 5-foot sections at a time along the length of the screen. This process draws in fines from the gravel pack and surrounding formation, and breaks up any bridges that may have occurred during the placement of the sand pack.
4. After surging for several minutes (depending on the height of the water column and length of screen), lower the bailer again to clean out any fines that were drawn into the casing as a result of surging. Continue this surge/bail technique until minimal fines are being pulled out with the bailer.
5. Lower a submersible pump down the well. Begin pumping at the top of the saturated portion of the screened interval to prevent sand from fouling the pump. The pump should be lowered at intervals of 5 feet or less until the pump is resting approximately 1 foot off the bottom of the well.
6. Monitor the water level continuously during the first few minutes of pumping in order to prevent drawing the water level below the pump intake and breaking the suction. Increase the discharge flow rate (if possible) until the well is pumping at its maximum yield without a drawdown beneath the pump. Continue pumping until volume and stabilization requirements are met.

3.6.3 Developing Wells in Low Hydraulic Conductivity Formations

Sometimes monitoring wells need to be installed in low hydraulic conductivity formations (for example, silts and clays) and thus are typically considered to be low-yield wells. Developing low-yield wells can be a lengthy process; the amount of time spent developing a low yield well is project-specific and will be determined individually for each project. For wells installed in clay or silt the method of development will be bailing only. Surging of such wells has been found to increase the turbidity of the water and does not improve hydraulic well response. These wells will be bailed dry a minimum of three times before development is considered complete and a record will be kept of the time it takes for the well to recharge 80 percent.

3.6.4 Documentation and Field Forms

Field details of monitoring well development will be recorded in either a field logbook or on a hardcopy Monitoring Well Development Form (Attachment A of the Field Sampling Plan). Field documentation procedures are outlined in SOP B.3, *Field Documentation*. The following information will be documented during well development:

- Project name
- Well location
- Weather locations
- Well identification number
- Installation date
- Date and time of development
- Measured total well depth (pre-development and post-development)
- Water levels (pre-development and post-development)
- Height of water column
- Pumping rate and water level drawdown (if applicable)
- Recharge rate (measured)
- Periodic water quality parameter readings
- Purge water observations (for example, color, odor)
- Type of equipment used
- Volume of water removed
- Completion date and time

3.7 Monitoring Well Abandonment

Temporary or permanent monitoring wells or boreholes should be abandoned, or sealed, to prevent the borehole or well from as acting as a conduit and/or to prevent cross contamination between hydrogeologic units. Boreholes and monitoring wells may be abandoned by sealing in place using grout or by removing or drilling out the well riser and sealing the remaining borehole. Surface casings may be abandoned by similar means.

3.7.1 Leaving the Well Screen and Riser and Sealing In-Place

Monitoring wells known to be constructed with an impermeable annular space seal may be abandoned by leaving the well riser in place and sealing the well by filling with grout.

1. The monitoring well screen and casing should be split or “ripped” prior to emplacement of the grout slurry whenever possible. This can be accomplished through the use of a casing splitting tool and drill rig. The splitting tool is attached to the lead drill rod and pushed down through the center of the monitoring well. As the tool is forced down, the splitting tool splits the polyvinyl chloride well casing and screen. This will allow better penetration of the grout slurry into the former annular space of the borehole and provide a more thorough grout seal.
2. Boreholes and monitoring wells should be completely filled with cement grout, bentonite-cement grout, bentonite grout, or concrete. The sealant should be delivered as a slurry which is pumped via a tremie pipe from the bottom of the borehole/monitoring well.

3. Following the completion of the grouting, the monitoring well stick-up or flush mounted protective cover and ground surface seal should be removed and the well riser should be cut off at least 24 inches bgs. The location should then be finished at ground surface with like material (for example, asphalt or concrete for paved areas and soil or sod in dirt or grass areas).

3.7.2 Well Riser Removal or Drilling Out and Sealing the Remaining Borehole

Monitoring wells that are not known to be constructed with an impermeable annular space seal should be abandoned by removing the well riser, if possible, or drilling out the well riser and then sealing the remaining borehole.

1. Prior to abandonment, the monitoring well stick-up or flush-mounted protective cover and ground surface seal should be removed.
2. The well riser may be removed by pulling on the riser or by overdrilling around the riser and then pulling the riser out of the ground. If it is not possible to remove the well riser, the well riser may be drilled over and removed from the borehole in pieces as the augers are removed from the borehole as borehole cuttings. The diameter of the auger used for the overdrilling should be at a minimum, the same size or larger than the diameter of the borehole to ensure that all of the well material is removed.
3. After the well riser is removed or drilled out, the remaining borehole should be sealed according to Section 3.7.1.

3.7.3 Surface Casing Removal for Double-Cased Wells and Sealing the Remaining Borehole

1. In the event that a surface casing is present around the well riser, information on the construction of the surface casing should be obtained, if possible. A decision must be made as to whether to remove the surface casing. If the integrity is uncertain, then the surface casing may be serving as a mode of cross connection. However, the assumption is that the surface casing does not fully penetrate the confining layer into which it is set, so it is often appropriate to leave it in place and abandon the well inside of it. The available information on the surface casing and its age and appearance should be considered in making this decision.
2. Any work to abandon the surface casing should be done after the well riser and screen have been removed and the borehole grouted up to the bottom of the surface casing. Otherwise, soil, groundwater, and possibly contamination may fall down the surface-casing borehole into the well borehole.
3. If the decision is made to leave the casing, it can be grouted up according to Section 3.7.1 and the aboveground part of the surface casing and any concrete pad removed.
4. If the decision is made to remove the surface casing, typically the surface casing should be overdrilled with a large auger and then removed. The borehole then is sealed according to Section 3.7.1. Alternatively, if the integrity of the annular seal appears to be poor, the surface casing may be removed by inserting an extraction tool in the surface casing, engaging it into the sides of the casing, and removing the casing accordingly. Again, the borehole then is sealed according to Section 3.7.1.

4.0 Decontamination and Waste Disposal

As stated in Section 3, before sampling begins, equipment will be decontaminated according to the procedures outlined in SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment* and the sample location noted in the handbook.

The soil cuttings are to be drummed and managed as described in the Investigative Derived Waste Management Plan.

5.0 Documentation and Field Forms

Field personnel will record all field sampling activities in the appropriate field form and/or field logbook as discussed in Section 3 and in SOP B.3, *Field Documentation*.

6.0 Quality Control

6.1 Equipment Cleaning

Sampling equipment that will be used at multiple sampling locations will be decontaminated after sampling at each location in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.

6.2 Quality Control Samples

- No quality control samples will be submitted for geotechnical analyses (for example, sieve, dry bulk density, USCS soil classification).
- Trip blanks will be submitted with every shipment of VOC samples.
- Field duplicates will be submitted at a frequency of 1 field duplicate per 10 normal samples per method as described in Section 5.9 of the Field Sampling Plan. Field duplicates will be collected in the same method and as close as possible to the original sample and submitted to the laboratory in a manner that prevents the laboratory from knowing the duplicate/parent sample relationships.
- Laboratory quality control samples (matrix spike [MS], matrix spike duplicate [MSD]) will be collected at a frequency of 1 MS/MSD per 20 normal samples per method. MS and MSD samples will be collected in the field as close as possible to and in the same method as the normal sample.
- Equipment blanks may be collected where non-disposable, non-dedicated sampling equipment is used. If collected, field personnel will collect equipment blanks by pouring the appropriate water into or over the decontaminated sampling equipment or vessel and then transferring the water to the sample bottles.

7.0 Attachments

Soil Boring Log

8.0 Relevant Literature

American Society for Testing and Materials (ASTM). 1985. Unified Soil Classification System.

American Society for Testing and Material (ASTM). 2000. ASTM D 1586, Standard Method for Penetration Test and Split-Barrel Sampling of Soils. *Annual Book of ASTM Standards*, Section 4, Vol 04.08.

American Society for Testing and Material (ASTM). 2000. ASTM D 1587, Standard Method for Thin-Walled Tube Sampling of Soils. *Annual Book of ASTM Standards*, Section 4, Vol. 04.08.

American Society for Testing and Material (ASTM). 2000. ASTM D 2487, Standard Test Method for Classification of Soils for Engineering Purposes. *Annual Book of ASTM Standards*, Section 4, Vol. 04.08.

American Society for Testing and Material (ASTM). 2000. ASTM D 2488, Standard Practice for Description of Soils (Visual-Manual Procedure). *Annual Book of ASTM Standards*, Section 4, Vol. 04.08.

American Society of Civil Engineers (ASCE). 1976. "Subsurface Investigation for Design and Construction of Foundations of Buildings." *American Society of Civil Engineers Manual on Engineering Practice*, No. 56, 53 pp.

Bell, F.G. 1981. *Engineering Properties of Soils and Rocks*. London: Butterworth Publishers, Inc.

Burmister, D.M. 1949. "Principles and Techniques of Soil Identification." *Proceedings of the Highway Research Board*, pp. 402-433.

Casagrande, A. 1947. "Classification and Identification of Soils." *American Society of Civil Engineers Transactions*, pp. 901-991.

Kovacs, W.D., L.A. Salomone, and F.Y. Yokel. 1981. *Energy Measurement in the Standard Penetration Test*. U.S. Dept. Commerce, National Bureau of Standards, Building Science Series 135.

Matula, M. 1981. "Rock and Soil Description and Classification for Engineering Geological Mapping. Report by the IAEG Commission on Engineering Geological Mapping." *Bulletin of the International Association of Engineering Geology*, No. 24, pp. 235-274.

Rice Engineering. 2012. Colorado Silica Sand Sieve Analysis. Accessed May 23, 2017. https://www.riceeng.com/PDFS/earth_sciences/environmental/2012%20Product%20PDF's/Colorado-Silica-Sand.pdf.

Sowers, G.F. 1979. *Introductory Soil Mechanics and Foundations: Geotechnical Engineering*. 4th edition. New York: MacMillan Publishing Co.

U.S. Bureau of Reclamation. 1974. *Earth Manual*. 2nd edition. Washington, D.C.: U.S. Government Printing Office.

SOP B.4 Attachment
Soil Boring Log

	PROJECT NUMBER	BORING NUMBER SHEET 1 OF
	# SOIL BORING LOG	

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

WEATHER CONDITIONS:

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS	VISUAL (%)		
	INTERVAL (FT)	NUMBER AND TYPE	RECOVERY (IN)	6"-6"-6" (N)	SOIL GROUP, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY,	STRUCTURE, SORTING, ODOR DEPTH OF CASING, DRILLING RATE, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole	GRAVEL	SAND	CLAY/SILT

SOP B.5 Downhole Geophysical and Flowmeter Logging

1.0 Purpose and Scope

This standard operating procedure (SOP) provides a general guideline for methods of downhole geophysical and flowmeter logging that are commonly used in investigations. The methods covered in this procedure include nuclear magnetic resonance (NMR), natural gamma, fluid resistivity/conductivity, temperature, deviation, induction resistivity, electromagnetic borehole flowmeter, and heat pulse flowmeter.

2.0 Equipment and Materials

- NMR logging tool
- Natural gamma logging tool
- Fluid resistivity/conductivity logging tool
- Temperature logging tool
- Deviation logging tool
- Induction resistivity logging tool
- Electromagnetic borehole flowmeter
- Heat pulse flowmeter

3.0 Procedures

3.1 Nuclear Magnetic Resonance Logging

The NMR logging method uses the physics of nuclear magnetic resonance to directly measure fluid hydrogen in groundwater. The downhole NMR sonde contains magnets that polarize the fluid hydrogen, creating a net nuclear magnetization with a magnitude proportional to the number of fluid hydrogen present. Radio-frequency coils within the probe transmit EM pulses to excite this hydrogen magnetization and to measure its time-varying behavior. The recorded NMR signal decays over time and provides useful information about the hydrogeologic properties of the investigated material.

The initial amplitude of the NMR signal directly reflects the quantity of hydrogen in the formation or the volumetric water content (porosity if saturated). The decay time of the signal, T_2, indicates whether the water is “bound” in small pores (for example, as in a silt) or is mobile in large pores (for example, a sand). In heterogeneous materials, the T_2 distribution provides an indication of the relative pore-size distribution with shorter T_2 components being associated with smaller pores and longer T_2 components being associated with larger pores. In the case of fracture porosity, T_2 can be considered sensitive to fracture dimension rather than pore dimension. Given the sensitivity to water content and pore size, the NMR data may also be used to estimate permeability or hydraulic conductivity. Nuclear magnetic resonance tools can be used in uncased, PVC-cased, or fiberglass-cased holes.

3.2 Natural Gamma Logging

Passive radioactivity logging methods measure the natural gamma-radiation with a natural gamma logging tool. Nearly all natural gamma rays in the earth come from potassium isotope 40 and decay products of uranium and thorium. These isotopes occur naturally in clay, making it possible to distinguish between sand and clay layers and to estimate the clay content. A natural gamma ray detector contains a sodium iodide crystal which gives a flash of light when struck by a gamma ray. The results of a gamma log are in counts per second. To compare measurements made with differently designed probes, the calibration is done in API (American Petroleum Institute) units according to international convention.

Natural gamma rays are usually highest in shales and clays. However, a small amount of clay or sand can sometimes yield a high response. A quantitative estimate of the amount of clay or sand in a layer cannot be obtained from a natural gamma log by itself. The interpretation of natural gamma logs is strictly qualitative. Natural gamma tools can be used in uncased, steel-cased, and PVC-cased holes.

3.3 Fluid Resistivity/Conductivity Logging

Fluid resistivity/conductivity logging provides a measurement of the resistivity/conductivity of the borehole fluid between closely spaced electrodes in the probe. Abrupt and significant changes in fluid resistivity/conductivity in the borehole may indicate the entry of groundwater of differing resistivity/conductivity into the borehole via fractures and other openings in the geologic formation surrounding the borehole. The logging record is taken continuously in units of ohm-meters.

Fluid resistivity/conductivity logging should be run at slow speeds to assure the proper flow of water through the tool. As long a time as possible should be allowed between drilling and logging the borehole so that the fluid resistivity/conductivity can equilibrate between the borehole and surrounding geologic formation. Fluid resistivity/conductivity tools can be used in uncased or PVC-cased holes.

3.4 Temperature Logging

Temperature logs are the continuous records of the temperature of the water in a borehole. They can provide information on the source and movement of groundwater into and out of the borehole. Generally, the temperature of the groundwater in the borehole will increase with depth with the geothermal gradient. Deviations from this general trend may indicate where groundwater is flowing up, down, into, or out of the borehole.

Temperature sensors have an inherent response lag, or time constant, so that the logging speed must be constant and slow enough that the temperatures are accurately reflected at the true depths on the log. The temperature log may be made using the same tool as the fluid-resistivity log. As long a time as possible should be allowed between drilling and logging the borehole so that the temperature can equilibrate between borehole and surrounding geologic materials. The temperature log should be one of the first logs run because other logging methods will disturb the water in the borehole. Temperature logging can be performed in uncased or cased holes.

3.5 Deviation Logging

Boreholes commonly deviate from the vertical. This deviation is oftentimes inconsistent, with both inclination and direction changing rapidly along the length of the borehole. This affects well completion and could affect future testing and logging in highly-deviated wells. This is especially the case in deeper boreholes that are often unintentionally deviated from the vertical as a result of drilling techniques, or bedding planes.

Deviation probes typically contain three magnetometers that measure direction relative to magnetic north and provide a record of the borehole’s departure from the vertical. Information on borehole deviation is also needed to calculate the true vertical depth to features of interest and to correct the strike and dip of fractures or bedding obtained from other geophysical logs. Deviation tools can be used in uncased, or PVC-cased, holes.

3.6 Induction Resistivity Logging

Induction tools are used to determine electrical conductivity/resistivity of the rock surrounding a borehole. A transmitter coil generates an alternating magnetic field around the borehole, which in turn induces electrical eddy currents that are proportional to the conductivity of the rock.

An induction tool usually contains two coil systems with different coil spacings and thus different investigation depths. Coil systems with several transmitter and receiver coils (5 – 6) are used to focus the field to minimize the influence of the borehole itself on the recorded signal. The investigation depth depends on the conductivity of the rock and is 60 – 350 cm for a dual induction log. The vertical resolution is about 150 cm for low conductivities and about 50 cm for higher conductivities. If the differences in conductivity are large, the resistivity curve recorded by focused systems overshoots the proper value when the logging tool passes the layer interface. In highly conductive rock, the signal is attenuated, due to the skin effect. Induction logging is particularly suitable for dry boreholes and those with plastic casing.

3.7 Electromagnetic and Heat Pulse Flowmeter Logging

Electromagnetic Flowmeters and Heat Pulse Flowmeters are used to measure the vertical groundwater flow within the borehole. Under non-pumping conditions, profiles of the vertical groundwater flow aid in the location of preferential flow zones and the apparent direction of vertical hydraulic gradients. Under pumping conditions, the flowmeter is useful for locating preferential flow zones and indicating the actual and percent contribution of each flow zone to the net groundwater flow within the open borehole.

In an electromagnetic flowmeter, an electromagnet is used to generate a magnetic field in a hollow cylinder within the tool. The flow of water (a conductor) through this magnetic field at a right angle to the field induces voltage that is measured by electrodes within the tool. This voltage is then used to calculate the velocity of the water through a fixed-diameter chamber, which is used to calculate a volumetric flow rate. Electromagnetic flowmeter measurements can be made while trolling (moving) in order to generate a continuous flow profile over a depth range or while stationary in order to measure flow at a specific location in the borehole. Under trolling conditions the movement of a flowmeter tool induces a measured flow in the direction opposite the direction of trolling. Measurements of ambient or stressed flow within the borehole are superimposed on the induced flow rates. An electromagnetic flowmeter with a fully fitted diverter can generally measure flow from 0.05 to 10 gallons per minute.

Heat-pulse flowmeter measurements are made with the tool at a stationary position in the borehole. A heat grid in the tool is activated to heat a packet of water in the borehole. If there is flow in the borehole, the heated packet of water will move with the flow toward the upper or lower sensor in the tool. The difference in temperature between the sensors is monitored. The equipment measures the time from when the heat grid was first activated to the moment when the greatest temperature change is detected by one of the sensors. This information is then used to calculate a rate of flow and direction of flow at that particular location and time. A heat pulse flowmeter with a fully fitted diverter can usually measure flow of 0.01 to 1.5 gallons per minute. It should be run at a constant logging speed slow enough that the groundwater temperatures are accurately reflected at the true depths on the log. In addition, the heat pulse flow meter log should be run once under non-pumping conditions and then under pumping conditions. Pumping conditions consist of installing a submersible pump into the water column above the tool and purging water from the well at a constant, low rate (below about 3.5 gallons per minute [gpm]). This low-flow pumping creates vertical movement of water from the borehole and induces flow from borehole fractures.

4.0 Key Checks and Preventative Maintenance

- The logging tools, cables and all other equipment coming into contact with groundwater or the inside of the well casing will be decontaminated before the first use on site, and between boreholes following SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.
- Ensure that subcontractor follows their procedures, particularly those for calibration of the instruments and the rate (speed) of logging. Logs are generally run in both the downward and upward directions.
- Obtain digital and printed copies of logs after each logging event. If the data were not recorded completely or properly, the subcontractor will be instructed to recalibrate the logging tools and to repeat the logging.
- Temperature and fluid resistivity/conductivity logs should be run first so that the disturbance caused by the other logging methods does not disrupt the results of these two methods.
- Adequate development of the well is important so that drilling fluids that may have been used in the borehole do not provide false readings of changes in fluid resistivity.

5.0 Documentation and Field Forms

All information concerning the logging activity will be recorded in a bound field logbook according to the procedures outlined in SOP B.3, *Field Documentation*. The date, time, and well number will be recorded on the paper printout of data from the data recorder.

6.0 Relevant Literature

United States Geological Survey (USGS). 2016. Vertical Flowmeter Logging. Groundwater Information: Hydrogeophysics Branch. https://water.usgs.gov/ogw/bgas/flowmeter/

Wonik, Thomas and Hinsby, Klaus. Borehole logging in hydrogeology. Section 4.8. p.107-122.

SOP B.6 Use of Data Loggers and Pressure Transducers

1.0 Purpose and Scope

This standard operating procedure (SOP) provides a guideline for the use of continuously recording data loggers and pressure transducers to monitor changes in water levels and barometric pressure. Procedures for using a particular type of data logger are not included and should be obtained from the equipment manuals.

2.0 Equipment and Materials

- Pressure transducers/continuously recording data loggers (for example, Schlumberger Mini-Diver DI 501 – 10 meter range) of adequate pressure ranges and cable lengths
- Laptop computer
- Electronic water-level meter (for example, Solinst) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Duct tape

3.0 Procedures

3.1 Key Checks and Preventative Maintenance

- Prior to each use, verify that the batteries are charged and that there is sufficient space in the data-logger memory for the data to be collected.
- Also prior to each use, the date and time should be synchronized between the data logger and the rugged reader or laptop.
- Ensure that all settings are appropriate for the transducer pressure range and the type of test.
- Protect the logger from inclement weather and vandalism.

3.2 Data Logger Procedures

The procedures for using the specific model of data logger should be obtained from the equipment operating manuals. In general, all data loggers have a means of specifying such data as the pressure range of the transducer, the type of monitoring to be performed (for example, slug test), the frequency of measurements, the length of the test, and the number of transducers to be monitored.

3.3 Pressure Transducer Procedures

Transducers should be selected with the appropriate pressure range for the expected range of water-level or barometric changes. A change of 1 pound per square inch (psi) of pressure is equivalent to a change of 2.3 feet of water level.

For downhole applications, measure the initial water level with the water-level meter. Lower the transducer into the piezometer or well until it is at least 2 feet below the water surface. Tape the transducer cable to the casing or affix the cable holder to the locking cap or stickup with zip-ties so that the transducer does not move in the piezometer or well. Attach the transducer cable to a rugged reader or a port on the back of a laptop computer. Connect to the transducer and confirm that the transducer is at the proper depth in the water by reading the data logger. Program the data logger for the appropriate frequency of data collection.

Transducers for measuring barometric pressure are attached to a secure fixture (for example, casing or light post) and are programmed with the rugged reader or laptop. Transducers for measuring the changes in water level in surface-water bodies are attached to a weight and lowered to the bottom. The depth of water above the transducer can be read from the data logger. Care should be taken to prevent the cable from interfering with boat or other surface water traffic.

4.0 Documentation and Field Forms

Field personnel will record all field sampling activities in the field logbook and appropriate field forms as outlined in SOP B.3, *Field Documentation*. The master field logbook will be maintained by the field team leader.

SOP B.7 Aquifer Testing

1.0 Purpose and Scope

This standard operating procedure (SOP) provides guidance for the implementation of aquifer tests. Aquifer testing generally involves displacing fluid in a well and monitoring the response(s) of water levels in one or more nearby wells. Several types of information can be gained from this displacement-response data, including the following:

- Estimates of hydraulic properties of the aquifer governing groundwater flow, such as transmissivity, horizontal hydraulic conductivity, and storativity.
- Hydraulic connections between aquifers or layers in a stratified aquifer
- Hydraulic boundaries (that is, no-flow or recharge) that may influence groundwater flow
- Extraction well performance

This information supports development of the hydrogeological conceptual model, numerical modeling of groundwater flow and contaminant transport, and design of groundwater extraction systems, where applicable.

There are two types of aquifer tests: instantaneous change in head (or “slug”) tests and pumping tests. This SOP describes the field procedures for both types of tests. The procedures given here are based on guidance by the U.S. Geological Survey (USGS, 2010) and U.S. Environmental Protection Agency (EPA) (1993).

2.0 Slug Tests

2.1 Equipment and Materials

1. Tools or key to open the well.
2. Field logbook and field forms for data entry with waterproof paper and waterproof black or blue pens.
3. Well-construction diagram.
4. Slug of polyvinyl chloride (PVC) or other relatively inert material, such as the following:
   - Solid steel fitted with an eye bolt at one end to affix a bailing line
   - Stainless steel or Teflon bailers
5. The slug should be about 1-inch less in diameter than the inside diameter of the well and should be a length of between about 3 and 5 feet. If hollow pipe is used, the slug can also be filled with clean silica sand and capped.
6. Nylon cord or other strong line of sufficient length to reach below the water level in order to secure the slug.
7. Wooden or metal rod, or 2 × 4 piece of lumber to secure the slug line at the surface
8. Vented pressure transducer and data logger rated for 10 pounds per square inch (psi) with direct-read cable and field or laptop computer
9. Electric water level indicator

10. Personal protective equipment
11. Decontamination supplies (bucket, spray bottle of detergent/water mixture, spray bottle of distilled water, garbage bags, paper towels)

2.2 Procedures

1. Confirm well identification with well-construction diagram
2. Measure the water level in the well and record in the field forms.
3. Measure the total depth of the well and record in field forms.
4. Determine the appropriate depth for placement of the transducer. This depth should be at least 10 feet below the static water level and at least 2 feet above the bottom of the well, if possible. The transducer should also be placed below the depth at which the slug will be emplaced.
5. Mark the depth of placement of the transducer with duct or electrical tape on the cable.
6. Zero the transducer to atmospheric pressure.
7. Lower the transducer to the indicated depth.
8. Affix the transducer cable to an immovable object at the surface, such as the well casing. The cable should be secured in at least two ways to ensure that it does not move during testing. For example, the cable could be secured with a combination of zip ties, alligator clips, and/or duct tape.
9. Connect the transducer to the field computer and check the depths that the transducer is reading—check that the depth compares well with the planned deployment depth minus the depth to water. If the readings are inaccurate, retrieve the transducer and deploy again, ensuring that the transducer is hanging freely in the well. If inaccuracies persist, the transducer may be defective and require replacement.
10. Allow the transducer to equilibrate upon deployment according to the manufacturer's guidance.
11. Allow water levels to equilibrate following deployment of transducer.
12. Measure and record the static water level after equilibration.
13. While the transducer and water levels are equilibrating, prepare the slug.
    a. Affix the slug to the slug line.
    b. Measure the maximum length of slug line that will be used. This length should allow the slug to completely submerge, at least 1 feet below water surface. A piece of duct tape or zip ties can be affixed to the line to indicate the depth of slug emplacement.
    c. Connect the top of the slug line with a 2 × 4 or similar equipment that will be used to secure the slug at the surface.
14. Program the transducer for data collection:
    a. Ensure that the transducer has adequate memory and battery power (that is, at least 80%).
    b. Synchronize the transducer clock to the field PC clock.
    c. Create a file and title appropriately (for example, "well name_slug_in").
    d. Set the reference to static water level so that the transducer is reporting changes in
    e. The reference point should be the static water level from Step 7 so that the transducer records "Level – Distance to Water."

f. Set the recording frequency to logarithmic, adjusted as needed to meet the objectives of the test; do not start recording until the slug is emplaced.

15. On a pre-determined count, lower the slug rapidly but gently to the planned depth and start the data logger (this simultaneous lowering of the slug and starting of the data logger will require two people).
16. Affix the top of the slug line to a stable surface (for example, a 2 × 4 placed across a flush-mount wellhead or tied to a tow-hitch on the back of a work truck). The slug should not move once it has been emplaced.
17. Allow the data logger to complete its logarithmic data recording cycle (several minutes).
18. Take a manual water level measurement and check the data being collected by the transducer/data logger.
19. Check water levels periodically thereafter. Once the well has equilibrated to at least 90 to 95 percent of static water level, or readings change less than 0.01 foot per 10 minutes, the test can be terminated by stopping the data logger. At this point, a slug-withdrawal, rising head test will be conducted as follows:
    a. Measure and record the initial water level.
    b. Start a new data collection file for the transducer/data logger (for example, "well name_slug_out").
    c. Configure the transducer data logging similarly to the previously described methods.
    d. Initiate the slug out test by starting the data logger and nearly simultaneously withdrawing the slug quickly but gently from the water to minimize disturbance at the water surface or movement of the transducer cable. The slug must be removed from the water column; however, it is not necessary to completely remove it from the well.
    e. After several minutes and periodically thereafter, check the water level and transducer data: the test can be terminated when water levels stabilize according to the criteria described in Step 18.
20. It is recommended that this cycle of slug-in, slug-out testing is repeated at least once more, time allowing, to allow for assessment of reproducibility of the results.
21. Decontaminate all equipment placed down the well according to SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.

3.0 Pumping Tests

3.1 Equipment and Materials

1. Pressure transducers and automatic data loggers. Equipment will be of appropriate pressure rating and will provide instantaneous digital readings of water levels in the pumping and observation wells.
2. Barometric pressure transducer and automatic data logger (for example, BaroTroll).
3. Submersible pump with an appropriate capacity for "stressing" the aquifer and variable speed control (for example, Grundfos 3-inch diameter submersible pump or equivalent).
4. Service rig (for example, hoist truck) and associated equipment for pump deployment.
5. Pump/discharge line assembly, including secondary containment as approved by the project environmental manager.

6. Drop pipe for pump assembly should be of stainless steel or PVC. An in-line check valve will be included within the drop pipe to reduce the potential for backflow of purge water from the drop pipe into the pumping interval after shutting off the pump.
7. In-line digital flowmeter/totalizer, in-line adjustable/variable discharge control valve, and in-line sample port on the pump discharge piping.
8. Electrical water level indicators
9. Boring logs and well construction diagrams
10. Laptop computer and field computer for programming transducers
11. Stopwatch
12. Calculator
13. Log book
14. Decontamination and spill containment equipment
15. 55-gallon drums and labels
16. Generator(s) when onsite power is not available
17. Barometric pressure logger
18. Frac tanks for containerizing discharge water if permission is not granted to discharge to the sanitary sewer
19. Personal Protective Equipment
20. Water sampling equipment, bottles, containers, coolers, and ice if samples are to be taken
21. Hand-held radios or cellular telephones.

3.2 Procedures

Aquifer testing will proceed in three stages: (1) development and step-testing (optional), (2) background water level data collection, and (3) constant-rate testing. The following sections provide the procedures for each phase.

3.2.1 Step-Testing

1. The discharge line mush be leak checked (that is, with air or potable water) before beginning the test program by running air or potable water through the discharge line.
2. During development of a well planned for subsequent pumping tests, a pressure transducer/data logger should be deployed during development to between 3 and 5 feet from the top of the pump. The data logger must be rated for the appropriate pressure considering the depth of submergence. The data logger should be programmed to record depth data at least once per minute.
3. During development, the well should initially be pumped at a low rate (for example, less than 5 gpm for testing of a 4-inch well screened across coarse-grained units) to estimate the specific capacity (drawdown per unit discharge) of the well according to Equation (1):

$$S.C. = \frac{H_o - H_i}{Q} \quad (1)$$

where:

H_i = initial water level (feet)
H_o= observed pseudo steady-state water level in response to pumping (feet)
Q = discharge rate (gpm)

4. Based on the estimated specific capacity, step-discharge testing could be performed either during development or after development and before performing the constant rate pumping test. The step testing would be performed to help choose an appropriate rate for the constant rate testing. From the initial specific capacity estimate, at least 3 to 4 discharge rates should be chosen (for example, at rates estimated to result in 20%, 40%, 60%, and 80% of maximum available drawdown).
5. Each step will be performed until drawdown stabilizes. If drawdown has not stabilized within 2 hours, the project team will contact the task or project manager to discuss options for next steps, including possibly reducing the rate and terminating the step test.
6. Manual water level measurements will be collected during step testing at least once every 10 minutes.
7. Water levels in the pumping well will be monitored in real time based on the transducer readings. If water level drops quickly, the pumping rate will be reduced to a lower steady rate. Record the time and adjustments made for correlation and post-processing of the transducer data set.
8. Discharge rates will be monitored with an in-line flowmeter/totalizer, periodically checked with "bucket tests," or timing the rate at which a known-volume container fills.
9. All downhole equipment (for example, pump and water-level monitoring devices) and discharge line components must be decontaminated before and after use.
10. Discharged water will be controlled at the well head, containerized and stored in onsite frac tanks if permission is not granted to discharge to a sanitary sewer access point.
11. Water-level measuring devices, flowmeters, and pressure transducers must be calibrated and tested where appropriate before actually being used in a test program. Calibration (source check) of transducers may be accomplished by submerging all transducers in a column of water and verifying that each unit provides comparable measurement readings.

3.2.2 Background Water Level Measurement

1. Prior to initiating the constant rate tests, a period of background water level data collection will be performed on the pumping and observation wells. The objectives of this background data collection period are to characterize ambient water level trends, to monitor for other influences beyond the test pumping, and to gauge atmospheric pressure influences on water levels.
2. During this period, pressure transducers will be deployed to the target in the pumping well and observation wells, with static water levels measured with an electric water level indicator concurrent with deployment and recorded in the field logs. The target depths for deployment of transducers in observation wells is approximately 15 feet below static water level to enable use of a 10 psi instrument. The target depth of the transducer in the pumping well will be selected based upon the depth of placement of the pump (at least 3-5 feet from the bottom of the well); the transducer placement will be at least 2-3 feet from the top of the pump (if possible) and at least 10 feet below maximum anticipated drawdown (if possible). These distances can be marked on the transducer cable with duct tape. These deployment depths will be documented in field logs.
3. A barometric pressure logger will also be deployed in the vicinity of the pumping well.
4. Prior to deployment, zero the transducers to atmospheric pressure (for vented instruments).
5. Upon deployment to the target depths, secure the transducer cables with at least two methods, such as with zip ties, alligator clips, and/or duct tape, to an immobile object at the surface (for example, the surface completion).

6. The transducers will be programmed to record data in at least 10-minute increments during the background data collection period, which will ideally be at least one week following development/step testing (field schedule allowing).
7. The reference point should be the static water level so that the transducer records “Level – Distance to Water.”
8. Check the transducer depth readings against the static water levels.

3.2.3 Constant Rate Pumping Tests

1. Generators and electrical power systems will be tested prior to commencing the tests. Generators must be fully fueled and of an appropriate size to provide uninterrupted power throughout the test.
2. Well caps will be left open on all wells with pressure transducers installed so that atmospheric pressure fluctuations are not inhibited in the well.
3. Water level measurements in all wells will be taken manually just before beginning any test from the pumping well and all observation wells.
4. All transducer clocks and clocks/watches used by field personnel must be synced to one testing “master” clock.
5. The transducers deployed in observation wells will be programmed to record data in at least 10-minute increments; the transducers deployed in pumping wells will be programmed as follows:
   - Background logging will be done at the same frequency as other observation wells
   - A new log will be set up to record data logarithmically, adjusted as needed to meet the objectives of the test, immediately prior to pumping to maximize capture of early-time data. This logging must be started simultaneously with the start of pumping.
   - Another log will be set up just prior to cessation of pumping to record recovery data logarithmically. This log must be started simultaneously with shut-down of the pump. The time between stopping the pumping log and starting the recovery log should be minimized to the extent practical.
6. The pumping well setup will include deployment of an electric submersible pump with variable rate control to a depth of at least 2-3 feet from the bottom of the well. The drop pipe must be connected to several feet of straight runs of pipe to the inlet and outlet of an in-line flowmeter, sampling port, and gate-type valve for adjustment of flow rate. Discharge will be routed to a sanitary sewer access point (permission pending), or to a temporary storage tank at the surface.
7. Upon pump startup, the discharge rate will be brought up to the target rate as soon as possible (ideally within 1-2 minutes).
8. Manual water level measurements should be taken and recorded from the pumping well as frequently as practical for the first 15 minutes of the test. Manual measurements should be taken at least hourly from all wells thereafter, with measured depths compared to transducer readings.
9. Discharge rate should be monitored closely and recorded in field forms in the first hour after start-up with checks of flowmeter measurements against “bucket” tests, and should not be allowed to vary by more than about 10 percent from the target rate. Discharge rates should be checked with cross-checks of flowmeter and bucket test measurements at least hourly thereafter with deviations from the target rate and adjustments noted thereafter. While deviations from the target rate are not desirable, they can be accounted for in subsequent data analysis as long as the amount of deviation and time of deviation is known accurately.

10. When the pumping portion of the test is complete, the pump will be shut down and manual water level measurements should be taken as frequently as possible from the pumping well for the first 15 minutes of recovery.
11. Pumping equipment will be retrieved and decontaminated.
12. Transducers will be left in the wells for up to one week to record recovery and ambient trend data.
13. All equipment will be decontaminated according to SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*, following retrieval after the recovery period.

4.0 References

U.S. Environmental Protection Agency (EPA). 1993. Suggested Operating Procedures for Aquifer Pumping Tests. EPA/540/ S-93/503. p. 23.

U.S. Geological Survey (USGS). 2010. "GWPD 17—Conducting an Instantaneous Change in Head (Slug) Test with a Mechanical Slug and Submersible Pressure Transducer. Version 2010.1. Accessed January 24, 2017. https://pubs.usgs.gov/tm/1a1/pdf/GWPD17.pdf.

SOP B.8 Groundwater Elevation Measurements

1.0 Purpose and Scope

This standard operating procedure (SOP) discusses the method for collecting groundwater elevation measurements in completed wells, piezometers, or temporary wells using electric water level indicators.

2.0 Equipment and Materials

- Electric water-level indicator
- Disposable gloves
- Distilled water
- Cleaning detergent
- Field form and/or logbook

3.0 Procedures

1. Prior to opening the well don personal protective equipment as required.
2. Open and unlock the well; note the condition of the well and well completion in the field logbook and/or the field form if applicable
3. Test the sounder prior to operation to check the battery condition. Replace the battery if necessary.
4. Lower the probe slowly into the well. Upon contact with water, the buzzer should sound and the sound and indicator light should glow. Raise and lower the probe slightly a few times to confirm the accurate point of contact and the measuring point on the casing or wellhead.
5. Record the location, date, time, and water level in the field logbook or applicable field form.
6. Decontaminate probe according to the procedures in SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.
7. Lock and secure the well after water level measurements/sampling is complete.

SOP B.9 Low-flow Groundwater Sampling from Monitoring Wells

1.0 Purpose and Scope

This standard operating procedure (SOP) presents general guidelines for the collection of groundwater samples from monitoring wells using low-flow purging and sampling procedures. Equipment manuals should be consulted for specific calibration and operating procedures.

2.0 Equipment and Materials

- Meter to monitor pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), specific conductance (SC), turbidity, and temperature (for example, YSI 6920 V2).
- Flow-through cell with inlet/outlet ports
- Water-level indicator
- Inert gas tank (for example, nitrogen) and regulator
- Bladder pump controller (for example, Geotech BP Controller 300/500 PSI), air hoses, and adapters
- Disposable polyethylene tubing
- Calibrated bucket or other container and watch with second hand to determine flow rate
- Container for purge water
- Disposable gloves
- Plastic sheeting
- Sample containers
- Sample labels
- Sharpie pen
- Calculator
- Cleaning detergent
- Distilled water
- Paper towels
- Plastic sheeting
- Well construction information
- Shipping supplies (cooler, ice, plastic resealable bags, custody seals, chain-of-custody forms)
- Field form and/or logbook

3.0 Procedures

3.1 Setup and Purging

1. Obtain information on well location, diameter(s), depth, screened interval(s), and the method for the disposal of purge water.
2. Calibrate instruments each workday prior to sampling according to manufacturer's instructions. The calibration information (date, time of calibration, standards used, readings before and after calibration) should be recorded on the field form.
3. Record the well number, site, date, and condition in the field logbook and on the field sampling form.

4. Place plastic sheeting on the ground and unblock and open the well. Don personal protective equipment as required prior to opening the well. Place all decontaminated equipment to be used on the plastic sheeting until after the sampling has been completed.

5. Clean and decontaminate all non-dedicated sampling equipment and any other equipment to be placed in the well in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment.*

6. Collect the static water level in accordance with SOP B.8, *Groundwater Elevation Measurements.*

7. Calculate the volume of water in the pump and tubing using the well diameter, static water level, tubing length, and volume per foot of tubing (available from the manufacturer). The minimum volume to be purged from the well is two times the volume of the tubing and pump.

8. Insert the meter into the flow-through cell and attach the tubing from the pump to the flow-through cell inlet at the base of the flow-through cell. Attach polyethylene tubing to the discharge port at the top of the flow-through cell to the purge water container.

9. Connect the air-in and air-out hoses to the bladder pump controller, inert gas tank, and pump tubing. Open the tank valve.

10. Begin purging the well. Adjust the tank pressure and bladder pump controller to set an initial purge rate of 0.2 to 0.5 liter per minute. Record the initial purge rate and the initial field parameters for pH, ORP, DO, SC, turbidity, and temperature in the field form. To measure the purge rate time, the filling of a 0.5-liter measuring cup graduated in 50-millilter increments and divide the volume of water by the time in minutes.

11. Record observations about the color, turbidity, and odor (if present) of the purge water. Record observed changes in the field form during purging.

12. Record the water-level, purge volume, and field parameters in 5-minute increments. Adjust the purge rate as necessary to eliminate or minimize drawdown in the well (that is, set the purge rate to equal the well recharge rate). Drawdown should not exceed 0.30 foot. Purge rate should not exceed 1 liter per minute. Record any adjustments to the purge rate in the field form.

13. Field parameters are considered stabilized when the measurements meet the following criteria for three consecutive readings:

Conductivity	± 10%
pH	± 0.2 units
Temperature	± 1 degree Celsius
Dissolved Oxygen	± 0.2 mg/L
ORP	± 10 millivolts
Water Level	± 0.1 foot

14. Any alterations from the above procedures will be noted on the field form. If stabilization criteria cannot be met prior to sampling, the project manager will be consulted to determine whether further purging is necessary or whether sampling can be initiated.

15. Prior to sample collection, pause pumping and remove the meter and flow-through cell from the pump discharge line. Discharge purge water in the flow-through cell into the purge water container.

3.2 Sample Collection

The well should be sampled immediately after the water quality parameters have stabilized (dependent on well recovery). Samples will be collected in bottles appropriate to the respective analysis. Sample labels will follow the naming convention defined in the SAP/QAPP and be applied to each sample container and include the following information:

- Sample name/number
- Time and date of sample collection
- Site name and location
- Project number
- Sample type and matrix
- Container
- Preservative
- Analysis Method

The following information will be recorded on the field form prior to sample collection:

1. Site name and location
2. Weather conditions
3. Sample name/number
4. Sampler identity
5. Field observations and measurements
6. Date and time of sample collection
7. Sample type(s)
8. Number of sample containers

Sample collection will proceed as follows:

1. Disposable gloves and eye protection should be worn at all times during sample collection. Gloves should be replaced if they are compromised or contaminated.
2. Samples should be collected directly from the well discharge line at the same flow rate at which the monitoring well was purged or lower.
3. Samples collected for volatile organic compounds (VOCs) should be collected first. If necessary, reduce the pumping rate prior to sampling volatile organic compounds to prevent bubbles and splashing. The flow rate should not be reduced below the volume necessary to fill a VOC container. VOC bottles should be filled above the brim to eliminate air bubbles without splashing or over-diluting the container preservative.
4. If any sample analysis requires filtration, a disposable in-line filtration module should be used.
5. Cap each sample container and label as described above. Pack samples in the cooler with ice as soon as practical.
6. Collect and analyze groundwater for additional field parameters if any (that is, total nitrogen or alkalinity). Record results on field form.
7. Sample equipment should be decontaminated after sample collection per the procedures outlined in SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment.*

4.0 Documentation and Field Forms

Field personnel will record all field sampling activities in the field logbook and appropriate field forms as outlined in SOP B.3, *Field Documentation*. The master field logbook will be maintained by the Field Team Leader.

5.0 Quality Control

5.1 Equipment Cleaning

Sampling equipment that will be used at multiple sampling locations will be decontaminated after sampling at each location in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.

5.2 Quality Control Samples

- Trip blanks will be submitted with every shipment of VOC samples.
- Field duplicates will be submitted at a frequency of 1 field duplicate per 10 normal samples per method as described in Section 5.9 of the Field Sampling Plan. Field duplicates will be collected in the same method and as close as possible to the original sample and submitted to the laboratory in a manner that prevents the laboratory from knowing the duplicate/parent sample relationships.
- Laboratory QC samples (matrix spike [MS], matrix spike duplicate [MSD]) will be collected at a frequency of 1 MS/MSD per 20 normal samples per method. MS and MSD samples will be collected in the field as close as possible to and in the same method as the normal sample.
- Equipment blanks may be collected where non-disposable, non-dedicated sampling equipment is used. If collected, field personnel will collect equipment blanks by pouring the appropriate water into or over the decontaminated sampling equipment or vessel and then transferring the water to the sample bottles.

SOP B.10 Groundwater Sampling Procedures for Low-Yield Wells

1.0 Purpose and Scope

This standard operating procedure (SOP) provides general guidelines for groundwater sampling from wells with slow recharge rates that cannot be sampled using low-flow methods.

2.0 Equipment and Materials

- Equipment for purging and sampling the well (for example, bailer and cord, peristaltic pump and disposable tubing. For wells instrumented with bladder pumps, see the equipment and materials list in SOP B.9, *Low-flow Groundwater Sampling from Monitoring Wells.*
- Water-level indicator
- Meter to monitor pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), specific conductance (SC), turbidity, and temperature (for example, YSI 6920 V2).
- Extra-long cord and screen for water-quality meter (optional; for measuring water-quality parameters in situ)
- Container for purge water
- Disposable gloves
- Plastic sheeting
- Sample containers
- Sample labels
- Sharpie pen
- Cleaning detergent
- Distilled water
- Paper towels
- Well construction information
- Shipping supplies (cooler, ice, plastic resealable bags, custody seals, chain-of-custody forms)
- Field form and/or logbook

3.0 Procedures

3.1 Prior to Sampling

1. Obtain information on well location, diameter(s), depth, screened interval(s), and the method for the disposal of purge water.
2. Calibrate instruments prior to sampling according to manufacturer's instructions. The calibration information (date, time of calibration, standards used, readings before and after calibration) should be recorded on the field form.
3. Record the well number, site, date, and condition in the field logbook and on the field sampling form.
4. Place plastic sheeting on the ground and unlock and open the well. Don personal protective equipment as required prior to opening the well. Place all decontaminated equipment to be used on the plastic sheeting until after the sampling has been completed.
5. Clean and decontaminate all sampling equipment and any other equipment to be placed in the well in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment.*

3.2 Purge/Recovery

1. Measure the static water level in accordance with SOP B.8, *Groundwater Elevation Measurements.*
2. Purge the well completely. If the well is instrumented with a bladder pump it can be purged using the procedures outlined in SOP B.9, *Low-flow Groundwater Sampling from Monitoring Wells.* If the well is not instrumented with a pump it can be purged with a bailer or peristaltic pump. The volume of water removed from the well should be documented on the field form and/or logbook.
3. Allow the water level to recover to 90 percent of the pre-purge water column thickness. If necessary, the well can be left to recover overnight. If possible, the well should be sampled within 24 hours of purging. Sample collection procedures are described in Section 3.3.
4. After sample collection water-quality parameters can be collected depending on the available volume of water in the well. Water-quality parameters can be measured by either lowering a calibrated water-quality meter into the well to measure the parameters in situ or by filling the meter calibration cup with sample water. If collected the parameters and method should be recorded on the appropriate field form.

3.3 Sample Collection

Samples will be collected in bottles appropriate to the respective analysis. Sample labels will follow the naming convention identified in the SAP/QAPP and be applied to each sample container. Sample labels will include the following information:

- Sample name/number
- Time and date of sample collection
- Site name and location
- Project number
- Sample type and matrix
- Container
- Preservative
- Analysis method

The following information will be recorded on the field form prior to sample collection:

1. Site name and location
2. Weather conditions
3. Sample name/number
4. Sampler identity
5. Field observations and measurements
6. Date and time of sample collection
7. Number of sample containers and types of samples collected

Sample collection will proceed as follows:

1. Disposable gloves and eye protection should be worn at all times during sample collection. Gloves should be replaced if they are compromised or contaminated.
2. Samples should be collected directly from the well discharge line at the same flow rate at which the monitoring well was purged or lower.
3. Samples collected for volatile organic compounds (VOCs) should be collected first. If necessary, reduce the pumping rate prior to sampling volatile organic compounds to prevent bubbles and splashing. The flow rate should not be reduced below the volume necessary to fill a VOC container. VOC bottles should be filled above the brim to eliminate air bubbles without splashing or over-diluting the container preservative.
4. If any sample analysis requires filtration, a disposable in-line filtration module should be used.
5. Cap each sample container and label as described above. Pack samples in the cooler with ice immediately after sample collection.
6. Collect and analyze groundwater for additional field parameters if any (that is, total nitrogen or alkalinity). Record results on field form.
7. Sample equipment should be decontaminated after sample collection per the procedures outlined in SOP B.2, *Decontamination Procedures for Personnel and Equipment.*

4.0 Documentation and Field Forms

Field personnel will record all field sampling activities in the field logbook and appropriate field forms as outlined in SOP B.3, *Field Documentation*. The master field logbook will be maintained by the Field Team Leader.

5.0 Quality Control

5.1 Equipment Cleaning

Sampling equipment that will be used at multiple sampling locations will be decontaminated after sampling at each location in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.

5.2 Quality Control Samples

- Trip blanks will be submitted with every shipment of VOC samples.
- Field duplicates will be submitted at a frequency of 1 field duplicate per 10 normal samples per method. Field duplicates will be collected in the same method and as close as possible to the original sample and submitted to the laboratory in a manner that prevents the laboratory from knowing the duplicate/parent sample relationships.
- Laboratory QC samples (matrix spike [MS], matrix spike duplicate [MSD]) will be collected at a frequency of 1 MS/MSD per 20 normal samples per method. MS and MSD samples will be collected in the field as close as possible to and in the same method as the normal sample.
- Equipment blanks may be collected where non-disposable, non-dedicated sampling equipment is used. If collected, field personnel will collect equipment blanks by pouring the appropriate water into or over the decontaminated sampling equipment or vessel and then transferring the water to the sample bottles.

SOP B.11 ZIST Groundwater Sampling

1.0 Purpose and Scope

This standard operating procedure (SOP) presents general guidelines for the collection of groundwater samples from monitoring wells equipped with multilevel ZIST pumps (manufactured by BESST, Inc.).

2.0 Equipment and Materials

- Inert gas tank (for example, nitrogen) and regulator
- ZIST 4-Channel timer-control unit (requires a 120-volt power source)
- ¼-inch nylon high pressure tubing fitted with a ¼-inch tube fitting hex nut ferruled onto one end and a quick-connect on the other
- ¼-inch Teflon tubing fitted with a ¼-inch tube fitting hex nut ferruled onto one end
- Two small crescent wrenches (for tightening fittings)
- Stop watch
- Calibrated water quality meter to monitor pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), specific conductance (SC), turbidity, and temperature (for example, YSI 6920 V2).
- Cup for measuring water-quality parameters
- Disposable polyethylene tubing
- Disposable gloves
- Properly labeled container for purge water
- Sample containers
- Sample labels
- Sharpie pen
- Calculator
- Well construction information
- Shipping supplies (cooler, ice, plastic resealable bags, custody seals, chain-of-custody forms)
- Field form and/or logbook

3.0 Procedures

3.1 Setup

1. Don appropriate personal protective equipment (PPE) prior to opening the well
2. Attach a length of nylon high pressure tubing to the gas out fitting of the pressure gauge. The other end of the nylon tubing should be fitted with a quick-connect.
3. Plug in the four-channel timer-control unit to a 120-volt power source rated for at least 500 watts.
4. Attach the quick-connect from the nylon tubing to the gas-in port on the timer-control unit.

5. Locate the gas-in line for the ZIST pump. Each ZIST pump is equipped with a gas-in line and a sample-return line and should be marked accordingly.
6. Attach the ZIST gas-in line to the timer control unit using a length of nylon high pressure tubing fitted with a quick-connect and a ¼-inch fitting hex nut. Up to four gas-in lines can be connected to the timer-control unit.
7. Connect one end of a ¼-inch Teflon tube to the ZIST sample-return line and **securely fasten** the other end to the purge container.
8. Repeat steps 5 through 7 for each ZIST pump.
9. Tool tighten all tube fitting connections (quick-connects do not need to be tool tightened).
10. Rotate the regulator T-handle counterclockwise to ensure the pressure regulator is fully "closed."
11. Slowly open the dial on top of the nitrogen tank. Set the pressure output of the regulator to the highest pressure used for each zone to pressurize the timer-control unit.

3.2 Purging

1. Set the red ON-time dial on the timer control unit somewhere above zero on the gauge. Set the OFF-time dial below the zero. This means the pressure will continually stay ON, pushing nitrogen gas with no OFF-time.
2. Push the manual switch on the timer control unit to the ON position. Because the OFF dial is set below zero, the system will turn ON immediately and nitrogen gas will begin to flow into the gas-in tubing.
3. Adjust the zone-specific pressure gauge to the required pressure.
4. Gas will now be pushing the water in the tubing to the surface. Be prepared to flip the manual on/off switch to the OFF setting right before the water finishes purging.
5. Water should begin streaming out of the sample-return line. The sound of the system will intensify as it finishes pushing out the water. **Warning: the water will be followed by a burst of pressurized nitrogen gas along with a water droplet spray. Take precautions (PPE, safe distance) to prevent injury or splashing of purge water.**
6. Purging is complete once the discharge of water is followed by a loud exhalation of gas and spray. **Turn the system off with the manual ON/OFF switch.**
7. Allow the system to fully recharge (5-10 minutes) before finishing the purge cycle.
8. Determine the zone's purge ON-time by purging the system again while taking a time measurement and measuring the volume of water discharged from the tubing.
9. Leave the pressure settings the same as was used in the first purge cycle.
10. Flip the manual switch to the ON position while starting a stopwatch timer.
11. Flip the manual switch to the OFF position several seconds before the system fully purges and the exhalation of gas and spray is emitted to save on time and gas.
12. Stop the stopwatch timer at the exact moment that the discharge changes from water to gas and the system exhales.
13. Record the volume purged and the time recorded on the stopwatch.
14. Calculate the purge time by subtracting 15 seconds from the time recorded in step 13. This is to reduce the wasted volume of nitrogen gas.

15. Record the calculated purge time.
16. Test the calculated purge time by setting the OFF-time to 5 minutes. Set the ON-time to the calculated purge time. Flip the switch to the “ON” position. The OFF-time will begin, allowing the system to recharge fully. The ON-time will be correct if the system switches off right before the system fully purges.
17. Record the time for the OFF cycle by starting the stopwatch when the OFF cycle begins. Stop the stopwatch when no nitrogen is being expelled from the sample-return tube.
18. Record the ON and OFF times and the psi on the zone-specific pressure gauge.

3.3 Priming the System

When sampling volatile organic compounds (VOCs) it is unacceptable for the water/gas interface in the gas-in line to reach the pump as it results in bubbles in the air and tubing. The system must be primed to enter sample mode when sampling VOCs.

1. Set the pressure slightly below the pressure used for the purging cycle. This pressure can be adjusted to achieve the optimal prime cycle time, or the time that allows the maximum amount of fluid discharge without allowing the water/gas interface in the gas-in line to reach the pump
2. Set the initial ON time to 30 seconds for the shallowest interval. Increase the ON time by 15 seconds for each deeper sample interval. For example, a well with four ZIST pumps would have ON times from 30 to 75 seconds.
3. Turn the manual switch to ON.
4. Allow the timer-control unit to cycle through the ON and OFF cycle. **IF several cycles are completed with any water discharge, do not worry.** Water is being slowly ratcheted upwards within the tubing. **If the water completely purges during the first ON cycle, the pressure or the ON time must be lowered.** The goal is to find a time and pressure which prevents water discharge from being followed immediately by the exhalation of nitrogen gas. It is easiest to change the ON time.
5. If 5 cycles of the ON/OFF times occur with no water discharge, then try increasing the ON time by 10 seconds. Repeat as necessary.
6. Priming the system is complete when water begins discharging during the ON periods. While the gas is OFF, the water in the sample-return tubing should come to stasis and not return below the surface of the well. When the water has reached the surface, samples can be collected.

3.4 Sample Collection

If collecting water quality parameters with a meter, **do not use the flow-through cell.** Water quality parameters can be measured by filling the calibration cup. The exhalation of high pressure gas could damage the meter sensors.

To optimize the sample mode, the ON time should be increased as much as possible without causing the line to purge. Follow the steps below to optimize the sample mode and begin sampling.

1. Allow the timer-control unit to run one or more cycles on the Prime settings until the sample water discharges from the sample-return line. If the velocity of the discharge is too high for sampling, adjust the pressure downward until the flow velocity is lessened.
2. Calculate the maximum amount of water that can be sampled per ON/OFF by multiplying the purge volume by 0.5 for the shallowest zone and 0.4 for deeper zones.

3. Each time the timer-control unit is in the OFF cycle, turn the ON time up by 5-10 seconds until the maximum amount of water that can be sampled per cycle is reached. If the line purges, multiply the purge volume by 0.3 instead of 0.4 and retest the system.
4. Once the sample volume has been reached at the desired velocity without purging during the ON cycle the system is ready for sampling.
5. Collect samples by filling VOC sample containers first. If any sample analysis requires filtration, a disposable in-line filtration module should be used.
6. Cap each sample container and label. Pack samples in the cooler with ice following sample collection.
7. Once sample containers have been filled, fill the cup for measuring water-quality parameters. The cup should be decontaminated prior to sample collection.
8. Record the water quality parameters on the field form. Record the method for measuring water-quality parameters on the field form.
9. Collect and analyze samples for any additional field parameters (for example, total nitrogen and alkalinity) and record the results on the field form.
10. Decontaminate sample equipment after sample collection per the procedures outlined in SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment.*

3.5 Procedure for Measuring Water Levels

This procedure outlines the method for measuring water levels in ZIST wells using an electronic water level meter. This procedure does not apply to wells instrumented with pressure transducers.

1. Remove the plastic dust cover from the top of the riser pipe.
2. Insert the water level meter into the riser pipe. Follow the procedures outlined in SOP B.8, *Groundwater Elevation Measurements.*

4.0 Documentation and Field Forms

Field personnel will record all field sampling activities in the field logbook and appropriate field forms as outlined in SOP B.3, *Field Documentation*. The master field logbook will be maintained by the Field Team Leader.

5.0 Quality Control

5.1 Equipment Decontamination

Sampling equipment that will be used at multiple sampling locations will be decontaminated after sampling at each location in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.

5.2 Quality Control Samples

- Trip blanks will be submitted with every shipment of VOC samples.
- Field duplicates will be submitted at a frequency of 1 field duplicate per 10 normal samples per method as described in Section 5.9 of the Field Sampling Plan. Field duplicates will be collected in the same method and as close as possible to the original sample and submitted to the laboratory in a manner that prevents the laboratory from knowing the duplicate/parent sample relationships.

- Laboratory QC samples (matrix spike [MS], matrix spike duplicate [MSD]) will be collected at a frequency of 1 MS/MSD per 20 normal samples per method. MS and MSD samples will be collected in the field as close as possible to and in the same method as the normal sample.
- Equipment blanks may be collected where non-disposable, non-dedicated sampling equipment is used. If collected, field personnel will collect equipment blanks by pouring the appropriate water into the decontaminated sampling equipment or vessel and then transferring the water to the sample bottles.

6.0 References

BESST, Inc. *Zist Operations Manual.* San Rafael, California.

SOP B.12 Direct Push and Hydropunch Groundwater Sample Collection

1.0 Purpose and Scope

This standard operating procedure (SOP) presents general guidelines for the collection of groundwater samples using direct-push (Geoprobe or cone penetrometer [CPT]) and Hydropunch sampling methods.

2.0 Equipment and Materials

- Direct push sampling equipment (for example, Geoprobe, CPT testing rig)
- Direct-push sampling rods and lead rod with retractable slotted screen sampler/ Drive rods and Hydropunch sampling device
- Polyethylene sampling tubing and stainless steel foot/check valve
- Properly labeled container for purge water
- Peristaltic pump and environmental grade tubing (if using CPT a stainless steel bailer should be used)
- Narrow diameter bladder pump and appropriately sized disposable tubing
- Pre-cleaned/prepared sample containers
- Clean disposable gloves (latex or surgical)
- Personal protective equipment as specified in the Health and Safety Plan
- Field logbook

3.0 Procedures

3.1 Sample Collection

1. Decontaminate the sampling device and other downhole equipment according to the guidelines presented in SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment.*
2. Advance the drill bit using direct push drilling methods to approximately 5 feet above the desired sampling depth.
3. Confirm the depth of the borehole using a water level meter or weighted cloth tape and measure to the closest 0.5 foot.
4. Verify the presence of water by visual inspection of soil cutting, using site-specific geologic information, or by sounding the depth to water using a water level meter.
5. Drive the sampling device into the formation beyond the end of the auger bit to the desired sampling interval. Alternatively, drive the sampling device to the desired sampling depth using the geoprobe.
6. Retract the outer cylinder, exposing the perforated entry barrel and filter material and allow the groundwater sample to enter the device.

7. If a cone penetrometer testing rig is used, follow the procedures outlined in ASTM Standard D5778.
8. After about 15 minutes, remove the sampling device from the ground.
9. Fill all sample containers, beginning with the containers for volatile organic compound analysis.
10. Abandon the borehole with neat cement grout or bentonite at each sampling location in accordance with Section 3.7 of SOP B.4, *Rotosonic Drilling.*

Alternate methods of grab groundwater collection can be employed depending on the type of sampling method. These include using the following: (1) vacuum pump and clean disposable tubing to pump water to the surface from the hydropunch sampling ports, (2) peristaltic pump (limited to about 25 feet deep) and clean disposable tubing to collect grab groundwater samples directly from the base of the drill string (or geoprobe tip), (3) narrow diameter stainless steel thief bailer or disposable polyethylene bailer to collect a sufficient volume of groundwater directly from the drill string, or (4) narrow diameter bladder pump and clean disposable tubing to collect grab groundwater samples directly from the base of the drill string (or geoprobe tip).

3.2 Key Checks

The following items should be checked prior to and after the sample collection process:

- Evaluate site-specific information such as monitoring well logs or other borehole information prior to drilling and advancing in-situ groundwater sampling
- Verify the equipment is clean and in proper working order
- Ensure that the operator follows the decontamination procedures between sampling locations
- Verify that the borehole made during sampling activities has been properly abandoned.
- All materials generated during sampling disposed of as outlined in the Investigative Derived Waste Management Plan.

4.0 Documentation and Field Forms

Field personnel will record all field sampling activities in the appropriate field form and/or field logbook following the procedures outlined in SOP B.3, *Field Documentation*. The following information specific to direct push or hydropunch groundwater sampling procedures should be included in the field form or field logbook:

- Project name
- Site information
- Weather conditions
- Type of rig
- Name of driller and drilling crew
- Approximate location of sample point
- Sample depth
- Sample time
- Type of sample collected
- Sample equipment (for example, sample device specifications, peristaltic or bladder pump)
- Abandonment procedures
- Sample submission information (shipping method or laboratory)
- Sample identification (sample identification will follow the proper naming convention identified in the SAP/QAPP)

5.0 Quality Control

5.1 Equipment Decontamination

Sampling equipment should be decontaminated according to the procedures outlined in SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment.* Consult equipment manuals for specific decontamination procedures, if necessary.

5.2 Quality Control Samples

- Trip blanks will be submitted with every shipment of VOC samples.
- Field duplicates will be submitted at a frequency of 1 field duplicate per 10 normal samples per method as described in Section 5.9 of the Field Sampling Plan. Field duplicates will be collected in the same method and as close as possible to the original sample and submitted to the laboratory in a manner that prevents the laboratory from knowing the duplicate/parent sample relationships.
- Laboratory QC samples (matrix spike [MS], matrix spike duplicate [MSD]) will be collected at a frequency of 1 MS/MSD per 20 normal samples per method. MS and MSD samples will be collected in the field as close as possible to and in the same method as the normal sample.
- Equipment blanks may be collected where non-disposable, non-dedicated sampling equipment is used. If collected, field personnel will collect equipment blanks by pouring the appropriate water into or over the decontaminated sampling equipment or vessel and then transferring the water to the sample bottles.

SOP B.13 Sample Handling and Shipping

1.0 Purpose and Scope

This standard operating procedure (SOP) describes the requirements for sample identification, chain-of-custody (COC) documentation, and sample handling, storage, and shipping.

2.0 Equipment and Materials

- Sample containers
- Sample labels
- Sharpie/pens
- COC forms (pre-printed or obtained from the laboratory)
- Custody seals
- Plastic resealable bags
- Ice
- Cooler
- Cushioning material (shipping peanuts, cardboard, or bubble wrap)
- Strapping tape
- Copier or digital camera (to document COC records prior to shipment)

3.0 Procedures

3.1 Sample Identification

Sample labels will include the following information:

- Sample name/number
- Time and date of sample collection
- Site name and location
- Project number
- Sample type and matrix
- Container
- Preservative
- Analysis method

Sample labels will be applied to sample containers immediately following sample collection. All sample identifications will follow the naming convention identified in the SAP/QAPP. If pre-printed labels are used, the sampler is responsible for filling out any of the above information not included on the label. Samples containers should be dry and placed in resealable plastic bags and stored on ice immediately following sample collection.

3.2 Chain-of-Custody Documentation

COC records will be used to document the samples taken and the analyses requested. COC records will include the following information:

- Client name
- Project name
- Project location

- Sampling location
- Signature of sampler(s)
- Date and time of collection
- Sample designation (grab or composite)
- Sample matrix
- Signature of individuals involved in custody transfer (including date and time of transfer)
- Airbill number (if appropriate)
- Type of analysis and laboratory method number
- Laboratory name

COC records will be placed in a waterproof resealable plastic bag and taped to the inside lid of the cooler and transported with the samples. Both receiving and relinquishing individuals will sign the COC record during sample transfer. The original COC will be copied before being submitted to the laboratory and the copy retained by the field team leader or sample manager.

3.3 Sample Handling, Storage, and Shipping

After sample collection all samples will be securely capped, labeled, placed in resealable plastic bags, and stored on ice. Samples will be shipped overnight on the same day the samples are collected unless otherwise specified by the Field Sampling Plan. The following procedures will be used for cooler preparation, sample packaging, and shipment.

3.3.1 Cooler Preparation

1. Remove all previous labels on the cooler.
2. Seal all drain plugs with tape (inside and outside).
3. Place a cushioning layer of bubble wrap at the bottom of the cooler.
4. Line the cooler with a large plastic bag to contain samples and prevent leaks.
5. Double-bag all ice in resealable plastic bags and seal.

3.3.2 Sample Packing – Soil/Water Samples

1. Place sealed and labeled sample containers in resealable plastic bags, and place in a cooler containing ice. Wrap glass bottles in bubble wrap prior to placing in resealable plastic bags.
2. Place samples in an upright position in the cooler.
3. Place ice on top of and between samples. The cooler should contain sufficient ice to keep the contents at 4 degrees Celsius.
4. Fill any remaining voids with bubble wrapped or double-bagged ice.
5. Place the COC form in a resealable plastic bag and tape to the underside of the cooler lid.

3.3.3 Sample Shipment – Soil/Water Samples

1. Place signed and dated COC seals on two sides of the lids perpendicularly across the seam of the cooler cover.
2. Use clear strapping tape to encircle the cooler in the same orientation as the seal. The tape should completely circle the cooler at least twice.
3. Secure the shipping label to the cooler. It is preferable to attach the shipping label to the lid rather than the handle due to handle breakage during shipment.
4. Ship the cooler overnight to the contracted laboratory on the same day as sample collection. Samples should not be shipped on Fridays without making arrangements with the contracted laboratory regarding analytical holding times.

3.3.4 Sample Packaging and Shipment – Air Samples

1. Attach a completed sample tag to the Summa canister or Tedlar bag for each investigative or quality control sample. The tag will include the field sample number, location, date and time of sample collection and type of analysis.
2. Tedlar bags should be placed upright in a waterproof metal (or equivalent strength plastic) ice or cooler. Summa canisters should be placed in their original shipping container. A heavy cardboard shipping box is adequate for shipping Summa canisters and Tedlar bags.
3. Place sufficient cushioning material in the cooler or cardboard box to prevent the sampling containers from shifting.
4. Attach the COC record and custody seals as described in Section 3.3.3.

4.0 Documentation

A copy of all COC records and tags will be retained by the field team leader or sample manager. Field personnel will record all field sampling activities and shipping details in the appropriate field form and/or field logbook as discussed in SOP B.3, *Field Documentation*.

SOP B.14 Direct-Push Soil and Soil Gas Sample Collection

1.0 Purpose and Scope

This standard operating procedure (SOP) provides a general guideline for the collection of soil samples using direct-push (for example, Geoprobe) sampling methods.

This SOP also provides general guidelines for the collection of soil vapor samples from temporary soil vapor probes [for example, Geoprobe direct-push system with post-run tubing (PRT) adapters or the AMS Retract-A-Tip system], or from permanently installed soil vapor probes, into evacuated canisters. Soil vapor sample integrity is verified by using a real-time leak checking procedure before taking each sample. This must be done after probe installation and prior to sampling, as well as before each subsequent soil vapor sample from permanent probes.

2.0 Equipment and Materials

- Direct push drill rig or truck-mounted hydraulic percussion hammer
- Sampling rods
- Sampling tubes and acetate liners
- Sample labels
- Sharpie pen
- Pre-cleaned sample containers and stainless-steel sampling implements
- Disposable gloves
- Cleaning detergent
- Distilled water
- Paper towels
- Shipping supplies (cooler, ice, plastic resealable bags, custody seals, chain-of-custody forms)
- Field form and/or logbook

2.1 Specific to Soil Gas Sampling

- Materials to create a flush mount or stick up casing (for permanent probes)
- Glass beads (very small beads, similar to sand) to create a permeable layer around the probe screen (for permanent probes).
- Bentonite seal mixture (25 percent glass beads and 75 percent powdered bentonite clay [hi-yield type] to grout the hole from above the screen to the ground surface (for permanent probes).
- Teflon tubing, ¼-inch outside diameter (OD) sample tubing. Ensure there is enough tubing to use new tubing at each sample location.
- Swagelok ¼-inch nut and ferrule sets for connecting the probe tubing to the sampling manifold (part #SS-400-NFSET)
- Helium canister containing high-purity 99.999 percent helium (NOT balloon grade) and regulator for the canister
- Enclosure/shroud that fully encloses the soil vapor probe and sampling apparatus.

- Helium detector (such as a Dielectric MGD-2002)
- MultiRAE Five Gas Meter (optional if field screening of purged soil vapor is required)
- LandTec GEM Landfill Gas Meter (optional if field screening of purged soil vapor is required)
- Vacuum pump for purging, with rotameter to control flow to 200 milliliters/minute (mL/min)
- Electric supply for the pump (either battery, generator, or power inverter with adapter for car battery)
- Sampling manifold consisting of Swagelok gas-tight fittings with three valves and one vacuum gauge to attach the probe to the vacuum pump and the sample canister (Figure 1).
- Swagelok valve (only necessary for extended sampling periods so that the sampling manifold can be disconnected without introducing air into the probe after the purging is completed) (part # SS-4P4T).
- Wrenches, various sizes as needed for connecting fittings and making adjustments to the flow controller (if field-adjustable).
- Gas sampling bag (for example, Tedlar bag) (1 or 3 liters) to collect the purged soil vapor, so the volume of purged soil vapor can be measured and so field screening can be performed on the purged vapor
- Canister, stainless steel, polished, certified-clean, and evacuated. These are typically cleaned, evacuated, and provided by the laboratory.
- Flow controller or critical orifice, certified-clean, and set at desired sampling rate. These are typically cleaned, set, and provided by the laboratory. Soil vapor samples are typically collected in 1- or 6-liter canisters at a flow rate of no greater than 200 mlL/min; however, lesser flow rates may be used in finer grainer soils.
- Digital pressure gauge with 0.50 "Hg accuracy. Accuracy should be verified annually.
- Shipping container, suitable for protection of canister(s) during shipping. Typically, strong cardboard boxes are used for canister shipment. The canisters should be shipped to the laboratory in the same shipping container(s) in which they were received.

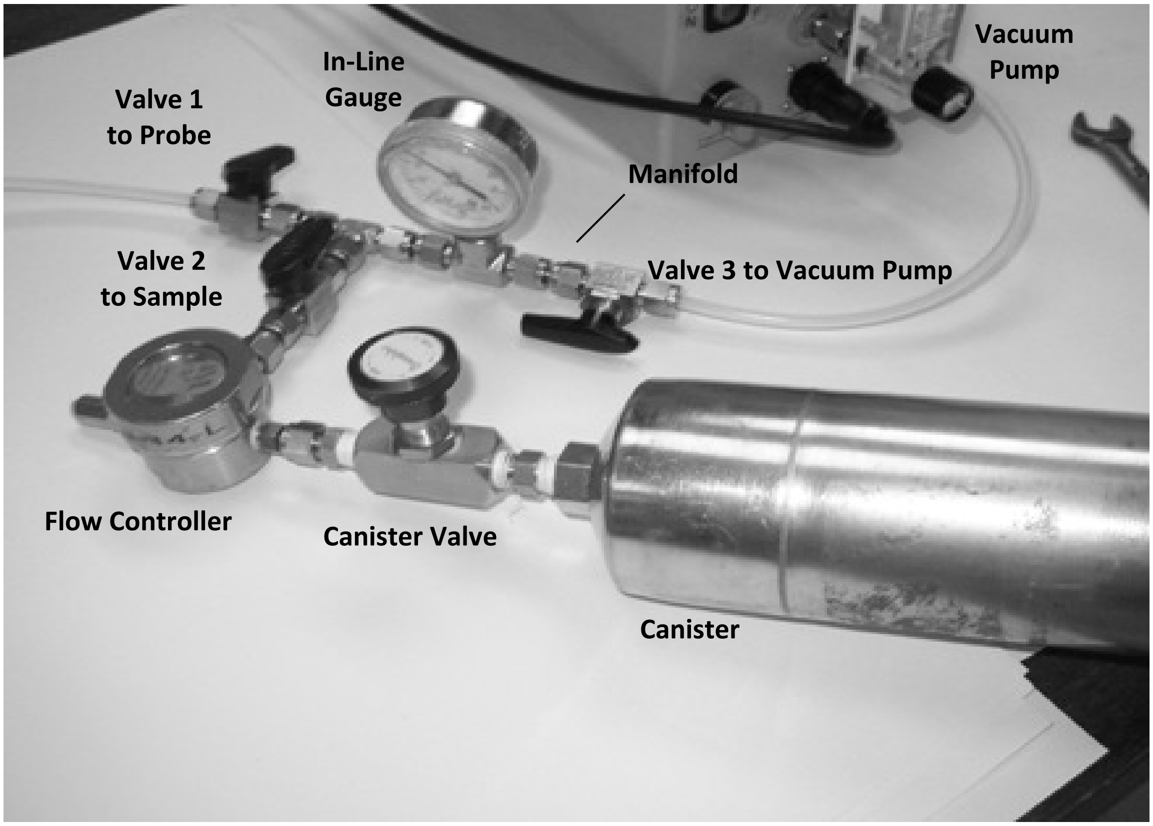


Figure 1. Sampling Manifold

3.0 Procedures

3.1 Soil Sampling

1. Decontaminate sampling tubes and other non-dedicated downhole equipment in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.
2. Drive sampling tube to the desired sampling depth using the direct-push drill rig or truck-mounted hydraulic percussion hammer. If soil above the desired depth is not to be sampled, first drive the lead rod, without a sampling tube, to the top of the desired depth.
3. Remove the rods and sampling tube from the borehole and remove the sampling tube from the lead rod.
4. Cut open the acetate liner using a specific knife designed to slice the acetate liners.

5. Screen the soil with a photoionization detector (PID). Fill all sample containers, beginning with the containers for volatile organic compounds (VOC) analysis, using a decontaminated or dedicated sampling implement. For the VOC samples, place the sample into a pre-preserved VOA vial or direct sample container such as an **En Core** or **Terra Core** sampler and seal the cap tightly. Ideally, the operation should be completed in 1 minute. Label the vials and immediately place samples on ice for shipment to the laboratory.
6. Decontaminate all non-dedicated downhole equipment (rods, sampling tubes, etc.) in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipmentt*.
7. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

3.2 Soil Gas Sampling

3.2.1 Site-Specific Considerations

1. Soil vapor sampling should not be performed until 5 days after a significant rain event (defined as ½ inch or greater of rainfall during a 24-hour period).
2. Methane and carbon dioxide (CO_2) can cause positive bias with a helium leak detector, if a helium leak-check procedure is used as detailed in this SOP. If methane or CO_2 are expected or encountered at a site, then it may be necessary to explore different strategies to determine soil vapor probe integrity.
3. The subsurface needs time to equilibrate after probe installation; 30 minutes for temporary direct-push probes, and 48 hours for direct-push or hand-augered permanent probes.
4. Prior to attempting sampling of soil vapor probes, there should be an understanding of subsurface conditions at the site.
   a. **Depth to Groundwater** – soil vapor samples must be collected in the vadose zone (and above the capillary fringe).
   b. **Soil permeability** – It may not be feasible to collect soil vapor from finer-grained or tight soils, such as clays. If there are clay layers present in the subsurface, these intervals should be avoided. For sampling in these soils, using permanent soil vapor probes with a wider borehole is recommended. Care should be taken during purging and sampling so that the vacuum in the sampling system never exceeds 7 inches mercury ("Hg) or approximately 100 inches water.
5. Air pressure decreases with elevation. Therefore, a canister evacuated at a laboratory located at sea level will show a lower vacuum measurement at a higher altitude. Generally, a 1,000-foot rise in elevation corresponds to a 1-inch Hg drop in pressure OR a 1-inch Hg decrease in measured vacuum. For example, a canister evacuated to 30 inches at sea level and used at 3,000 feet would show an initial vacuum of 27 "Hg.

3.2.2 System Set Up

1. Obtain soil gas sampling probes in sufficient quantity to carry out the assessment (Figure 2). These systems and their installation can be obtained from geotechnical firms that provide direct-push supplies and services or from AMS for the hand tool method. Their basic installation procedures can be followed as long as the details below are included.
2. Manufactured soil gas probes (such as the Geoprobe Soil Gas Implant, and AMS dedicated gas vapor probe tip) are specifically manufactured for soil gas collection and facilitate installation, improve sampling, are easily decontaminated between each use, and offer consistency and ease of use.

3. It is necessary to coordinate the hardware (that is, size of tubing, fittings, sampling interface assembly, etc.) that mates the soil gas probe sampling line to the sampling system (for example, Tedlar bags, SUMMA canisters). Appropriate hardware is critical to achieving a leak-free system. All connections should be inert gas-tight compression fittings (that is, Swagelok or equivalent), and all sample transfer lines should be made of Teflon or tubing. Typically, all tubing and fittings should be ¼-inch OD. These fittings will match up with the sampling manifold specified in the soil gas sampling SOP B.14, *Direct-Push Soil and Soil Gas Sample Collection*.
4. The soil gas probes and equipment must be decontaminated prior to use. Steam cleaning is the preferred method of decontamination; however, a three-stage decontamination process consisting of a wash with a non-phosphate detergent, a rinse with tap water and a final rinse with distilled water may be used. The equipment should be allowed to dry before use. Once decontaminated, the probes must be shown to be free of contaminants. At a minimum, a suitably sensitive organic vapor meter should be used for this purpose. Any probe that does not pass decontamination should not be used.
5. Handle and store decontaminated soil gas probes in a manner that prevents contamination.
6. Inspect each gas probe assembly for ware and faulty parts. Replace probe tips, o-rings, adapters, and probe rods as needed. New parts and parts in good working condition greatly reduce the chances of ambient air leaking into the soil gas sample and reduce the need for re-pushing probes.

3.2.3 Permanent Probe Installation

1. Assemble the drive point holder, implant anchor/drive point, and drive rod. Drive the rod to the desired bottom screen depth (for example, for a probe screened from 5 feet 6 inches to 5 feet bgs, the rod should be driven to 5 feet 6 inches). Do not disengage the drive point at this time.
2. Attach the ¼-inch Teflon tubing to the probe screen. Use enough tubing so that at least 2 feet will be left above ground. Make sure that the tubing does not spin on the probe screen; if it does, it will not be possible to screw the probe screen into the drive point/anchor. Electrical tape can be used to secure the tubing to the screen. Plug the exposed end of the tubing with the probe cap.
3. Remove the drive head and thread the probe screen (Geoprobe Systems implant) and tubing down the inside of the drive rod. Once the implant reaches the drive point, turn the tubing counterclockwise with a gentle downward force to thread the screen into the drive point/anchor. Test that the screen is seated by gently pulling up on the tubing. It is very important to ensure that the screen is seated before moving on to the next step.
4. Retract the drive rod 12 inches while pushing down on the Teflon tubing. This is to ensure that as the rod is being removed while the anchor/drive point and implant stay at depth.
5. Thread the tubing through a funnel and place the funnel on top of the drive rod. Determine the volume of glass beads needed to fill the space around the screen plus an additional 6-inch space above the screen. Remove the cap placed over the end of the tubing. Pour the beads into the funnel and down the inside diameter of the drive rod. Use the Teflon tubing to stir the glass beads and ensure they make it all the way down to the bottom. Do not pull on the tubing. Note: Failure to remove the cap during this step can result in bridging of glass beads (due to air displacement issue) and therefore an insufficient filter pack around screen (Figure 2).
6. Lift the drive rod up an additional 18 to 24 inches and pour in the bentonite seal mixture. The mixture is 25 percent glass beads and 75 percent powdered bentonite clay (hi-yield type). It takes approximately 154 mL of this mixture per foot. At least 2 feet of the mixture are recommended to adequately seal the hole and prevent contribution from ambient air during sampling. Pour 50 ml of water down the drive rod to initiate the bentonite seal.

7. Replace cap over end of tubing. Pull the drive rod the rest of the way out of the ground and fill the remaining hole to about 1 foot from the ground surface with either bentonite or cement.
8. Install either a stick up or flush mount cover to finish the probe. Coil the extra tubing inside the enclosure and cover (Figure 3).
9. Wait at least 24 hours before sampling, so that the subsurface has time to equilibrate. Follow the proper procedures as presented in Section 3.2.5, and be sure that leak-check procedures are employed.
10. When calculating dead volume, use the internal volume of the Teflon tubing, the internal volume of the screen, and the volume of the glass bead pack (assume 30 percent porosity).
11. The surrounding ground surface will be replaced and repaired to original condition.

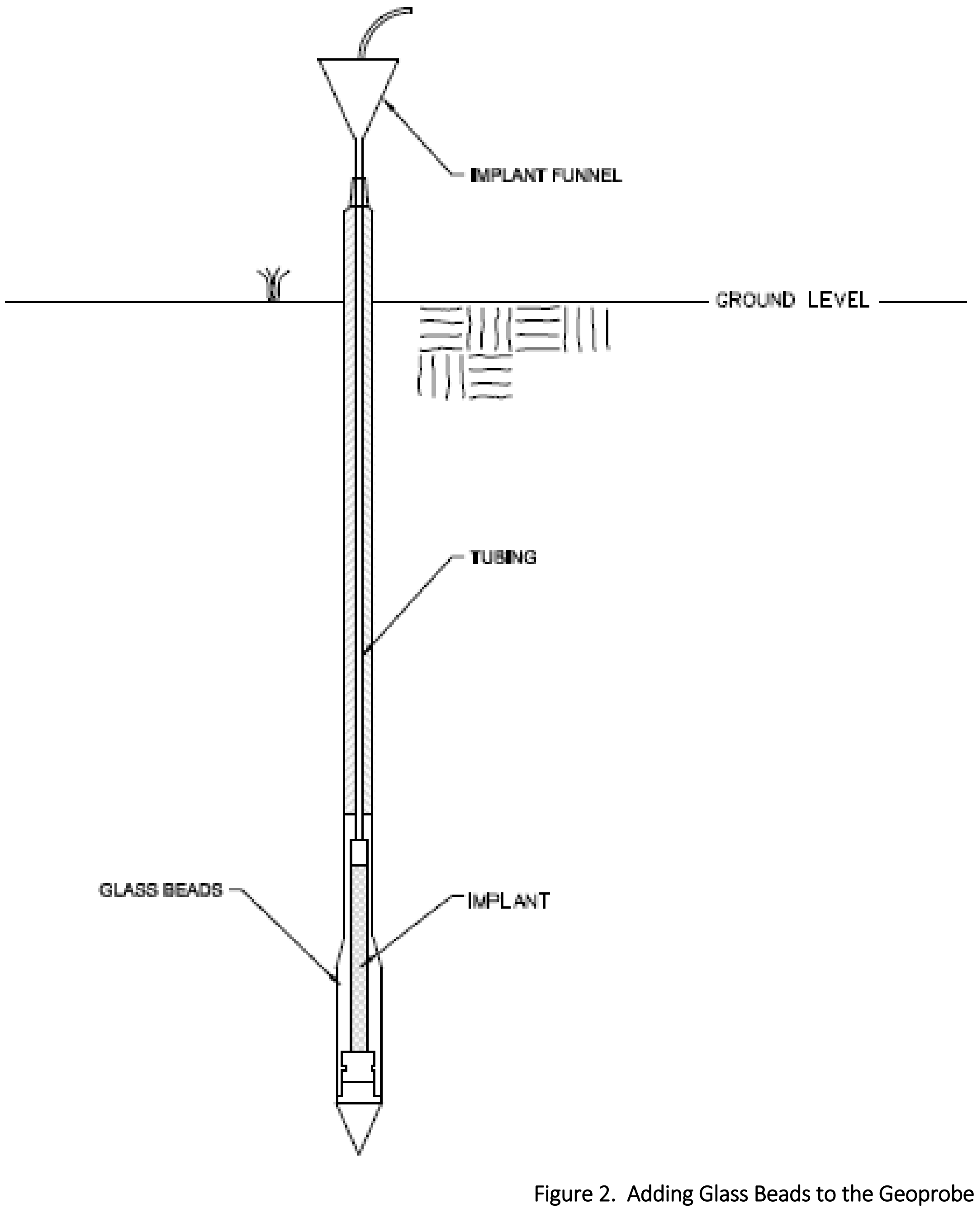


Figure 2. Adding Glass Beads to the Geoprobe Implant

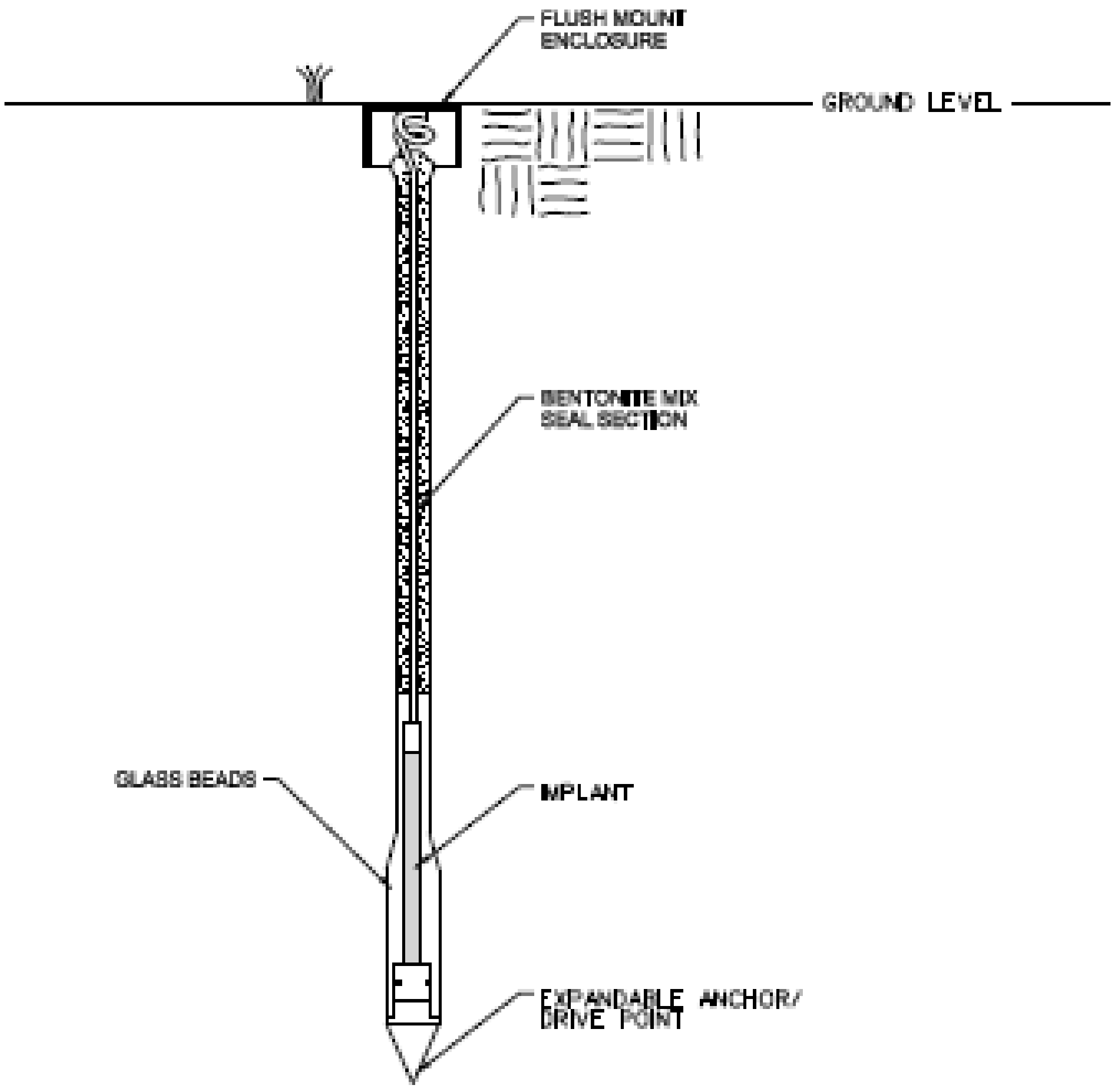


Figure 3. Installed Geoprobe Implant with Flush Mount Cover

3.2.4 Soil Gas Probe Installation and Removal for the AMS Dedicated Gas Vapor Probe Method

1. Assemble the probe as shown on Figure 3 and attach the tubing. Thread the tubing through the hollow rod and attach the drive end to the top of the rod. Electrical tape may be used to secure the tubing to the tip, and protect the tubing from the drive end.
2. Push the probe to the desired depth with either the slide hammer or hammer drill. Attach extra rods to achieve the desired depth. Ensure that the final depth of the drive point includes extra depth to include the length of the retracted tip.
3. Retract the rod with the removal jack to expose the screen within the probe tip.
4. Install the probes in a manner that creates a leak-free seal between the above-ground atmosphere and the probe tip, while minimizing the impact on ground surface covers (for example, asphalt, concrete, driveways, lawns) by following steps 6.5 to 6.7 below.
5. Determine the volume of glass beads needed to fill the space around the screen plus an additional 6-inch space above the screen. Remove the cap placed over the end of the tubing and thread the tubing through a funnel and place the funnel on top of the hole. Pour the glass beads into the funnel and down the inside of the hole. Use the Teflon tubing to stir the glass beads and ensure they make it all the way down to the bottom. Do not pull on the tubing. Note: Failure to remove the cap during this step can result in bridging of glass beads (due to air displacement issue) and therefore an insufficient filter pack around screen.
6. Pour in a bentonite seal mixture an additional 18 to 24 inches on top of the glass bead filter pack. The mixture is 25 percent glass beads and 75 percent powdered bentonite clay (hi-yield type). At least 2 feet of the mixture are recommended to adequately seal the hole and prevent contribution from ambient air during sampling. Pour enough water down the hole to initiate the bentonite seal.
7. Fill the remaining hole to about 1 foot from the ground surface with either bentonite or cement. Remove funnel and replace cap over end of tubing.
8. In the event the installation technique does not work, and a pre-drilled pilot hole is needed, this procedure must be coordinated with the project engineer. Use of pre-drilled holes will require careful control as to not over-drill and may also create the need for back-grouting to overcome leakage from the aboveground ambient atmosphere.
9. Wait 30 minutes after the probe is installed and sealed properly to begin sampling, so that the subsurface has time to equilibrate. The probe cap should be tightened on the end of the tubing during the equilibration period. Follow the proper procedures as presented in Section 3.2.5, and be sure that leak-check procedures are employed.

Figure 4. AMS Gas Vapor Probe Assembly

3.2.5 Sampling Set Up

1. Measure the initial canister pressure with the digital pressure gauge. The initial pressure should be between -28 to -30 "Hg. If it is less than -26 "Hg do not use the canister for sampling. If it is between -28 to -26 "Hg only use the canister if there are no other spare canisters available. In the field log record the canister identification (ID), flow controller ID, initial pressure, desired flow rate, sample location information, and all other information pertinent to the sampling effort.
2. Connect the flow controller to the canister. When the flow controller is attached correctly it will not move separately from the canister (it will not spin around).
3. Connect the canister via the flow controller to the sampling manifold.
4. Connect the probe tubing to the sampling manifold using a Swagelok nut and ferrule set.
5. If the sample will be collected over a period of time greater than 30 minutes, a flow diversion valve (Swagelok part# SS-4P4T) should be placed in-line between the probe and the manifold. Once purging has been completed, the flow diversion valve can be turned to the off position, allowing disconnection of the manifold and vacuum pump for use at another location, without the loss of purge integrity at the purged location.

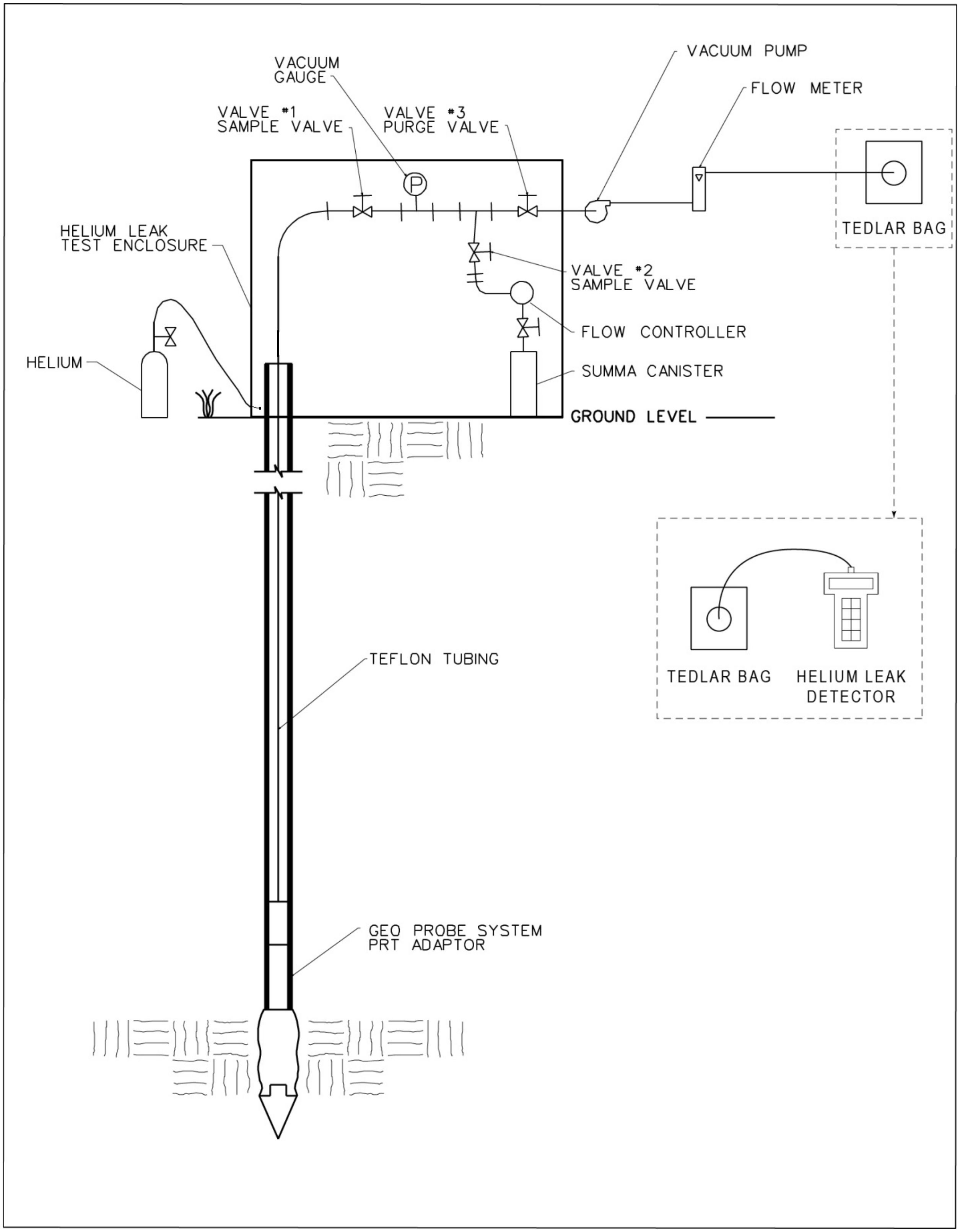


Figure 5. Soil Vapor Sampling System

1. **Manifold Vacuum Leak Check** (shut in test) – The purpose of the manifold leak test is to make sure the connections in the sampling train are air tight. The connections on the sampling manifold through the flow controller to the valve on the canister will be leak tested.
   a. Close the valve to the probe (Valve 1), open the valves to the pump (Valve 3) and the canister (Valve 2) on the manifold. The valve on the canister is closed.
   b. Turn the pump on and wait for the gauge on the manifold to approximately -10 "Hg. Close the valve to the pump (Valve 3) and turn the pump off. The sampling train is now a closed system.
   c. Wait approximately 1 minute to ensure that the vacuum is maintained and there are no leaks (as shown by the stability of the pressure gauge).
   d. If there is a loss of vacuum, tighten the connections and redo the leak test until it passes.
2. **System Purge and Helium Leak Check** – A purge of the soil vapor probe and sampling manifold system is required before taking each sample. The helium leak check procedure is also performed during this **step**. This helium leak check will verify the integrity of the sampling adapter (or PRT adapter if using the Geoprobe system) seal and the probe and ground interface.
   a. Place the helium leak check enclosure around the soil vapor probe and sampling apparatus (Figure 5). The enclosure should not be so tightly sealed that pressure builds up in the enclosure.
   b. Flood the enclosure with helium, and then measure the helium concentration in the enclosure. It should be at least 10 percent helium in the enclosure during purging. Measure and record the helium concentration in the enclosure periodically during the entire purge so that an average concentration can be calculated.
   c. Purge 3 dead volumes (internal volume) of the in-ground annular space, sample line, and sampling manifold system. The purging flow rate should not exceed 200 mL/min.
      i. The purged soil vapor should be collected in a Tedlar bag to measure the volume purged and so that field readings of the purged vapor can be measured.
      ii. If the vacuum gauge reads greater than 7 "Hg during the purge, then close the purge valve (Valve 3) and monitor the vacuum in the manifold and probe for 3 minutes. If there is no noticeable change in vacuum after a minute, then there is an insufficient amount of soil vapor to collect a sample and the vacuum is too great to collect a soil vapor sample. Several factors can cause this situation.
         A. The soil formation is too "tight" (that is, high clay or moisture content). Try using a lower flow rate (temporary or permanent probe), or try sampling a different depth or location (temporary probe).
         B. With a temporary probe system, the expendable tip may not have released when the drive rod was retracted. Try retracting the probe a little further, or use a long, thin rod to poke the tip loose.
         C. If water is visible in the flexible soil vapor tubing, **stop the purging immediately**. It is not possible to take a soil vapor sample at that depth or location.
   d. Turn off the pump and close the valve to the pump (Valve 3) once the purging is completed.
   e. Measure the helium concentration in the last purged dead volume with the helium detector. The helium concentration in the purged soil vapor must be less than 5 percent of what it was in the helium enclosure during purging to pass the leak test.

i. If the probe fails the leak check then corrective action is required. This includes first checking the fittings and connections and trying another purge and leak check. It may also be necessary to remove the soil vapor probe and re-install it in a nearby location. The leak test must be performed again after corrective actions are taken until the soil vapor probe passes the leak test.

ii. Note: **Helium detectors may be sensitive to high concentrations of methane or carbon dioxide.** If these are expected to be present in the soil vapor, then caution should be used with this technique, as false positive readings may be encountered during leak testing. Use a LandTec GEM Landfill Gas Meter to determine if methane or carbon dioxide is present in the soil vapor.

f. The purged soil vapor in the Tedlar bag can be screened with a LandTec GEM Landfill Gas Meter to get field readings of carbon dioxide, oxygen, and methane, and/or a MiniRAE or MultiRAE PID to get field readings of total VOCs, hydrogen sulfide, carbon monoxide, oxygen, and lower explosive limit.

g. Record the purge and leak test information on the Soil Vapor Sampling Log.

3. **Sample Collection**

a. The canister (with attached flow controller) should already be attached to the probe via the sampling manifold. The valve to the pump (Valve 3) should be closed, and the valve to the probe (Valve 1) should be open.

b. Open the valve to the canister (Valve 2) and open the valve on the canister.

c. After sampling for the appropriate amount of time, close the canister's valve and the sample valve (Valve 2).

d. Measure the final canister pressure with the digital pressure gauge. The final pressure should be between -2 and -5 "Hg. If necessary, reconnect that canister and allow the sample to collect for longer. If the pressure is between 0 and -2 "Hg the sample may be submitted for analysis if the laboratory confirms there is some measurable vacuum on receipt. If the final canister vacuum is 0 "Hg, the sample must be recollected.

e. Record the sampling date, times, canisterID, flow controller ID, vacuum gauge ID(s), and any other observations pertinent to the sampling event on the Soil Vapor Sampling Log.

f. Disassemble the sampling system.

g. For permanent probes, replace the probe cap and make sure it is securely in place. For temporary probes, remove the probe and abandon the bore hole.

h. Fill out all appropriate documentation (chain of custody, sample tags) and return canisters and equipment to the laboratory in the same shipping container in which they were received. The samples should not be cooled during shipment. DO NOT put ice in the shipping container. Do not place sticky labels or tape on surface of the canister.

4.0 Documentation and Field Forms

Field personnel will record all field sampling activities in the field logbook and appropriate field forms as outlined in SOP B.3, *Field Documentation*. The master field logbook will be maintained by the Field Team Leader.

5.0 Quality Control

5.1 Equipment Cleaning/Adjustment

- Sampling equipment that will be used at multiple sampling locations will be decontaminated after sampling at each location in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.
- Laboratories supplying canisters must follow the performance criteria and quality assurance prescribed in U.S. Environmental Protection Agency (EPA) Method TO-14/15 for canister cleaning, certification of cleanliness, and leak checking. SOPs are required from the laboratory.
- Laboratories supplying flow controllers must follow the performance criteria and quality assurance prescribed in EPA Method TO-14/15 for flow controller cleaning and adjustment. SOPs are required from the laboratory.

5.2 Quality Control Samples

- Trip blanks will be submitted with every shipment of VOC samples.
- Field duplicates will be submitted at a frequency of 1 field duplicate per 10 normal samples per method as described in Section 5.9 of the Field Sampling Plan. Field duplicates will be collected in the same method and as close as possible to the original sample and submitted to the laboratory in a manner that prevents the laboratory from knowing the duplicate/parent sample relationships.
- Laboratory QC samples (matrix spike [MS], matrix spike duplicate [MSD]) will be collected at a frequency of 1 MS/MSD per 20 normal samples per method. MS and MSD samples will be collected in the field as close as possible to and in the same method as the normal sample.
- Equipment blanks may be collected where non-disposable, non-dedicated sampling equipment is used. If collected, field personnel will collect equipment blanks by pouring the appropriate water into or over the decontaminated sampling equipment or vessel and then transferring the water to the sample bottles.

SOP B.15 Cone Penetration Testing

1.0 Purpose and Scope

This standard operating procedure (SOP) provides the general guidelines for cone penetration testing (CPT) procedures.

2.0 Equipment and Materials

- Hydraulic pushing system with rods (CPT rig or truck-mounted drill rig)
- Push rods
- Electronic penetrometer
- Cable or transmission device
- Depth recorder
- Data acquisition unit
- Field form and/or logbook

3.0 Procedures

3.1 Permits and Clearances

Before beginning field work, required drilling/exploratory boring permits must be acquired as described in SOP B.1, *Equipment Calibration*. This is the responsibility of the field geologist. In addition to drilling/exploratory boring permits, utility clearances must be acquired from all pubic and/or private companies that potentially have utilities within the investigation site (SOP B.1, *Equipment Calibration*). Utilities must be clearly marked so the rig operator can avoid these lines. The subcontract should stipulate responsibility for severed utilities and damaged CPT/direct-push sampling equipment.

3.2 Testing Operations

Efficient field operations with electric cone testing require skilled operators and adequate technical back-up facilities for calibration and maintenance of equipment.

Baseline readings of the porewater pressure transducers are recommended and should be obtained immediately after assembly to prevent evaporation. To do so, remove protective caps or covers from the penetrometer tip (these could be a source of pressure on the system) and hang it freely in air or immersed in a bucket of water. Another round of baseline readings is recommended after the sounding has been completed and the penetrometer has been withdrawn to the surface.

Equipment operators begin by leveling the CPT rig over the testing point. Leveling is accomplished with hydraulic jacks. Once level, the operator may run a “dummy cone” into the upper zone (0 to 3 feet, 0 to 1 meter below ground level), if gravel or random fill is suspected. Next, the operator prepares the piezo-element, which involves de-airing of the porous filter element; de-airing of the cone (especially with respect to the pressure chamber immediately adjacent to the pressure transducer); and assembling of the cone and filter. The prepared cone is then lowered on a string of push rods. The rate of penetration is set between 2 to 4 feet per minute (10 to 20 millimeters per second), ±25 percent when obtaining resistance data. During penetration, the electric penetrometer produces continuous data that requires relatively complex data collection and processing. The signals are usually transmitted via a cable pre-threaded down the standard push rods.

The digital data are incremental in nature, typically recording all channels every 2 inches (5 centimeters) in depth. Data are stored on floppy diskette for future transfer to an office computer and plotter. In addition, printers and plotters are typically used in the field with microprocessors to calculate and plot data immediately after the completion of or during cone tests.

In the field, simple check calibrations and procedures are essential after connecting the equipment to ensure that all is functioning properly. The field geologist should verify that load measurement systems are calibrated at intervals not to exceed three months, and more frequently when the equipment is in use continuously. Between tests, the CPT operator should check the cone and friction sleeve for obvious damage or wear. The seals between different elements should also be cleaned and inspected.

3.3 Borehole Abandonment

To comply with groundwater regulatory ordinances, all CPT boreholes must be sealed to protect aquifers from surface contamination and cross aquifer contamination. Typically, a tremie pipe is run to the bottom of the borehole through a string of push rods. The tremie pipe remains in the borehole while the push rods are removed, then the borehole is grouted with a bentonite/cement slurry through the tremie pipe, from the bottom of the borehole to the ground surface. The tremie pipe is removed as the slurry rises in the borehole. For shallow CPT (typically less than 50 feet total depth), the tremie pipe may be lowered by hand after the rig mobilizes off site, if the rig operator is confident that the formation will not close. Pressure grouting a CPT borehole as the push rods are removed is also an acceptable grouting method if artesian conditions are not expected in the subsurface.

4.0 Documentation and Field Forms

During testing, field personnel should keep a written log that includes:

- Location and characteristics of contacts
- Number of outer sounding tubes, as their weight can be an appreciable part of the record
- Number of inner rods, to maintain the record of depth of penetration
- Depth and length of long pauses in pushing
- Initial and final baselines for each sounding
- Any unusual condition affecting test procedures or results

Additionally, field personnel will record all field sampling activities in the field logbook and appropriate field forms as outlined in SOP B.3 *Field Documentation*. The master field logbook will be maintained by the Field Team Leader.

5.0 Relevant Literature

American Society for Testing and Materials (ASTM). 2000. *Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils*. D5778-95(2000).

Robertson, P.K., and R.G. Campanella. 1986. *Guidelines for Geotechnical Design using the Cone Penetrometer Test and CPT with Pore Pressure Measurement*. Hogentogler and Company, Inc..

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS). 2012. "Cone Penetrometer." *National Engineering Handbook*, Chapter 11.

SOP B.16 Surface Soil/Hand-auger Sampling

1.0 Purpose and Scope

This Standard Operating Procedure (SOP) provides the general guidelines for the collection and handling of surface soil samples and near-surface samples collected using a trowel and a hand-augering device. This method is applicable to loosely packed soils.

2.0 Equipment and Materials

- A hand auger or other device that can be used to remove the soil from the ground. Sample materials should be limited to stainless-steel, Teflon, acetate, or glass materials.
- A stainless-steel spatula and stainless steel bowls (to remove materials from the sampling device).
- Calibrated photoionization detector (if sampling in a contaminant source area)
- Disposable scoop or trowel (optional)
- Disposable gloves
- Paper towels
- Distilled water
- Sample jars/containers
- Unpainted wooden stakes or pin flags (to mark sample location)
- Measuring tape
- Sample labels
- Sharpie pen
- Shipping supplies (cooler, ice, plastic resealable bags, custody seals, chain-of-custody forms)
- Field form and/or field logbook

3.0 Procedures

The following general steps should be followed in conjunction with the directions specific to the soil core sampling device.

1. Wear appropriate personal protective equipment (PPE) including disposable gloves.
2. If the sample location has not been previously marked, locate the sample location and mark the point with an unpainted wooden stake or pin flag. Use a measuring tape to locate the position from a fixed landmark (for example, corner of building, parking lot, or intersection). Record the sample location in the field form and/or field logbook.
3. In selecting a sample location, avoid locating samples in debris, tree roots, standing water, or in areas where residential activities (for example, barbecue areas, driveways, garbage areas) may impact the sample. To the extent possible, differentiate between earthen fill and natural soil.
4. Remove organic material (for example, grass, leaves) adjacent to the location marker using a decontaminated stainless-steel or a new disposable scoop or trowel.
5. To sample surface soil, scoop the soil using the augering scoop or trowel.
6. To sample subsurface soil, use a decontaminated hand auger to obtain soil from the desired depth. Mark depth intervals on the hand auger and extensions or periodically measure the depth using the measuring tape.

7. If sampling in a contaminant source area, a calibrated photoionization detector should be used to measure the response of the sampled soil. Field personnel should consult the health and safety plan to determine the appropriate level of PPE required.
8. Empty the contents of the scoop/trowel into the appropriate sample container. For volatile organic compounds, sample containers should be filled directly from the trowel/scoop and capped immediately upon filling. Samples collected for other analyses may be sampled from a stainless steel bowl.
9. Label the sample containers using the convention identified in the SAP/QAPP and store the samples for shipment.
10. Decontaminate sampling equipment after use (SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*, for decontamination procedures).
11. Dispose of PPE and investigative-derived waste according to the procedures outlined in the Investigative Derived Waste Management Plan.

4.0 Documentation and Field Forms

Field personnel will record all field sampling activities in the field logbook and appropriate field forms as outlined in SOP B.3 *Field Documentation*. The master field logbook will be maintained by the Field Team Leader.

5.0 Quality Control

- Trip blanks will be submitted with every shipment of VOC samples.
- Field duplicates will be submitted at a frequency of 1 field duplicate per 10 normal samples per method as described in Section 5.9 of the Field Sampling Plan. Field duplicates will be collected in the same method and as close as possible to the original sample and submitted to the laboratory in a manner that prevents the laboratory from knowing the duplicate/parent sample relationships.
- Laboratory QC samples (matrix spike [MS], matrix spike duplicate [MSD]) will be collected at a frequency of 1 MS/MSD per 20 normal samples per method. MS and MSD samples will be collected in the field as close as possible to and in the same method as the normal sample.
- Equipment blanks may be collected where non-disposable, non-dedicated sampling equipment is used. If collected, field personnel will collect equipment blanks by pouring the appropriate water into or over the decontaminated sampling equipment or vessel and then transferring the water to the sample bottles.

SOP B.17 Analytical Method for the Determination of Volatile Organics in Air Using the HAPSITE Field GC/MS

1.0 Scope and Application

This document provides standard operating procedures for using a HAPSITE gas chromatograph/mass spectrometer (GC/MS) for use at field projects using U.S. Environmental Protection Agency (EPA) Method TO-15 as guidance. This procedure is intended to be used by GC/MS chemists with proper training and experience. These procedures are based upon EPA Method TO-15 as published in "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air", Second Edition, January 1999 and the HAPSITE user manual. This method is applicable to specific Volatile Organic Compounds (VOCs) in air. Table 1 presents a list of VOCs with reporting limits which can be analyzed with this procedure. This SOP covers the standard operating procedures for the HAPSITE, however, site specific requirements provided in other project specific documents (such as a QAPP or SAP) may override this SOP. Additionally, field conditions encountered during field work may require modifications to the procedures.

2.0 Overview of the Analytical Process

- Air samples are collected through the sampling probe at ambient pressure.
- The HAPSITE can be operated in two different modes. Analytical mode for quantitative and qualitative results, or survey (sniff) mode for qualitative screening.
- Analytical mode: Samples are introduced into the GC/MS system by way of a sample probe and concentrator. The concentrator traps the sample onto an adsorbent trap which allows atmospheric gases to pass through (CO_2, O_2, N_2, etc.). The trap is then heated and the analytes are transferred to the GC column, then to the MS detector.
- Survey mode: Samples are introduced through the sample probe directly into the MS detector.
- Data is collected and stored into the HAPSITE system memory. The data can then be used by an external computer for calibration, data processing, reporting of samples, and data archiving.
- SIM and SCAN: The MS system is capable of operating in SCAN or SIM mode, depending on analytical or specific project requirements. SCAN mode is used for more conventional TO-15 analysis or if tentatively identified compounds (TIC) are required. In this mode, the MS scans a range of ions (typically 35-250 amu). This range contains all ions necessary to identify and quantitate all compounds in the TO-15 list. If lower detection levels are required, SIM mode may be utilized. In SIM mode, the analyzer only looks at ions specific to the target compounds. Up to three ions are used per compound, 1 for quantitation, and 1 or 2 for qualification. This increases the dwell time that the analyzer spends scanning for each specified ion, which increases sensitivity at the cost of selectivity. Because of this, it is not possible to produce TIC reports in SIM mode.
- After samples are analyzed, processed, and meet all acceptance criteria herein, a client report is generated and typically reviewed by a peer.
- HAPSITE method files and data files will be retained on the project drive.

3.0 Target Analytes, Reporting Limits, and Detection Limits

Standard target analytes and reporting limits for the base analyte list for analysis in SIM mode are listed in Table 1. In order to keep the analysis time as short as possible, the analyte list should be kept to the minimum number of compounds of interest. In order to produce the analyte list and reporting limits in Table 1, it takes approximately 10-15 minutes from injection to injection (including sampling time, analytical run time, post run instrument cool down.)

The reporting limits (RL) will be at or above the lowest calibrated point on the initial calibration curve. Reporting limits may increase or decrease based on the amount of time the sample is loaded onto the concentrator. Typical achievable limits for a 1-minute fill time are listed in Table 1 for SIM mode.

4.0 Interferences

- Contamination may occur in the sampling system if it is not properly cleaned before use. Therefore, the probe should be heated and an ambient system flush performed at the start of each day, or between samples with elevated concentrations of VOCs.
- Contamination may occur from impurities in the carrier gases and from background sources. These sources of contamination are monitored through analysis of method blanks.
- Cross-contamination can occur whenever samples containing high VOC concentrations are analyzed. Therefore, whenever an unusually concentrated sample is encountered, the analyst uses professional judgment when reviewing the following samples to determine whether reanalysis is necessary.

5.0 Sample Collection, Storage, Holding Times, and Preservation

Samples are typically drawn directly through the sampling probe; therefore, no sample media is necessary. However, it is possible to analyze a diluted sample collected in a Tedlar bag. Analysis of Tedlar bags should be performed immediately after sample collection. As this procedure will most typically be performed immediately in the field, holding times and preservation are typically not applicable.

6.0 Apparatus and Materials

1. Inficon HAPSITE Smart, Smart Plus or ER GC/MS.
2. GC Column – 100% methyl silicone phase, 15 m or 30 m × 0.32 mm ID × 1 µm film.
3. Tedlar bags in various sizes as needed. Include Summa to bag adapter for calibration standards.
4. Gastite syringes in various sizes from 25 µL to 100 mL with Teflon plunger and rounded needle tip.
5. Two stage regulator for nitrogen cylinder (optional if HAPSITE will be used in a fixed location). CGA 580 fitting.
6. A portable Windows based lap top computer. The computer utilizes the HAPSITE Smart IQ software for acquisition, integration, quantitation, and storage of mass spectral data. The HAPSITE can operate without connection to a computer, but a computer is necessary for higher quality data reprocessing.

7. Power source. Either line power or an automobile power inverter. The HAPSITE has an onboard battery, but it needs to be re-charged periodically.

7.0 Standards, Gases, and Reagents

1. **Calibration standards** – Purchase a pre-made standard or have the vendor prepare a calibration standard in a 6 L SUMMA canister. Actual concentration and composition varies by project, but typically 5 ppbv and 0.5 ppbv are good targets.
    a. **Stock standards** – standards are purchased as custom made mixtures in gas cylinders. Cylinders purchased from vendors are traceable to a National Institute of Standards and Technology (NIST). 62-component mixture from Scott Gases (catalog number 41973-U). Stock standard is 1,000 ppbv.
    b. **Primary Field Standard (5 ppbv)** – Dilute the 1,000 ppbv primary standard(s) 1:200. Evacuate a clean 6L canister. Add 50 µl of DI water. Add 90 mL of 1000 ppbv standard. Fill canister to final pressure of 2280 torr using UHP N2. This provides 12 L of usable 5 ppbv standard (16L total).
    c. **Primary Field Standard (0.5 ppbv)** – Dilute the 1,000 ppbv primary standard(s) 1:2000. Evacuate a clean 6 L canister. Add 50 µl of DI water. Add 9 mL of 1000 ppbv standard. Fill canister to final pressure of 2280 torr using UHP N2. This provides 12 L of usable 0.5 ppbv standard (16 L total).
    d. **Daily Field Calibration standards** – Primary Field Daily Calibration Standard –Fill a 1 liter Tedlar bag with 5 ppbv primary field standard.
2. **Internal/Surrogate/Tuning standard** – The internal/surrogate/tuning standard mix is provided with the HAPSITE in a disposable gas cylinder. Each cylinder is prepared with bromopentafluorobenzene (BPFB) and 1,3,5-Tris (trifluoromethyl) benzene (TRIS) at approximately 5 ppbv with nitrogen as the balance gas.
3. **Nitrogen Carrier Gas** – Ultra High Purity (UHP) 99.999% or better. Either in disposable Inficon canisters or commercially provided cylinder (if HAPSITE will be used in a fixed location and large quantities are required.)

8.0 Quality Assurance/Quality Control

All reporting limits, QC frequency, and QC acceptance criteria are subject to change on a project specific basis.

1. The instrument is tuned using BPFB and TRIS. This is generally performed before analysis each day. The HAPSITE software runs a tuning program set to optimize its instrument parameters for analysis. This program optimizes sensitivity and enables library matching of the spectra.
    a. There are short and long tune algorithms. Typically, the short tune is performed. A long tune is typically performed only after major instrument maintenance.
    b. After running a successful tune (tune passes internal instrument criteria), it is saved to the default tune file.
    c. The HAPSITE is not designed to pass the typical TO-15 bromofluorobenzene (BFB) tune criteria to operate at its highest potential. Therefore, BFB tune criteria are not relevant for this SOP.

2. **Initial Calibration.** An initial calibration curve is required to demonstrate adequate instrument performance for sensitivity, linearity, resolution, and absence of active sites.

   a. A valid initial calibration curve must be established before samples can be analyzed. The GC/MS is calibrated following the outline below. Variations from this standard calibration scheme are sometimes necessary because of project reporting limit requirements.

   b. As the reporting limit is driven by the lowest calibration point, any lowering of the RL will require either (1) calibrating to a lower level, or (2) injection of more sample volume.

   c. **Calibration Schemes.** The following calibration schemes have been successfully used, the actual scheme used should be tailored to the instrument and project requirements. It is based on a 1-minute sampling period (1 minutes at 100 mL/min = 100 mL)

Cal Levels (1-minute sampling time normalization)

Cal Level – SIM	Standard Concentration, ppbv	Sampling time, (min)	Concentration, ppbv
Level 1	0.5	0.2	0.1
Level 2	0.5	1.0	0.5
Level 3	0.5	2.0	1.0
Level 4	5.0	1.0	5.0
Level 5	5.0	5.0	25.0

   d. The curve can be shifted to be more or less sensitive by increasing or decreasing the sampling time. Longer sampling time increases sensitivity, and vice versa.

   e. For the initial calibration, a response factor (RF) and a percent relative standard deviation (RSD) are calculated for each analyte.

   f. After a new calibration is performed the method needs to be saved with the correct filename. The method name should be the date followed by an identifier. For example, an ICAL performed on October 29, 2014 for client x will be named 102914X.

   g. There must be at least 3 points to have a valid calibration curve. The lowest point must be at or below the reporting limit.

   h. The %RSD for all compounds must be less than 30%.

   i. If the %RSD >30%, then a linear curve fit may be used as long as the curve fit >0.995.

   j. If the above requirements are not met, then a new initial calibration must be performed. If this does not result in an acceptable initial calibration, then system maintenance may be necessary.

   k. Calibrations are valid for one year (or until the end of the project, whichever occurs first) as long as QC continues to meet acceptance criteria.

   l. In the following instances, a new calibration will be required:

      i. Major instrument maintenance such as cleaning the MS.
      ii. Repeated failure to pass continued calibration criteria.

   m. If an analyzed sample falls above the calibrated range of the instrument, it should be diluted (if possible).

3. **Method Blanks** – method blanks are required at a rate of one per day. Method blanks are analyzed to monitor possible instrument contamination. Method blanks are prepared with UHP nitrogen in a Tedlar bag every day samples are to be analyzed. The method blank is carried through the same analytical procedure as a field sample.
    a. Method blanks are analyzed by injecting the full normalized volume of nitrogen (varies by system) into the HAPSITE and following procedures outlined in Section 9.
    b. The blank must not contain any target analyte at a concentration greater than the RL and must not contain additional compounds with elution characteristics and mass spectral features that would interfere with identification and measurement of a method analyte. If target analytes are found in the method blank above the reporting limit, the source of the contamination must be considered. Usually, re-running the blank will resolve most problems (especially if the sample run prior to the blank was high in target analyte concentration.) If blank contamination is still present, the analyst should perform system maintenance. Some common problems that cause a blank to show contamination are:
        i. Cold spots – check heated zones for failure.
        ii. Contaminated sample probe – flush the probe
        iii. Dirty Tedlar bag – flush and refill the bag or use new bag.
    c. Note: In situations where expected concentrations are going to be significantly greater than the reporting limit and/or outdoor air, a background air sample may be substituted for nitrogen.
4. **Continuing Calibration Verifications (CCV)** – a primary source standard analyzed at the beginning of an analytical batch to ensure that the instrument continues to meet the instrument sensitivity and linearity requirements originally established by the initial calibration.
5. The opening calibration verification for each compound of interest will be verified prior to sample analysis using the same introduction technique and conditions as used for samples. This is accomplished by analyzing one of the calibration standards used for initial calibration.
    a. Typical concentrations for calibration verification are at or below the midpoint of the instrument calibration curve.
6. No closing calibration check is required for EPA Method TO-15 analysis. However, if time allows, it is good practice to analyze a closing calibration check to increase confidence in data quality.
7. The %D for each compound may not exceed 30 percent.
8. Failure to pass continuing calibration criteria requires corrective action are performed. Repeated failure to pass response factor criteria requires the performance of a new initial calibration.

9.0 Procedure

1. Startup when the HAPSITE is received:
    a. Unpack the HAPSITE. It is usually shipped with the power off and the mass spec pumped down. Be sure that it has a significant amount of time (at least an hour, but overnight if possible) to warm up and equilibrate before use.
    b. Insert the carrier gas (or attach external supply) and internal standard gas cylinders. Verify that the sample trap has not broken during shipment.
    c. Plug the HAPSITE into an external power source. The HAPSITE has an onboard battery, but it needs to be re-charged periodically.

d. Attach the computer (turn on and start software). Then push the power button on the HAPSITE. The HAPSITE will go through a warm up routine, then a tune. When prompted for a trap clean out, press “yes” on the HAPSITE screen.

e. Load the desired method on the HAPSITE screen and then denote this method as the default method. This is important because otherwise it will default to a different method at the end of each run and change zone temperature settings. Note: All files (method, tune, data) reside on the HAPSITE not the PC.

f. To keep data files in an orderly manner, it is recommended to create a new subdirectory each day. This can be done in the method editor (Data page)

2. Startup from extended standby:

   a. Press power button
   b. Insert internal standard and carrier gas.
   c. Wait for instrument to warm up and run tune.

3. Analytical standards and/or diluted samples in Tedlar bags are attached to the sample probe manifold with a compression fitting. Ambient air samples are simply drawn directly into the probe. Pressurized or evacuated sample or standard sources cannot be used as they will significantly change instrument response.

4. Survey mode (Sniff mode)

   a. Load the appropriate survey method on the HAPSITE. This can either be done from the touch screen or the PC. Be sure that the method is appropriate for the target compounds. If necessary, sensitivity can be increased by using SIM to target the most important ions of interest.

   b. Once the instrument starts sampling, place the probe in the locations (cracks, drums, etc.) to be sampled.

   c. Record on the field log the elapsed time into the run and the location of each sampling. Field logs will be handwritten in the field.

   d. When complete, press the stop button on either the HAPSITE screen or the PC.

   e. Note: It requires about 2 ppmv of total VOCs to register a discernable change in baseline in scan mode and about 100 ppbv in SIM mode.

5. Quantitation mode

   a. Using the method editor on the PC, verify that the desired sample time is set correctly in the method to be used for analysis. Typically, this will be 1 minute, but may differ depending on project requirements or dilutions. Save the method.

   b. Load the appropriate quantitation method onto the HAPSITE. This can either be done from the touch screen or the PC. Be sure that the method is appropriate for the target compounds. If necessary, sensitivity can be increased by using SIM to target the most important ions of interest.

   c. Run the QC (either an ICAL or CV and blank). Attach a Tedlar bag containing the standard or UHP blank gas to the sample probe. Open the bag and press run on the HAPSITE. Once QC has passed criteria then sample analysis can begin.

   d. Place the probe in the location to be sampled. Press the run button on the HAPSITE. Once the desired sample time has been completed, the probe can be removed from the sampling location.

e. Once the analysis is complete, allow the GC oven to cool, then inject the next sample.

f. All of the sample and QC information for an analytical run such as lab and client sample IDs, injection volumes, standard IDs, and run methods, (etc.), are added to the handwritten field log.

6. Sample Dilution

   a. Any sample that has target analytes over the calibrated range of the instrument should be diluted if possible. The subsequent dilution should be run such that the final value of the maximum concentration analyte recovers within the calibrated range on the instrument (before dilution factors are applied).

   b. Required dilutions for HAPSITE analysis can be achieved in two different ways.

      i. **Concentrator fill time:** Inject a smaller sample volume. Record all dilutions in the field form. For example, normalized to a 1-minute fill time (100 mL), a dilution of 5× can be performed by only sampling for 0.2 minute (20 mL). Using the method editor on the PC, set the desired sample time in the method to be used for analysis. Save the method. Then load the appropriate quantitation method onto the HAPSITE. This can either be done from the touch screen or the PC

      ii. **Tedlar bag dilution:** Take a sample with a syringe and inject it into a Tedlar bag with a known volume of clean air. Attach the bag to the instrument sampling port and withdraw an aliquot. The aliquot can be less than the normalized value (as in the section before). Both the Tedlar bag dilution factor and concentrator fill injection factors are applied to the final instrument result.

7. At the end of the day, put the HAPSITE into external standby and remove carrier gas and ISTD if the instrument is going to be used again next day. Otherwise the HAPSITE can be powered off.

10.0 Tables

Table 1. Typical Method Analytes (SIM Mode, 1-minute fill time)

Standard Analytes	Reporting Limit $\mu g/m^3$
1,2-DCE (cis)	2.0
1,2-DCE (trans)	2.0
PCE	0.69
TCE	0.55
Vinyl Chloride	1.3

All reporting limits are subject to change on a client specified basis as requested by that client.

HAPSITE Log Sheet: Quantification Mode

Project: ______________________

Parent ID ______________________

Sample Date: ______________________

HAPSITE: ______________________

Quant. Method: ______________________

Cali. Date: ______________________

Cali. Range: ______________________

Run #	Date	Time	Sample ID	Sample Location Description	CIS	TCE	PCE	Notes

Notes:
Cali. = Calibration
CIS = cis-1,2-Dichloroethene
ID = Identification
PCE = Tetrachloroethene
Quant. = Quantification
TCE = Trichloroethene

HAPSITE Log Sheet: Sniff Mode

Project: ______________________

Parent ID ______________________

Sample Date: ______________________

HAPSITE: ______________________

Survey Method: ______________________

Run #	Date	Time	Survey Method	Sample Description	Notes

Note:
ID = Identification

SOP B.18 HAPSITE Screening with the Headspace Sampling System

INFICON

HAPSITE ER/Smart Plus Training

Headspace Sampling System

INFICON

HSS Module Outline

- **HSS Assembly**
- **HSS Theory**
- **HSS Internal Standards**
- **Preparing Blanks/Samples**
- **Running Analyze**
- **Quantitation Reports**
- **Contamination Issues**

INFICON

What is the Headspace Sampling System

- HAPSITE accessory
- Sampling system for:
  - Water
  - Soil
  - Liquids
- Detects VOCs
  - Qualitative methods
  - Quantitative methods
  - PPB to PPT range

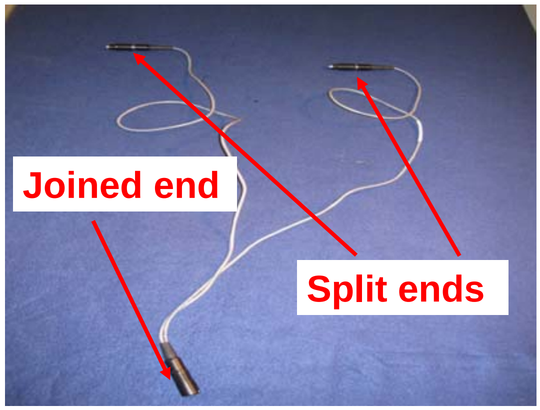
INFICON

HSS Assembly

- Insert a charged battery into the HAPSITE
- Disconnect the HAPSITE power supply cord

Connecting the Y-Cable for Stationary Use

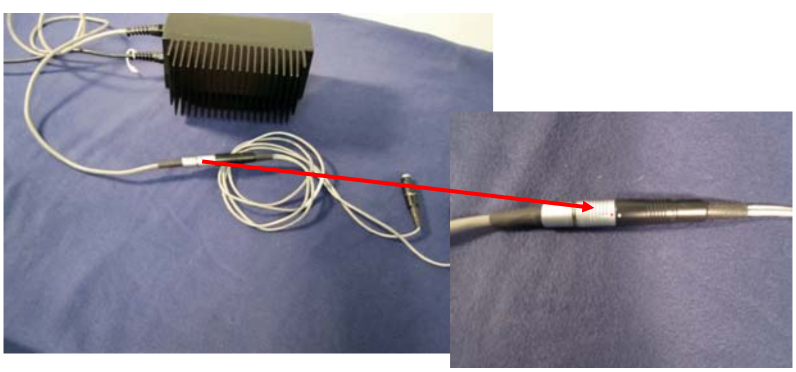
- As the name implies, the cable forms a Y



Connecting the Y-Cable for Stationary Use

- Connect the joined end to the HAPSITE power supply cord

NOTE: Align the dots on the cable with the dots on the cord



INFICON

Connecting the Y-Cable for Stationary Use

- Connect one split end of the cord to the HAPSITE
- Connect the other split end to the Headspace Sampling System

NOTE: Align the dots on the cable with the dots on the instruments to properly connect

7

INFICON

Transfer Line

- Provides communication between the HAPSITE ER/Smart Plus and the HSS
- Sample travels through the transfer line to the HAPSITE ER/Smart Plus

HAPSITE ER Transfer Line

HAPSITE Smart Plus Transfer Line

8

INFICON

Transfer Line

- Encompassed by a foam sleeve
  - Provides insulation
  - Reduces power requirements
- Directional
  - Multi-connector end connects to the HAPSITE ER Universal Interface
  - For the HAPSITE Smart Plus, the direction of the transfer line is labeled directly on it

9 Copyright © 2010

INFICON

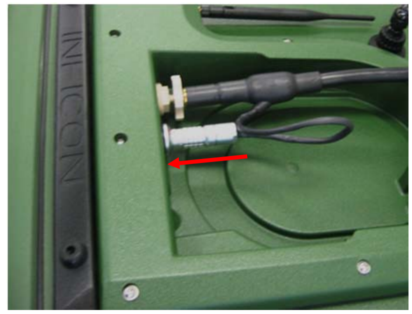
Inserting the Transfer Line

- For the HAPSITE ER, plug the end with the single *LEMO*® connection into the HSS
  - Align the red dots
- For the HAPSITE Smart Plus, plug the side labeled *This End to Accessory* into the HSS
  - Align the red dots

10 Copyright © 2010

Inserting the Transfer Line

- Remove the probe from the HAPSITE ER/Smart Plus
- To attach the transfer line to the HAPSITE ER
  - Screw the *Universal Bulkhead* connection into place
  - Align the red dots
  - Insert the *LEMO* ® connection
- To attach the transfer line to the HAPSITE Smart Plus
  - Align the red dots
  - Insert the *LEMO* ® connection



HAPSITE ER View

11 Copyright © 2010

Portable HSS Use

- The HSS is designed for portable use
  - Requires a battery
- Open the front door of the HSS
- Insert the battery into the slot
  - The arrow on the battery will be facing the battery release button
  - The INFICON label will be in the lower left-hand corner

12 Copyright © 2010

INFICON

Portable HSS Use

- Push battery into slot until a "click" is heard
- Verify that the battery is securely fastened

13 Copyright © 2010

INFICON

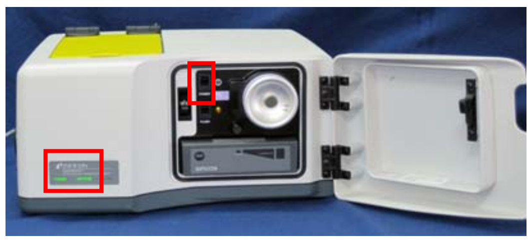
Nitrogen Canister

- Insert the nitrogen canister

14 Copyright © 2010

Turning on the HSS

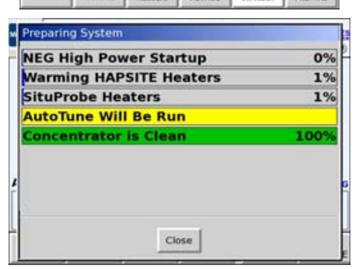
- Press down on the *POWER* switch
  - The *POWER* switch is a toggle switch
    - Once pressed, it will return to its original position
- The word *POWER* will illuminate
  - If the Headspace is powered by the HAPSITE power supply, the *RMT POWER* (Remote Power) will also illuminate
- Close the front door



15

Preparing Analyze

- The HAPSITE ER/Smart Plus will automatically begin preparing a Headspace method
  - All components will be heated to their set point temperature
  - AutoTune will be run
  - Concentrator Cleanout will be run if a concentrator is installed

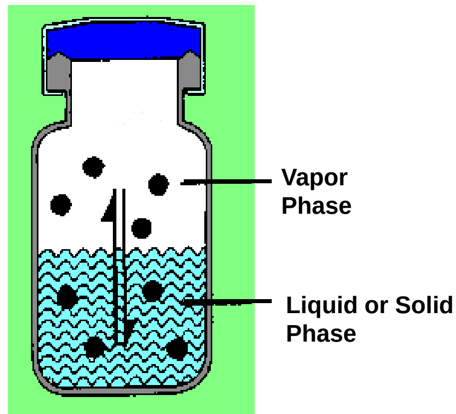


16

INFICON

HSS Theory

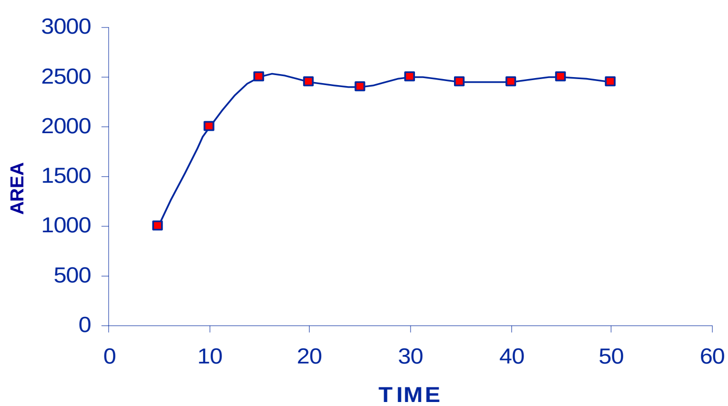
- VOCs collect as a gas in the headspace above the liquid or solid sample
- Samples need to heat for ~15-20 minutes to reach equilibrium
- Equilibrium occurs when the rate of VOCs leaving the sample is equal to the rate of VOCs returning to the sample



17 Copyright © 2010

INFICON

Determining Equilibration Times

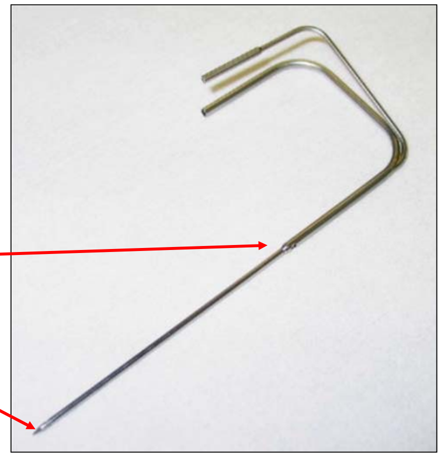


18 Copyright © 2010

INFICON

HSS Sampling

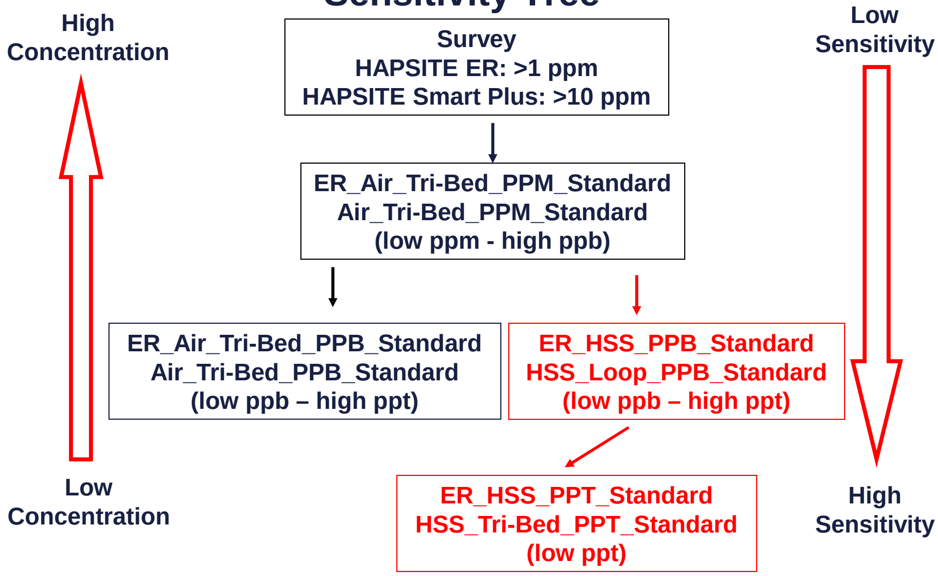
- The Headspace needle is concentric and has two openings
  - Sample is drawn in from the top opening
  - Nitrogen is bubbled out of the bottom opening



19 Copyright © 2010

INFICON

Sensitivity Tree



20 Copyright © 2010

INFICON

HSS Internal Standards

- The matrix of the internal standard must match the sample matrix
  - Liquid samples use a liquid internal standard
  - Gas samples use a gas internal standard
- TRIS and BPFB are gas standards
  - These standards will not be automatically injected into the HAPSITE during a HSS run
- HSS internal standards are liquid
  - Standards must be manually injected into each sample vial using a syringe

21

INFICON

HSS Internal Standards

- Internal standards are used as:
  - A reference for quantitative methods
  - An aid to estimate concentrations
- 4 component mix (p/n 071-748)
  - Fluorobenzene (250 µg/mL)
  - Chlorobenzene-d5 (250 µg/mL)
  - 1,4-dichlorobenzene-d4 (250 µg/mL)
  - Bromopentafluorobenzene (BPFB) (500 µg/mL)

22

INFICON

HSS Internal Standard Addition Concentration Calculation

$$V_1C_1 = V_2C_2$$

Initial Volume x Initial Conc. = Final Volume x Final Conc.

0.010 mL x 250 µg/mL (IS) = 20 mL x ? Final Conc. µg/mL

Final Conc. = 0.125 µg/mL = 0.125 ppm = 125 ppb

- Keep the same units on both sides of the equation
- Internal standard concentration will vary based on sample size

23

INFICON

HSS Internal Standards

- Final concentrations of various IS additions

Sample Configuration	Addition	10 mL Water	20 mL Water	5 g Soil	10 g Soil
Loop Method (HAPSITE Smart Plus only) PPB Standard method (HAPSITE ER and Smart Plus)	10 µL of 250 µg/mL IS	0.250 µg/mL (250 ppb)	0.125 µg/mL (125 ppb)	0.500 µg/g (500 ppb)	0.250 µg/g (250 ppb)
	10 µL of 500 µg/mL IS (BPFB)	0.500 µg/mL (500 ppb)	0.250 µg/mL (250 ppb)	1.000 µg/g (1 ppm)	0.500 µg/g (500 ppb)
PPB Quant method (HAPSITE ER only) PPT Standard method (HAPSITE ER and Smart Plus)	1.0 µL of 250 µg/mL IS	0.0250 µg/mL (25 ppb)	0.0125 µg/mL (12.5 ppb)	0.0500 µg/g (50 ppb)	0.0250 µg/g (25 ppb)
	1.0 µL of 500 µg/mL IS (BPFB)	0.0500 µg/mL (50 ppb)	0.0250 µg/mL (25 ppb)	0.1000 µg/g (100 ppb)	0.0500 µg/g (50 ppb)

24

INFICON

Preparing Blank/Samples

- In general, HSS samples are prepared as follows:
  - Liquids
    - Fill vials ½ full
      - 20 mL
  - Solids
    - Use 10 grams
      - Do not block needle opening
  - Inject 10 µL internal standard for PPB (or Loop) methods
  - Inject 1 µL internal standard for PPT methods

INFICON

Preparing Blank/Samples

- Prepare a blank using VOC-free water and internal standard
  - Verifies that the Headspace and the HAPSITE ER/Smart Plus are operating properly
    - Proper gas flow
    - Acceptable pressure
    - Monitors carryover or contamination

INFICON

Preparing the Blank/Samples

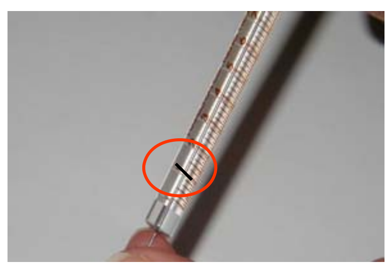
- Add 20 mL of VOC-free water into the vial
- Clean the 10 µL glass syringe three times with methanol
  - Allow syringe to completely fill with methanol
    - Discard excess methanol into waste vial

27

INFICON

Preparing the Blank/Samples-Syringe Techniques

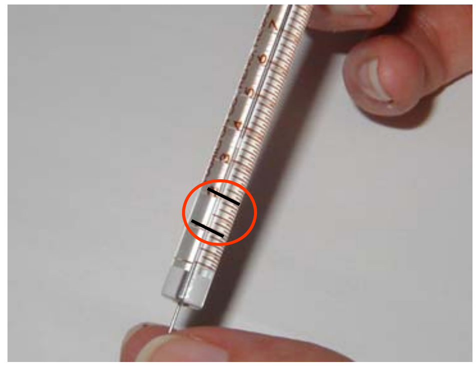
- Practice proper syringe technique using methanol
  - Draw the syringe plunger back to the 1 µl mark
  - Insert the tip of the syringe needle into the methanol
    - Be careful not to move the plunger
  - Carefully draw the plunger back to the 2 µl mark
  - Withdraw the syringe from the vial
    - Be careful not to move the plunger



28

Preparing the Blank/Samples-Syringe Techniques

- Draw the plunger back until there is a 1 µL plug of liquid between the 1 µL and 2 µL mark
  - Plunger will be drawn back to ~4 mL
- Inject this liquid into a waste vial
  - Disregard small air pockets that may appear near the plunger
- Repeat this same procedure for sample preparation



29 Copyright © 2010

Inserting Blank and Purge Vial into the HSS

- Open the top lid on the Headspace
- Lift the needle assembly
- Place the standard blank into a well
- Place an empty vial into another well
  - This is the purge vial

30 Copyright © 2010

INFICON

Inserting Blank and Purge Vial into the HSS

- **Center the needle over the septum and gently insert it into the vial for the standard blank**
  - **Needle guides can be used to help position the needle**
- **Close the top lid**
  - **Allow the blank to heat for 15-20 minutes**

INFICON

Running Analyze

- **Touch *RUN ANALYZE***
  - **Nitrogen from the headspace needle and bubble into the sample**
    - **This will purge the sample to release VOCs dissolved in the water**

INFICON

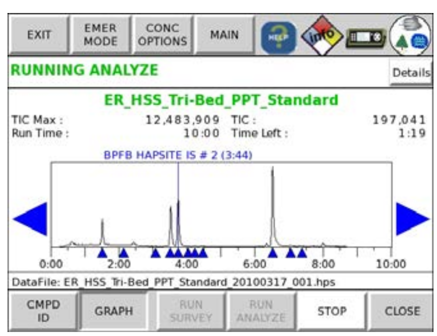
Collecting a Sample

- *Collecting Sample For* screen
  - The Headspace will automatically collect a sample
  - No action is required from the user
- *Sampling is Done* screen
  - Sample collection is complete
  - Again, no action is required from the user

INFICON

GRAPH View

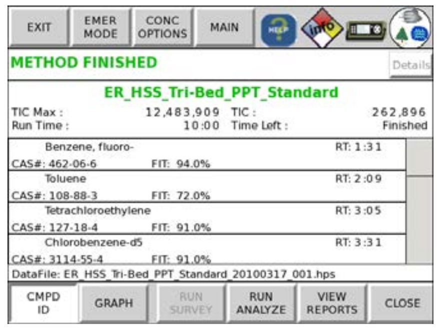
- Compounds will be displayed on the front panel
- *GRAPH* is the default view
  - Displays the chromatogram during the run
- Displays:
  - Compound Name
  - Retention Time
  - TIC
  - TIC Max



INFICON

CMPD ID View

- The data can be viewed as a list by touching *CMPD ID* during a run
- Displays:
  - Compound Name
  - CAS Number
  - Retention Time
  - Net Fit

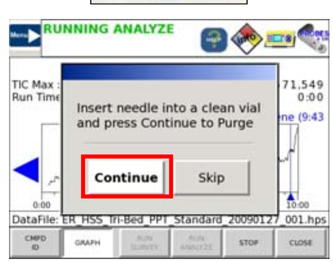


35 Copyright © 2010

INFICON

Purge Headspace

- A prompt will appear to purge at the end of each run
- To purge, insert the Headspace needle into the purge vial
  - Average purge time is 2 minutes
  - Cleans residual sample from the needle
- Touch *Continue*

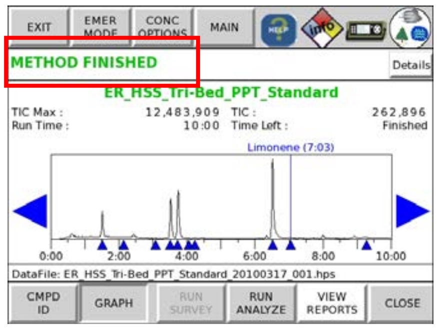


36 Copyright © 2010

INFICON

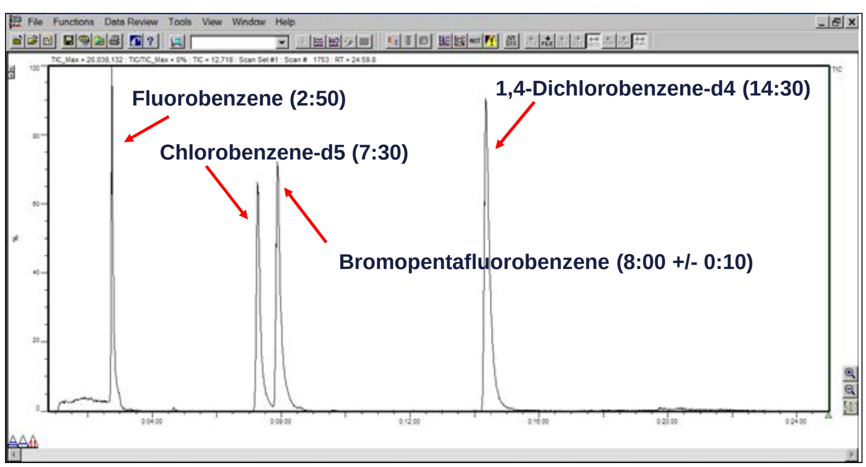
Method Finished

- When the method and purge are complete, *METHOD FINISHED* will be displayed



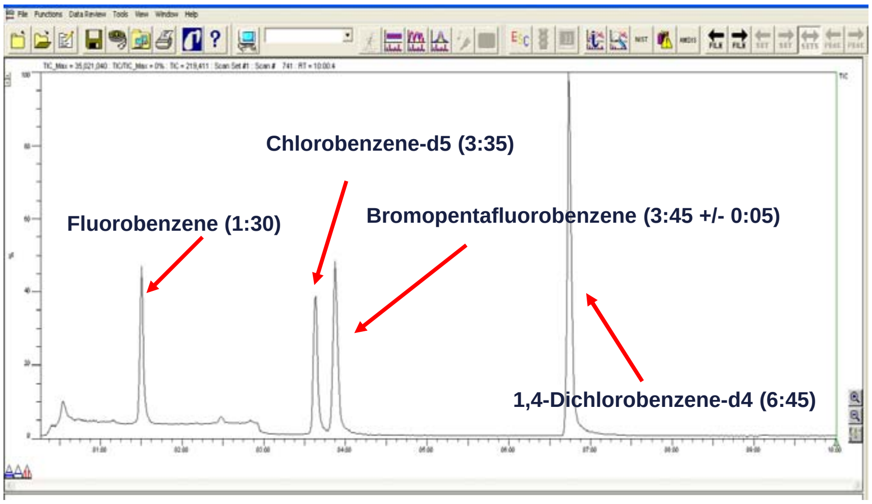
INFICON

HSS Blank from the Smart Plus



INFICON

HSS Blank from the ER



INFICON

Exercise: Preparing a HSS Sample

- **Use a 40 mL vial to prepare the sample**
  - **Add 20 mL VOC-free water**
  - **Inject 1 μL HSS Internal Standard**
  - **Inject 1 μL Sample for Scenario**
  - **Place the sample in the HSS and allow to equilibrate for 20 minutes**
- **Run Method ER_HSS_Tri-Bed_PPB_Quant**
- **Select**  **and use the *Quant* tab to view data**

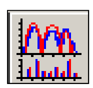
INFICON

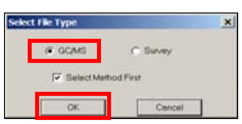
Worksheet: HSS Blank

41

INFICON

Accessing Quantitation Reports

- Double-click on the *ID Unknowns* icon 
- The user is prompted to select the method type
  - Select GC/MS



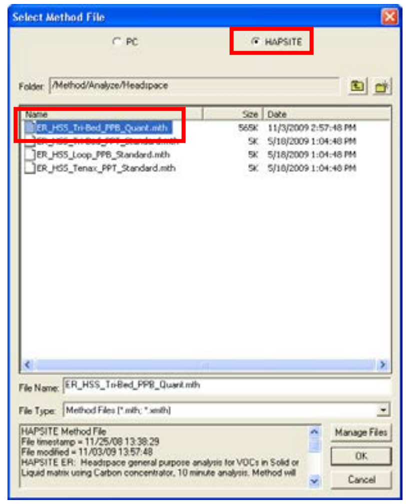
- Click *OK*

42

INFICON

Accessing Quantitation Reports

- **Select *HAPSITE***
- **Double-click on the desired method**

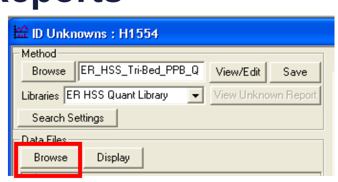


43 Copyright © 2010

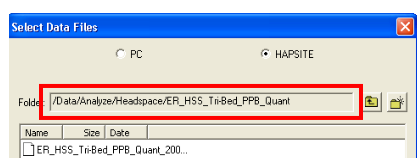
INFICON

Accessing Quantitation Reports

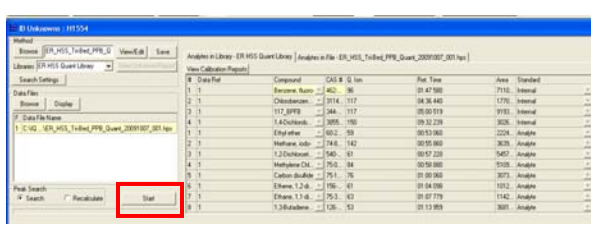
- **Click *Browse* to select the desired data file**



- **The pathway for the data file:**



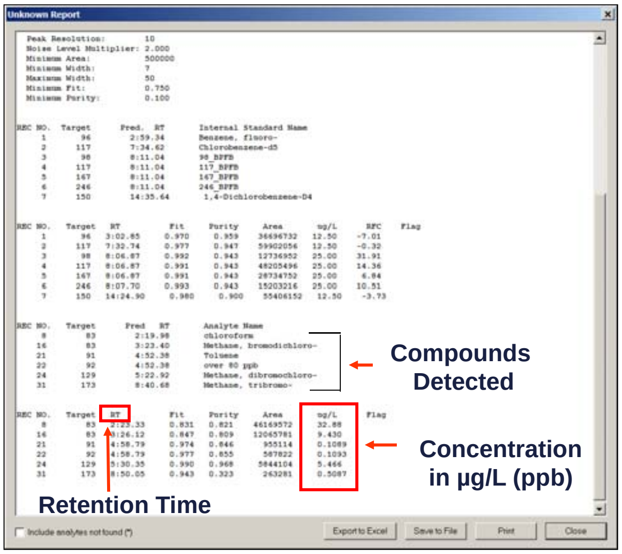
- **Click *Start***



44 Copyright © 2010

INFICON

Quantitation Report


Unknown Report

Peak Resolution:	10
Noise Level Multiplier:	2.000
Minimum Area:	500000
Minimum Width:	7
Maximum Width:	50
Minimum Fit:	0.750
Minimum Purity:	0.100

REC NO.	Target	Pred. RT	Internal Standard Name
1	96	2:59.34	Benzene, fluoro-
2	117	7:34.62	Chlorobenzene-d5
3	98	8:11.04	98_BPFB
4	117	8:11.04	117_BPFB
5	167	8:11.04	167_BPFB
6	246	8:11.04	246_BPFB
7	150	14:35.64	1,4-Dichlorobenzene-D4

REC NO.	Target	RT	Fit	Purity	Area	ug/L	RFC	Flag
1	96	3:02.85	0.970	0.959	36696732	12.50	-7.01	
2	117	7:32.74	0.977	0.947	59902056	12.50	-0.32	
3	98	8:06.87	0.992	0.943	12736952	25.00	31.91	
4	117	8:06.87	0.991	0.943	48205496	25.00	14.36	
5	167	8:06.87	0.991	0.943	28734752	25.00	6.84	
6	246	8:07.70	0.993	0.943	15203216	25.00	10.51	
7	150	14:24.90	0.980	0.900	55406152	12.50	-3.73	

REC NO.	Target	Pred RT	Analyte Name
8	83	2:19.98	chloroform
16	83	3:23.40	Methane, bromodichloro-
21	91	4:52.38	Toluene
22	92	4:52.38	over 80 ppb
24	129	5:22.92	Methane, dibromochloro-
31	173	8:40.68	Methane, tribromo-

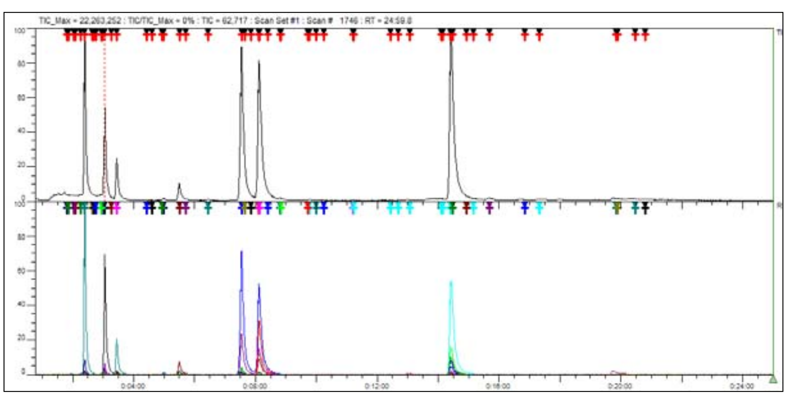
REC NO.	Target	RT	Fit	Purity	Area	ug/L	Flag
8	83	2:23.33	0.831	0.821	46169572	32.88	
16	83	3:26.12	0.847	0.809	12065781	9.430	
21	91	4:58.79	0.974	0.846	955114	0.1089	
22	92	4:58.79	0.977	0.855	587822	0.1093	
24	129	5:30.35	0.990	0.968	5844104	5.466	
31	173	8:50.05	0.943	0.323	263281	0.5087	

45 Copyright © 2010

INFICON

Accessing Quantitation Reports

- *ID Unknowns* **will label the peak of each chemical from the calibration library with a "T"**

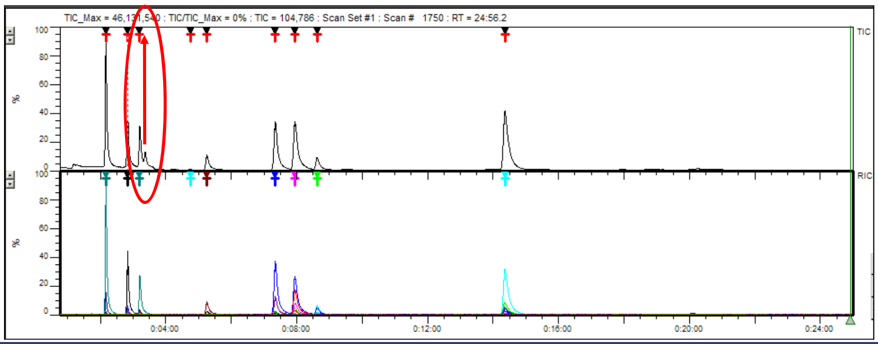


46 Copyright © 2010

INFICON

Quantitation Reports

- **Use caution when using *Quantitation* reports**
  - **The report identifies and quantifies only the chemicals that are specifically referenced in the calibration library**
  - **The chromatogram must be visually inspected for additional peaks that were not identified in the report**



47

INFICON

Quantitation Reports

- **ID the unidentified peak(s) using:**
  - **AMDIS Search**
  - **Automatic NIST Search**
  - **Manual NIST Search**
- **Estimate the concentration**

48

INFICON

HSS Concentration Estimates

- This formula is used to estimate concentration of chemicals based on the internal standards

$$\frac{\text{Max normalization value of compound of interest}}{\text{Max normalization value of nearest internal standard}} \times 12.5 \text{ ppb } (25 \text{ if using BPFB}) = \text{Approximate Concentration}$$

(+/- one order of magnitude)

$$\frac{\text{Max normalization TCE } (15{,}900{,}000)}{\text{Max normalization fluorobenzene } (7{,}000{,}000)} \times 12.5 \text{ ppb} = 28 \text{ ppb}$$

(2.8 to 280 ppb)

NOTE: This calculation is for a concentrator method using a 1 µL internal standard injection

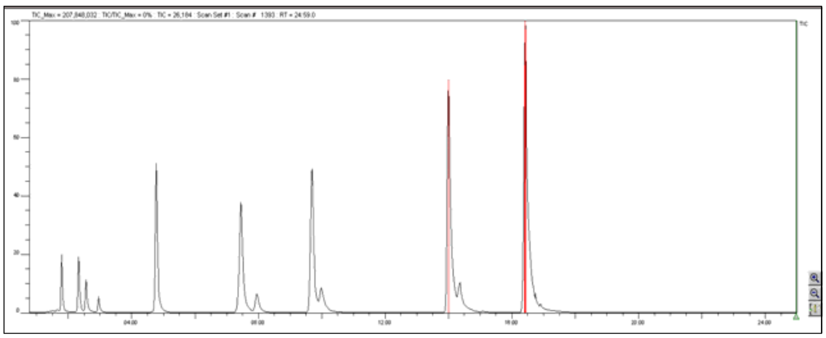
INFICON

- Worksheet: Headspace Concentration Estimation

INFICON

Headspace Contamination Issues

- Contamination can be caused by carry over
  - Occurs from highly concentrated samples
  - Appears as extraneous peaks that continuously appear in successive blank runs



51

INFICON

HSS Contamination Issues

- To minimize carryover, screen the sample with Survey prior to HSS sampling
  - Aids in determining the proper method to run
- To remove carryover
  - Run blanks until extraneous peaks no longer appear
- Persistent contamination
  - Flush the HSS

52

INFICON

Flushing the Headspace

- **Disconnect the transfer line from the HAPSITE ER/Smart Plus**
- **Insert a full canister of nitrogen**
- **Press down on the *FLUSH* switch**
  - **The *FLUSH* switch is a toggle switch**
  - **Once pressed, it will return to its original position**

53 Copyright © 2010

INFICON

Flushing the Headspace

- **Flush for two hours**
- **Press the *FLUSH* switch again to end flushing**
- **Verify that contamination has been cleared**
  - **Repeat blank run**

54 Copyright © 2010

INFICON

HSS Module Summary

- HSS Assembly
- HSS Theory
- HSS Internal Standards
- Preparing Blanks/Samples
- Running Analyze
- Quantitation Reports
- Contamination Issues

55

INFICON

SCENARIO

56

SOP B.19 Surface Water Sampling

1.0 Purpose and Scope

This standard operating procedure (SOP) describes methods and equipment commonly used for collecting environmental samples of surface water for laboratory analysis.

2.0 Equipment and Materials

- Stainless steel or glass beaker
- Sample containers
- Sample labels
- Calibrated water-quality meter
- Distilled water/Alconox™ (for decontaminating sample equipment)
- Paper towels
- Resealable plastic bags
- Disposable gloves
- Field logbook or field form
- Shipping supplies (cooler, ice, plastic resealable bags, custody seals, chain-of-custody forms)

3.0 Procedures

1. When sampling in a stream or creek, field personnel should start downstream and work upstream to avoid cross-contaminating unsampled areas.
2. Prior to sample collection record the sample location in the field logbook and/or appropriate field form.
3. Decontaminate all field sampling equipment prior to use.
4. Calibrate all field measurement equipment prior to use.
5. If possible, fill the sample containers directly from the source. If the sample container cannot be filled directly (for example, when filling a pre-preserved vial in running water) a decontaminated stainless steel or glass beaker can be used to collect the sample and fill the sample containers.
6. Immerse the sample container or clean glass or stainless steel beaker with the opening facing upstream to collect sample volume. The beaker should be immersed gently to avoid turbulence. Avoid collecting floating surface debris or disturbed bottom sediment in the water sample.
7. If collecting from a running stream, the decontaminated sample container can be attached to a pole for sample collection.
8. Collect the sample into appropriately labeled sample vials and bottles. Volatile organic compound (VOC) samples should be collected first. Transfer the sample gently to avoid turbulence and bubble formation in the vial.
9. If insufficient water is present in the water source to directly collect a sample, a small hole can be dug near the source using a decontaminated trowel or shovel. Sediments within the water should be allowed to settle before obtaining the sample. The samples will then be collected directly into the sample containers if possible.
10. Cap the sample bottles immediately after sample collection and store on ice in the sample cooler.

11. Decontaminate collection vessels between uses if using non-dedicated equipment. Wherever possible sample from areas of lowest contamination to highest contamination.
12. As soon as possible after sample collection is complete collect additional surface water in a beaker for measuring water quality parameters. Allow sufficient time for parameters to stabilize and record a single set of water quality measurements.
13. Store and ship the samples according to the procedures in SOP B.13, *Sample Handling and Shipping.*

4.0 Documentation and Field Forms

Field personnel will record all field sampling activities in the appropriate field form and/or field logbook as discussed in SOP B.3, *Field Documentation*.

5.0 Quality Control

5.1 Equipment Decontamination

Sampling equipment that will be used at multiple sampling locations will be decontaminated after sampling at each location in accordance with SOP B.2, *Decontamination of Personnel, Heavy Equipment, and Sampling Equipment*.

5.2 Quality Control Samples

- Trip blanks will be submitted with every shipment of VOC samples.
- Field duplicates will be submitted at a frequency of 1 field duplicate per 10 normal samples per method as described in Section 5.9 of the Field Sampling Plan. Field duplicates will be collected in the same method and as close as possible to the original sample and submitted to the laboratory in a manner that prevents the laboratory from knowing the duplicate/parent sample relationships.
- Laboratory QC samples (matrix spike [MS], matrix spike duplicate [MSD]) will be collected at a frequency of 1 MS/MSD per 20 normal samples per method. MS and MSD samples will be collected in the field as close as possible to and in the same method as the normal sample.
- Equipment blanks may be collected where non-disposable, non-dedicated sampling equipment is used. If collected, field personnel will collect equipment blanks by pouring the appropriate water into or over the decontaminated sampling equipment or vessel and then transferring the water to the sample bottles.

SOP B.20 Data Management Plan

1.0 Introduction

This data management plan (DMP) outlines the systems and processes that will support data management during the environmental investigations performed at the 700 South 1600 East Tetrachloroethene (PCE) Plume Site (hereafter referred to as the "PCE Plume Site") located near the George E. Wahlen Veterans Affairs Medical Center in Salt Lake City, Utah. The work will be performed under Contract No. W912DQ-15-D-3014, Task Order (TO) 0005, between the U.S. Army Corps of Engineers, Kansas City District (USACE-KC) and CH2M HILL, Inc. (CH2M). The scope of work includes revisions made to the initial scope of work, as documented in the approved Work Variance Notices. These investigations are being managed by the U.S. Department of Veterans Affairs - Veterans Healthcare Administration (VHA) Salt Lake City Health Care System, Salt Lake City, Utah. This DMP was prepared to support the data collection activities described in the Operable Unit 2 remedial investigation work plan (RIWP), which was under preparation at the time this DMP was prepared, as well as Accelerated Operable Unit 1 (AOU-1) data that include data currently stored in an existing database, and data from the planned March 2017 AOU-1 sampling event that will be provided with the legacy data. This document includes the data management standards and guidelines for data generated, validated, and distributed during the project duration.

This DMP will be used by project team members and subcontractors involved in generating, managing, and reporting data. This DMP describes quality assurance and quality control procedures (QA/QC) specific to managing project data. QA/QC procedures for data generation will be described in the quality assurance project plan (QAPP), a component of the RIWP. This plan may be revised or amended to accommodate changes in site conditions or data management requirements to better achieve project objectives.

1.1 Remedial Investigation Scope

The remedial investigation (RI) field activities associated with this project may include the following activities. Some of these, such as soil, soil gas, and surface water sampling, are not included in the current task order, but may be included in future task orders, as necessary, to define the nature and extent of contamination.

- Installing and sampling new groundwater monitoring wells
- Sampling existing monitoring wells and other types of groundwater wells such as Salt Lake City or University of Utah water-supply wells
- Collecting and testing geotechnical samples
- Conducting geophysical and groundwater flow logging in new groundwater monitoring wells
- Conducting aquifer testing in new and existing wells
- Sampling indoor air in structures overlying AOU-1
- Sampling soil and soil gas in potential source areas
- Sampling surface water in areas outside AOU-1

The data management system (DMS) will support efficient and accurate information storage and access, with traceable documentation from the point of data generation through final data storage.

1.2 Data Management Objectives

The overall goal of the DMS is to provide the VHA project team members ready access to consistent and accurate data. This involves developing a DMS that will integrate multiple types of data, including geographic, tabular, text, image, and written documentation data from a variety of sources. The following are the objectives of the VHA project-specific DMS:

- Standardize data management methods
- Support efficient delivery of high-quality data to project team members including reduction in time between data collection, entry, and analysis
- Standardize data management QA/QC procedures, consistent with the current AOU-1 QAPP and the OU-2 QAPP currently being developed
- Maintain adequate data backup
- Support long-term integrity of digital data and associated metadata through archival storage standards and practices
- Provide for storage and archiving of non-digital information such as log sheets, inspection forms, documents, published and unpublished reports, and maps
- Subsequent sections of this plan describe the types of information required, provide guidelines for data management operations, and summarize roles and responsibilities of project team members.

1.3 Roles and Responsibilities

The overall responsibility for implementing the DMP is assigned to the project data coordinator (PDC). Designated qualified individuals will assume execution responsibility of this plan as described below. Figure 1-1 shows the project team organizational chart. The roles and descriptions provided below pertain specifically to this DMP. The individuals assigned to these roles may serve other functions during the RI and such responsibilities will be described in the project management plan and RIWP, as appropriate.

Project Manager (PM). The PM directs the project team in determining potential sources of existing data, identifying the project area, and selecting the most effective data collection approach. The PM also communicates the flow down of data management requirements to subcontractors.

Project Data Coordinator (PDC). The PDC develops and implements the project DMP. The PDC supervises incorporation of applicable existing data or new project data into the project's hard copy data record file or database, as appropriate. The PDC has primary authority over the master and archival data sets, data security, data access and dissemination, and maintenance of data documentation and supports overall database configuration, implementation, maintenance, and security. The PDC generally has general responsibility for generating and verifying data, and will assess whether data are considered complete enough for inclusion in the master data series. The PDC may assign tasks to other project personnel who are trained and qualified commensurate with the tasks. The PDC also interacts with project team members to facilitate data collection and access.

RI Fieldwork Task Manager (TM). The TM recognizes and complies with relevant data collection and data management standards. The TM reviews field logbooks or data collection forms (paper or electronic) to assess compliance with the DMP, QAPP, and field sampling plan (FSP). Responsibilities include reviewing field records and determining if samples were labeled properly, instruments were appropriately calibrated before taking measurements, and information was recorded correctly. The TM records nonconformance or deviations and coordinates with the PM and PDC on developing corrective actions.

Geographic Information System (GIS) Data Coordinator (GDC). The GDC creates and maintains geospatial data, project maps, and figures using the GIS functionality that is built into the EQuIS EDMS. The GDC acquires or digitizes maps and features, uses survey data to locate and check attributes of surveyed features, combines spatial data with attribute data from the project database to display features with their attributes, and customizes maps to include color, tabular information, and interpretive features. The GDC supervises final maps submitted in deliverables and produces customized figures and maps according to the needs of the project. The GDC works with the PM, TM, and PDC to update data displayed on maps and figures and to implement QA/QC procedures.

Project Chemist (PC). The PC develops the project-specific statement of work to be performed by the analytical laboratory, including data-deliverable requirements such as specifications for hard copy and electronic deliverable formats. The PC oversees data validation and provides the PDC with validated electronic data deliverable (EDD) files for incorporation into the project database and raw (unvalidated) EDDs for archiving.

Project Field Team. The field team consists of those individuals who perform or supervise field activities such as inspections, monitoring, sampling, and drilling oversight. Field team members are responsible for recording field activities in field logs and data sheets. Field team members will provide completed field forms to the PDC or designated project assistants who will enter data into the field database. Field team members may also help with data entry.

Data User. Data users typically are members of the project team who require access to project information to perform data reviews, analyses, or ad hoc queries.

Stakeholder. Stakeholders, which include VHA and USACE staff, will have access to project documents through the SharePoint site and will have access to the project database through a standard web interface. Data will be provided in the form of tabular exports and standard CH2M report summaries or in custom reports that can be created at the request of VHA to meet project requirements or preferences.

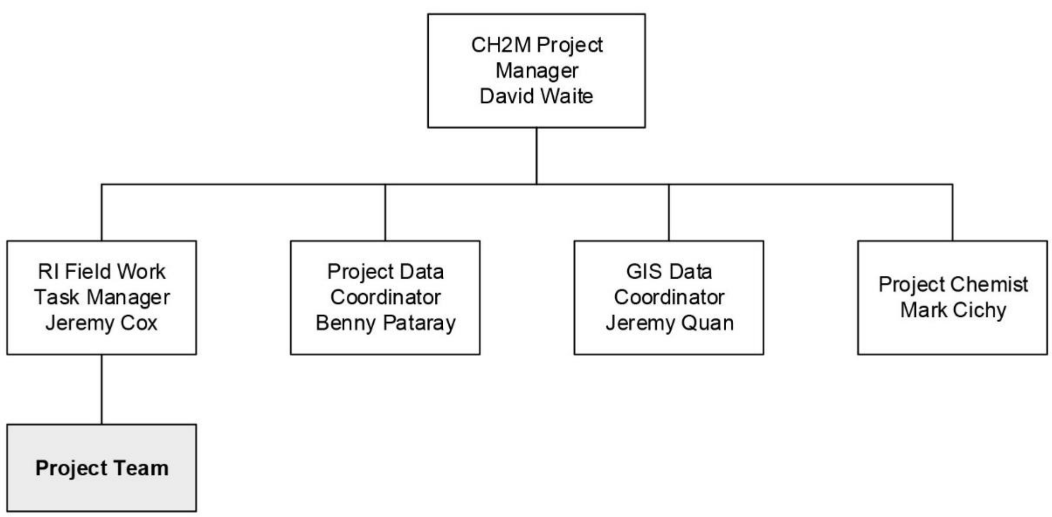


Figure 1-1. Data Management Plan Team Organization Chart
Data Management Plan, Remedial Investigation 700 South 1600 East PCE Plume, Salt Lake City, Utah

2.0 Data Management System and Processes

This section describes the DMS and related processes that will be used during Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) activities at the VHA site.

2.1 Data Management System

The data management system will be set up to manage chemical, geological, hydrogeological, and geospatial data; well-construction data; and project documents. The system is composed of the following major elements, and are shown on Figure 2-1.

An environmental data management system (EDMS) is built in the EarthSoft EQuIS™ system. This is a third-party, commercial, off-the-shelf, packaged EDMS software system. EQuIS is also being used by the prime contractor currently managing CERCLA activities at AOU-1, and the existing AOU-1 analytical data will be imported into the project EDMS after validated data from the planned March 2017 AOU-1 sampling event are available. The EDMS will be configured on a structured query language (SQL) server for implementation of EQuIS and will house the following data types:

- Location information for wells and other sampling points
- Well construction information
- Simplified lithological information for boring logs
- Water level data
- Field parameters (for example, pH and specific conductivity)
- Sample information including location, date and time, sampling method, and matrix
- Analytical chemistry data

Provision for web-based access to the EQuIS EDMS wherein data users, including USACE-KC and VHA personnel can access the analytical chemistry and other data in spatial context. The EQuIS Enterprise web interface will provide query, view, and sort capabilities without any special hardware or software requirements.

Provision for GIS is built in the Environmental Systems Research Institute (ESRI) ArcGIS system. The GIS will be used to house and visualize geospatial data including project specific location information such as wells and sample points and reference entities such as roads, buildings, and water bodies. The GIS will be integrated into the EQuIS EDMS and will be accessed through a map widget in EQuIS Enterprise. EQuIS map widgets will display site data over a map background.

Users will be directed to specific on line documentation and training videos on the EarthSoft website for guidance in using EQuIS Enterprise (http://help.earthsoft.com/default.asp?W3032#Interface and http://earthsoft.com/support/office-hours-videos/)

A document management system consisting of the following:

- A Microsoft SharePoint site containing draft and final documents and including native files
- A Microsoft Access document management database showing the status of each document and containing hyperlinks to the SharePoint site, with a provision to export data to an alternative file format like Microsoft Excel

2.2 Data Management Processes

Data management tasks will follow a definitive flow, starting with planning field activities and ending with the release of final data to team members for use in reports, maps, and other project deliverables. Project data planning and data management tasks are shown on Figure 2-1. The VI Factors Database is shown on Figure 2-1 as outside of the EQuIS EDMS. This database was created as part of the AOU-1 Remedial Investigation/Feasibility Study project to capture information about buildings and samples related to vapor intrusion. However, the structure of the DMS will allow future interaction with the VI Factors Database, specifically through relationships between location and sample identifiers common to the two systems.

The project's QA/QC requirements will be specified in a QAPP, which is being prepared concurrently with this DMP. Specific data collection activities will be described in the FSP, also currently under development. An auditable trail of the information workflow will be implemented. The six steps in the workflow process include the following:

- Project Planning
- Sample Collection and Management
- Laboratory Analyses
- Data Validation
- Data Management
- Reporting, Data Evaluation, and Analysis

The process of data management planning and implementation for the VHA project is composed of the following elements:

- **Planning:** Features are named and located on maps and appropriate field forms are identified. Planned sample tables are created according to the QAPP and FSP. They include location and sample identifiers, requested methods, laboratories, sample containers, proposed sample depths, and so forth. The PDC loads the sampling and analysis requirements into the CH2M Sample Tracking and Scheduling Program (STSP) field database before field activities, and use this tool to generate sampling plans and labels. The TM reviews standard field forms prepared for the sampling activity.
- **Sample Collection:** Field data and sample collection data are captured on paper, reviewed by the field team members, and forwarded to the TM. Field samples include those collected for field or laboratory analyses. The TM verifies field data entered in the field database against the hard copy field forms and chain-of-custody (COC) forms for accuracy and completeness. The PDC receives field forms and COC forms from the TM as they become available. The PDC coordinates updating the field database as data become available.
- **QC Checking:** Data are reviewed for legibility, completeness, and technical accuracy by the TM and forwarded to the PDC for data entry and/or upload to the database. The STSP field database has record-level fields that capture user and date information. Record status is tracked to identify record creation, modification, and export information. Field data exports that include tracking information will be provided to VHA after completion of a sampling event. The extent of technical review will be described in the QAPP.
- **Data Entry:** The PDC reviews the field forms, assigns valid data codes, and facilitates data entry by using the EDD template appropriate for the data collected. The data are entered by data entry staff with instruction and guidance from the PDC. Field data are prepared for upload in the appropriate field EDD template. Analytical data are provided by the laboratory in the required EDD format.

- **QC Checking of the Entered Data:** Field and analytical EDDs are checked for valid values by electronic data verification tools, specifically the EQuIS data processor. Laboratory EDDs are validated according to the QAPP. The PC receives COC information in an electronic format from the PDC, and final EDD and hard copy from the analytical laboratory. The PC coordinates data validation, reviews validated data, and transmits validated EDD and data quality summary report to the TM and PDC. The PDC verifies field and validated data before data upload.
- **Upload Final Data:** The reviewed data set is transferred to the PDC and uploaded to the EQuIS EDMS. Before uploading, the PDC notes inconsistencies or problems encountered and resolves outstanding issues before uploading the final data. The PDC coordinates integration and uploading of draft and final documents to the project SharePoint site.
- **QC Checking of the Uploaded Data:** The PDC performs QC checks to assess whether the data being uploaded are logical. Errors are resolved and corrected by contacting the PM, TM, or the data provider. The PM approves the final data set.
- **Data Use:** The PDC notifies the project team that the data are available for use in reports, figures, maps, risk assessments, or other project deliverables.

The project data planning and data management plan are described on Figure 2-2.

Both field and laboratory data will be collected throughout the project duration. Initially, the planned sampling and analysis tables will be uploaded into the STSP field database (the backend database is stored in the CH2M Salt Lake City office network). STSP is a Microsoft Access-based tool with a frontend database installed in standard-issue and secure Dell laptops that is used by CH2M personnel to aid in sample collection such as project planning, managing bottles, capturing field sampling data, producing labels and COC forms, tracking sample analysis, and verifying sample and analysis data completeness. STSP has an embedded Help file that describes its functionality. Once collected and captured in STSP, field data will be checked and then uploaded into the project database within 1 week after the end of a sampling activity. Field data will be regularly reviewed and made available to VHA as tabular data exports within 2 weeks after a sampling event. The project database will house the field-generated sample collection data and the laboratory analytical data, and will be integrated into the EDMS. The EDMS has built-in reporting, thus allowing data users the ability to access data components as they become available, within 30 days after data validation. New custom reports can be created at the request of VHA to meet project requirements/preferences.

Sample collection information will be forwarded to the laboratory through hard copy COC forms. Laboratory data will be forwarded to CH2M electronically following the laboratory EDD specification included in SOP B.20 Attachment A.

Field forms will be provided as an appendix to the OU-2 FSP. Project-required validation will be documented in the QAPP.

Databases and standalone electronic files and documents will be maintained in the CH2M database environment and file servers. Paper-generated records will be placed in the project file and maintained per contract requirements. At the conclusion of the project, final field and laboratory data will be stored and delivered in a project database in either Microsoft Access, comma-separated value, or extensible mark-up language format exported from the EQuIS database.

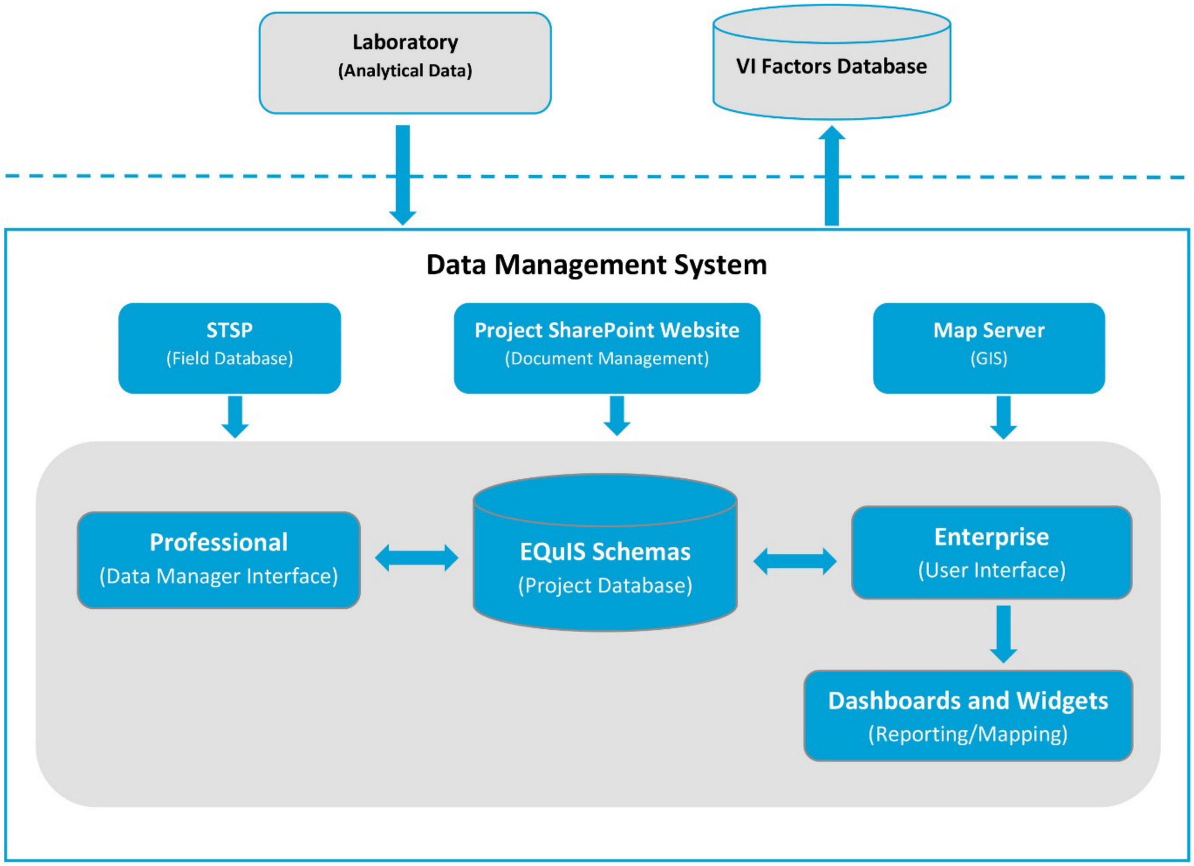


Figure 2-1. Data Management System Schematic

Fieldwork Planning

Project Manager (PM)

- Creates an event-specific Sampling and Analysis Plan (SAP) and schedule and distributes to TM, PDC, PC and Project Team.
- Communicates data management requirements to subcontractors.

Task Manager (TM)

- Reviews field notebooks and field forms.
- Coordinates with PDC in loading SAP and preparing container labels.

Project Data Coordinator (PDC)

- Prepares field database.
- Loads SAP in field database.
- Distributes field forms
- Prepares field data screening tools and criteria.
- Sets up document management scheme.

GIS Data Coordinator (GDC)

- Coordinates global positioning system equipment setup.
- Prepares maps for field sampling activities.

Data Collection During Field Activities

Task Manager (TM)

- Performs daily field data quality control (QC).
- Reviews forms for completeness and accuracy.
- Transmits chain of custody (COC) forms, field forms, field notes to PM and PDC.

Project Data Coordinator (PDC)

- Receives COC forms, field notes, and hardcopy forms from the field as they become available.
- Coordinates transmittal, backup, and update of field database as data from completed field forms become available.

GIS Data Coordinator (GDC)

- Receives field sampling location data and incorporates in GIS data set.

Sample Tracking and Analyses, Data Verification/Validation

Project Chemist (PC)

- Receives COC information in an e-format as a field database export from PDC.
- Receives final Electronic Data Deliverable (EDD) and hardcopy from analytical laboratory.
- Reviews EDD from laboratory and receives validated EDD from validation data package.
- Receives laboratory hardcopies.
- Reviews data validation and assigned qualifiers.
- Transmits validated EDD and data quality summary report to TM and PDC.
- Performs final QC of laboratory data and validation codes.

Project Data Coordinator (PDC)

- Reviews COC forms and performs QC of planned vs. actual.
- Transfers COC information electronically from field database to PC.
- Reviews EDD of validated data, assigns data codes, and loads to database.
- Coordinates the transcription of field data manually entered in field logs into field database.
- Reviews field data submitted on field forms and entered into the field database.
- Performs QC checks, and makes and coordinates corrections.
- Coordinates filing of original hardcopy field records in project files.
- Updates field database.
- Reviews data loaded for completeness.
- Prepares field data in format for upload in project database.
- Reviews Validation Memo and transmits findings to PM.

Integration into Data Management System

Project Data Coordinator (PDC)

- Provides additional QA/QC checks when loading to database.
- Makes revisions as needed.
- Distributes draft data to PM for review and approval.
- Integrates document data and field, analytical, and geotechnical data into project database.

Project Manager (PM)

- Approves final data set.

GIS Data Coordinator (GDC)

- Incorporates geospatial data into project database.

Database Access

Project Data Coordinator (PDC)

- Releases final data to project team.
- Reports to PM if there are any data quality issues that require action.
- Coordinates preparation of deliverables and final analytical data reports.

Project Team (PT)

- Query, review, and analyze data in reports, tables, field diagrams, maps, contours, graphs, GIS, modeling, etc.

Figure 2-2. Project Data Planning and Data Management Plan

3.0 Data Products and Documentation

This section describes the types of data products and documentation that will be created, managed, and archived during the project. To meet the needs of the project and subsequent work, data will be presented in tables, charts, graphs, forms, and maps for evaluation and reporting. Once data have been entered into the DMS (and reviewed by the project team), the list of requested report data entities (tables, figures, and diagrams) can be finalized and submitted to the PDC or appropriate TM. The tables, figures, and diagrams will be created from the DMS. Standalone data tools should interact with the DMS through data exports from the DMS report library to avoid omissions of data or incorrect data resulting from errors in exporting. For example, software such as the U.S. Environmental Protection Agency (EPA) ProUCL may be used to analyze data during the RI. In such cases, exports directly from the EDMS should be used as input files rather than compiling input files from other data sources such as printed tables.

3.1 Field and Laboratory Chemistry Data

Data collected during this project will consist of field observations and measurements and analytical laboratory data. Field observations and measurements will be documented in field notebooks and on hard copy field forms. Standard field forms will be the primary data source documents. Field data will be recorded, and field quality will be maintained, following the procedures outlined in the contractor quality control plan (CH2M, 2017). Field forms will be provided as an appendix to the FSP. Monitoring data sheets will be developed for recording data. Data sheets, field forms, field notebooks, and other standard forms (field sampling logs and COC forms) will be catalogued and stored in three-ring binders kept with the project files. Pertinent data will be tabulated and stored in electronic and hard copy format. Field data captured in field forms will be entered into the field database and will be uploaded to the project EDMS as described in Section 2.2.

Analytical laboratory data will be stored with the project files in electronic format and summarized in project reports. Data summaries also will be presented in tabular and graphical formats, as necessary or requested within the scope of active task orders. Analytical data will be maintained in a SQL relational database implementation of EQuIS EDMS. Data will be exported from the project database for use in presentation applications, such as Microsoft Excel and geospatial modeling environments. The project database standard reporting library will be used to generate reports. Custom code, queries, and reports for producing tabulated data may be written and saved in the reporting library so they can easily be rerun to recreate a tabulated data set. These tabulated data sets will be downloaded and saved for use in applications for formatting, graphical presentation, and publication.

The PDC or TM will use tools provided in the DMS reporting module to generate data summary tables, criteria comparison tables, analytical data tables, and figures. The PDC or TM will also generate deliverables suitable for data screening, analysis, and assessment and will support data consumers in using the data. In addition, the PDC or TM will support the generation of deliverables, analytical data reports, and other client and regulatory agency data deliverables.

Figure 3-1 describes the data flow of analytical laboratory data.

3.2 Document Data

Document data consist of documents produced by the project team members that are pertinent to activities at the project site. Types of documents that should be uploaded to the project database or on the CH2M SharePoint site include tabular electronic data, reports, work plans, boring logs, well completion records, well development logs, permits, sample logs and COC forms, and digital photographs. Metadata associated with the main data that are available electronically will be captured as well. Examples of metadata include record identifiers, user information, and data change information. The SharePoint site is set up and configured with version control enabled to manage and track revisions of electronic documents and files. The site will include document types and descriptions.

3.3 Geographic Information System Data

The primary types of geospatial information that will be stored or dynamically linked to the DMS include cartographic spatial data, georeferenced spatial data and images, and point spatial data. The geospatial information will be represented in ESRI shapefiles. Cartographic spatial data will be submitted to the GIS coordinator for storage on the DMS map server. Map generation activities will be performed using the standard map interface of the DMS.

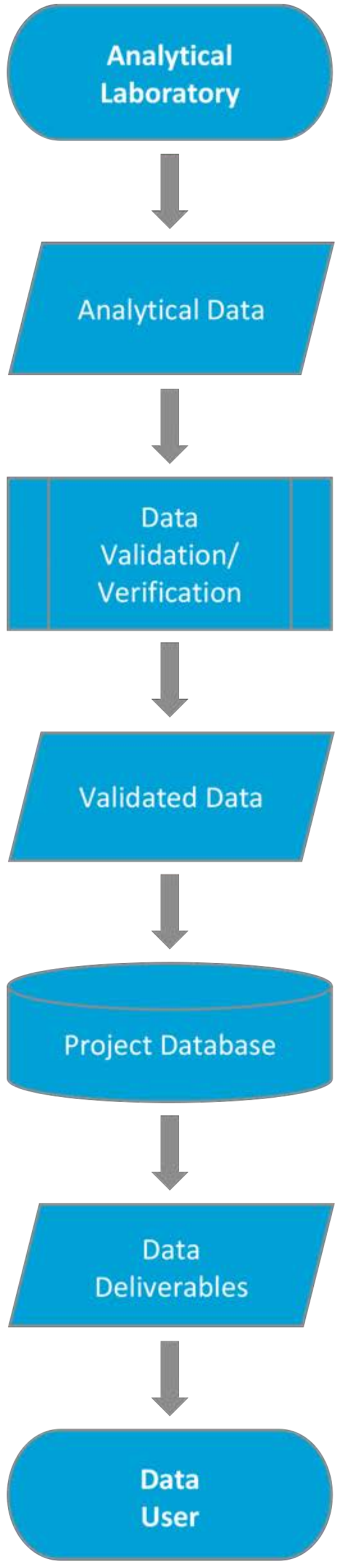


Figure 3-1. Analytical Laboratory Data Flow

4.0 Database Administration and Security

4.1 Database Administration

The PDC will oversee the administration of the DMS and will manage the setup, configuration, operation, and maintenance of the project database and data management processes. Database maintenance will consist of the following:

- Allocating sufficient system storage for the project database
- Adding, altering, and deleting users, roles, and privileges
- Upgrading database software and applications as necessary
- Providing routine backup of the database to tape storage
- Maintaining an approved list of valid values for data consistency
- Maintaining redundancy control to ensure that each data record is unique and consistent with conventions

4.1.1 Valid Values and Reference Values

Valid values are critical to large relational databases. Inconsistencies in naming conventions, subtle analyte, or method spelling differences, and the use of nonstandard abbreviations can result in lost data and incorrect conclusions. EDDs, tables, and forms in the project database use reference tables for acceptable valid values and will not allow the entry of data that do not conform. Valid value lookup tables are incorporated into the project database. Reference tables will use the reference values for EQuIS version 6.5 EPA Region 2 format. This is included in SOP B.20 Attachment B as an electronic file, EQuIS_EPAR2.rvf. The electronic data processor tool, format file, and format reference values can be downloaded from the EarthSoft website at http://earthsoft.com/products/edp/edp-format-for-epar2/.

4.1.2 Data Integrity Control

Database schema updates and modifications will be managed only through vendor database upgrades. Data management operations will be performed using the EQuIS standard interfaces. Users will not be allowed to modify database data and reference tables directly. Open Database Connectivity access to the database is not allowed to avoid compromising data integrity and to avoid degrading database performance. Updates to valid values in the reference tables will be controlled to conform to EPA Region 2 reference value specifications.

4.2 Data Management and Archiving Procedures

The TM and PDC will collect hard copy and electronic data and verify that the incoming records are legible and are in suitable condition for storage. Project-related information will be managed and stored by CH2M. Record storage will be performed in the following two methods:

- Back-up storage during the project
- Permanent storage of project records

CH2M storage facilities will provide an environment that will minimize deterioration or damage and prevent loss. Physical records will be secured in steel file cabinets labeled with the project identification in the Salt Lake City, Utah office. The EQuIS EDMS project database will be managed in the hosted environment, and other electronic data will be maintained on CH2M servers in the Salt Lake City, Utah, and Denver, Colorado networks. Electronic copies including native files will be provided to USACE at the time of project close out.

Information generated from field activities will be documented on appropriate forms and will be maintained in the project file. These include COC records, field logbooks, well construction forms, well development logs, boring logs, field parameters, sample logs, location sketches, and site photographs.

Both hard copy deliverables and EDDs will be managed and stored. Hardcopy data packages will be filed by year, month, and sample delivery group or laboratory batch, as appropriate. Hardcopy data packages will be handled by team staff during the data loading and validation phase and will be sent to project files for storage. Upon project closeout, data packages will be archived with the project files.

The raw laboratory EDD files will be stored in the data validation project folder on the CH2M network, and loaded and processed data will be managed in the EDMS database. File names for the EDDs will include the sample delivery group or laboratory batch, facility code, and EDD format designation to facilitate document control and retrieval. The original laboratory electronic deliverable will be archived in the project files.

4.3 Change Management

This DMP is a “living” document and content may be revised or amended to accommodate changes in the scope of the VHA project activities or data management requirements that affect successful completion of the project. In addition, the DMP appendices will be subject to modification as new or improved methods of data management are developed and implemented.

Any modifications made to the tools will be communicated to the project team via email. As revisions are finalized, they will be distributed electronically to all users. After revision, it is the user’s responsibility to conform to revised portions of the DMP.

4.4 Data Backup and Recovery

The EQuIS project database in the hosted environment includes the following important data protection features:

- 99.99 percent uptime with 24/7/365 network and server monitoring
- Daily incremental backups, full weekly backups
- Fully redundant fiber optic connections
- Peering with multiple major Internet backbones
- Diesel backup generators and uninterruptible power supply
- Fire suppression, and 24/7 emergency system restoration within 1 hour of an incident

The project data management files on CH2M servers will be managed as part of the CH2M network server management policy. Backup and recovery procedures will include backup rotations to accommodate daily incremental backups to disk saved for 2 weeks, weekly backups saved to disk and tape for 4 weeks, and each fourth tape backup from the weekly full backup saved for 4 months (SOP B.20 Attachment C). Permanent archival tapes will be stored in a climate-controlled offsite facility and retained for a duration corresponding to Federal Acquisition Regulation (FAR) 52.215-2, Audit and Records, which specifies that records should be retained for 3 years after final payment.

4.5 Personally Identifiable Information

Personally Identifiable Information, such as names or addresses of residents participating in indoor air sampling, will be managed per the VHA privacy program policy (SOP B.20 Attachment D).

5.0 References

CH2M HILL, Inc. (CH2M). 2017. *Contractor Quality Control Plan, OU-2 Remedial Investigation, 700 South 1600 East PCE Plume, Salt Lake City, Utah.* Final. January.

SOP B.20 Attachment A
Laboratory Electronic Data Deliverable (EDD) EQuIS Definition

SOP B.20 Attachment A Laboratory Electronic Data Deliverable EQuIS Format Definition

A.1 Introduction

Analytical data generated by the laboratory will undergo quality control (QC) reviews by laboratory staff to ensure that the electronic data match those on the hard copy reports. Additionally, the laboratory will use the laboratory electronic deliverable format specified in this appendix. This data structure will allow the laboratory to use electronic data processors to verify that the electronic data deliverable (EDD) is in the correct format and uses correct, valid values established by the project. After submission, review, and acceptance of the electronic data, the data can be uploaded into the Valid Data Management System for validation and further verification.

A.2 Electronic Data Deliverable Format

The main EDD file from the laboratory will be EQuIS 6.5 using U.S. Environmental Protection Agency Region 2 electronic data processor (EDP) Format. The EDP tool, format file, and format reference values can be downloaded from the EarthSoft website http://earthsoft.com/products/edp/edp-format-for-epar2/. There will be one file per hard copy report, and the name of the EDD file will be in the format <Unique ID>.<Facility Code>.<Format Name>.zip.

Where:

<Unique ID>	A unique identifier such as the date or Sample Delivery Group name
<Facility Code>	The facility code for the facility to which this EDD will be loaded
<EDD Section Name>	The name of the section within the EDD (i.e., EPAR2_Sample_v3, EPAR2_Batch_v3, EPAR2_TestResultQC_v3, etc.)

For example, a zip file may be received/named “20161225.VHA.EPAR2.zip” that contains:

- “20161225_VHA_EPAR2_Sample_v3.txt”
- “20161225_VHA_EPAR2_Batch_v3.txt”
- “20161225_VHA_EPAR2_TestResultQC_v3.txt”

The analytical laboratory will provide EDDs in EQuIS and Labspec7 formats. CH2M will use the Labspec7 EDD format to validate the data, and then CH2M will apply the validation information to the EQuIS EDD for upload.

SOP B.20 Attachment B
Electronic Reference Value File
(EQuIS_EPAR2.rvf)
(provided electronically)

SOP B.20 Attachment C
Backup Rotation
and Retention Schedule

SOP B.20 Attachment C Backup Rotation and Retention Schedule

Table C-1. Backup Rotation and Retention Schedule for Infrastructure Servers in CH2M Data Centers[a]

System	Primary copy (daily to local disk)	Secondary copy (daily to DR disk)	Tertiary copy (monthly to offsite storage)
DEN File System			
Windows	3 weeks	5 weeks	18 months
NAS	3 weeks	5 weeks	18 months
Unix	3 weeks	3 weeks	18 months
DEN Database			
SQL Prod	3 weeks	5 weeks	18 months
SQL Transaction Logs	70 days	70 days	none
SQL Test/Dev	3 weeks	none	18 months
Oracle	3 weeks	3 weeks	18 months
Oracle RAC	3 weeks	3 weeks	18 months
Oracle Archive Logs	3 weeks	3 weeks	none
ODC File System			
Windows	3 weeks	5 weeks	none
NAS	3 weeks	5 weeks	none
Unix	3 weeks	5 weeks	none
ODC Database			
SQL	3 weeks	5 weeks	none
SQL Transaction Logs	70 days	70 days	none
Oracle	3 weeks	3 weeks	none
Oracle RAC	3 weeks	3 weeks	none
Oracle Archive Logs	3 weeks	3 weeks	none
HUK File System			
Windows	3 weeks	5 weeks	none

Notes:
[a]Retention schedule is effective as of September 22, 2016.

DEN = Denver CH2M office
DR = Disaster recovery
HUK = Host utilities kit
NAS = Network-attached storage
ODC = Open document chart
SQL = Structured query language
RAC = Real application clusters

C.1 Backup Rotation Schedule

The backup rotation schedule consists of the following:

- Incremental backups are done daily with a full backup or synthetic full backup done once a week for file system and databases.
- The first successful full backup of each month is copied to either an encrypted tape or encrypted cloud storage and stored offsite for tertiary backups.
- Differential backups are done daily with a full backup once a week for Microsoft standard query language (MSSQL) availability groups.
- Transaction logs are produced hourly for MSSQL databases in full mode.
- Oracle archive log backups are done every 6 hours.
- If a system or database is duplicated to more than one site, that system is backed up from one site only following that site's retention schedule.

This rotation schedule is set by CH2M Global Information Technology Systems and may change as resources or processes are added.

C.2 CH2M Operations Data Servers Backup and Information Retention

The process for backing up and retaining information on CH2M Operations Data Servers consists of the following:

1. Operations data is backed up in five regional hub sites in North America rather than in the corporate data center.
2. Operations servers use an approximately 4-month rotating backup strategy rather than indefinite tape backups. This strategy can be best outlined as:
    a. Incremental backups to disk (Monday through Thursday) are saved for 2 weeks.
    b. Weekly backups are saved to disk and tape for 4 weeks (every Friday)
    c. Each fourth tape backup is saved for 4 months, from the weekly full backup.
    d. The weekly rotation strategy is best outlined as A, B, C, D1, A, B, C, D2, A, B, C, D3, A, B, C, D4 and then that pattern is repeated.
3. SQL data is backed up as a feature using Shadow Copy to copy full database backups and transaction logs, using the same backup schedule outlined above. Optionally, some databases are backed up as files created by maintenance tasks.

SOP B.20 Attachment D
VHA Privacy Program Policy

DEPARTMENT OF VETERANS AFFAIRS (VA)
SALT LAKE CITY HEALTH CARE SYSTEM
Salt Lake City, Utah

MEMORANDUM 00Q.08

March 3, 2014

PRIVACY PROGRAM POLICY

1. PURPOSE:

This memorandum implements facility privacy policy for the VA Salt Lake City Health Care System (VASLCHCS) in compliance with Veterans Health Administration (VHA) Handbook 1605.1 and establishes responsibilities and procedures for the privacy protection of information that is accessed, collected, maintained, used, disclosed, transmitted, amended and/or disposed of by the staff and systems of the VASLCHCS.

The components in this policy are designed to meet all of the specific requirements of the HIPAA Privacy Rule and VA and VHA policy. If any of the policy elements contained herein are removed, this facility policy will not be fully compliant.

In this document, the term workforce refers to on-site or remotely located employees, residents, students, Without Compensation (WOC) staff, volunteers, and any other appointed workforce members. Contractors will be held responsible for adhering to these policies and procedures in accordance with contracts and Business Associate Agreements.

2. POLICY:

A. The VA Salt Lake City Health Care System (VASLCHCS) will develop, implement, maintain, and enforce a structured privacy program to properly use, disclose and safeguard individually identifiable information. The privacy program is designed to allow continued operation of mission-critical activities while ensuring the integrity, availability, confidentiality, and authenticity of data and information; minimum necessary access to protected health information; and a continuing awareness of the need for, and the importance of, information privacy within the facility.

B. All members of the workforce are responsible for complying with this privacy policy, applicable federal laws and regulations, VA and VHA policies, as well as the procedures and practices developed in support of these policies. All facility privacy policies and procedures must be consistent with VHA Directive 1605, BAA Handbook 1605.5 and VHA Handbooks series 1605.

C. All privacy, and other workforce members responsible for implementing and complying with these policies and procedures will be provided copies of or access to this policy.

D. Violations of privacy policies or procedures will be brought to the attention of management for appropriate disciplinary action and/or sanctions, and reported in accordance with national and local policy. Privacy violations will be reported through the Privacy and Security Event Tracking System (PSETS) to the VA Network and Security Operations Center (VA-NSOC) by the Privacy Officer (PO) within one hour of discovery during normal business hours or as soon as possible outside of normal business hours. Outside of normal business hours, employees are to call the Night Administrator in the Emergency Department, describe the alleged privacy violation and then the Night Administrator will call the Privacy Officer to report the incident. If a privacy violation presents the risk of media involvement, congressional inquiry, legal action, immediate harm to any individual or any other high-risk outcome, the incident must be reported within one hour of discovery regardless of discovery time (even during non-business hours).

E. All policies and procedures, and any actions/activities taken as a result of a privacy complaint/violation, must be documented in writing and if applicable a written response letter must be given to the complainant. In addition to policies and procedures, privacy-related communications, decisions, actions, and activities or designations, including any signed authorizations, must be documented and kept in a complaint file. All documentation must be retained in accordance with the VA records control schedule (RCS-10).

F. All documentation related to the information privacy program will be reviewed and updated as needed in response to operational changes affecting the privacy of individually identifiable information (III).

G. There is a designated Privacy and FOIA Officer and the HIMS Supervisor over the files unit, release of information and transcription has been designated as the alternate.

3. <u>RESPONSIBILITY</u>:

A. Executive Management (Director, Associate Director, Associate Director, Patient Care Services, Chief of Staff, Associate Director, Quality and Safety Systems) is responsible for:

(1) Providing the necessary resources (funding and personnel) to support the Privacy Program, maintaining a culture of privacy, and ensuring that the facility meets all the privacy requirements mandated by VA/VHA policy and other federal legislation [e.g., Freedom

of Information Act (FOIA) [5 U.S.C. §552], Health Insurance Portability and Accountability Act (HIPAA), Privacy Rule [45 C.F.R. Parts 160 and 164], Health Information Technology for Economic and Clinical Health (HITECH) Act, Privacy Act (PA) [5 U.S.C. §552a], the VA Claims Confidentiality Statute [38 U.S.C. §5701], Confidentiality of Medical Quality Assurance Review Records [38 U.S.C. §5705], and Confidentiality of Drug Abuse, Alcoholism and Alcohol Abuse, Human Immunodeficiency Virus (HIV) Infection, and Sickle Cell Anemia Medical Records [38 U.S.C. §7332].

(2) Ensuring adequate Privacy Officer (PO) coverage for the facility and its associated clinics. It is required by VHA Privacy Policy that the facility Privacy Officer report directly to the Medical Center Director or Associate Director. When the Privacy Officer or Alternate is not available, provide coverage for off-hours operations if conducting 24/7 operations.

(3) Ensuring PO's are fully involved in all projects concerning the access, collection, maintenance, use and/or disclosure, transmission, amendment and/or disposal of III.

(4) Ensuring that new and revised Memorandums of Understanding (MOU), Contracts, Data Use Agreements (DUA), Business Associate Agreements (BAA), or similar agreements which involve the collection, transmission, use or sharing of information are reviewed by the facility Privacy Officer, in accordance with VA Handbook 6500.6, Contract Security, prior to approval by Executive Leadership.

(5) Ensuring that the facility Privacy Officer is included in discussions and privacy concerns of the facility which are addressed in strategic initiatives and maintains a facility culture of privacy.

(6) Cooperates with the facility Privacy Officer in any investigation, mediation strategies, or correspondence that is required in order to investigate and resolve a complaint or allegation. Reports promptly to the VHA Privacy Office any potential privacy complaint, allegation, or activity that has VISN-level or national-level impact.

(7) Certifies annually or on an as needed basis, to the VHA Privacy Office, that privacy training has been completed for all personnel. This shall include all employees, volunteers, contractors, students, residents, and any other person performing or conducting services on behalf of the facility.

(8) Cooperates fully in submissions of Facility Self-Assessments (FSA) and On-site Privacy Compliance Assurance Assessments as required by the Privacy Compliance Assurance (PCA) Office.

(9) Ensuring that facility employees exercise appropriate precautions and safeguards when discussing Veterans' individually-identifiable information in public areas, such as clinic waiting rooms.

B. Privacy Officer is responsible for:

(1) Developing, implementing and updating local privacy policies and procedures.

(2) Conducting periodic assessments, compliance reviews and/or audits of the facility's collection, use, storage and maintenance of personal information.

(3) Establishing effective working relationships with the Information Security Officer (ISO), Facility Chief Information Officer (FCIO), Contracting Officer, Research Compliance Officer, Compliance Officer and Human Resources Management personnel to ensure that local policies and procedures which may impact the privacy program support and complement each other.

(4) Ensuring that Executive Leadership is apprised of all privacy related issues.

(5) Coordinating with the ISO for the assurance of reasonable safeguards as required by the HIPAA Privacy Rule, HITECH or other federal privacy statutes.

(6) Serving as the facility's point of contact for matters relating to the privacy policies and procedures.

(7) Ensuring that members of the workforce receive training and education about privacy policies and procedures as required by VHA Privacy Program.

(8) Ensuring that members of the workforce know who to contact when a privacy complaint, incident or observation is identified or received.

(9) Monitoring facility and workforce compliance with VHA privacy policies and procedures as well as compliance with local privacy policies and procedures.

(10) Identifying and reviewing areas within the facility for auditory privacy risks, to ensure appropriate safeguards are in place to limit incidental disclosures.

(11) Ensuring processes are in place for the appropriate accounting of disclosures of individually identifiable information made by the facility and appropriate utilization of the DSS Release of Information (ROI) Manager software or other tracking mechanism are used in accordance with the facility's policies and procedures. The processes will include accounting for authorizations electronically conducted through iMed Consent.

(12) Collaborating with various program officials and the Contracting Officer, to ensure identification of all entities meeting the definition of Business Associates.

(13) Maintaining a list of active Business Associates utilized by the facility and ensuring all Business Associates have a signed BAA in place prior to disclosure of individually-identifiable health information (IIHI) and that the Business Associate adheres to the requirements of the BAA.

(14) Ensuring that the facility does not maintain any unauthorized Privacy Act system of records.

(15) Ensuring all facility developed paper, web-based or electronic forms that collect personal information contain the appropriate Privacy Act statements.

(16) Reviewing and approving all Memorandums of Understanding (MOU), Contracts and/or Data Use Agreements (DUA) when required for the sharing of VA sensitive data between the facility and other parties.

(17) Ensuring prompt investigation and follow-up on allegations or known occurrences of privacy violations or complaints including logging the violation or complaint in the Privacy and Security Event Tracking System (PSETS). PSETS should be initiated upon notification of the violation or complaint during normal business hours, within one hour of discovery during normal business hours or as soon as possible outside of normal business hours. If a privacy violation presents the risk of media involvement, congressional inquiry, legal action, immediate harm to any individual or any other high-risk outcome, the incident must be reported within one hour of discovery regardless of discovery time (even during non-business hours).

(18) As a non-voting member of the facility R&D committee, the Privacy Officer will review all human subject research protocols, exempt and non-exempt, in accordance with VHA Handbook 1200.05 and other applicable guidance to ensure legal authority exists prior to use and disclosure of VHA information for research.

(19) Collaborating with the facility ISO, FCIO and System Owner to ensure that a Privacy Impact Assessment (PIA) is completed on all information technology systems, applications or programs that collect, maintain, and/or disseminate personally identifiable information (PII).

(20) Reviewing, processing, and monitoring requests to amend any information or record retrieved by an individual's name that is contained in a VA system of records, to include designated record sets, and coordinating such amendments with the author of the document.

(21) Collaborating with the ISO, Contracting Officer Representative (COR) and the Contracting Officer to ensure all contracts are reviewed in compliance with VA Handbook 6500.6.

(22) Ensuring all facility's policies and procedures relating to HIPAA, HITECH, Privacy Act, 38 USC §5701, §5705, and §7332, and FOIA are consistent with current guidelines and requirements, complementing and supporting each other.

(23) Ensuring local departmental policies and procedures are developed if not specifically outlined in the facility privacy and FOIA policies.

(24) Provide awareness training through various means for Veterans to inform them of their privacy rights and responsibilities.

(25) Complete the Facility Self Assessment by the last business day of each quarter or as required by PCA.

(26) Ensuring that the reduction of SSN usage is reviewed to determine the necessity.

(27) Other responsibilities as defined by the VHA Privacy Officer.

C. FOIA Officer is responsible for:

(1) Processing all FOIA requests for Federal records that would not otherwise be disclosed in accordance with HIPAA or the Privacy Act.

(2) Ensuring that all FOIA requests or HIPAA/PA requests where information was withheld are entered into FOIAXpress within the same day as receipt.

(3) Other responsibilities as defined by the VHA FOIA Office.

D. Information Security Officer is responsible for:

(1) Coordinating with the Privacy Officer for the assurance of reasonable safeguards as required by the HIPAA Privacy Rule, HITECH or other federal privacy statutes.

(2) Coordinating, facilitating, and updating the establishment of information security policies and procedures, to work in tandem with privacy policies and procedures.

(3) Establishing effective working relationships with the Privacy Officer, FCIO, Contracting Officer, Research Compliance Officer, Compliance Officer, and Human Resources Management personnel to ensure that information technology (IT) security and HIPAA/FOIA/PA/Federal Information Security Management Act (FISMA) policies and procedures compliment and support each other.

(4) Reviewing and evaluating the security program impact(s) of any proposed facility information privacy policy and procedure changes.

(5) Collaborating with the Privacy Officer on addressing/resolving privacy complaints, investigations, and access rights to audits and other information maintained by the ISO.

E. Clinical Staff or designees are responsible for:

(1) Reviewing and determining appropriateness for granting individuals' requests for record amendment.

F. Facility Chief Information Officer (FCIO) or designee is responsible for:

(1) Coordinating with ISO and Privacy Officer to provide technical advice and other assistance relative to the reasonable safeguards requirements of privacy statutes and regulations dealing with implementation of IT systems, policies and procedures.

(2) Identifying each locally maintained computer system that contains III and providing technical input for various mandated documents, reports, and investigations.

(3) Ensuring all computer rooms meet acceptable reasonable safeguards and that minimum necessary access is maintained.

G. Chief, Human Resources Management Service (HRMS), or designees are responsible for:

(1) Providing guidance to supervisors and managers regarding personnel actions, sanctions, or other actions to be taken when employees have violated information privacy practices, laws, regulations, policies and procedures, and rules of behavior (see VA Directive 5021).

(2) Providing appropriate information to Privacy Officer for completion of PSETS entries in a timely manner.

(3) Coordinating with the Privacy Officer on the privacy of personnel records and other records maintained by HRMS.

(4) Ensuring that personnel records maintained by the HRMS are maintained in compliance with applicable privacy policies, statues and regulations.

H. VA Contracting Officer/Contracting Officer Representative (COR) is responsible for:

(1) Working in collaboration with the Privacy Officer to ensure that privacy responsibilities are listed in all contracts (see VA Directive 6500.6, Appendix C).

(2) Ensuring through the COR that contractors are aware of, and abide by, those privacy responsibilities as stated in contracts with VA and VHA.

(3) Ensuring that Business Associate Agreements (BAA) are enacted for contracts which the contractor meets the definition of a Business Associate. A BAA should be a separate document from the contract.

(4) Ensuring that contractors receive the appropriate privacy and if applicable security training upon initiation of the contract and annually thereafter.

(5) Ensuring that contract performance meets privacy requirements including mediating and/or terminating the contract if information privacy requirements are not being met.

I. Local Managers, Supervisors, and their designees (e.g. ADPAC) are responsible for:

(1) Identifying and protecting all individually-identifiable information (III) used by supervised personnel, including contractors and other workforce members.

(2) Ensuring that III, whether computerized or printed, is secured when work areas are unattended.

(3) Training new personnel on roles and responsibilities for protecting III.

(4) Identifying functional categories in accordance with facility policy and ensuring VA personnel have only the minimum necessary access level required to carry out their authorized functions or assigned duties and that VA personnel understand what their minimal level of access is.

(5) Ensuring applicable personnel complete the "Information Security and Privacy Awareness and Rules of Behavior" training. If access to protected health information (PHI) is required then "Privacy and HIPAA" training must be completed within 30 days of hire or before access to PHI is given. Training must be completed annually thereafter and documented using the Talent Management System (TMS). Workforce members must be enrolled in TMS either through self enrollment (e.g. contractors and volunteers) or automatic enrollment upon hire.

(6) Ensuring that all media (paper, electronic, CDs, disks, portable devices, etc.) with III is disposed of via approved means. Employees will use the locked HIPAA bins located throughout the facility to dispose of III.

(7) Assists the Privacy Officer and Human Management Resource Services with the investigation and resolution of privacy incidents involving their employees and/or program(s).

J. Quality Manager serves as Quality Management (QM) Confidentiality Officer and is responsible for coordinating with the Privacy Officer on requests for copies of or access to QM documents. The Privacy Officer serves as the final approval authority for determining which documents are classified as quality management documents in accordance with VHA Directive 2008-077, Quality Management (QM) and Patient Safety Activities That Can Generate Confidential Documents prior to disclosure.

K. Administrative Officer of the Day (AOD) is responsible for resolving and responding to disclosure issues consistent with VHA Directive 1605, VHA Handbooks 1605 series during non-business hours.

L. All individuals who have access to sensitive information are responsible for:

(1) Accessing the minimum necessary data for which they have authorized privileges and on a need-to-know basis in the performance of their official VA duties.

(2) Protecting an individual's rights to privacy and ensuring proper use and disclosure of information. All workforce members will be held accountable for compliance with these policies, procedures, and applicable laws.

(3) Appropriately safeguarding printed and electronic individually-identifiable information.

(4) Reporting complaints and/or violations of privacy policies or procedures to the Privacy Officer immediately upon discovery.

(5) Consulting the facility Privacy Officer and VHA Handbook 1605.I for guidance in privacy situations not addressed in this document.

4. RESCISSIONS: Policy Memorandum 136.04 Privacy of Health Information dated January 13, 2011.

5. REFERENCES:
VHA Directive 1605
VHA Handbook 1605.1
VHA Handbook 1605.2
VHA Handbook 6500.6
Privacy Act 1974 – 5 U.S.C. §552a
Freedom of Information Act – 5 U.S.C. §552
HIPAA Privacy Rule – 45 C.F.R. Parts 160 and 164
Health Information Technology for Economic and Clinical Health (HITECH) Act
VA Claims Confidentiality Statute (38 U.S.C. §5701), Confidentiality of Medical Quality Assurance Review Records (38 U.S.C. §5705), and Confidentiality of Drug Abuse, Alcoholism and Alcohol Abuse, Human Immunodeficiency Virus (HIV) Infection, and Sickle Cell Anemia Medical Records (38 U.S.C. §7332)].

6. AUTOMATIC RESCISSION DATE: 3/3/17

7. FOLLOW-UP RESPONSIBILITY: Associate Director, Quality Management; Privacy Officer

STEVEN W. YOUNG, FACHE
Director

ATTACHMENTS:

Procedures Table of Contents
Appendix I: Glossary of Terms
Appendix II: Acronyms

PROCEDURES TABLE OF CONTENTS

A. ADMINISTRATIVE REQUIREMENTS

1.0 Compliance with Privacy Policies

a. The facility and its workforce will comply with the contents of this policy, VHA Handbook 1605.1, and all other applicable privacy laws, regulations, and VA policies.

b. The facility Privacy Officer will monitor compliance with this policy through various means, including continuous assessment for privacy compliance.

2.0 Documentation

a. This policy and any changes thereto, must be maintained in writing, either on paper or in electronic form, for a period of at least six (6) years.

b. Changes in VHA Handbook 1605.1: When VHA Handbook 1605.1, is updated which necessitates alteration of facility policies and procedures, the local privacy policies and procedures will be revised without delay, in accordance with VASLCHCS policy 00Q.16.

3.0 Complaint Process

a. All privacy complaints received by the facility are to be referred immediately to the facility Privacy Officer or Alternate Privacy Officer.

b. The facility Privacy Officer will enter all facility privacy complaints, regardless of validity, into the VA Privacy and Security Event Tracking System (PSETS), within one hour of discovery during normal business hours or as soon as possible outside of normal business hours. If a privacy violation presents the risk of media involvement, congressional inquiry, legal action, immediate harm to any individual or any other high-risk outcome, the incident must be reported within one hour of discovery regardless of discovery time (even during non-business hours).

c. The facility Privacy Officer is responsible for:

(1) Investigating all complaints regarding facility privacy practices regardless of validity,

(2) Documenting the results of the investigations,

(3) Maintaining an administrative file for all complaints by PSETS ticket number,

(4) Determining whether the complaint is a privacy violation/incident,

(5) Responding as soon as possible or no later than 60 working days, in writing to the complainant when the complaint does not result in an incident,

(6) Appropriately notating the privacy complaint/incident in PSETS.

d. If the NSOC determines that an incident warrants a notification letter or credit monitoring protection services they will notify the Privacy Officer. (See VA Directive 6500.2, Appendix G). The notification letter or credit monitoring letter, which offers credit protection services, should be mailed no later than 30 working days from when the incident was reported by the Privacy Officer.

e. A Privacy Complaint File containing all of the documentation of the privacy complaint and investigation will be retained by the facility Privacy Officer in accordance with RCS 10-1, XLIII-8, Privacy Complaint File. Documentation will consist of the initial written complainant's concern or a Report of Contact by the Privacy Officer, if the complaint is made orally; written documentation of all interviews or statements; and all written correspondence, including e-mails.

f. All complaints received by the facility from the Department of Health and Human Services (HHS) – Office for Civil Rights (OCR) will be forwarded immediately to the VHA Privacy Office in VHACO for appropriate processing. The facility does not have authority to respond to HHS-OCR complaints. If an investigation arises as a result of a HHS-OCR complaint, this facility and its Business Associates must permit the Secretary of HHS access to information, during normal business hours, after coordinating with the VHA Privacy Office.

g. The facility Privacy Officer is responsible for cooperating immediately and fully with the VHA Privacy Office on all HHS-OCR complaints and all other privacy complaints submitted to VHACO.

h. When addressing complaints the facility Privacy Officer should reference Privacy Complaint and Violation Resolution Guide available at http://vaww.vhaco.va.gov/privacy/ComplaintTracking.htm. When Human Resources is contemplating employee disciplinary action, they should refer to VA Directive 5021 and VA Handbook 5021, Employee/Management Relations.

i. All employees are required to fully cooperate with the facility Privacy Officer and/or the VHA Privacy Office throughout the complaint investigation process.

4.0 Reasonable Safeguards

a. All facility workforce members shall ensure that appropriate administrative, technical, and physical safeguards are used to maintain the security and confidentiality of III, including protected health information (PHI), and to protect against any anticipated threats or hazards to their security or integrity. The facility's personnel shall make reasonable efforts to limit III to the minimum necessary to accomplish the intended purpose of any use, disclosure, or request. This does not pertain to the treatment provision under the HIPAA Privacy Rule.

b. All personnel may access and use information contained in VHA records as required for their official duties related to treatment, payment, and health care operations purposes.

c. When disclosing VHA information, all applicable laws and regulations are reviewed and applied to the request in order to assure utilization of the most stringent provisions for all uses and/or disclosures of data in order to provide the greatest rights to the individual and the minimum necessary of III. III disclosure is mandatory with a valid written authorization, signed by the individual but disclosure must be limited to only the information necessary to satisfy the purpose of the request.

d. **Disposal of Paper Documents**: Staff disposes of paper and electronic documents that contain III by using the locked HIPAA bins provided by the VALSCHCS's contracted disposal service. Data that is not destroyed at the site of production, such as that which is transported for contracted shredding, must be secured in locked containers or in locked areas until it is removed for destruction. See VA Handbook 6500 and VA Directive 6371 for more detailed procedures.

e. **Disposal of Electronic Media:** Electronic media containing III will be destroyed by the facility's ISO in accordance with MCM 142.28.

f. **Disposal of Non-paper Items:** Non-paper items (i.e. I.V. bags, wristbands, prescription bottles, etc.) containing III are destroyed by placing them in the locked HIPAA bins throughout the facility.

g. **Maintaining Auditory Privacy**: Staff only discusses patient care issues in appropriate areas, which allow the maintenance of auditory privacy. Facility staff does not discuss patient information in areas not conducive to confidentiality (e.g., canteen, elevators, or hallways). Signs must be posted alerting Veterans to auditory privacy concerns in waiting areas. VASLCHCS health care providers and staff must refrain from discussing patient information within hearing range of anyone who is not on the patient's treatment team or does not have a need to know the specific patient information unless an emergent condition arises whereby auditory privacy cannot be maintained. Administrative staff should follow the same guidance in any discussion involving individually-identifiable sensitive information, i.e. employee health or disciplinary actions. Appropriate safeguards include training all staff on auditory privacy to include:

(1) Using the Veterans Identification Card (VIC) for identification upon check-in, if available;

(2) Using an appropriate tone of voice when speaking with the Veteran in a public area or during check-in;

(3) Only discussing the information necessary to accomplish the functions; for example, not asking for the full Social Security Number (SSN) when the last four of the SSN is sufficient;

(4) Asking other Veterans in line for clinical check-in to wait a short distance away from the desk to allow a zone of audible privacy as opposed to being right behind the Veteran being assisted;

(5) Only calling Veterans back to an exam room, pharmacy window or other treatment area by name; and

(6) Going behind closed doors to have discussions pertaining to the personal information of the Veteran.

h. **Use of facsimile (fax)**: When using fax technology, facility staff adheres to VA Handbook 6500. III is only transmitted via facsimile (fax) when absolutely necessary. Any disclosure of faxed information containing or requesting individually-identifiable patient information must be accounted for in the DSS ROI Manager Software or on a manual spreadsheet.

Any staff member utilizing facsimile as a means of transferring III must take the following steps to ensure that III is sent to the appropriate destination and not to a machine accessible to the general public:

(1) Verify the fax number prior to sending the fax and, in order to prevent misdialing, do not use pre-programmed numbers unless the number is tested to faxing. Periodically verify the fax numbers of frequent recipients. Ask those frequent recipients to notify the facility of any fax number changes.

(2) A fax cover sheet with an appropriate confidentiality statement, instructing the recipient of the transmission to notify the facility if received in error, must be sent with all outgoing faxes.

For example when transmitting outside VA:

"This fax is intended only for the use of the person or office to which it is addressed and may contain information that is privileged, confidential, or protected by law. All others are hereby notified that the receipt of this fax does not waive any applicable privilege or exemption for disclosure and that any dissemination, distribution, or copying of this communication is prohibited. If you have received this fax in error, please notify this office immediately at the telephone number listed above."

(3) Notify the recipient before sending the fax in order to ensure that someone is present to receive the information or that the fax machine is in a secure location (e.g., locked room).

(4) Review the fax confirmation slip to verify that the confidential information went to the proper destination number. If there has been an error, immediately contact the incorrect recipient and request return or destruction of the fax.

i. Electronic mail (e-mail) and information messaging applications and systems are used as outlined in VA policy (VA Directive 6301 and VA Handbook 6500). These types of messages never should contain III, unless the authentication mechanisms have been secured appropriately (see VA Handbook 6500). Responding to a patient via email which contains protected health information should be done through MyHealtheVet Secure Messaging.

j. Mailing of Sensitive Information. Mailing of Veteran's correspondences such as copies of records, appointment letters may be done so using the United States Postal Service. Envelopes, parcels, packaging or boxes containing sensitive information must be secured in a manner that prevents unauthorized access, tampering, or accidental loss of contents. Window envelopes must show the recipients' names and addresses, but no other information. (See VA Directive 6609).

k. To the extent practicable, this facility mitigates any harmful effect known to have resulted from an improper use or disclosure of III. Mitigation may include, but is not limited to: operational and procedural corrective measures; re-training, reprimanding, or disciplining workforce members; addressing problems with any involved business associates; incorporating the chosen mitigation solution(s) into facility procedures. The VASLCHCS workforce reports improper uses or disclosures of III or any other privacy incident to the Privacy Officer and or the Information Security Officer during regular business hours. After hours and weekend staff will call the Night Administrators in the Emergency Department and give them all of the details concerning the privacy incident. The Night Administrator will then notify the Privacy Officer of the incident and appropriate action will be taken within an hour of discovery.

5.0 Sanctions

a. All individuals who use or have access to VA information systems or sensitive information must sign and adhere to the Rules of Behavior, which bind them to the legal and moral responsibility of preventing unauthorized disclosure. (See VA Handbook 6500, Information Security Program). This facility has established sanctions, which are applied against members of its workforce as appropriate, for failures to comply with privacy policies and procedures and Rules of Behavior.

b. This facility has established a set of rules that describes the information privacy operations of the facility and clearly delineates the responsibilities and expected behaviors of all workforce members. These rules address all significant aspects of using III and the consequences of inconsistent behavior or non-compliance. The entire workforce of the VASLCHCS will have access to a copy of these rules for purposes of review. A signed (manually or electronically) acknowledgement of these rules is necessary for each workforce member.

c. The Privacy Officer will determine information privacy violations and provide evidence thereof. The employee's supervisor will determine appropriate actions and may, in conjunction with human resources management, take necessary steps and apply appropriate sanctions for any employees who are non-compliant with privacy policies and procedures. Penalties will be assessed against any individual(s) who knowingly and/or willfully use, disclose, or obtain information without the individual's written authorization or not as authorized by law.

d. Appropriate legal authorities outside of VHA may levy civil or criminal sanctions for privacy violations. Depending on the statute, penalties range from $50,000 and/or one year in jail to $250,000 and/or up to ten years in jail, per offense. If a penalty is levied, the offending employee, not VA, is responsible for payment. In addition, other adverse actions, administrative or disciplinary may be taken against employees who violate the statutory provisions. Under the HITECH Act, applicable to violations occurring on or after February 18, 2009, the Secretary can impose civil monetary penalties for each violation ranging from at least $100 to a maximum of $50,000 for the lowest category violation. Under the highest category violation, the Secretary can impose a $50,000 penalty per violation. Additionally the HITECH Act increases the maximum penalty that the Secretary can impose for all such violations of the same HIPAA provision in a calendar year from $25,000 to $1,500,000.

e. Adverse actions may include, but are not limited to, progressive discipline. The facility will follow processes and procedures outlined in VA Handbook 5021 for adverse actions in compliance with the stated Table of Penalties.

6.0 Privacy Training and Education

a. The facility Privacy Officer, in coordination with the facility Education Coordinator or Education Office, is responsible for developing a local-level privacy training policy that outlines the facility procedures for ensuring compliance with the annual privacy training requirement of VHA Directive 1605 and VHA Handbook 1605.1.

(1) For a detailed explanation of local requirements for timeframes and completion of training, see VASLCHCS policy 05.39. The Education Specialist will send out a monthly list to all managers and supervisors of employees who are delinquent with their mandatory training requirements. If these employees do not complete their training within one week of notification, the ISO will remove their access to the network.

(2) The facility Privacy Officer will conduct privacy training at the facility's New Employee Orientation (NEO) programs. The Privacy Officer shall ensure that all new personnel are trained role specific so that the appropriate privacy training is completed in accordance with VHA Directive 1605 and VHA Handbook 1605.1.

(3) Employees are responsible for annual completion of their mandatory privacy training requirement prior to or on their anniversary date of privacy training the following year.

b. The facility Privacy Officer is responsible for developing a local training strategy in conjunction with the facility Education Coordinator or Education Office. See VASLCHCS policy 05.39 which documents the overall training strategy for how the facility will provide privacy training to personnel that heightens awareness of facility and personnel privacy requirements and patient privacy rights. The facility Privacy Officer will also provide, when requested by the managers and/or supervisors, privacy in-service trainings to employees. The health care Director will make the strategy available to the VHA Privacy Office upon request.

c. The facility Privacy Officer, in coordination with the facility Education Coordinator, TMS Coordinator or Education Office, shall maintain a process of compiling annual training records in order to report the facility privacy training completion status to the VHA Privacy Office and to the health care facility Director upon request. These reports will be pulled from the TMS web site by the Education Coordinator.

(1) The annual training records of completion of privacy training must be kept for all workforce members to include the following; employees, volunteers, students, and contractors in order for reporting of facility privacy training completion numbers by each group.

(2) The facility Director will certify annual training completion to the VHA Privacy Office for all workforce members based on the reports generated by the health care facility Privacy Officer and Education Coordinator, TMS coordinator or Education Office upon request.

d. The facility Privacy Officer shall conduct other activities within the facility to enhance awareness of privacy and that have a positive impact on the overall privacy culture and posture of the facility. These activities include, but are not limited to, participation in VA's annual Privacy Week activities, posting privacy posters and announcements throughout the facility, and conducting one-on-one training with personnel who have been observed displaying negative privacy culture behaviors.

B. Individual Rights

1.0 Verification of Identity

a. In order to receive or view information from his or her VHA record, an individual must present staff with adequate information for verification of identity. Individuals may not verify identity by e-mail.

b. A Veteran Identification Card (VIC), passport, driver's license, or employee identification card may be used to identify an individual who appears in person. Mail or fax identification requests may be verified by social security number, address(es) and signature comparison to the VHA record.

c. The VASLCHCS shall recognize legally designated personal representatives as the individual when the individual is unavailable or unable to act on his/her own behalf. Staff should recognize the following representatives of the individual:

(1) Legal Guardian: A person designated by a court of competent jurisdiction to manage the property and rights of another person who, due to defect of age, medical condition, understanding, or self-control, is considered by the court to be incapable of administering the individual's own affairs. Depending on the circumstances, the court may appoint a legal guardian for a specific purpose (Note: A VA Federal fiduciary is not a legal guardian). Three of the most common types of guardianships are: Legal Guardian of the Person; Legal Guardian of the Property; and Legal Guardian of the Person and Property.

(2) Power of Attorney (POA): All POA's are to be referred to the Privacy Officer for determination that the POA meets the legal requirements for making disclosure decisions.

d. A personal representative of a deceased individual is a person, who under applicable law, has authority to act on behalf of the deceased individual. This may include power of attorney (if binding upon death), the executor of the estate, or someone under federal, state, local or tribal law with such authority. The next of kin of a deceased individual is considered a personal representative of the deceased individual but not of a living individual. They are recognized as having the same rights as the deceased individual. When there is more than one surviving next-of-kin, the personal representative will be determined based on hierarchy: spouse, adult child, parent, adult sibling, grandparent, or adult grandchild.

Note: Regardless of the type or source of the POA presented, the reviewer always carefully checks the document with General and Special Powers of Attorney. The document must be: in writing; signed by the individual giving the power; dated; notarized and signed by a licensed notary public; and specifically designate, by name, the third party agent, which may be an organization or entity, to act on behalf of the individual.

e. The Release of Information Office (ROI) will handle all requests from personal representatives.

f. When a request from a personal representative is received in the Release of Information Office (ROI), the staff will review the individual's scanned documents, found in CPRS under tools for the Vista Imaging Display option which allows them to view scanned documents for a Power of Attorney or Advance Directive (which indicate that the personal representative may receive copies of the medical records).

2.0 Right of Access

a. If access is legally appropriate, individuals may obtain a copy of, or inspect, their record or III. A request to obtain a copy or inspect their record or III must be made in writing by the individual or a personal representative. Individuals may use VA Form 10-5345a, Individuals Request for a Copy of their Own Health Information, to accomplish this purpose.

b. All requests for copies of individual's own health information will be directed to the Release of Information Office (ROI). All requests must show date received whether by use of a date stamp, writing date received on request, or entering the request in the ROI Plus software the exact same day as received in person or mail.

c. If the individual or the individual's representative is not entitled to the records under any legal provisions, the facility will not provide him or her with a copy of the records. NOTE: this is an infrequent occurrence.

d. Access to view a record must be processed as follows:

(1) When individuals appear in person at a VA health care facility, they must be advised at that time whether the right of access or review of records can be granted. When immediate review cannot be granted due to staffing or availability of records, necessary arrangements must be made for a later personal review, or if acceptable to the individual, the copies may be furnished by mail.

(2) Mailed requests must be referred to the Privacy Officer for determination if the right of access by review will be granted.

I. If additional information is required before the request can be processed, the individual requesting review of the records must be advised.

ii. If it is determined that a request to review will be granted, the individual must be advised by mail that access to view the records will be given at a designated location, date and time in the facility, or a copy of the requested record will be provided by mail, if the individual has previously indicated or has been contacted to verify that a copy of the record will be acceptable.

e. If all right of access requests, granted requests, denial and adverse determinations are document in the ROI Plus software, in accordance with VHA Directive 2011-010, Mandated Utilization of Release of Information (ROI) Plus software. Other departments, that are not using the ROI Plus software, are required to keep an electronic spreadsheet and/or a paper copy documenting the access requests where individuals were provided copies of their own information.

3.0 Notice of Privacy Practices

a. An individual will be provided with a copy of IB 10-163, Notice of Privacy Practices, by this facility upon verbal or written request. All Veterans receive a copy of this notice from the Health Eligibility Center upon enrollment.

b. An individual may obtain a copy of IB 10-163, Notice of Privacy Practices, from the Release of Information office (ROI), the Enrollment office, and/or the Privacy Officer. The Notice of Privacy Practices is included in the packet that is sent out to all new enrollees.

c. A Non-Veteran who receives care and treatment at a facility whether for humanitarian purposes or a VA research study must be given a copy of the Notice of Privacy Practices. Non-Veterans are provided a copy of the Notice of Privacy Practices when they check in to the Emergency Department or when they are consented to participate in a research study.

4.0 Amendment Request

a. This facility may receive and must process Veteran's written requests to amend any information or records contained in any VA system of records that is retrievable by their name or other unique identifying number, symbol, or other identifying particular assigned to the individual. Requests must contain an adequate description of the information that is in dispute, and the reason for this dispute.

b. An amendment file must be kept by the Privacy Officer for a period described below per RCS 10-1, XLIII-6, Privacy Amendment Care File:

(1) Amendment Grant: Dispose of in accordance with the approved disposition instruction for the related subject individual's record or 4 years after the facility's agreement to amend, whichever is later.

(2) Amendment Denial: Dispose of in accordance with the approved disposition instructions for the related subject individual's record or 4 years after final determination by agency or 3 years after final adjudication by agency or courts, whichever is later.

(3) Appealed Requests to Amend: Dispose of in accordance with the approved disposition instructions for related subject individual's record or 3 years after final adjudication by courts, whichever is later.

(4) Amendment requests of a Veteran's health record must be maintained for 75 years after the last episode of care. Amendment files include the following (Original request for amendment, author of the note response, statement of Disagreement and or any facility rebuttal and any appeal related documents).

c. The request must be delivered to the ROI office in order for a date to be placed on the request. The Privacy Officer will then be notified of the request in the ROI office.

d. Requests to amend records must be acknowledged, in writing, or completed within 10 working days of receipt and if a determination cannot be made within this time period the individual is advised of when the facility expects to notify the individual of the action taken on the request. The review must be completed as soon as possible, in most cases within 30 workdays from receipt of the request. If the anticipated completion date, indicated in the acknowledgement letter cannot be met, the individual must be advised, in writing, of the reasons for the delay and the date action is expected to be completed. The delay may not exceed 90 calendar days from receipt of the request. The Privacy Officer or their Alternate will be responsible for sending the acknowledgement letter and any subsequent follow-up letters to the amendment request.

e. The Privacy Officer refers the request and related records to the health care provider who authored the information in order for the provider to determine if the record needs to be amended as requested.

f. When an amendment is approved, the following actions are taken:

(1) Information that is requested for deletion must be made illegible. For electronic records, the Privacy Officer or Chief, Health Information Management (HIM) is required to use the Computerized Patient Record System (CPRS) Test Integrated Utility (TIU) functions for amending documents. For all other records, the Privacy Officer will work with the responsible record custodian to amend their records, e.g. police or employee records.

(2) Any new material must be recorded on the original document. For paper records, the words "Amended-Privacy Act and/or 45 CFR Part 164" must be recorded on the original document. New amended material may be recorded as an addendum if there is no room on the original document; however, the original document should state that there is an addendum. If the original document cannot be amended and an addendum cannot be

attached, then a link to the location of the amendment must be provided. The amendment must be validated with the date as well as the signature and title of the person making the amendment. For electronic records, VistA will automatically place the appropriate notation on amended records.

(3) The individual making the request must be given a copy of the amended record and be advised in writing that the record was amended. The individual must also identify and agree to have notification sent to any relevant persons or organization who they gave copies of their record to. If Title 38 U.S.C. §7332 protected health information was amended, the individual must provide written authorization to allow the sharing of the amendment with relevant persons or organizations.

(4) In addition, the Chief of HIM, or designee, or the Privacy Officer, or designee, must notify all relevant persons or organizations who the facility disclosed the amended information. other persons or organizations that had previously received the record must be provided copies of the amended records. If Title 38 U.S.C. §7332 protected health information was amended, the individual must provide written authorization to allow the sharing of the amendment with relevant persons or organizations. This can be accomplished by reviewing the accounting of disclosures summary.

g. When a request to amend a record is denied, the Privacy Officer promptly notifies, in writing, the individual making the request. The written notification must include:

(1) Reason for the denial (i.e., information was not created by VHA; information is accurate, relevant, complete or timely in its current form; or information is not part of a VHA system of records or designated record set);

(2) Advisement of appeal rights (the individual may appeal to the Office of General Counsel (024), 810 Vermont Avenue, N.W., Washington, D.C. 20420). If the General Counsel sustains the adverse decision, the individual must be advised, in the appeal decision letter, of the right to file a concise written statement of disagreement with the VASLCHCS that made the initial decision;

(3) Instruction that if an appeal is not filed, the individual has the right to request the VASLCHCS to provide a copy of the initial request for amendment and the subsequent denial with all future disclosures of information;

(4) Instruction that the individual may also provide a statement of disagreement to the facility and request that the facility provide the statement of disagreement with all future disclosures of the disputed information;

(5) Instruction that the individual may complain about the denial to VHA Privacy Officer or to the Secretary, Health and Human Services;

(6) The Privacy Officer can be reached at 801-582-1565, extension 1636 for any questions regarding amendment requests; and

(7) The facility Director has formally, in writing, designated the Privacy Officer with the ability to sign amendment denial letters.

h. Should the individual choose to have his/her amendment request and the agency's subsequent denial attached to future disclosures, the Privacy Officer identifies the III that is the subject of the disputed amendment and appends, or otherwise links, the individual's request for an amendment, and the facility's denial of the request, to the individual's record.

5.0 Confidential Communications Request

a. An individual's request to receive any or all types of communications (correspondence) from facility staff via a confidential alternative means, or at an alternative location, must be processed in accordance with VHA Directive 2009-013, Confidential Communications or subsequent directive.

b. All confidential communications requests will be referred to the Enrollment Office.

c. When the veteran makes the request of a staff member to allow for the receipt of written communications at an alternative address other than the permanent address of record:

(1) Veterans must specify a start date for use of the confidential correspondence address. Dates occurring in the past are not acceptable. Veterans may specify an end date for use of the address, but it is not required.

(2) The staff member must access screen the Load/Edit Patient Data menu option and answer the prompts. VistA allows the capture of the new confidential communications address fields including date started and stopped, street address, city, state, zip code including the four digit geocode, and country.

d. If the confidential communications data is on file for the Veteran, that address is used for the mailing of all communications under a specified correspondence type (see VHA Directive 2009-013, Attachment A for definitions of the five correspondence types for Health Insurance Portability and Accountability Act (HIPAA) Confidential Communication).

e. Requests to split communications under a correspondence type are considered unreasonable and will be denied. With an exception to MyHealtheVet, a request to receive communications via electronic mail is also to be considered unreasonable and will be denied.

f. The confidential communications address and correspondence type is transmitted nightly to the Austin Information Technology Center (AITC).

g. A confidential communications address that results in undeliverable mail is considered invalid; and that the correspondence is resent or re-mailed to the Veteran's permanent address as notated in VistA.

h. When a confidential communications address is activated for health records, the address is viewable through the ROI Plus software for utilization by the ROI Clerks. ROI Clerks must use the confidential communications address when activated to provide individuals with copies of their own records regardless of the address on the request.

6.0 Restriction Request

a. An individual's request for restrictions on the use or disclosure of his or her Individually Identifiable Health Information (IIHI) that is used to carry out treatment, payment, or health care operations are referred to the Privacy Officer. All restriction requests must be made in writing.

b. All requests for restrictions of individually-identifiable health information need to be reviewed on a case by case basis by the facility Privacy Officer. If the facility is **considering granting** the request, the VHA Privacy Office should be consulted. Restriction requests are not considered unless they meet the following criteria:

(1) Submitted in writing;

(2) Identify which information is to be restricted;

(3) Identify who the information is to be restricted from;

(4) Indicate for what purposes (e.g., use for payment) the identified information is to be restricted;

(5) Be signed and dated by the individual to whom the record pertains.

c. Although this facility is not required to agree to restrictions requested by individuals, any restriction granted must be appropriately documented. If a request for restriction is granted, all facility programs and employees must adhere to the restriction unless the information covered by the restriction is needed to provide a patient with emergency treatment. When the restriction request is granted, a facility wide e-mail is sent out to all Supervisors/Managers, who would have a need to know this information, instructing them to notify their staff of the restriction on this Veteran's health records.

d. When a restriction request is denied, the Privacy Officer promptly informs the individual of the decision. The notification includes the reason for the denial and the signature of the facility Director or designee. All restriction requests and denials are documented and retained by the Privacy Officer. There are no appeal rights given for a denial of a restriction request.

e. A facility has a right to terminate a restriction request. A facility may terminate a restriction, if it informs the individual in writing that it is terminating its agreement to a restriction and that such termination is only effective with respect to protected health information created or received after VHA has so informed the individual.

NOTE: A facility health care provider may NOT grant a restriction request. A verbal request by the Veteran to not share his/her information is not a restriction request. The provider must refer the Veteran to the Privacy Officer for consideration. An e-mail will be sent, with the guidance on restriction requests, to the Managers/Supervisors asking them to provide a copy of the e-mail to all of their medical care providers.

7.0 Facility Directory Opt-Out

a. Individuals may request exclusion from the Facility Directory during each inpatient admission, in accordance with the Chief Business Office Procedure Guide 1601B.02. The facility Directory Opt-Out provision does not apply to the Emergency Room unless the patient is going to be admitted to an inpatient setting. The facility Directory Opt-Out provision does not apply to Outpatient clinics.

b. Upon admission, VistA will prompt the user to select either opt-in or opt-out for each inpatient in the facility directory. During the RN admission screening process, the nurse must ask each inpatient to specify whether he or she wishes to be excluded from the facility directory and document his/her decision in the VistA system at each admission episode.

c. VistA should be edited utilizing either the Admit a Patient or Extended Bed Control options to indicate the patient's preference.

d. Each patient must be advised that if they request to be excluded, medical center staff will not be permitted to provide any information to visitors or callers concerning whether a patient is an inpatient at this facility. This includes family, friends, colleagues, deliveries (i.e., flowers, cards, etc.) or anyone asking about the patient.

e. A patient may, at any time during an admission, change the initial decision to be included or not in the facility directory.

f. If an inquiry is received concerning a patient who elects to opt-out of the facility directory, the sample response may be "I am sorry, but I do not have any information I can give you on whether John Q. Veteran is a patient".

g. If the patient is incapacitated or unable to make this decision at the time of admission, the facility health care provider admitting the patient makes a determination based on the patient's prior admissions and the best interest of the patient.

(1) The provider must document this decision in the patient's medical record in CPRS.

(2) Once the patient is able to communicate or make the facility directory opt-out decision, the patient must be given an opportunity to do so. The nurse in charge of that patient will explain the OPT-OUT process to the patient when he is able to communicate and let the patient decide if he or she wants to be included in the hospital directory.

(3) The Privacy Officer will meet with the Charge Nurses in their staff meetings to discuss the process for OPTing out patients. The Nurse Educator will provide training to the nursing staff on how to explain the OPT-OUT process to their patients. The OPT-OUT/OPT-IN category was added to the Nursing Admission Assessment in CPRS.

8.0 Accounting of Disclosures

a. The facility maintains an accounting of all disclosures of III for six (6) years after the date of disclosure or for the life of the record, whichever is longer. (See RCS 10-1 for additional guidance or your Records Control Officer). This accounting includes disclosures made with or without patient authorization. Disclosures of data to VHA employees performing their official duties in regards to treatment, payment and health care operations and disclosures of de-identified data do not require an accounting.

b. In most circumstances, the accounting will be maintained electronically via the most current version of the ROI Plus software as part of the record from which the disclosure was made. See VHA Directive 2011-010, Mandated Utilization of the Release of Information Records Management Software.

c. For those departments within the VASLCHCS that do not utilize the ROI Plus software, the Privacy Officer will enter these disclosures into the software after notification of the disclosures and/or the departments will keep spreadsheets with this information and will send these spreadsheets to the Privacy Officer on a monthly basis.

d. An individual may request a copy of an accounting of disclosures from his/her records. The request must be made in writing and adequately identify the system of records or designated record set(s) for which the accounting is requested. The request must be delivered to the facility Privacy Officer, so that a date can be put on the request for processing and completion within the 60 calendar days.

e. Accountings must contain the name of the individual to whom the information pertains, date of each disclosure; the nature or description of the disclosed information; a brief statement of the purpose of each disclosure, or in lieu of such statement, a copy of a written request for each disclosure; and the name and, if known, address of the person or agency to whom the disclosure was made.

f. The accounting of disclosure must be made available within 60 calendar days of the facility's receipt of the request, except for disclosures made for health oversight activities or law enforcement purposes authorized by 38 CFR §1.576(b)(7) and 45 CFR §164.528(a)(2)(i).

(1) If the accounting cannot be provided within the specified timeframe, the timeframe may be extended 30 days.

(2) In order to extend the timeframe, the requestor must be issued a written statement from the facility Privacy Officer that includes the reasons for the delay and the date by which the accounting will be provided. Only one such extension of time for action on a request for an accounting of disclosures is permitted.

C. Uses and Disclosures

1.0 Minimum Necessary

a. The minimum necessary requirements do not apply to disclosures to, or requests by, a health care provider who requires the information for treatment purposes.

b. All facility staff should have minimum necessary (for completion of job duties) access to Protected Health Information (PHI). Specific minimum necessary policies and procedures, including appropriate staff access levels are explained in VHA Handbook 1605.2, Minimum Necessary Standard for Protected Health Information.

(1) An e-mail is sent to the Supervisors/Managers mail group with a statement explaining the need for the completion of VA form 10-0539, Assignment of Function Categories, also, it is recommended by the Privacy Officer that the Functional Categories Assignment be included in the workforce Performance Standards so it can be discussed during annual performance reviews. VA form 10-0539 is also included in the New Employee package that is sent to all Supervisors when they have made a selection to fill a vacancy. When the Supervisor/Manager has met with their employees and completed VA form 10-0539, an e-mail will be sent to the facility Privacy Officer informing him/her that their department is at 100% compliance.

(2) VA form 10-0539 is very clear as to what access to PHI that each workforce member needs to have to perform their official duties. The supervisors of each service in the facility will meet with the employee and discuss which functional categories they need to perform their official duties.

2.0 Authorizations

a. The facility does not use or disclose III without appropriate authority conferred by applicable federal privacy laws and regulations or individual written authorization. Valid authorizations are used only for the purpose(s) stated in the authorization and only disclosed by or released to the personnel or office listed in the authorization.

b. A written authorization signed by the individual to whom the health information or information pertains is required when:

(1) The facility needs to utilize III for a purpose other than treatment, payment, and/or healthcare operations, and other legal authority does not exist; and

(2) The facility discloses information for any purpose for which other legal authority does not exist.

c. An authorization to release information must be made in writing and include the following information:

(1) The identity (i.e., name, date of birth and last four of the social security number) of the individual to whom the information pertains.

(2) Veteran Request: If 38 U.S.C. §7332 protected health information is to be disclosed, this information must be specifically identified by checking the boxes.

i. If the authorization indicates specific 38 USC §7332 protected information is to be released to include future health information with a future expiration date but the Veteran does not have the indicated 38 USC §7332 protected diagnosis at the time of signature, the authorization is considered to be invalid for any future 38 USC §7332 protected information acquired after the signature. This newly acquired §7332 protected information cannot be disclosed without a new authorization being obtained. Marking all boxes on VA Form 10-5345 for 38 USC §7332 protected information when the Veteran only has one is not an acceptable practice. If the Veteran marks all 38 U.S.C. §7332 boxes and does not have the diagnoses AND this authorization is for <u>one time use</u>, then the authorization is still valid.

(3) A description, which identifies the information in a specific and meaningful fashion, of the information to be used or disclosed.

(4) The name of the person(s) or office(s) authorized to make the requested use or disclosure.

(5) The name or specific identification of the person(s) or office(s) to which the agency may make the requested use or disclosure.

(6) A description of the purpose(s) for the requested use or disclosure. A statement "insurance purposes" etc. is sufficient. A purpose is not required when disclosing the information to the individual to whom the information pertains.

(7) An <u>expiration date, condition or event</u> that relates to the individual or the purpose of the use or disclosure of the information. If the purpose section is not filled out and there is no expiration date, condition or event, the authorization is considered <u>invalid</u>. Examples of appropriate expiration date language specific to research are:

i. The "end of the research study" or similar language is sufficient if the authorization is for use or disclosure of III for research.

ii. The statement "none" or similar language is sufficient if the authorization is for the agency to use or disclose III for a research database or research repository. The statement "none" cannot be used as an expiration date for any other purpose other than research.

(8) The signature of the individual, or someone with the authority to act on behalf of the individual, the date of the signature must be included on the authorization.

(9) A statement that the individual has the right to revoke the authorization in writing except to the extent that this facility has already acted in reliance on it, and a description of how the individual may revoke the authorization.

(10) A statement that VHA, this facility, or the entity requesting the information may not condition treatment, payment, enrollment, or eligibility for benefits on the individual's completion of an authorization. **NOTE:** This is only required if the requestor is another HIPAA covered entity.

(11) A statement that III disclosed in response to the authorization may no longer be protected by federal laws or regulations and may be subject to re-disclosure by the recipient.

(12) All authorizations for information received at the VASLCHCS will be sent to the Release of Information Office for processing. Authorizations for employee personnel or health records will be processed in the Human Resources department and a spreadsheet will be kept for an accounting of disclosure. Credentialing and Privileging will also handle their own authorizations and they will enter these into the DSS ROI Records Manager software.

(13) Authorization may be given:

i. On VA Form 10-5345, Request for and Authorization to Release Medical Records or Health Information, or any subsequent authorization form approved to replace this form.

ii. Using an outside entity's authorization form (e.g., social Security Administration Authorization form) as long as all of the authorization content requirements are met.

d. Information will not be disclosed on the basis of an authorization form that:

(1) Fails to meet all the preceding requirements;

2) Has expired;

(3) Is known to have been revoked;

(4) Has been combined with another document to create an inappropriate compound authorization; or

(5) Is known, or in the exercise of reasonable care should be known, to facility staff as false with respect to any item of the authorization requirements.

(6) Authorizations will be forwarded to the Release of Information Office for action.

(7) If an authorization form is determined to be invalid, the Release of Information office will notify the requestor of the deficiencies, unless 38 U.S.C. §7332-protected information is involved.

(8) Facility staff will not check off any of the 38 U.S.C. §7332 boxes on the VA Form 10-5345, Request for and Authorization to Release Medical Records or Health Information unless the individual is specifically asked in person while a clerk completes the form for the individual prior to signing or a telephone discussion with the individual before mailing the authorization for signature. Staff may not arbitrarily check off boxes without the individual's oral approval. Oral approval is documented by an Administrative Note being placed in the individual's CPRS records by the Release of Information office.

3.0 Processing a Request for Release of Information

a. Anyone may request VHA to disclose any record. Any request for information maintained in VHA and facility records must be processed under all applicable confidentiality statutes and regulations.

b. A request for copies of facility records must be in writing, under the signature of the requestor, and describe the record(s) sought, so it may be located in a reasonable amount of time.

c. All written requests for copies of individually identifiable information (III) maintained within the facility will be forwarded to the ROI Department except as indicated below. The facility Privacy Officer will be consulted on any requests received that are unusual or are not addressed in this policy.

(1) The Medical Care Cost Recovery (MCCR) coordinator, or equivalent, is responsible for disclosing billing information. MCCR staff is also responsible for coordinating with Release of Information staff in order to account for disclosures of health information.

(2) The CBOC's will only disclose health information to the Veteran. All other requests that are received in the facility's CBOC's will be sent to the Release of Information Office at the main facility. Social Work and Infectious Disease staff, when performing a Duty to Report, will add the Privacy Officer as an additional signer on their notes. Social Workers will also consult with the facility Privacy Officer prior to making a report.

d. The ROI Department will need to determine who is making the request for a copy of the facility record or information.

(1) If the requestor is the individual to whom the records pertain, follow the guidance under B. Individuals Rights, 2.0 Right of Access.

(2) If the requestor is other than the individual to whom the record pertains (third party), determine what information or record is requested and for what purpose and is there a written valid authorization from the individual or other legal authority prior to disclosure.

e. The ROI office will need to determine what information is being requested.

(1) If the record requested does not contain individually-identifiable information, process the request in accordance with section D. Freedom of Information Act.

(2) If the record requested contains individually-identifiable information, review the paragraphs under C. Uses and Disclosures, 4.0 Uses/Disclosures for Treatment, Payment, and Health Care Operations, and Other Operations Not Requiring Authorization for guidance directed at the specific requestor and/or purpose.

(3) If the record requested contains individually-identifiable information and the guidance in section C. Uses and Disclosures, 4.0 Uses/Disclosures for Treatment, Payment, and Health Care Operations, and Other Operations Not Requiring Authorization is not applicable and a signed, written authorization was not received, refer the request to the facility Privacy Officer for an opinion. The facility Privacy Officer will review the request and determine if disclosure authority exists by reviewing the applicable Federal privacy laws and regulations.

(4) If the request is on a deceased individual, process the request in accordance with section C. Uses and Disclosures, 5.0 Deceased Individuals.

f. The ROI office must process requests for individually-identifiable information within specified time standards and charge the applicable fees, as appropriate.

(1) Request for copies of individually-identifiable information must be answered within 20 workdays from the date of receipt.

(2) When, for good cause shown, the information cannot be provided within 20 workdays from the date the request was initially received, the requester must be informed in writing as to the reason the information cannot be provided and the anticipated date the information will be available.

(3) Copying fees may be charged for copies of records provided to requestors. Only copying fees as stated in 38 CFR §1.577(f) or subsequent regulations may be charged. The facility is prohibited for charging more for copies than is allowed in VA regulations.

g. A requestor may ask that the facility disclose or provide individually-identifiable information in an electronic format, such as on Compact Disk (CD), in lieu of paper copies. When the records requested exist electronically and can be reproduced in the requested format, the facility must accommodate such a request. The ROI Department has the capability, in the ROI Plus software, to place individually identifiable information and protected health information in electronic format, i.e. compact disk when requested.

4.0 Uses/Disclosures for Treatment, Payment, and Health Care Operations, and Other Operations Not Requiring Authorization

a. The VASLCHCS uses and discloses Individually Identifiable Health Information (IIHI) as permitted by the HIPAA Privacy Rule, the Privacy Act of 1974 and other federal rules and regulations. Certain disclosures, within VA, for purposes other than treatment, payment, and health care operations, may be made without authorization.

b. Individuals are not required to and cannot be forced to waive their rights under the HIPAA Privacy Rule, 45 CFR §160.306 as a condition of the provision of treatment, payment, enrollment in a health care plan, or eligibility for benefits.

c. The VASLCHCS workforce (e.g., staff, employees, volunteers) uses and discloses IIHI in the following manners:

(1) Within VHA on a need to know basis for treatment, payment, and/or health care operations without the written authorization of the individual.

(2) To the extent necessary, on a need-to-know basis, and in accordance with good medical and/or ethical practices, staff may disclose general patient information to the patient's next-of-kin. If the patient is listed in the facility directory, staff also may disclose to the general public, without authorization, the patient's location and general condition.

(3) To next-of-kin and family members in the presence of the individual if the patient does not object or if it is reasonably inferred from the circumstances that the patient does not object.

(4) To next-of-kin and family members when, in the professional judgment of attending medical center staff members, disclosure is in the best interest of the patient.

(5) To VBA for use in the determination of eligibility for, or entitlement to, benefits.

(6) To VA contractors or business associates for a contracted service or service provided on behalf of the facility related to treatment, payment, and/or health care operations provided that the disclosure is within the scope of the contract or agreement and when necessary, a signed Business Associate Agreement (BAA) with the contracted company or business associate is on file.

(7) To a receiving facility when a patient is transferred to, or being treated at a community hospital (including other federal hospitals), State Veteran Home, or community nursing homes.

(8) To the Office of Resolution Management (ORM) when necessary for determining compliance with Equal Employment Opportunity (EEO) requirements and upon the request of the Office of Resolution Management.

(9) To the Board of Veterans Appeals for benefits, including the processing and adjudication of claims appeals.

(10) To the National Cemetery Administration for determinations of eligibility for, or entitlement to, benefits.

(11) To VA Unions, in the course of fulfilling their representational responsibilities. VA Unions may make a request to management for copies of facility records

pursuant to its authority under 5 U.S.C. §7114(b)(4). Unions may request any records that are maintained by a VA facility. For example, this might this might include releasable portions of completed Administrative Investigation Boards (AIB), patient medical records and/or an employee's personnel records. However, under certain circumstances, unions may not be legally entitled to receive IIHI, or information protected by other statutes such as the Privacy Act. All requests for information submitted by VA Union Representatives are referred to the servicing HRMS, which coordinates the response with the Regional Counsel and the facility Privacy/FOIA Officer (designee).

(12) To a Member of Congress (including a staff member acting on the Member's behalf) when responding to an inquiry from a Congressional office that is made at the request of the individual to whom the information pertains under the following conditions:

i. If prior written authorization has not been provided and the Member provides a copy of the original correspondence from the individual requesting the member's assistance.

ii. If a prior written authorization is provided and conforms to the requirements of a valid authorization.

iii. If the request is not the result of an inquiry made on behalf of the individual's family or another third party. VASLCHCS staff cannot provide information to a Congressional member if the inquiry was initiated by a family member or party other than the individual to whom the information pertains.

iv. VASLCHCS policy 00.07 directs staff on how to process the requests for Congressional inquiries.

(13) To health insurance carriers or health plans for payment activities related to seeking reimbursement for VA care.

(14) To General Counsel and/or Regional Counsel for the purposes of health care operations, e.g.; legal services, as long as a business associate agreement (BAA) is in effect. In addition, information may be provided to the Office of General Counsel (OGC) for any official purpose authorized by law as long as VHA Central Office maintains a Memorandum of Understanding (MOU) or BAA with OGC authorizing the sharing of IIHI for legal counsel provided to VHA.

(15) Except for criminal law enforcement activities, to the VA Inspector General or Office of Inspector General (OIG) Investigators for any official purpose authorized by law, such as health care oversight.

(16) Except for criminal law enforcement activities, to the facility VA Police for enforcement of physical security (e.g., escort of high-risk patients).

d. Addiction Treatment Center personnel are responsible for preparing evidence of attendance at court ordered treatment and for forwarding copies of letters to the Release of Information Office for documentation of disclosure.

NOTE: Use of a patient's photograph or voice for purposes other than the identification, diagnosis, or treatment of the patient is not permitted unless a signed consent is obtained on VA Form 10-3203, Consent for Use of Picture and/or Voice (38 C.F.R. 1.218). If photographs are taken to support treatment, those photographs are included in the medical record maintained for each patient. Disclosure of the patient's photograph or voice would require written authorization from the individual or other legal authority.

e. Public affairs will obtain signed consents from the Veteran's using VA Form 10-3203, Consent for Use of Picture and/or Voice (38 CFR 1.218), when the facility is taking pictures at an event sponsored for the Veterans. These forms will then be sent to the Files Unit to be scanned into the Veterans CPRS administrative file in VistA Imaging.

5.0 Deceased Individuals

a. Except for uses and disclosures for research purposes discussed in section C. Uses and Disclosures, 10.0 Research Activities; this facility shall protect the PHI of a deceased individual in the same manner, and to the same extent, as required for the PHI of living individuals.

b. PHI, excluding 38 U.S.C. §7332 information, of a deceased individual may be disclosed to coroners, medical examiners, and funeral directors unless information is required for determining cause of death or required for collection of death or vital statistics per State law.

c. Disclosure of autopsy findings:

(1) The Diagnostic Service Line Manager is responsible for preparing the autopsy provisional diagnoses report and ensuring its availability to the attending physician; for disclosing pathology/tissue slides/blocks; for releasing radiographic films and for following up

to ensure return of this VA property and coordinating with Release of Information to account for the disclosure.

(2) Managers of Clinical Service Lines are responsible for translating autopsy findings into layman's terms, composing a timely autopsy letter in lay terminology upon request.

(3) A copy of the autopsy clinical finding summary and the listing of clinical-pathological diagnoses on Standard Form (SF) 503, Medical Record-Autopsy Protocol, are disclosed, when requested by the next-of-kin.

(4) All cases in which the autopsy reveals drug abuse, alcoholism or alcohol abuse, HIV infection, or sickle cell anemia information (which is subject to additional disclosure restrictions), the autopsy results are not disclosed to the next-of-kin unless the Privacy Officer has determined that such disclosure is necessary for the survivor to receive benefits.

6.0 Contracts and Business Associate Agreements

a. In contracts/agreements that involve the use or disclosure of PHI, appropriate privacy requirements, specifications, and statements of work must state that privacy requirements and specifications should be properly implemented before the contract/agreement goes into operation.

b. All contracts must meet the contracting requirements dictated by VA's Office of Acquisition and Material Management and the Federal Acquisitions Regulations (FAR). Any contract which necessitates the use of III must conform to the policies and procedures in FAR Subpart 24.1, Protection of Individual Privacy and VA Directive 6500.6, Contract Security.

c. All contracts, agreements, and relationships must be assessed to determine if a business associate relationship exists.

d. The contracting officer, the Privacy Officer, and the ISO will work together to identify those entities that qualify as Business Associates under HIPAA and ensure that Business Associate Agreements (BAAs) are enacted for these identified entities in accordance with HIPAA and BAA policies and procedures (**NOTE:** a business associate relationship exists if the facility is required to release PHI to a contractor or business partner for the provision of services on the facility's behalf).

e. If a business associate relationship is determined to exist, a business associate agreement is enacted utilizing only the most current version of the VHA Health Information

Access Office approved BAA language available at
http://vawwvhadataportal.med.va.gov/DataAccess/BusinessAssociateAgreements.

f. If a business associate is determined to serve more than one VA facility, the facility Privacy Officer should contact the VHA Health Information Access (hia.va.gov) mail group to discuss enacting a national BAA. Any national BAA takes precedence over a local BAA. Local and regional BAA's should not be initiated if a national BAA exists for the same services as described in the national BAA preamble. BAA's are kept updated and documented as long as the agreement is in force. (Refer to VHA Handbook 1605.05, Business Associate Agreements).

f. Per the agreement, business associates will abide by the terms and conditions spelled out in the agreement.

g. If a pattern of activity or practice of the business associate constitutes a material breach or violation of the business associate's obligation under the contract or other agreement is discovered, the facility Privacy Officer reports the problem to NSOC and works with the Contracting Officer for resolution. All Business Associates must report the breach within 24 hours to the Director of Health Information Governance and submit a written report within 10 days.

h. The Contracting Officer's Representative (COR) responsible for the contract will monitor compliance with the applicable privacy policies required under the Business Associate Agreement with assistance and in consultation with the Privacy Officer.

7.0 Emergency Situations and Serious Threats

a. When an employee becomes aware of a threat to the patient, another individual (e.g. family of veteran) or to the public, the VAMC staff should contact the facility Privacy Officer in order to determine if, and how, to report or address the serious or imminent threat to the health or safety of the patient, other individual or public.

b. See policy 11.26 for VASLCHCS's procedures on Duty to Report and Duty to Warn – Release of Information in Cases of Child Abuse, Disabled Adult Abuse and Potential Violence.

c. VHA may disclose IIHI in accordance with:

(1) 5 U.S.C. §552a(b)(8)-to a person pursuant to a showing of compelling circumstances affecting the health or safety of an individual if, upon such disclosure,

notification is transmitted to the last known address of the individual to whom the records pertain; and

(2) 45 CFR §164.512(j)(1)(i)-to avert a serious and imminent threat to the safety of an individual as long as the disclosure is made to a party which is in a position to prevent or lessen the threat, such as a law enforcement official or the individual threatened; or

(3) 45 CFR §164.512(k)(2)-to avert serious threats to the safety of the public as long as the PHI is given to authorized federal officials for the conduct of lawful intelligence, counter-intelligence, or other national security activities.

NOTE: This disclosure requires accounting through the ROI Plus software.

8.0 Standing Letters

a. VALSCHCS staff may disclose IIHI, excluding 38 U.S.C. §7332 protected information, pursuant to a valid standing written request letter to State Agencies charged with the protection of the safety and health of the public. Information disclosed in response to a standing written request letter is provided for the purpose of cooperating with a State law enforcement reporting requirement. Regional Counsel will be consulted to determine if State laws would allow for standing written request letter to be implemented.

b. Standing written request letters may be needed for the following purposes:

i. Law Enforcement – Law enforcement entities routinely require reporting from VHA records for suspected child abuse, suspected elder abuse, gunshot wounds, and other administrative actions, e.g., suspension or revocation of a driver's license.

ii. Public Health – Examples of public health reporting requiring a standing written request letter include:

1. Communicable diseases (e.g., hepatitis, tuberculosis, sexually transmitted diseases, etc.);

2. Vital statistics (e.g., deaths, etc.);

3. Other State reporting requirements (e.g., animal bites).

iii. State and Other Public Registries (e.g. State Cancer Registries, **NOTE:** VHA may not disclose individually-identifiable information to private registries without the prior written authorization of the individual to whom the information pertains).

iv. Coroner or Medical Examiner

c. With the exception of public health reporting requirement defined in VHA Directive 2013-008, all other disclosures are discretionary on behalf of the facility.

d. The Privacy Officer is responsible for ensuring all standing written request letters meet the guidelines as defined in 1605.1 (21)b. A copy of all standing written request letters must be maintained by the Privacy Officer and renewed every 3 years.

e. The Privacy Officer is responsible for obtaining the standing written request letters from state agencies.

f. Departments responsible for disclosing information pursuant to a valid standing written request letter must coordinate the disclosure with the Privacy Officer in order to account for the disclosure.

g. If a standing letter is not in place the party requesting the IIHI must submit a written request under the authority of 5 U.S.C. 552a(b)(7) for the information. The request must be:

i. In writing;

ii. Specify the particular portion of the record desired;

iii. Specify the law enforcement activity or purpose for which the record is sought;

iv. State that de-identified data could not reasonably be used; and

v. Be signed by the head of the agency.

9.0 State Prescription Drug Monitoring Program

a. VHA may disclose individually-identifiable health information to a State Prescription Drug Monitoring Program (SPDMP) without the signed, written authorization of the Veteran for whom the medication was prescribed. Disclosure may be for the purpose of querying the SPDMP or reporting mandatory prescription information to the State (e.g., batch reporting). **NOTE:** Batch reporting will not be possible until such time as the VA Office of Information Technology provides the software solution to facilities).

(1) A CPRS note will be generated when a query is made to the SPDMP. The Privacy Officer will be added as an additional signer to ensure that the accounting of disclosure is entered in ROI Plus.

10.0 De-identification of PHI

a. Information is only considered de-identified if the methods outlined in VHA Handbook 1605.1 are followed. Section 164.514(a) of the HIPAA Privacy Rule provides the standard for de-identification of protected health information. Under this standard, health information is not individually identifiable if it does not identify an individual and if VHA has no reasonable basis to believe it can be used to identify an individual. This is accomplished by either:

(1) Having an expert with appropriate knowledge of and experience with generally accepted statistical and scientific principles and methods for rendering information not individually identifiable determines that the risk is very small that the information could be used, alone or in combination with other reasonably available information, by an anticipated recipient to identify an individual who is a subject of the information; and documents the methods and results of the analysis that justify such determination; or

(2) All eighteen (18) identifiers listed in VHA Handbook 1605.1 are removed.

b. De-identified data is not PHI. Therefore, when data is appropriately de-identified, the HIPAA Privacy Rule, the Privacy Act and other federal privacy regulations do not apply and information may be disclosed under the Freedom of Information Act.

c. VA Directive 6511 Presentations Displaying Personally Identifiable Information must be followed prior to presenting at VA and non-VA conferences. Any questions concerning whether or not information is de-identified prior to disclosure, should be referred to the Privacy Officer.

11.0 Research Activities: General

a. VA Research investigators must have appropriate legal authority to collect, access or use individually identifiable information in a research study. The "need-to-know" in their official performance of their job duty does not cover all federal privacy regulations specific to research.

b. The Privacy Officer and the Information Security Officer will serve in non-voting capacities on the Research and Development committee pursuant to VHA Handbook 1200.05, Requirements for the Protection of Human Subjects in Research.

c. The Privacy Officer will review all initial submissions of human subject research protocols, including exempt protocol submissions, for the use and/or disclosure of individually-identifiable information and other privacy considerations prior to the convened Institutional Review Board Meeting (IRB) at which the study is to be reviewed, except for those research projects approved by the VA Central IRB. It is expected that review submissions and approval process will be timely submitted by all parties involved. The Information Security Officer will review all initial submissions of human subject research protocols for compliance with all applicable federal security requirements. The Privacy Officer and the Information Security Officer will provide a final written approval to the IRB, prior to the use and/or disclosure of III by the researcher or his/her team.

d. The Privacy Officer and Information Security Officer will review all continuing reviews of human subject protocols or proposed human subject protocol amendments impacting privacy or information security. The Privacy Officer will receive notification from the IRB of a pending Continuing Review or an Amendment. After reviewing the human subject protocol, the Privacy Officer will provide the Administrative Assistant in Research the results of this review which will then be placed in the research file. The IRB will be notified by the Administrative Assistant in Research that the Continuing Review and/or Amendment has been approved by the Privacy Officer and the Information Security Officer.

e. Facility research office staff verifies the qualifications of VA researchers seeking to use and/or disclose III, (i.e. they have completed their mandatory privacy and security training) and ensures that the VA researchers take appropriate measures to protect the privacy of study subjects.

12.0 Research Activities: Use

a. VA Research investigators may use III for reviews preparatory to VA research, provided that the information is being sought solely for purposes preparatory to research and that no PHI will be removed by the VA researcher. All other requirements related to the use of III for reviews preparatory to VA research are set forth in VHA Handbook 1200.05, Requirements for Protection of Human Subjects Research must be followed.

b. VA Research investigators may use PHI for VA approved research if the Privacy Officer has determined that:

(1) A Research HIPAA authorization compliant with VHA Handbook 1605.1 Para. 14 will be obtained for each research subject; or

(2) The IRB has approved a waiver of HIPAA authorization, in full or in part, and the IRB approval has been appropriately documented as required by the HIPAA Privacy Rule and VHA Handbook 1200.05; or

(3) A Limited Data Set will be used and a valid DUA has been signed as required by the HIPAA Privacy Rule.

c. If the researcher has not completed his or her study by the time of the expiration of the Research HIPAA authorization, the researcher can no longer use any of the information previously collected from the study subjects.

d. PHI/III and other VA sensitive data for a VA approved research study that is stored, collected, or maintained outside of VA custody; either electronic or paper must have prior approval and safeguards in place to protect the data. The Privacy Officer will work with the Information Security Officer and Chief Information Officer to ensure the appropriate safeguards are in place. See VA Handbook 6500 for further guidance.

e. For certain sensitive research studies, a VA researcher may request a Certificate of Confidentiality from the National Institutes of Health (NIH) which, if granted, could prevent the facility from being forced to disclose individually identifiable information on research subjects, by a court order/subpoena in any civil, criminal, administrative, legislative, or other proceedings that are maintained in 34VA12, Veteran, Patient, Employee, and Volunteer Research and Development Project Records.

13.0 Research Activities; Disclosure

a. For the facility to disclose protect health information to a non-VA researcher or other non-VA entity for research purposes, either for VA research purposes, or for non-VA research programs, there must be legal authority under all applicable federal privacy laws and regulations including 38 U.S.C. §5701, the Privacy Act, HIPAA Privacy Rule and 38 U.S.C. §7332. The applicable legal authority is as follows:

(1) 38 U.S.C. §5702 – If the non-VA researcher or non-VA entity is requesting III, that may be disclosed under 38 U.S.C. §5701, a written request stating records sought and

purpose of the records that is dated and signed by the non-VA researcher is required. If VA is initiating the disclosure of information under 38 USC §5701 for a research purpose, a written request from the non-VA researcher or non-VA entity is not required.

(2) 38 U.S.C. §5701 – For purposes of disclosing records pertaining to any claim under any of the laws administrated by the Secretary for non-VA Research, a "federal" non-VA researcher may be provided name and address of individuals under 38 U.S.C. §5701(b)(3). For a "non-federal" researcher or other entity, the researcher or entity must provide to VA the names and addresses of the individual whose claims information is being sought in order to obtain those individuals' identifiable information.

(3) 38 U.S.C. §7332 – The non-VA researcher to whom 38 U.S.C. §7332 protected health information (related to drug abuse, alcoholism or alcohol abuse, infection with the human immunodeficiency virus, or sickle cell anemia) is disclosed must provide written assurance that the purpose of the data is to conduct scientific research and that no personnel involved in the study may identify, directly or indirectly, an individual patient or subject in any report of such research or otherwise disclose patient or subject identities in any manner. This assurance may be documented in the research protocol. In addition, the Medical Center Director based on input from the ACOS, Research and Development must determine that the non-VA researcher is qualified to conduct the research; has a research protocol that stipulates how the information will be maintained in a secure manner; and a written statement that the research protocol has been reviewed by an IRB who found that the individual's rights are adequately protected and that the potential benefits of the research outweigh any potential risks to patient confidentiality.

NOTE: If a VA researcher plans to disclose 38 U.S.C. §7332 protected health information to an outside non-VA entity or use within a publication, this written assurance must also be obtained.

(4) Privacy Act of 1974 – If an individual does not provide prior written consent for the disclosure of his/her record contained in a system of records (SOR), there must be a routine use under the applicable Privacy Act System of Records that permits the disclosure. (See 34VA12, Routine Use 19).

(5) HIPAA Privacy Rule – Either a research HIPAA authorization compliant with VHA Handbook 1605.1 Para. 14 will be obtained for each research subject; or the IRB has approved a waiver of HIPAA authorization and the IRB approval has been appropriately documented as required by the HIPAA Privacy Rule and VHA Handbook 1200.05. **NOTE:** A waiver of HIPAA authorization approved by the IRB does not affect or override the other legal requirements that must be met.

b. A VA researcher must have appropriate legal authority to disclose individually-identifiable information to a non-VA entity, including a research sponsor or an academic affiliate who is collaborating on this study. This disclosure authority is outlined in the written HIPAA authorization signed by the individual unless other legal authority exists, e.g., Court Order.

c. Decedents' information may be disclosed to a source other than the researcher who has use of this data if the HIPAA Privacy Rule allows for disclosure to a non-VA entity. See your facility Privacy Officer in regards to any questions concerning disclosure authority.

d. This facility may distribute a limited data set, information that excludes direct identifiers, but still contains potentially identifying information, without consent of the individual. A limited data set is only protected under the HIPAA Privacy Rule as the data is not considered identifiable for purposes of the Privacy Act and 38 U.S.C. §7332. Disclosure of a limited data set is dependent upon the receipt of a DUA, which must:

(1) Establish the permitted uses and disclosures of the information;

(2) Establish who is permitted to use or receive the data set; and

(3) Provide that the data set recipient:

i. Does not use for further disclosure of the information other than as permitted;

ii. Uses appropriate safeguards to prevent improper use or disclosure of the information;

iii. Reports to the facility/VHA any improper use or disclosure of which it becomes aware;

iv. Ensures that any agents to whom it provides the data set agrees to the same restrictions and conditions that apply to the data set recipient; and

v. Does not identify the information or contact the individuals.

e. A contracted entity involved in VA research is not a business associate of the covered entity and no business associate agreement is required.

f. A research disclosure made pursuant to a signed, written research HIPAA authorization to a non-VA entity (study monitor, sponsor, academic affiliate, or other non-VA entities) who is not a research team member or contractor requires an accounting of disclosure to be maintained. The accounting of disclosure may be maintained concurrently or be created retrospectively from the VA researcher's files. See above Section B, Individual's Rights, 8.0 Accounting of Disclosures.

g. Facility will not disclose any personal information about VHA personnel engaged in animal research in response to a FOIA request if the FOIA Officer determines a risk to the facility or research personnel.

NOTE: Further guidance on Research requirements is available in VHA Handbook 1605.1, VHA Directive 1200, and other applicable 1200 series handbooks.

14.0 Logbooks

a. Unnecessary collection of sensitive personal information (SPI) in physical logbooks is prohibited.

b. Logbooks must only be maintained for a VHA compelling business need as prescribed in this policy. Use of an unapproved physical logbook will be considered a privacy violation and a violation of VHA Directive 1059 Use of Physical Logbooks containing Sensitive Personal Information in Veterans Health Administration. An approved physical logbook may only contain those data elements that are necessary to satisfy the compelling business need. Individuals are prohibited from compiling historical documentation containing SPI that is not directly related to an approved compelling business need.

c. VHA SPI contained in approved physical logbooks must be handled and maintained in a secure manner with measures in place to prevent the unauthorized disclosure of SPI data. The physical logbook shall be treated as "For Official Use Only" and shall not be removed from its intended place of business except to securely store it.

d. The VASLCHCS process for obtaining written approval allowing use of a physical logbook can be found under the facilities policies, number 00.39.

e. When a staff member or Service needs a physical logbook containing SPI to meet or satisfy a compelling business need or requirement, the facility program or service requesting the physical logbook will work with the Privacy Officer to evaluate if a physical logbook is required. When no other alternative can be achieved, physical logbooks may be approved by the facility Director.

f. Supervisors, service chiefs or other responsible parties will attest to the compelling business requirement (why it is needed), the physical location (where the physical logbook will be kept both during and after normal business hours), the extent of security controls (how the logbook will be protected), and a list of the elements that are being collected in the physical logbook.

g. If a compelling business need is identified and alternative to a physical logbook has not been identified then the VHA facility must work with the appropriate Privacy Officer, Information Security Officer and Records Manager to make the logbook electronic and secure with VHA technical systems with appropriate information technology (IT) security controls. Every effort will be made to furnish equipment (such as encrypted thumb drives) or technology (secure shared drives) that will meet the compelling business need in an alternate secure fashion. The solution provided to the staff member, service or program must adequately address the identified business need.

h. Approved physical logbooks must be maintained no longer than their useful purposes and in accordance with VHA Records Control Schedule 10-1. Approved physical logbooks shall not be created or maintained in any form for anything other than official VHA business.

i. Exceptions: Notwithstanding the above, a physical logbook is authorized in the following instances:

1. Emergency or computer contingence plan physical logbook used in a national disaster or when computers are down.

2. Facility Sign-in roster. A sign-in roster is a temporary record that may be maintained for the purpose of personnel accountability such as training; or management of appointment scheduling. Sign-in rosters shall contain only the name and the time/date of access or arrival and purpose for visit (when in a non-clinical environment). Sign-in rosters will remain in direct unobstructed view of VHA staff. Sign-in rosters used for the purpose of appointment check-in shall contain only the name or signature and the time/date of access or arrival and must be destroyed at the completion of each business day using a VHA approved destruction method. In clinical settings, supervisors shall implement measures to prevent patients from viewing the names and other SPI of patients who have previously signed in.

3. VHA Form 4793, Visitor Register. Visitor registers may be used to record the name, destination, check-in and checkout times of individuals when they are visiting an area. Registers may be placed, as necessary, at several locations throughout a facility. At the

end of the day the data must be destroyed or if there is a requirement to keep the data for a longer period of time the data must be transferred to an electronic tracking system or log, and the physical logbook pages must be shredded using a VHA approved method.

4. Security monitoring of restricted areas such as computer rooms. A sign-in sheet in a computer room may be maintained for the purpose of personnel accountability. If there is a requirement to keep the data for longer than a day then all security and NARA requirements must be met.

D. Freedom of Information Act (FOIA)

1.0 General

a. The FOIA requires disclosure of VA records, or any reasonably segregable portion of a record, to any person upon signed, written request.

b. A FOIA request may be made by any person (including foreign citizens), partnerships, corporations, associations, and foreign, State, or local governments with some exceptions.. The following types of requests are not proper FOIA requests:

1. Requests for records by Federal agencies and their employees acting in their official capacity.

2. Requests for records by fugitives from justice seeking records related to their fugitive status.

c. VHA administrative records not retrieved by name, social security number, or other identifier must be made available to the greatest extent possible in keeping with the spirit and intent of the FOIA.

d. Before releasing records in response to a FOIA request, the record must be reviewed by the facility FOIA Officer to determine if all or only portions of the record cannot be released, in accordance with the nine (9) exemptions provided in the FOIA. The process of deleting portions of documents before releasing them is referred to as "redaction".

e. The facility leadership, Public Affairs Officer, and the VHA FOIA Office will be consulted when a FOIA request is made by a member of the news media, congressional requests (not related to constituent inquires), and requests from law firms or individuals when it is known that the particular law firm or individual is involved with pending or future litigation against the agency.

2.0 Requests for Copies of Records

a. Records or information customarily furnished to the public in the regular course of the performance of official duties (e.g., information posted on VAMC Internet site) may be furnished without a written request.

b. Requests from individuals for information about themselves, which is retrieved by their names or other personal identifiers, need to be processed as outlined in section B. Individual's Rights, 2.0 Right of Access.

c. Requests for official records under FOIA must be in writing and reasonably describe the records so that they may be located. This procedure should not be waived for reasons of public interest, simplicity, or speed. Generally, the request does not have to be designated a FOIA request and the individual does not have to explain why access to official records is desired.

3.0 Processing a FOIA Request

a. A request for records received at the VASLCHCS must be promptly stamped with the date the request was received and referred for action to the facility's FOIA Officer. Prompt referral of any request for facility records to the facility FOIA Officer is required in order to ensure the below time limitations are met.

b. All FOIA request must be entered and tracked in the FOIAXpress, the web-based FOIA tracking system.

c. The facility FOIA Officer and the FOIA Alternate are the only individual's who may process and complete a FOIA request. All FOIA requests for contracts will be forwarded to the VISN 19 contracting office for responsive records. Requests for police reports that contain more than one person will be sent to the facility FOIA Officer for a response.

d. Once the requester has been notified of a determination to comply with the request, the document(s) must be made available promptly. When the agency determines that response to a FOIA request will take longer than ten (10) or more business days, the FOIA requester must be notified in writing. The 10-day time limitation begins upon receipt of the request by the facility.

(1) The acknowledgement letters to the FOIA requestor will contain the following information:

i. date the FOIA Officer received the FOIA request,

ii. cut-off date of the records search,

iii. FOIAXpress tracking number.

e. In unusual circumstances, extensions of not more than 10 workdays (for a total of 20 workdays from receipt of the request by the facility) may be approved by advising a requester in writing whether VA will grant or deny the request.

f. Ensure a responsive FOIA program by handling FOIA requestors' inquiries and questions in a timely way and keeping the requestor informed during delays in processing.

g. The initial agency's determination letter (IAD) must contain the following information:

(1) Date the FOIA Officer received the request,

(2) Clearly re-state the requested records,

(3) Refer to the FOIAXpress tracking number provided in the original acknowledgement letter,

(4) Cite the exemption(s) when information is being redacted or withheld specifically identify the type of information being redacted or withheld (i.e. name, SSN, address, etc.), and

(5) Provide the right to appeal to the Office of General Counsel (OGC).

h. IAD's for FOIA requests denied in whole or part must be signed by the Medical Center Director. The Medical Center Director has provided the facility FOIA Officer with a delegation of authority letter to sign these types of FOIA requests.

i. FOIA request files will be maintained in accordance with RCS 10-1, XLIII-10, XLIII-11 and XLIII-12 and contain the following information:

(1) Copy of the perfected FOIA request,

(2) A copy of the signed acknowledgement letter,

(3) Evidence demonstrating that the FOIA Officer conducted a thorough search for responsive records,

(4) Un-redacted copies of responsive records,

(5) Redacted copies of responsive records sent to the FOIA requestor, and

(6) A copy of the signed initial agency decision (IAD) letter.

NOTE: Refer to VHA Handbook 1605.1 Privacy and Release of Information paragraph 32 Freedom of Information Act for additional information on processing FOIA requests.

4.0 Coordination of Releases with Regional Counsel

a. In any case where a FOIA request involves matters or subjects involved in ongoing or anticipated litigation, administrative proceedings, or criminal or civil investigation, health care facility personnel must coordinate the facility's response to the FOIA request with the Regional Counsel at 801-584-1281.

b. If a request involves matters pertaining to ongoing litigation, the Regional Counsel must be informed of the request to ensure coordination of the VA's position in the litigation with any release of documents.

c. Coordination with the VHA FOIA Officer is also advisable when the facility receives a FOIA request of high visibility or importance to the Department.

5.0 Annual Report of Compliance with FOIA

a. The FOIA requires each agency to submit to the Congress a report, on or before March 1st of each year, of its activities and efforts to administer the FOIA during the preceding fiscal year. The facility FOIA Officers must ensure that all requests for information are properly entered into the FOIAXpress to allow an accurate reporting on the Annual FOIA Report.

b. The facility annual FOIA reports, quarterly reports, or other requested reports made by or through the VHA FOIA Officer will be maintained in accordance with RCS 10-1, XIII-13.

c. The VHA Directive Annual Report of Compliance with the Freedom of Information Act (FOIA) is available on the following web site: http://vaww.vhaco.va.gov/privacy/FOIA.htm

APPENDIX I: Glossary of Terms

Access means the ability or means necessary to read, write, modify, or communicate data/information or otherwise use any system resource.

Availability means that data or information is accessible and useable upon demand by an authorized person.

Business associate means a person or organization that performs a function or activity on behalf of a covered entity, but is not part of the cover entity's workforce. A business associate can also be a covered entity in its own right.

Compelling Business Need is one that requires the capture of SPI in logbook form to meet a policy, regulatory, accreditation or statutory requirement. Additionally, compelling business needs may support reasonable and appropriate business operations, patient safety or quality improvement efforts, or other prudent and important health care operations needs such as the board certification of clinical staff including residents and trainees.

Computer matching describes the computerized comparison of records from two or more automated systems of records. For more information, reference VHA Handbook 1605.1, section 37.

Confidentiality means that property, data, or information is not made available or disclosed to unauthorized persons or processes.

De-identified information is health information that is presumed not to identify an individual and with respect to which there is no reasonable basis to believe that the information can be used to identify an individual because the 18 Patient Identifiers described in the HIPAA Privacy Rule have been removed. De-identified information is no longer covered by the Privacy Act, 38 U.S.C. §5701, 38 U.S.C. §7332, or the HIPAA Privacy Rule.

Disclosure means the release, transfer, provision of, access to, or divulging in any other manner, of information outside the entity holding the information.

Electronic media means:

(1). Electronic storage media including memory devices in computers (hard drives) and any removable/transportable digital memory medium, such as magnetic tape or disk, optical disk, or digital memory card; or (2) transmission media used to exchange information already in electronic storage media. Transmission media include, for example, the Internet (wide-open), extranet (using internet technology to link a business with information accessible only to collaborating parties), leased lines, dial-up lines, private networks, and the physical movement of removable/transportable electronic storage media. Certain transmissions, including of paper, via facsimile, and of voice, via telephone, are not considered to be transmissions via electronic media, because the information being exchanged did not exist in electronic form before the transmission.

Health care operations means any of the following activities of the covered entity to the extent that the activities are related to covered functions:

(1) Conducting quality assessment and improvement activities, including outcomes evaluation and development of clinical guidelines, provided that the obtaining of generalizable knowledge is not the primary purpose of any studies resulting from such activities; patient safety activities (as defined in 42 CFR 3.20); population based activities relating to improving health or reducing health care costs, protocol development, case management and care coordination, contracting of health care providers and patients with information about treatment alternatives; and related functions that do not include treatment;

(2) Reviewing the competence or qualifications of health care professionals, evaluation practitioner and provider performance, health plan performance, conducting training programs in which students, trainees, or practitioners in areas of health car learn under supervision to practice or improve their skills as health care providers, training of non-health care professionals, accreditation, certification, licensing, or credentialing activities;

(3) Underwriting, enrollment, premium rating, and other activities related to the creation, renewal, or replacement of a contract of health insurance or health benefits, and securing, or placing a contract for reinsurance of risk relating to claims for health care (including stop-loss insurance and excess of loss insurance);

(4) Conducting or arranging for medical review, legal services, and auditing functions, including fraud and abuse detection and compliance programs;

(5) Business planning and development, such as conducting cost-management planning related analyses related to managing and operating the entity, including formulary development and administration, development or improvement of methods of payment or coverage policies; and

(6) Business management and general administrative activities of the entity, including, but not limited to management activities relating to implementation of and compliance with the HIPAA requirements; customer service, including the provision of data analyses for policy holders, plan sponsors, or other customers, provided that protected health information is not disclosed to such policy holder, plan sponsor, or customer; resolution of internal grievances; creating de-identified health information or a limited data set; and fundraising for the benefit of the covered entity.

Health Information is any information, whether oral or recorded in any form or medium, created or received by a health care provider, health plan, public health authority, employer, life insurers, school or university, or health care clearinghouse or health plan that relates to the past, present, or future physical or mental health or condition of an individual; the provision of health care to an individual; or payment for the provision of health care to an individual. This encompasses information pertaining to examination, medical history, diagnosis, and findings or treatment, including laboratory examinations, X-rays, microscopic slides, photographs, and prescriptions.

Individual means the person who is the subject of protected health information.

Individually Identifiable Information (III) is any information pertaining to an individual that is retrieved by the individual's name or other unique identifier, as well as Individually Identifiable Health Information regardless of how it is retrieved. Individually Identifiable Information is a subset of Personally Identifiable Information and is protected by the Privacy Act.

Individually-identifiable health information is a subset of health information, including demographic information collected from an individual, that:

i. Is created or received by a health care provider, health plan, or health care clearinghouse (e.g., a HIPAA covered entity, such as VHA);

ii. Relates to the past, present, or future physical or mental condition of an individual, or provision of, or payment for, health care to an individual; and

iii. Identifies the individual or where a reasonable basis exists to believe the information can be used to identify the individual.

Limited Data Set is protected health information from which certain specified direct identifiers of the individuals and their relatives, household members, and employers have been removed. These identifiers include name, address (other than town or city, state or zip code), phone number, fax number, e-mail address, Social Security Number (SSN), medical record number, health plan number, account number, certificate and/or license numbers, vehicle identification, device identifiers, web universal resource locators (URL), internet protocol (IP) address numbers, biometric identifiers, and full face photographic images. The two patient identifiers that can be used are dates and postal address information that is limited to town or city, State or zip code. Thus, a Limited Data Set is not De-identified Information, and it is covered by the HIPAA Privacy Rule. A Limited Data Set may be used and disclosed for research, health care operations, and public health purposes pursuant to a Data Use Agreement.

Non-identifiable Information is information from which all Unique Identifiers have been removed so that the information is no longer protected under the Privacy Act, 38 U.S.C. §5701, or 38 U.S.C. §7332. However, Non-identifiable Information has not necessarily been de-identified and may still be covered by the HIPAA Privacy Rule unless all 18 Patient Identifiers listed in the Rule's de-identification standards are removed.

Patient Identifiers are the 18 data elements attributed to an individual under the HIPAA Privacy Rule that must be removed from health information for it to be de-identified and no longer covered by the Rule.

Payment, except as prohibited under 45 CFR §164.502(a)(5)(i), payment is an activity undertaken by a health plan to obtain premiums, to determine its responsibility for coverage, or to provide reimbursement for the provision of health care including eligibility, enrollment, and authorization for services. It includes activities undertaken by a health care provider to obtain reimbursement for the provision of health care including pre-certification and utilization review. NOTE: VHA is both a health plan and a health care provider.

Physical Logbook is any written (i.e., not electronic) record of activities or events comprised of data which may uniquely identify an individual or contain SPI that is maintained over a period of time for the purpose of monitoring an activity, tracking information or creating a historical record.

(1) The following are examples of physical logbooks:

a. Respiratory therapy logs,

b. Laboratory logs,

c. Autopsy logs,

d. Facility access logs,

e. Wound care logs,

f. Logs of cases cleared,

g. Printouts of Excel spreadsheets,

h. Access data base printouts.

(2) Examples of items which are NOT physical logbooks include:

a. Any electronic file,

b. A list of codes only, such as study identification codes that does not identify an individual.

c. Paper documents required by health care providers for the care of individual patients (e.g., index cards),

d. Police pocket note cards, with incident information and daily activities,

e. Paper sign-out records (hand-offs) with information on multiple patients constituting a team or panel, and required to transfer the care of patients between health care providers,

f. A contact list of employees' names, work phone numbers or work addresses,

g. Work process list.

Personally Identifiable Information (PII) is any information which can be used to distinguish or trace an individual's identity, such as their name, social security number, biometric records, etc. alone or when combined with other personal or identifying information which is linked or linkable to a specific individual, such as date and place of birth, mother's maiden name, etc. Information does not have to be retrieved by any specific individual or unique identifier (i.e., covered by the Privacy Act) to be personally identifiable information.

NOTE: The term "Personally Identifiable Information" is synonymous and interchangeable with "Sensitive Personal Information".

Protected Health Information (PHI) if defined by the HIPAA Privacy Rule as Individually Identifiable Health Information transmitted or maintained in any form or medium by a covered entity, such as VHA.

NOTE: VHA uses the term protected health information to define information that is covered by HIPAA but, unlike individually-identifiable health information, may or may not be covered by the Privacy Act or Title 38 confidentiality statutes. In addition, PHI excludes employment records held by VHA in its role as an employer.

Right of access is an individual's right to have access to (e.g., look at, view) or obtain a copy of records pertaining to the individual that contain individually-identifiable information.

Sensitive Personal Information (SPI) is the term, with respect to an individual, means any information about the individual maintained by VA, including the following:

(1) Education, financial transactions, medical history, and criminal or employment history,

(2) Information that can be used to distinguish or trace the individual's identity, including name, social security number, date and place of birth, mother's maiden name, or biometric records. SPI is a subset of VA Sensitive Information/Data.

NOTE: The term "Sensitive Personal Information" is synonymous and interchangeable with "Personally Identifiable Information".

Subcontractor is a person to whom a business associate delegates a function, activity, or service, other than in the capacity of a member of the workforce of such business associate.

System of records refers to any group of records under the control of the Department from which a record is retrieved by personal identifier such as the name of the individual, number, symbol, or other unique retriever assigned to the individual.

Treatment is the provision, coordination, or management of health care or related services by one or more health care providers. This includes the coordination of health care by a health care provider with a third party, consultation between providers relating to a patient, and the referral of a patient for health care from one health care provider to another.

Unique Identifier is an individual's name, address, social security number, or some other identifying number, symbol, or code assigned only to that individual (e.g., medical record number and claim number). If these identifiers are removed, then the information is no longer Individually Identifiable Information and is no longer covered by the Privacy Act, 38 U.S.C. §5701, or 38 U.S.C. §7332. However, if the information was originally Individually Identifiable Health Information, then it would still be covered by the HIPAA Privacy Rule unless all 18 Patient Identifiers listed in the de-identification standard have been removed.

NOTE: The VA Office of General Counsel has indicated that the first initial of the last name and last four of the social security number (e.g., A2222) is not a unique identifier; therefore, inclusion of this number by itself does not make the information identifiable or sensitive.

Use is the sharing, employment, application, utilization examination, or analysis of information within VHA.

VA Sensitive Information/Data is all Department information and/or data on any storage media or in any form or format, which requires protection due to the risk of harm that could result from inadvertent or deliberate disclosure, alteration, or destruction of the information. The term includes not only information that identifies an individual but also other information whose improper use or disclosure could adversely affect the ability of an agency to accomplish its mission, proprietary information, and records about individuals requiring protection under applicable confidentiality provisions.

Workforce means on-site or remotely located employees, contractors, students, WOC, volunteers, and any other appointed workforce members.

APPENDIX II: Acronyms

ADPAC: Automated Data Processing Application Coordination

ADUSH: Assistant Deputy under Secretary for Health

AIB: Administrative Investigation Board

AITC: Austin Information Technology Center

AOD: Administrative Officer of the Day

BAA: Business Associate Agreement

CCA: Confidential Communications Address

CFR: Code of Federal Regulations

CMS: Centers for Medicare and Medicaid Services

COR: Contracting Officer Representative

CPRS: Computerized Patient Record System

DUA: Data Use Agreement

EEO: Equal Employment Opportunity

FOIA: Freedom of Information Act

HHS: Department of Health and Human Services

HIPAA: Health Insurance Portability and Accountability Act

HRMS: Human Resources Management Service

IIHI: Individually Identifiable Health Information

III: Individually Identifiable Information

IRB: Institutional Review Board

ISO: Information Security Officer

IT: Information Technology

MCCR: Medical Care Cost Recovery

MOU: Memorandum of Understanding

OCIS: Office of Cyber and Information Security

OCR: Office of Civil Rights

OGC: Office of General Counsel

OIG: Office of the Inspector General

ORM: Office of Resolution Management

ORC: Office of Regional Counsel

PA: Privacy Act

PHI: Protected Health Information

PO: Privacy Officer

POA: Power of Attorney

PSETS: Privacy and Security Event Tracking System

QM: Quality Management

R&D: Research and Development

RCS: Records Control Schedule

ROI: Release of Information

TIU: Text Integrated Utilities

USC: United States Code

VA: Department of Veterans Affairs

VAMC: Department of Veterans Affairs Medical Center

VHA: Veterans Health Administration

VHACO: Veterans Health Administration Central Office

VHIC: Veteran Health Identification Card

VIReC: VA Information Resource Center

VISN: Veterans Integrated Service Network

VistA: Veterans Health Information Systems and Technology Architecture

VSSC: VHA Support Service Center

Appendix C
Investigation Derived Waste Management Plan

Investigation-Derived Waste

Standard Operating Procedures

VAHCS CERCLA Site

700 South 1600 East PCE Plume

Date:

DRAFT

TABLE OF CONTENTS

1.0 OBJECTIVES

The objective of this standard operating procedure (SOP) is to establish consistent methods to handle and manage all Investigation-Derived Waste (IDW) from the 700 South 1600 East PCE Plume, including:

- Solid waste, both hazardous and non-hazardous (e.g., soil cuttings, contaminated debris or equipment)

- Liquid waste both hazardous and non-hazardous (e.g., purge water, rinse water from decontamination, product removal)

- Personal Protective Equipment (e.g., gloves, spent respirator cartridges, spent granulated carbon filters (from air purifiers), chemical resistant coveralls)

This SOP provides procedures and standards that are in addition to applicable regulatory requirements and industry standards.

2.0 APPLICABILITY

Investigation sampling activities may generate solid, liquid, and Personal Protective Equipment (PPE) waste. The IDW Handling Procedures SOP will be implemented in the field and on-site at the VHA Salt Lake City Health Care System (VHASLCHCS).

3.0 RESPONSIBILITY

The *CERCLA Program Manager*, or designee, will have the responsibility to oversee and ensure that the IDWs are properly handled and managed in accordance with this SOP and any site-specific or project-specific planning documents.

Contractor field personnel will be accountable for the comprehension and implementation of this SOP during all field activities, as well as obtaining the appropriate field logbooks, forms, labels records and equipment needed to complete the field activities.

4.0 DEFINITIONS

Designated Waste: A solid or liquid waste which is not defined as hazardous, but which still may present a threat to groundwater, and which requires handling differently than a non-hazardous inert waste.

DOT: Department of Transportation. Typically referred to when specifying a type of container that is approved for transporting hazardous substances, either materials or waste, on streets.

Hazardous Waste: Soil, liquid or other wastes generated from site investigations that exhibit toxic (human or ecological effects), ignitable, corrosive, or reactive characteristics as defined by applicable state or federal regulation or which is otherwise classified as hazardous. Such waste requires special handling and documentation of disposal.

IDW: Investigation Derived Waste. Solid (e.g., soil) or liquid (e.g. groundwater, decontamination fluids) wastes resulting from field activities for the Site.

Non-hazardous Waste: A waste that does not exhibit characteristics of a hazardous waste and which is not otherwise classified as hazardous. Non-hazardous waste can be designated as inert waste.

PPE Filters: Personal Protective Equipment. Equipment worn by workers when potential for exposure to hazardous materials exists including respirator cartridges.

HASP: Health and Safety Plan. Plan written to coordinate and outline precautions that will be taken to initiate and monitor worker safety.

5.0 REQUIRED MATERIALS

The equipment and supplies required for implementation of this SOP include the following:

- Containers for waste (e.g., 55-gallon open and closed top drums) and material to cover waste to protect from weather (e.g., plastic covering)
- Equipment (i.e., pumps, generators, water/interface level indicators, safety monitoring equipment)
- Hazardous /non-hazardous waste drum labels (weatherproof)

- Permanent marking pens
- Inventory forms for project file
- Plastic garbage bags, zip lock storage bags, roll of plastic sheeting
- Steel-toed boots, chemical resistant gloves, coveralls, safety glasses, and any other PPE required in the site-specific HASP.

6.0 METHODS

The following methods are used to handle the IDW.

6.1 Labeling

Containers used to store IDW must be properly labeled. Two general conditions exist:

1) from previous studies or on-site data, waste characteristics are known to be; and
2) waste characteristics are unknown until additional data are obtained. The waste containers will be packaged, labeled, and stored in accordance with RCRA as delegated to State of Utah by U.S. EPA Region 8.

For situations where the waste characteristics are known, the waste containers will be packaged and labeled in accordance with RCRA regulations as delegated to the State of Utah by U.S. EPA Region 8 (Utah Administrative Code [UAC] R315). All hazardous wastes will be labeled with a hazardous waste label that addresses the R315 requirements.

The following information shall be placed on the containers for all non-hazardous waste and wastes where the waste characteristics are unknown:

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

Containers of IDW awaiting analysis will be labeled “IDW awaiting analysis” or similar words.

Once the waste has been characterized (e.g., TCLP analyses are received), the label should be changed as appropriate for a non-hazardous or hazardous waste.

All non-hazardous waste shall keep the labels which include description of waste, contact information, and date when the waste was first accumulated. Non-hazardous waste containers will also be labeled as non-hazardous waste.

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

Each container of waste generated shall be recorded in the field notebook used by the person responsible for labeling the waste. After the waste is disposed of, an appropriate record shall be made in the same field notebook to document proper disposition of IDW.

It should be noted that, based on available existing data and site history information in the Conceptual Model Update for the 700 South 1600 East PCE Plume site (EA, 2016), IDW generated from this site are not expected to be characterized as hazardous waste.

6.2 Types of Site Investigation Waste

Several types of waste are generated during site investigations that may require special handling. These include solid, liquid, and used PPE as discussed further below.

6.2.1 Solid Waste

Soil cuttings from boreholes will typically be shoveled back into the borehole after drilling is complete and do not require special handling. Drilling mud generated during investigation activities shall be collected in containers. Covers will be included on the containers and must be secured at all times and only open during filling activities. The containers shall be labeled in accordance with this SOP. An inventory containing the source, volume, and description of material put in the containers shall be logged on prescribed forms and kept in the project file.
If hazardous wastes are generated, they will be disposed off-site at an approved Treatment, Storage and Disposal Facility (TSDF); solid wastes generated during this investigation are expected to be non-hazardous.

It is expected that soil cuttings will be accumulated in a roll-off box for disposal; do not fill the roll-off box more than ½ full, so that the roll-off meets the DOT weight requirements and can be transported for disposal. Drums may be needed to collect excess cuttings at each borehole; the drum(s) would be transported to and emptied into the roll-off box. It is assumed that the roll-off box will be located at the VA building.

6.2.2 Liquid Waste

Groundwater and decontamination water generated during monitoring well development, purging, and sampling will be collected in truck-mounted containers and/or other transportable containers (i.e., 55-gallon drums). Lids or bungs on drums must be secured at all times and only open during filling or pumping activities. The containers shall be labeled in accordance with this SOP. Liquids generated during this investigation are expected to be non-hazardous and may be discharged to the local Salt Lake City Publicly Owned Treatment Works (POTW) facility. CH2M will discharge the liquids to the sanitary sewer and POTW as soon as possible, pending waste characterization and POTW discharge requirements.

If necessary, liquid waste drums or portable tanks will be held at the VA building in a fenced, secure location, pending POTW approval for discharge.

If hazardous waste liquids are generated, hazardous wastes will be handled separately and disposed off-site at an approved hazardous waste facility.

6.2.3 Personal Protective Equipment (PPE)

PPE that is generated throughout investigation activities shall be placed in plastic garbage bags. If the solid or liquid waste that was being handled is characterized as hazardous waste, then the corresponding PPE should also be disposed as hazardous waste. If not, all PPE should be disposed as non-hazardous waste in the designated State landfill. The PPE from this site is expected to be non-hazardous.

Trash that is generated as part of field activities may be disposed of in the landfill as long as the trash was not exposed to hazardous media. The media at this site are expected to be non-hazardous.

6.3 Waste Accumulation On-Site

Solid, liquid, or PPE waste generated during investigation activities that are classified as non-hazardous or "characterization pending analysis" should be disposed of as soon as possible. Until disposal, such containers should be inventoried, stored securely, and inspected regularly, as a general good practice.

Solid, liquid, or PPE waste generated during investigation activities that are classified as hazardous shall not be accumulated on-site longer than 90 days. All hazardous waste containers shall be stored in a secured storage area. The following requirements for the hazardous waste storage area must be implemented:

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

Weekly storage area inspections shall be performed and documented to ensure compliance with these requirements. Throughout the project, an inventory shall be maintained to itemize the type and quantity of the waste generated.

6.4 Waste Disposal

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

All waste generated during field activities will be stored, transported, and disposed of according to applicable state, federal, and local regulations. If hazardous wastes are generated, all wastes classified as hazardous will be disposed of at a licensed TSDF. Waste disposal will be coordinated with the facility receiving the waste.

Facilities receiving waste have specific requirements that vary even for non-hazardous waste. Characterization will be conducted to support both applicable regulations and facility requirements.

CH2M will contract with a local landfill and will dispose of non-hazardous soils, PPE, and trash in the local landfill. CH2M will also contact the local POTW to determine liquids discharge requirements for the POTW.

If hazardous wastes are generated, the scope of work will for this project will need to be modified, although disposal will still need to occur within 90 days of waste generation.

6.5 Regulatory Requirements

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

- Code of Federal Regulations (CFR), Title 40, Part 261;
- UAC R315;
- CFR, Title 49, Parts 172, 173, 178, and 179.

6.6 Waste Transport

A state-certified U.S. Department of Transportation (DOT) approved hazardous waste hauler shall transport all wastes classified as hazardous. Typically, the facility receiving any waste can coordinate a hauler to transport the waste. Shipped hazardous waste shall be disposed of in accordance with all RCRA/USEPA requirements.

All waste manifests or bills of lading will be prepared in accordance with DOT regulations and signed by the VA CERCLA 700 South 1600 East PCE Plume RPM or designee. The VASLCHCS will utilize the CERCLA 700 South 1600 East PCE Plume EPA ID number (UTD981548985) for shipment of all CERCLA wastes and *not* the VA Medical Center EPA ID number. Utilization of the CERCLA EPA ID number for transportation and disposal tracking of the wastes was approved by the State of Utah Department of Environmental Quality on July 22, 2016 for both hazardous and non-hazardous Investigation Derived Wastes so as not to impact the VASLC Medical Center Small Quantity Generator status.

Wastes generated by this investigation are expected to be characterized as non-hazardous waste. However, all non-hazardous wastes will be transported under a non-hazardous waste manifest or bill-of-lading to document disposal of IDW.

7.0 Spill Containment and Source Elimination

1. If there is no hazard to the safety of personnel, the first spill responder(s) should attempt to contain the spill only if there is no threat to their safety, to prevent its entry into a storm drain, a ditch, or leaving VASLCHCS property. The person first observing the spill alarm or evidence of the spill will implement emergency spill

response procedures in accordance with the VASLAHCS Spill Prevention Control and Countermeasure plan (SPCC), and notify as soon as practical:

- The Facility GEMS Coordinator Carlos Aguilar at 801-584-1226 (office) 385-228-8581 (cell),
- The Boiler Plant Operator at 801-582-1565 x 1043, and
- The CERCLA Program Manager D. Lynne Welsh at (801) 584-1565 x 2021or designee.

Materials used for spill response include shovels, absorbent materials and pads, drain covers, and dikes. Non-sparking tools, such as plastic shovels, if needed, will be used to clean up any spill that may be flammable. If spill clean-up is beyond the capability of appropriate VASLCHCS staff, the GEMS Coordinator will arrange for a spill response contractor.

CH2M will also follow the incident procedures in the CH2M HASP regarding spill response and notification.

2. If there is no hazard to the safety of personnel, the spill responder(s) will initiate corrective action to stop the source of the spill.

7.1 Spill Cleanup and Mitigation

After the appropriate notifications have been made and spill response guidance received from the GEMS Coordinator, the staff responsible for cleanup or the spill response contractor will collect the spilled material in the appropriate manner and place the material into containers appropriate for the spilled material. The GEMS Coordinator will determine what type of containers is appropriate for spilled materials.

1. The GEMS Coordinator will select the appropriate cleanup and decontamination method and provide this information to the appropriate VASLCHCS staff.

2. Spill material and debris will be managed in a manner that is compliant with applicable local, state, and federal laws regarding recycling or disposal of regulated waste materials.

The nearest Spill response and containment materials are available at Building 38 Warehouse.

8.0 REFERENCES

U.S. EPA Guide to Management of Investigative-Derived Waste, Publication: 9345.3-03FS, April 1992.

Code of Federal Regulations, Title 40, Section 262.32, Standards Applicable to Generators of Hazardous Wastes, Subpart C – Pre-transport Requirements, Marking, (periodically updated – use most current version).

EA. 2016. Conceptual Model Update for the 700 South 1600 East Street PCE Plume. 21 November 2016. George Tangalos, CH2M.

9.0 ATTACHMENTS

- IDW Container Management Log

IDW Container Management Log

From: Month/Year: **to: Month/Year:**

Location: **Bldg. 38** **POC:** **Susanne Kayser ex: 1952**

Date in Storage	Inspector (Printed name AND Initials)	Container										
		Good Condition			Closed			Labeled "IDW Awaiting Analysis"			Accumulation Logged	
		Yes	No		Yes	No		Yes	No		Yes	No

Appendix D
Accident Prevention Plan

FINAL

Accident Prevention Plan, Revision 0
OU-2 Remedial Investigation
700 South 1600 East PCE Plume
Salt Lake City, Utah

Contract No. W912DQ-15-D-3014 Task Order 0005

Prepared for

U.S. Army Corps of Engineers
Kansas City District
601 East 12th Street
CENWK-PM-ES
Kansas City, MO 64106-2824

Department of Veterans Affairs
Veterans Health Administration Salt Lake City Health Care System
500 Foothill Drive
Salt Lake City, UT 84148

February 2018

CH2M HILL, Inc.
4246 South Riverboat Road
Suite 210
Taylorsville, Utah 84123

Contents

Section | Page

Section Page

Section Page

Section Page

Appendix

Tables

Figures

Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
AHA	activity hazard analysis
AOU	Accelerated Operable Unit
APP	Accident Prevention Plan
BBP	bloodborne pathogen
bpm	beats per minute
CFR	*Code of Federal Regulations*
CH2M	CH2M HILL, Inc.
CO/COR	Contracting Officer/Representative
CPR	cardiopulmonary resuscitation
DART	Days Away, Restrictions, and Transfers
dBA	decibel
DFOW	definable feature of work
EM	Environmental Manager
EMR	Experience Modification Rate
EPA	U.S. Environmental Protection Agency
ERC	Emergency Response Coordinator
GDA	Government Designated Authority
HAZCOM	Hazardous Communication Standard
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSE	Health, Safety, and Environment
IARC	International Agency for Research on Cancer
IDW	investigation-derived waste
IIPP	Injury and Illness Prevention Program
LHE	Load Handling Equipment
LWD	lost workday
m^3	cubic meters
NFPA	National Fire Prevention Association
OSHA	Occupational Safety and Health Administration
PIM	potentially infectious material
PM	Project Manager
PPE	personal protective equipment
SC	safety coordinator
SDS	Safety Data Sheet
SHM	Safety and Health Manager
SOP	Standard Operating Procedure
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan

TBD	to be determined
TOM	Task Order Manager
USACE	U.S. Army Corps of Engineers
VHA	Veterans Health Administration

Signature Page

Accident Prevention Plan Remedial Investigation – 700 South 1600 East PCE Plume Superfund Site, Salt Lake City, Utah – June 2017.

		June 12, 2017
Plan Preparer	Josh Painter, CSP CH2M HSSE Manager Phone: (303) 993-9274	Date
		June 12, 2017
Plan Approval	David Waite CH2M Project Manager/Task Order Manager Phone: (385) 474-8560	Date
		June 9, 2017
Plan Approval HSSE Manager	Andy Strickland, CIH CH2M HSSE Director Phone: (720) 286-2393	Date

Background Information

This Accident Prevention Plan (APP) has been developed to protect and guide the personnel conducting the scope of work for this project.

This APP has been prepared to meet applicable requirements of the:

- U.S. Army Corps of Engineers (USACE) Safety and Health Requirements Manual Engineering Manual (EM) 385-1-1, 2014
- 29 *Code of Federal Regulations* (CFR) 1910.1200 Hazard Communication Standard, Hazardous Waste Operations or emergency response as required by 29 CFR 1910.120 and 29 CFR 1926.65
- Federal Acquisition Regulation (FAR) Clause 52.236-13 and Unified Facilities Guide Specifications, Section 01 35 26, Governmental Safety Requirements, 2015
- Corporate safety and health policies of CH2M HILL, Inc. (CH2M), including CH2M Standard Operating Procedures (SOPs) and Health, Safety, and Environment (HSE) Handbook.

This APP has been prepared to directly track with Data Item Description Worldwide Environmental Remediation Services -005.01 and EM 385-1-1 2014 Appendix A "*Minimum Basic Outline for Accident Prevention Plan*."

Various portions of this work will also be conducted under non-hazardous waste site protocols. The site safety and health plan (SSHP) for this project is included as Appendix A.

2.1 Contractor

CH2M HILL Constructors, Inc.

2.2 Contract Number

W912DQ-15-D-3014

2.3 Project Name

Remedial Investigation – 1600 East PCE Plume Superfund Site

2.4 Project Description and Location

This APP presents the hazards known or anticipated to be present for work to be completed at 1600 East PCE Plume Superfund Site. The George E. Wahlen VAMC is located in a residential area near the University of Utah in Salt Lake City, Utah. This facility operated a part-time dry cleaning service utilizing tetrachloroethylene (aka "perchloroethylene," "perc," and "PCE") from approximately 1976 through 1984 (EPA, 2012). As a result of these activities, PCE was discharged to the environment and a PCE plume has been detected in the neighborhood of 700 South and 1600 East Streets in Salt Lake City, Utah – a blended commercial and residential area of approximately 300 acres. PCE has been detected at part per billion (ppb) levels in one Salt Lake City's secondary drinking water wells (closed in 2004). PCE has also been detected at part per billion (ppb) levels in shallow and deep groundwater, surface water springs, and in the soil gas.

PCE contamination was first found in the groundwater in 1990 at the nearby Mount Olivet Cemetery during routine monitoring by the Salt Lake City Department of Public Utilities. This led to the U.S. Environmental Protection Agency's (EPA's) involvement at the Site. National Priorities List listing efforts for this Site were suspended in 2008 because the City wanted to pursue other options to address the contamination. In June 2010, the City reported elevated levels of PCE in residential springs down gradient of the Site. The source of the contamination was identified as the historic dry-cleaning facility once owned and operated by the VAMC.

The purpose of this Task Order is to complete a Phase 1 of a Remedial Investigation (RI) for Operable Unit 2 (OU-2). The field work consists of the following Definable Features of Work (DFOW):

1. Installation of shallow (~50 feet bgs) groundwater monitoring wells using roto-sonic drilling.
2. Installation of deep (~500 feet bgs) monitoring wells within the vicinity of Veterans Health Administration (VHA) Medical Center.
3. CH2M will conduct slug tests on two (2) new and two (2) existing 2-inch groundwater monitoring wells and 8-hour pump tests on two (2) newly installed 5-inch wells.
4. CH2M will conduct geophysical, geotechnical testing on soil cores collected during well installation and flow logging of installed wells.
5. CH2M will perform Vapor Intrusion (VI) assessments in the general area of Accelerated Operable Unit 1 (AOU-1) and at three (3) single family residences. This includes conducting VI screening and sampling for TO-15, if required. CH2M will also collect outdoor soil gas samples for laboratory analyses for volatile organic compounds and semivolatile organic compounds.

2.5 Project Site Map

A project location map is provided on Figure 1.

2.6 Contractor Accident Experience

CH2M's exceptional safety performance greatly exceeds the industry average. CH2M's injury and illness rates and Experience Modification Rate (EMR) have averaged 0.64 over the past 5 years (Table 2-1).

Table 2-1. CH2M Injury and Illness Rates and Experience Modification Rate, 2012-2016

Category	2012	2013	2014	2015	2016
Employee Hours	9,759,106	9,636,525	10,081,283	9,314.049	9,692,907
Experience Modification Rate	0.68	0.63	0.64	0.60	0.60
Fatalities	0	0	0	0	0
Recordable Incidents	12	13	9	5	16
Recordable Incident Rate	0.25	0.27	0.18	0.11	0.33
LWD Incidents (DART)	0	2	1	1	5
LWD Incident Rate (DART)	0.0	0.04	0.02	0.02	0.10

Notes:
DART = Days Away, Restrictions, and Transfers
LWD = lost workday

2.7 Project Tasks and Project Phases

Tasks included under this APP includes the following:

- Mobilization and Site Setup
  - Utility locates
  - Traffic Control
- Groundwater Well Drilling and Installation
  - Monitoring well sonic drilling
  - Install monitoring well with dedicated pumps and transducers
  - Geophysical, geotechnical testing on soil cores
- Groundwater Monitoring Well Slug Testing
- Investigation-Derived Waste (IDW) Management
- Decontamination/Demobilization

Anticipated project equipment to be used include:

- Skid Steer loader
- Forklift
- Sonic Drill rig
- Utility locate equipment
- Hand tools
- Motor vehicles, etc.

Anticipated project high risk activities include:

- None

This project-specific APP will be used by CH2M and its subcontractors to identify and mitigate task-specific hazards and to select appropriate health and safety protective measures. Project specific hazards are provided in the SSHP (Appendix A).

Onsite personnel must review the APP and sign an agreement to comply with its provisions before commencing onsite work. The APP and attached SSHP are considered operational documents that are subject to revisions in response to various site-specific conditions that may be encountered. However, the documents may be modified or updated only with the approval of the Safety and Health Manager (SHM) and Project Manager (PM). Furthermore, updates to the APP, SSHP, and/or activity hazard analyses (AHAs) may require client approval; the PM will make the client aware of updates to determine if another client review is necessary.

2.8 Work Requiring Activity Hazard Analysis

The planned field tasks requiring AHAs are as follows:

- Mobilization and Site Setup
  - Utility locates
  - Traffic Control
- Groundwater Well Drilling and Installation
  - Monitoring well sonic drilling
  - Install monitoring well with dedicated pumps and transducers
  - Geophysical, geotechnical testing on soil cores

- Groundwater Monitoring Well Slug Testing
- IDW Management
- Decontamination/Demobilization

AHAs for each of the field tasks, including the associated oversight tasks, are included in the SSHP (Appendix A).

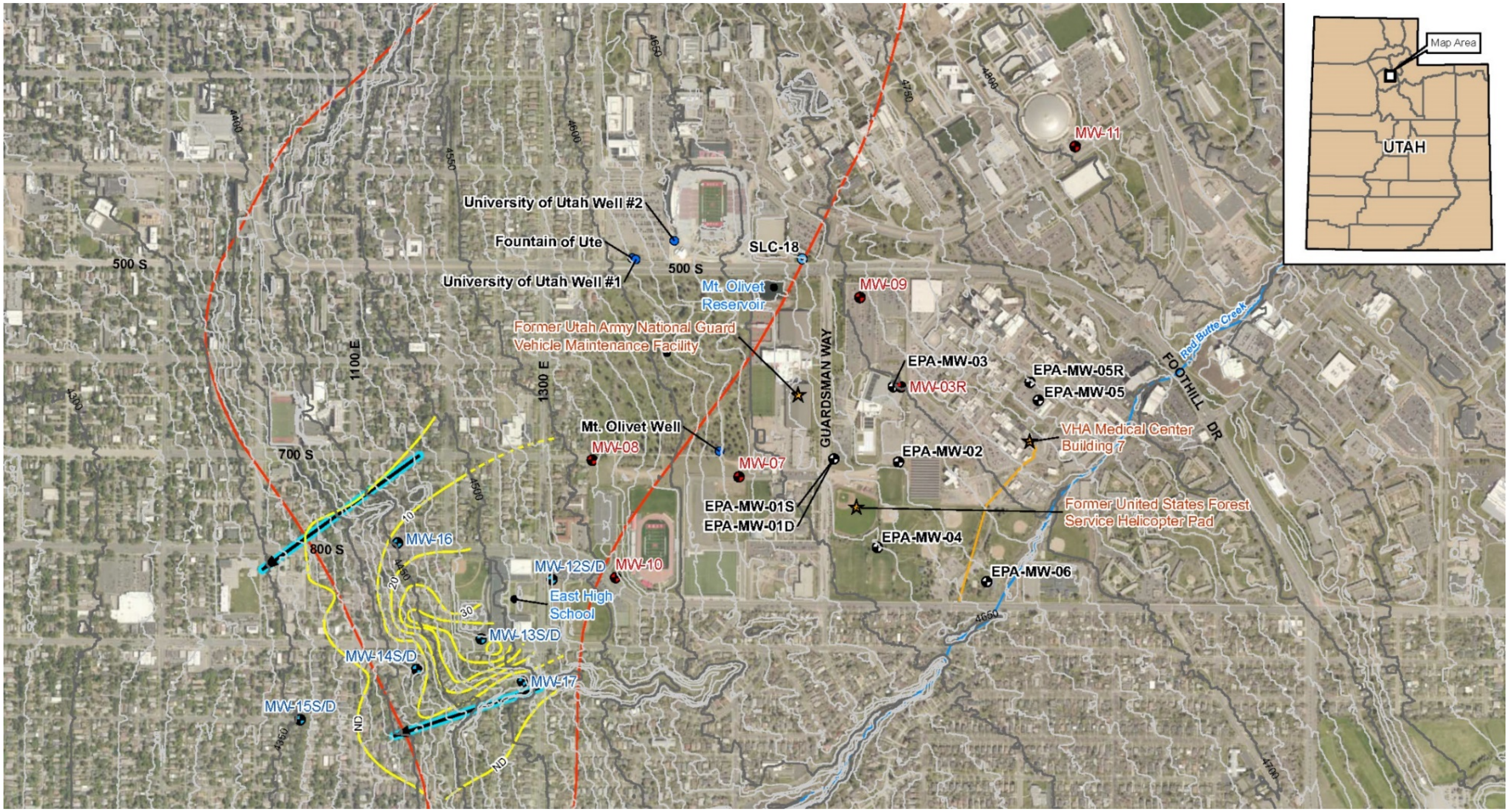


Figure 1. Location Map

Statement of Safety and Health Policy

Health, Safety and Environment Policy Commitment:

Protection of people and the environment is a CH2M core value. It is our vision to create a culture that empowers employees to drive this value into all global operations and achieve excellence in HSE performance. CH2M deploys an integrated, enterprise-wide behavior based HSE management system to fulfill our mission and the expectations of our clients, staff, and communities based on the following principles:

- We require all management and supervisory personnel to provide the leadership and resources to inspire and empower our employees to take responsibility for their actions and for their fellow employees to prevent injuries, illnesses, and adverse environmental impacts, and create a safe, healthy, and environmentally-responsible workplace.
- We provide value to clients by tailoring HSE processes to customer needs and requiring CH2M employees and subcontractors to deliver projects that identify HSE requirements and commit to compliance with applicable HSE laws and regulations, company standards, and external requirements.
- We are committed to pollution prevention in conjunction with our Sustainability Policy and by offering our clients sustainable solutions.
- We aspire to continually improve our performance and influence others to redefine world-class HSE excellence.
- We evaluate our design engineering and physical work environment to verify safe work conditions and practices are established, followed, and corrected as needed.
- We assess and continually improve our HSE program to achieve and maintain world-class performance by setting and reviewing objectives and targets, reporting performance metrics, and routinely evaluating our program.
- We are committed to improving Worker Welfare standards throughout our own operations and through offering our clients real, implementable solutions to address Worker Welfare concerns.
- We expect all employees to embrace our Target Zero culture, share our core value for the protection of people and the environment, understand their obligations, actively participate, take responsibility, and “walk the talk” on and off the job.

The undersigned pledge our leadership, commitment, and accountability for making this Policy a reality at CH2M.

Dated the 1st day of January, 2016

Jacqueline Hinman
Chief Executive Officer

Gary McArthur
Chief Financial Officer

Shelie Gustafson
Chief Human Resource Officer

Lisa Glatch
Executive Vice President, Client Solutions & Sales

Greg McIntyre
Global Business Groups

Tom McCoy
General Counsel and Corporate Secretary

Mark Fallon
President, Global Regions

Frank Gross
Executive Vice President, Services and Risk

William Brierly
Chief Ethics and Compliance Officer

3.1 Objective

The objective of the CH2M program is to provide a place of employment free of all recognized hazards that are causing or will likely result in death or serious physical harm to employees. The objective can be facilitated by developing and administering an overall health and safety program, which establishes written policies and procedures that will implement program requirements.

3.2 Purpose

The purpose of this project-specific APP, in conjunction with the project-specific or program health and safety documents, is to define the policies, procedures, and requirements that must be implemented for the CH2M program and to establish the requirements, responsibilities, and expectations for management, supervisors, employees, and subcontractors that may participate in the execution of the program projects. It is the intent of this APP to address applicable requirements set forth by 29 *Code of Federal Regulations* (CFR) 1910, 29 CFR 1926, EM 385 1-1, and CH2M policies and procedures incorporated by reference herein.

3.3 Goals

The health and safety goal for this project and the overall goal for the CH2M program are to eliminate workplace accidents, gain worker acceptance through cooperation and training, and provide clients with a responsible, well-trained, safety-oriented work force.

CH2M considers safety the highest priority during work at all project sites and in its business offices, and has established a goal of zero incidents. CH2M's program will be conducted in a manner that minimizes the probability of near misses, injury, illness, and equipment or property damage.

All management and employees are to strive to meet the project-specific health, safety, and environment goals outlined herein. The team will be successful only if each member of the team makes a concerted effort to accomplish these goals. The goals allow the project to stay focused on optimizing the health and safety of all project personnel; therefore, making the project a success.

The project has established 11 specific goals and objectives, as follows:

1. Create an injury-free environment.
2. Have zero injuries or incidents.
3. Provide management leadership for health, safety, and environment by communicating performance expectations, reviewing and tracking performance, and leading by example.
4. Ensure effective implementation of the SSHP and APP through education, delegation, and teamwork.
5. Ensure 100-percent participation in training programs, personal protective equipment (PPE) use, and health, safety, and environment compliance.
6. Continuously improve safety performance.
7. Maintain free and open lines of communication.
8. Make a personal commitment to safety as a value.
9. Focus safety improvements on high-risk groups.
10. Continue strong employee involvement initiatives.
11. Achieve health and safety excellence.

3.4 Safe Work Policy

It is CH2M's policy to perform work in the safest manner possible and confirm safety is never compromised. To fulfill the requirements of this policy, an organized and effective safety program must be carried out at each location where work is performed.

CH2M believes that all injuries are preventable, and is dedicated to the goal of a safe work environment. To achieve this goal, every employee, sub-contractor, and personnel on the project must assume responsibility for safety.

Every employee, sub-contractor, and personnel is empowered to:

- Conduct their work in a safe manner
- Stop work immediately to correct any unsafe condition that is encountered
- Take corrective actions so that work may proceed in a safe manner

Safety, occupational health, and environmental protection will not be sacrificed for production.

3.5 Subcontractor Default

If the subcontractor fails to comply with any of the requirements of the subcontract, SSHP and APP, or local safety laws and regulations, the prime contractor may issue a stop work order to the subcontractor. Thereupon, the subcontractor will immediately cease all work or portion of work that may be specifically designated in the stop work order until the prime contractor has concluded in writing that the subcontractor has corrected its failure of performance. No adjustments will be made to the subcontractor price or schedule as a result of any stop work orders being issued by the prime contractor. A stop work order will be given to the noncompliant subcontractor on the date of deficiency. If the subcontractor fails to correct the deficiencies noted in the stop work order within 3 working days following the written notice from the prime contractor, the prime contractor may, without prejudice to any other rights or remedies under the subcontract or at law or equity, suspend all further payments to subcontractor and/or terminate subcontractor's right to continue performance of the work.

3.6 Incentive Program

CH2M encourages all parties to implement a safety incentive program for the project that rewards workers for exhibiting exemplary safety behaviors; actions that qualify are those that go above and beyond what is expected. Actions that will be rewarded include spotting and correcting a hazard, bringing a hazard to the attention of your foreman, telling your foreman about an incident, coming up with a safer way to get the work done, and stopping a crew member from doing something unsafe. The program will operate throughout the project, covering all craft workers. The incentive program will be communicated to all employees during the project employee orientation and project safety meetings.

3.7 Posting of Health and Safety Information

There will be a posting area, accessible by all workers onsite, and in clear view for the posting of site-specific health and safety information. The posted information will be protected from the environment and kept updated as project information changes.

Responsibilities and Lines of Authorities

4.1 Statement of Employer's Responsibility

CH2M is committed to the prevention of personal injuries, occupational illnesses to all employees and subcontractors, and damage to equipment and property in all of its operations. This includes the protection of the general public whenever it comes in contact with the Company's work; and to the prevention of pollution and environmental degradation.

Company management, field supervisors, and employees plan safety into each work task in order to prevent occupational injuries and illnesses. CH2M management extends its full commitment to health and safety excellence.

4.2 Personnel with Safety Responsibilities

Participating personnel are responsible for complying with safety procedures and for proactively making safety awareness part of their day-to-day conduct.

The following positions have specific corporate and project safety responsibilities:

- Safety and Health Manager (SHM)
- PM/Task Order Manager (TOM)
- Site Safety and Health Officer (SSHO)
- Other project field staff

All staff members are accountable for their own health and safety, and have the authority to request a work stoppage when they feel unsafe behaviors, actions, or situations are occurring.

See Section 4 of Appendix A for duties of each position and additional roles and responsibility details.

4.3 Personnel Competencies

All work requiring a competent person per the Occupational Safety and Health Administration (OSHA) definition (29 CFR 1926.32(f)), will not be started until that competent person is designated and onsite. *Competent person* means one who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

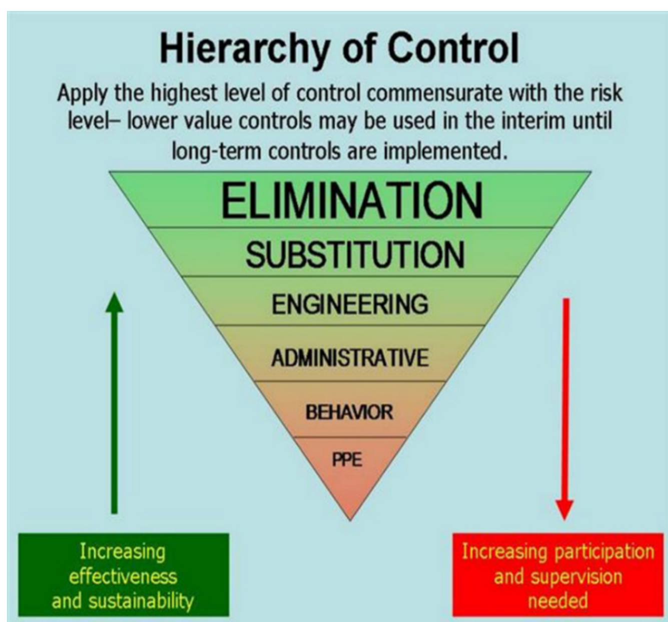
For all general tasks, the SSHO is the competent person, unless otherwise noted for specific tasks. Personnel competencies are shown in Table 4-1.

Table 4-1. Personnel Competencies

Name	Role	Qualifications
David Waite	PM/TOM	40-hour HAZWOPER, 8-hour HAZWOPER Annual Refresher, 8-hour Supervisor HAZWOPER, First Aid/CPR, HAZCOM, hazard specific training topics.
Josh Painter, CSP	SHM	Certified Safety Professional; Bachelor of Science in Environmental Remediation and Waste Management; OSHA 500, 501, 510 and 511; 40-hour HAZWOPER; 8-hour HAZWOPER Annual Refresher; 8-hour Supervisor HAZWOPER; First Aid/CPR; hazard specific training topics.
Jasin Olsen	SSHO	40-hour HAZWOPER, 8-hour HAZWOPER Annual Refresher, 8-hour Supervisor HAZWOPER, 30-hour OSHA Construction Safety training, SC-Haz Waste, First Aid/CPR, HAZCOM, hazard specific training topics. 5 years of continuous safety experience in managing environmental/general construction work. Resume available upon request.
Ryan Hamilton	Alternate SSHO	40-hour HAZWOPER, 8-hour HAZWOPER Annual Refresher, 8-hour Supervisor HAZWOPER, 30-hour OSHA Construction Safety training, SC-Haz Waste, First Aid/CPR, HAZCOM, hazard specific training topics.
Various	Other Project Staff	40-hour HAZWOPER, 8-hour HAZWOPER, 8-hour Supervisor HAZWOPER, First Aid/CPR, HAZCOM, hazard specific training topics.

Notes:
CPR = Cardiopulmonary Resuscitation
HAZCOM = Hazardous Communication Standard
HAZWOPER = Hazardous Waste Operations and Emergency Response
OSHA = Occupational Safety and Health Administration

4.4 Risk Management Process



A health and safety risk analysis is performed for each task of a given project. Risks and mitigations for each task are detailed in the site-specific AHAs. Initial activity-specific AHAs are to be submitted and accepted at preparatory meetings, prior to work being performed. In the order listed in the following bullet list, the SHM considers the various methods for mitigating the hazards. Employees are trained on this hierarchy of controls during their hazardous waste training and reminded of them throughout the execution of projects:

- Elimination of the hazards (that is, use remote sampling methodology to avoid going into a confined space)
- Substitution (that is, reduce exposure to vapors by using of a geoprobe instead of test pitting)
- Engineering controls (that is, ventilate a confined space to improve air quality)
- Warnings (that is, establish exclusion zones to keep untrained people away from hazardous waste work)

- Administrative controls (that is, implement a work and rest schedule to reduce chance of heat stress)
- Use of PPE (that is, use of respirators when action levels are exceeded)

When health and safety hazards cannot be Eliminated or Substituted, Engineering Controls, Warnings, and Administrative Controls shall be considered first. When these methods cannot eliminate the hazard, PPE shall be used. PPE is always the last control measure implemented.

4.5 Activity Hazard Analysis Review and Acceptance

All work is conducted under a behavior-based and loss prevention system program. AHAs are a vital part of this work, as well as using Pre-task Safety Planning.

An AHA must be developed for each CH2M field activity and approved by the SHM. AHAs are to be submitted and accepted at preparatory meetings, prior to work being performed. The AHA will define the work tasks required to perform each activity, along with potential HSE hazards and recommended control measures for each hazard. In addition, a listing of the equipment to be used to perform the activity, inspection requirements to be performed, and training requirements for the safe operation of the equipment listed must be identified. Workers are briefed on the AHA before performing the work and their input is solicited before, during, and after the performance of work to further identify the hazards posed and control measures required.

CH2M subcontractors are required to provide AHAs specific to their scope of work on the project for acceptance by CH2M. Each subcontractor will submit AHAs for their field activities, as defined in their scope of work, along with their project safety plan and procedures. AHAs are intended to be living documents, thus additions or changes in field activities, equipment, tools, or material used to perform work or hazards not addressed in existing AHAs requires either a new AHA to be prepared or an existing AHA to be revised. These changes will be initiated by the SSHO and approved by the SHM.

4.6 Work Authorization

Any phase of work will not begin until a designated SSHO/ Competent Person is present at the job site. Before work beginning, all applicable safety documents and AHAs will be reviewed and signed with each worker acknowledging the tasks to be performed.

4.7 Safety Compliance

CH2M should continue to observe personal safety performance and adherence to the health and safety plans and AHAs. This observation should be reasonable, and include looking for hazards or unsafe practices that are both readily observable and occur in common work areas.

4.7.1 Observed Hazard Form

When apparent noncompliance or unsafe conditions or practices are observed, notify the SHM or safety representative verbally, and document the observation using the Observed Hazard Form, included as an attachment to the SSHP, and require corrective action.

If necessary, stop work using the Stop Work Order Form (attached to the SSHP) until corrective actions are implemented for observed serious hazards or conditions. Update the Observed Hazard Form to document the corrective actions taken. The subcontractor is responsible for determining and implementing necessary controls and corrective actions.

4.7.2 Stop Work Order

CH2M has the authority, as specified in the contract, and the responsibility to stop work if any CH2M employee observes unsafe conditions or failure to adhere to safe work practices, or observes a condition or practice that may result in a release or violation of an environmental requirement. Failure to comply with safe work practices can be the basis for restriction or removal of the staff from the job site, termination, restriction from future work, or all three.

When an apparent imminent danger is observed, immediately stop work and alert all affected individuals. Remove all affected CH2M employees and subcontractor staff from the danger, notify the supervisor or safety representative, and do not allow work to resume until adequate corrective measures are implemented. Notify the PM, contract administrator, and SHM.

When repeated noncompliance or unsafe conditions are observed, notify the supervisor or safety representative and stop affected work by completing and delivering the Stop Work Order Form (attached to the SSHP) until adequate corrective measures are implemented.

4.7.3 Reporting Unsafe Conditions and Practices

Responsibility for effective health and safety management extends to all levels of the project and requires good communication between employees, supervisors, and management. Accident prevention requires a proactive policy on near misses, close calls, unsafe conditions, and unsafe practices. All personnel must report any situation, practice, or condition that might jeopardize the safety of the projects. All unsafe conditions or unsafe practices will be corrected immediately. CH2M has zero tolerance of unsafe conditions or unsafe practices.

No employee or supervisor will be disciplined for reporting unsafe conditions or practices. Individuals involved in reporting the unsafe conditions or practices will remain anonymous.

The following reporting procedures will be followed by all project employees:

- Upon detection of any unsafe condition or practice, the responsible employee will attempt to safely correct the condition.
- The unsafe condition or practice will be brought to the attention of the worker's direct supervisor, unless the unsafe condition or practice involves the employee's direct supervisor. If so, the SSHO needs to be notified at once by the responsible employee.
- Either the responsible employee or responsible employee's direct supervisor is responsible for immediately reporting the unsafe condition or practice to the SSHO.
- The SSHO will act promptly to correct the unsafe condition or practice.
- Details of the incident or situation will be recorded by the SSHO in the field logbook. If the subcontractor was involved, the Observed Hazard Form will be used.

4.7.4 Standards of Conduct Violations

All individuals associated with this project (including subcontractors / suppliers) must work injury-free and drug-free and must comply with the Standards of Conduct, the SSHP and APP, and the site safety requirements. Commonly accepted standards of conduct help maintain good relationships between people. They promote responsibility and self-development. Misunderstandings, frictions, and disciplinary action can be avoided by refraining from thoughtless or wrongful acts. Violations of the standards of conduct include, but not limited to the following:

- Failure to perform work

- Inefficient performance, incompetence, or neglect of work
- Willful refusal to perform work as directed (insubordination)
- Negligence in observing safety regulations, poor housekeeping, or failure to report on-the-job injuries or unsafe conditions
- Unexcused or excessive absence or tardiness
- Unwillingness or inability to work in harmony with others
- Discourtesy, irritation, friction, or other conduct that creates disharmony
- Harassment or discrimination against another individual
- Failure to be prepared for work by wearing the appropriate construction clothing or PPE, or bringing the necessary tools
- Violation of any other commonly accepted and reasonable rule of responsible personal conduct
- Violation of the safety and health requirements of their corporation's policy or of this APP
- Unauthorized or illegal possession, use, or sale of alcohol or controlled substances on work premises, during working hours, while engaged in corporate activities, or in corporate vehicles
- Use or sale of firearms or explosives on work premises

4.7.5 Intolerable Offenses

Certain employee conduct may be so intolerable as to justify removal from the project. Intolerable offenses and actions include, but not limited to, the following:

- Any manager, supervisor, foreman, or other person in charge of the work being performed who requires, requests, asks, threatens an employee's job, allows, or condones employees to work in or around unsafe acts or conditions.
- Any employee, supervisor, or manager who knowingly falsifies any investigative documents or testimony involving an investigation.
- Any employee, supervisor, or manager who openly exhibits disregard, defiance, or disrespect for the safety program.
- Any employee who violates established safety rules, regulations, or codes that endanger themselves or other employees.
- Any and all parties involved in workplace violence, including physical encounters (fighting) or threats of violence, theft, or destruction of property.
- Any employee, supervisor, or manager failing to comply with procedures contained in the subcontract, SSHP and APP, USACE EM 385-1-1 Manual, or local safety laws and regulations that create the potential for serious or costly consequences.
- Any employee who commits repeated minor offenses and shows a lack of responsible effort to correct these offenses.

4.7.6 Enforcement and Discipline

CH2M's Enforcement and Discipline procedures, the Standards of Conduct, the Intolerable Offenses, and the Drug-Free Workplace policy will be thoroughly reviewed with each employee during the employee project orientation.

4.7.7 Intolerable Offenses

CH2M practices zero tolerance for intolerable offenses. Individuals found participating in such offenses will be dealt with according to CH2M's policy and may be subjected to the following:

- Suspended from work for 3 days without pay
- Immediately discharged and not allowed to return

4.7.8 Other Violations

Other violations will be handled accordingly:

- First offense—employee will receive a written warning
- Second offense—employee will receive a 2-day suspension without pay
- Third offense—employee will be discharged

4.8 Lines of Authority

The following are the personnel roles and lines of authority:

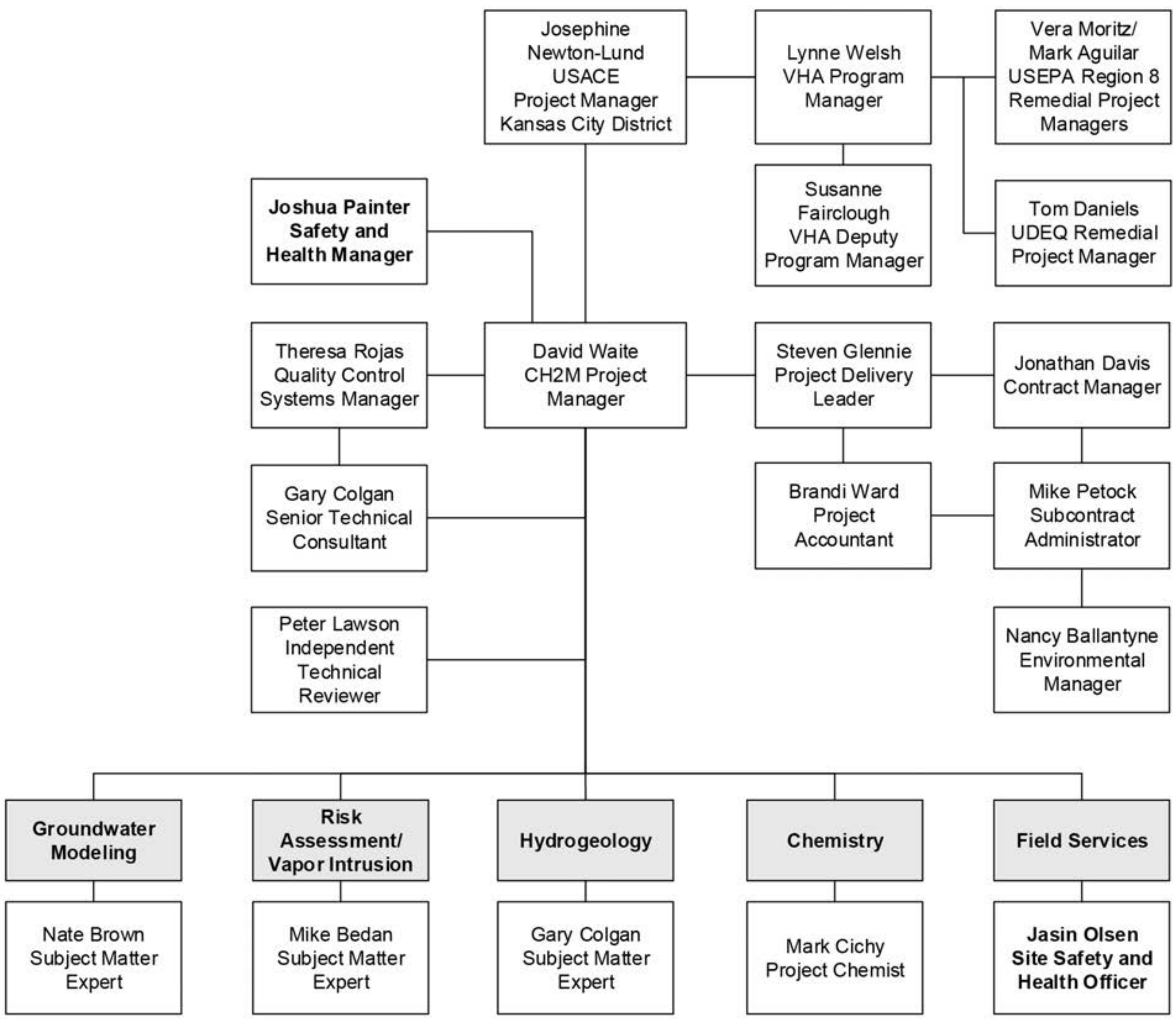


Figure 2. Project Lines of Authority

4.9 Managers and Supervisors Safety Accountability

4.9.1 Prohibited Behaviors and Actions

Managers and supervisors who openly or recklessly exhibit a disregard, defiance, or disrespect for CH2M's HSE programs, rules, procedures, processes, and training, or who violate established HSE programs, rules, procedures, processes or training endangering themselves or other employees, will be subject to disciplinary actions. Without limitation, behaviors and actions that warrant disciplinary action include the following:

- Requiring, requesting, demanding, asking, or threatening another person in any manner to entice the person to engage in or work around a patently-unsafe or environmentally-compromising act or condition.
- Condoning or knowingly allowing a person to engage in or work around a patently-unsafe or environmentally-compromising act or condition.
- Recklessly, knowingly, or purposely failing to wear required PPE.
- Failing to successfully complete any required HSE training that is scheduled and made available for completion.
- Failing to promptly notify a supervisor, project safety manager, coordinator, lead, or the PM when an unsafe condition or behavior is observed, and/or when an environmentally-compromising condition is encountered.
- Failing to promptly report to a supervisor, project safety manager, coordinator, lead, or the PM, a work-related HSE incident or near miss.
- If required of the position, failing to maintain as active and in good standing necessary health, safety, and/or environmental licenses or permits needed to support CH2M work and projects.
- Knowingly falsifying any HSE record or investigative document (whether internal to CH2M or external), or providing false testimony, during an HSE or outside agency incident investigation.
- Refusing to cooperate in an HSE incident investigation.
- Knowingly falsifying any inspection or sampling records (whether internal to CH2M or external).
- Performing field work without the required site HSE plan approved by a HSE manager.
- Engaging in any form of workplace violence described in Policy 201 Workplace Violence Awareness and Prevention, including physical encounters, destruction of property, and verbal threats of violence, harm, or mayhem.
- Failing to comply with any HSE procedures contained in any contract, subcontract, site health safety and environment plan, or any federal, state, or local health, safety, or environmental laws and regulations creating actual or potential significant risk for CH2M (whether monetary or otherwise).

In addition, no individual may have in their possession, bring to the project site, or maintain on CH2M property, concealed or otherwise, any weapon, explosive device or substance, firearm, ammunition or instrument that could be used as a weapon. All weapons, explosive devices or substances, firearms, and ammunition are banned from all project sites, properties, vehicles and/or any CH2M activities or events.

4.9.2 Disciplinary Actions

When CH2M Manager / Supervisors neglect to fulfill their responsibilities and/or project-specific HSE requirements, CH2M may discipline its employees. All CH2M Managers/Supervisors are equally subject to disciplinary action for failing to meet the expectations associated with this Policy and/or HSE programs, rules, procedures, processes, and training. CH2M reserves the right in its sole discretion to determine the appropriateness of any discipline imposed, but such disciplinary action may include, without limitation, denial of access to the worksite, verbal and/or written warnings/reprimands, and termination of employment.

Subcontractors and Suppliers

Subcontractors and suppliers providing services onsite will be subject to the safety provisions of this APP and those included in the SSHP (Appendix A). CH2M and any identified subcontractors (see Table 5-1) will conduct site work in accordance with this APP and associated documents. CH2M will address compliance with specific safety and health requirements, including those listed in Section 9, and through safety meetings at the start of each shift. The specific safety and health requirements and site conditions will be reviewed with field personnel during the meetings. All parties will also comply with the requirements of their respective Injury and Illness Prevention Programs (IIPPs) and AHAs.

Table 5-1. Subcontractors and Suppliers

Task	Subcontractor Contact Information
Sonic Drilling	TBD[a]
Waste Management	TBD[a]
Survey	TBD[a]

[a]The subcontractors for the following DFOWs/activities are not known at this time, but additional information will be submitted to the APP for acceptance prior to the start of any activities listed.

Note:
TBD = to be determined

5.1 Safety Responsibilities of Subcontractors and Suppliers

Subcontractors and suppliers must comply with the following activities, and are responsible for the following:

- Comply with all local, state, and federal safety standards.
- Comply with project and owner safety requirements.
- Actively participate in the project safety program and either hold or attend and participate in all required safety meetings.
- Provide a qualified safety representative to interface with CH2M.
- Maintain safety equipment and PPE for their employees.
- Maintain and replace safety protection systems damaged or removed by the subcontractor's operations.
- Notify the SSHO of any accident, injury, or incident (including spills or releases) immediately, and submit reports to CH2M within 24 hours.
- Install contractually-required general conditions for safety (for example, handrail, fencing, fall protection systems, and floor-opening covers).
- Conduct and document weekly safety inspections of project-specific tasks and associated work areas.

- Conduct site-specific and job-specific training for all subcontractor employees, including review of the CH2M SSHP, subcontractor health and safety plans, and subcontractor AHAs, and sign appropriate signoff forms.
- Determine and implement necessary controls and corrective actions to correct unsafe conditions.

The subcontractors listed in Table 5-1 may be required to submit their own site-specific health and safety plan and any other sub-plans applicable to their work. Subcontractors are responsible for the health and safety procedures specific to their work, and are required to submit their plans to CH2M for review and acceptance before the start of fieldwork.

Subcontractors are also required to prepare AHAs before beginning each activity posing hazards to their personnel. The AHA will identify the principle steps of the activity, potential health and safety hazards for each step, and will recommended control measures for each identified hazard. In addition, a listing of the equipment to be used to perform the activity, inspection requirements, and training requirements for the safe operation of the equipment listed must be identified.

All subcontractors will be evaluated based on past safety performance prior to contract award and a subcontractor HSE questionnaire will be completed by the subcontractor. Subcontractors must meet HSE criteria in CH2M SOP HSE-215, “Contracts and Subcontracts.”

Training

6.1 New Hire Training Requirements

New hire safety and occupational health orientation training at the time of initial hire of each new employee is a requirement. Site workers, supervisors, and managers will have training appropriate to their assigned duties and as specified in the SSHP and AHAs that are applicable to the work being performed.

As specified in Section 4.0 of Appendix A, the SSHO (who will also conduct the project safety and health inspections), will meet the training and indoctrination requirements prescribed in this APP and Appendix A, as well as the HAZWOPER supervisory training. All employees engaging in hazardous waste operations or emergency response will receive appropriate training as required by 29 CFR 1910.120 and 29 CFR 1926.65. At a minimum, the training will consist of instruction in the topics outlined in 29 CFR 1910.120 and 29 CFR 1926.65. Since there are tasks planned that require a competent person, competent-person-level training is required. Personnel who have not met these training requirements will not be allowed to engage in HAZWOPER activities.

All SSHOs (primary and alternates) will complete a 30-hour OSHA Construction Safety training, as well as all required internal training courses under CH2M requirements. The courses include, but are limited to: First-aid/cardiopulmonary resuscitation (CPR), Fire Extinguisher, Blood Borne Pathogens, and others.

The SSHO will also serve as the project competent person for all general tasks not covered by a specialized subcontractor.

6.2 Project-Specific Training Requirements

Before commencing field activities, all field personnel assigned to the project will have completed site-specific training that will address the contents of applicable APPs, including the activities, procedures, monitoring, and equipment used in the site operations. Site-specific training will also include site and facility layout, potential hazards, risks associated with identified emergency response actions, and available emergency services. Training will be verified documented and complete by the SSHO and SHM.

Project-specific training for this project are identified in Table 6-1:

- SSHPs/AHAs
- 40hr HAZWOPER / 8hr refresher (annual)
- Online, computer-based CH2M worker category training
- Field Vehicles – CH2M personnel will receive Smith Driving System training for vehicle operations
- HAZCOM
- Personal Protective Equipment
- Earthmoving Equipment Training
- Hand and Power Tool Training

Table 6-1. Medical Surveillance and Training Requirements

Training or Medical Surveillance Requirement	Applicability
APP/SSHP/AHA Training	All site personnel
Initial HAZWOPER *29 CFR 1910.120(e)(3)/29 CFR 1926.65(e)(3)* Note: 40-hour or 24-hour training as applicable to employee assigned duties. No periodic refresher performance so long as the requirements of *29 CFR 1910.120(e)(8)/ 29 CFR 1926.65(e)(8)* are maintained.	All site personnel performing HAZWOPER-regulated activities identified in this APP.
8-hour HAZWOPER refresher *29 CFR 1910.120(e)(8)/29 CFR 1926.65(e)(8)* annually	All site personnel performing HAZWOPER-regulated activities identified in this APP.
HAZWOPER Supervisor *29 CFR 1910.120(e)(4)/29 CFR 1926.65(e)(4)* with no specific recertification requirements.	All site manager, supervisory or SSHO personnel performing HAZWOPER-regulated activities identified in this APP.
First Aid/CPR/AED/Blood Borne Pathogens First Aid – typically 3-year renewal CPR – 1- or 2-year renewal (depending on sponsor)	All designated manager, supervisory or SSHO site personnel (two at all times).
HAZWOPER Medical Clearance *29 CFR 1910.120(f)/29 CFR 1926.65(f)* on an annual basis under the supervision of a licensed physician, preferably one knowledgeable in occupational medicine	All site personnel performing HAZWOPER-regulated activities identified in f this APP.
Respirator Clearance *29 CFR 1910.134(e)* annually under the supervision of a licensed physician, preferably one knowledgeable in occupational medicine.	All site personnel performing HAZWOPER-regulated activities identified in this APP and required to utilize respiratory protection.
OSHA 30-hour Construction Safety Training (or equivalent)	SSHO
Drill Rig Operator Qualification	Subcontractor operators
Traffic Control Safety	All site personnel
Traffic Control Flagger certification	Traffic control subcontractor flaggers
Hearing Conservation Training	Personnel working in noisy areas (>85 decibel time-weighted average)
Hazardous Waste Transport *49 CFR 172.700* Renewal, every 3 years	Each person who offers for transportation in commerce or transports in commerce hazardous materials

Notes:
AHA = activity hazard analysis
CFR = *Code of Federal Regulations*
HAZWOPER = Hazardous Waste Operations and Emergency Response
OSHA = Occupational Safety and Health Administration
SSHO = Site Safety and Health Officer
SSHP = Site Safety and Health Plan

6.3 Periodic Training Requirements for Supervisors and Employees

Periodic training for Supervisors and Employees will be provided through the following processes managed by the SSHO. Additionally, all supervisors and SSHOs are required to have the OSHA 8-hour HAZWOPER Supervisor training and 8-hour refresher training will be provided annually prior to expiration date. Supervisors also receive the 10-hour OSHA Construction Safety training. SSHOs shall maintain competency through having taken 8 hours of documented formal, online, or self-study safety and health-related coursework every year.

6.3.1 Safety Meetings and Toolbox Meetings

Safety meetings provide a method for maintaining safety awareness and providing safety-related information and training to employees. Safety meetings for project supervisory personnel and project employees will be held at least daily, and include relevant information for on- and off-the-job safety.

6.3.2 Activity Hazard Analysis Training

Each supervisor will review task-specific AHAs with all workers assigned to perform that task before the beginning of that task anywhere on the job site. All workers will sign the AHA document signifying they have been trained and understand the task steps, hazards, and hazard controls to be used.

6.3.3 Safety Pre-task Planning and Training

Each day, the onsite supervisors will hold informational safety training with each member of their crew. Information discussed and training performed will pertain to current project activities and scope of work. The subcontractor is encouraged to use the time for employee input and task-specific training.

VHA personnel and contractors will be included in these trainings and notified of when they will occur.

6.3.4 Vendor Training

Vendors that supply equipment to the project will be required to perform a training session to review and explain the safe operation procedures to the parties that will be using or operating the equipment.

6.3.5 Personal Protective Equipment Training

OSHA requires each PPE user to receive training on the proper care, maintenance, limitations, and instructions on how to wear and adjust PPE. The proper use of PPE will also be included in project safety briefings and toolbox meetings.

6.4 Emergency Response Plan Training

Emergency Response Plan training will occur during the employee site orientation and retraining will occur periodically in safety meetings. The Emergency Response Plan training will include evacuation alarms, site evacuation, designated evacuation assembly areas, and route to emergency medical facility. The SSHO will review site specific emergency response training with the project team prior to the start of onsite work.

Safety and Health Inspections

7.1 Inspection Details and Assignments

The project SSHO will provide daily onsite safety and health inspections for this project while work is being performed. Deficiencies will be identified in the deficiency tracking log and tracked to completion as identified below. The SSHO will meet the training and indoctrination requirements as prescribed in this APP and Appendix A, including HAZWOPER supervisory and OSHA 30 Hour Construction training. The SSHO will also have hands-on experience overseeing these types of tasks.

Subcontractor equipment operators/competent persons/qualified persons will conduct daily inspections of their equipment, and document according to company policy.

CH2M self-assessment, management inspection checklists and Safe Behavior Observations will be used for periodic site inspections. See Section 18.0 of Appendix A for further inspection details.

7.1.1 Deficiency Tracking System

Identified safety and health issues and deficiencies, and the actions, timetable, and responsibility for correcting the deficiencies, will be recorded using a deficiency tracking log. Follow-up inspections to ensure correction of any identified deficiencies shall be conducted and documented in a like manner.

The Deficiency Tracking Log will list the status of deficiencies in chronological order and in addition to being incorporated into the weekly inspection reports will be posted on the project safety bulletin board. The posted log will be updated daily and will provide the following information:

- Date deficiency identified
- Description of deficiency
- Name of person responsible for correcting deficiency
- Projected resolution date
- Date actually resolved

7.2 External Inspection and Certifications

External inspections or certifications will not be required for this work.

SECTION 8

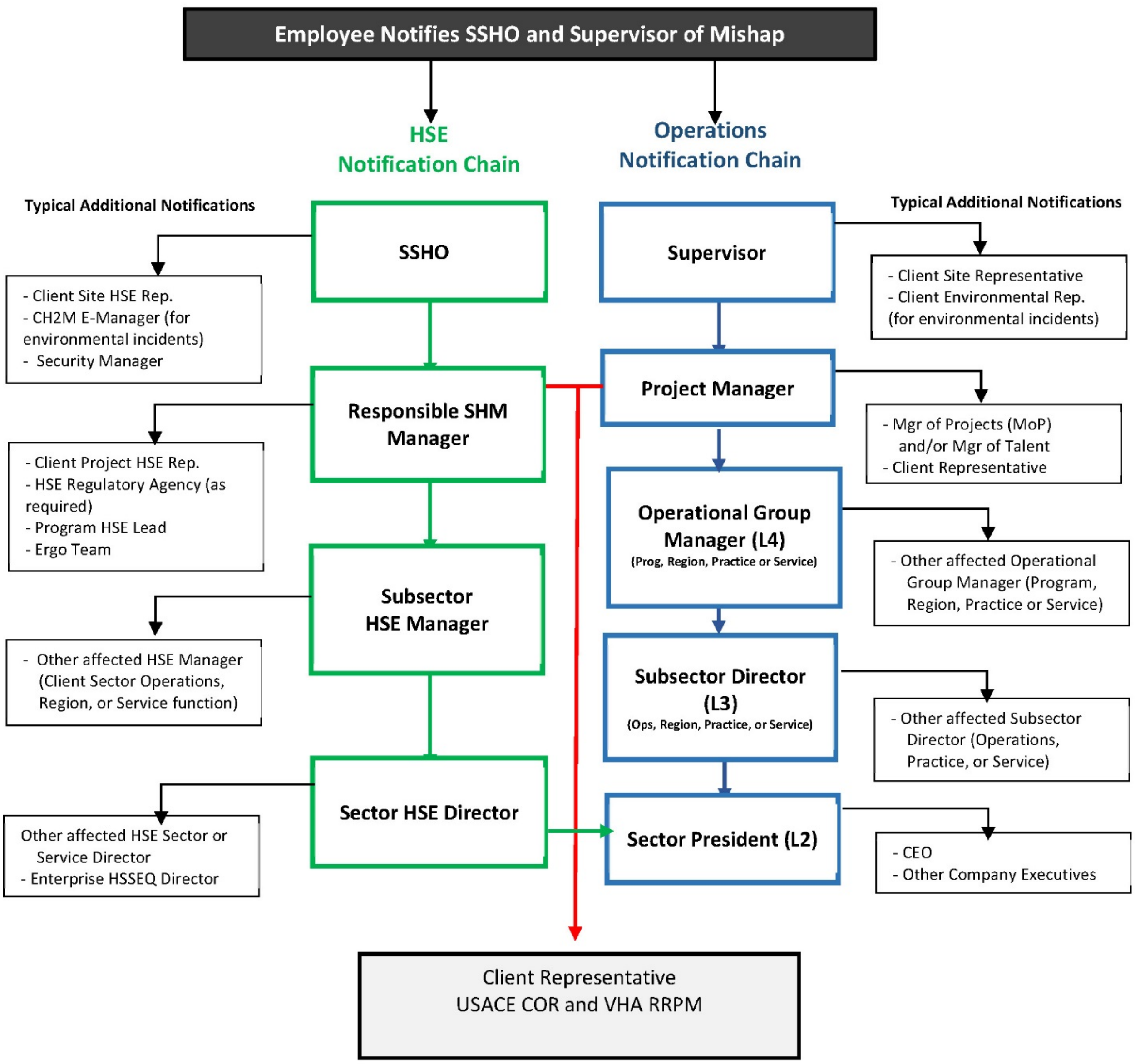
Mishap Reporting

8.1 Exposure Data (Man-hours Worked)

Man-hours worked for the project will be collected by the QC Manager for the project and reported on the Daily QC report. The hours will be tabulated weekly and entered on the Weekly Report. The project work hours for the month will be reported to the client PM by the fifth calendar day of the following month.

8.2 Mishap Reports, Investigations and Documentation

Report all accidents per the requirements covered in Section 01.D of EM385-1-1 (2014) and per the notification chart below. All mishaps shall be reported immediately to a supervisor. No supervisor may decline to accept a report of a mishap from a subordinate.



Mishaps shall be reported as soon as possible but not more than 24 hours afterwards to the client PM and Contracting Officer/Representative (CO/COR). CH2M will report, thoroughly investigate, and analyze all mishaps occurring incidentally to an operation, project or facility for which this manual is applicable. Corrective actions will be implemented as soon as reasonably possible and provide notice to the KO/COR when corrective actions are completed. Documentation, including incident reports, investigation, analysis, and corrective measure taken will be kept by the SSHO and will be maintained onsite for the duration of the project.

Note: A mishap is an unplanned, undesired event that occurs during the course of activity being performed. The term "mishap" includes accidents, incidents, and near-misses.

CH2M is required to report the following to PM and KO/COR within 24 hours:

- Property damage (exceeding $5,000)
- Days Away Injuries
- Days Away Illnesses
- Restricted/Transfer Injuries

CH2M is required to <u>immediately</u> report the following to the PM and KO/COR:

- Fatal injury/illness
- Permanent totally disabling injury/illness
- Permanent partial disabling injury/illness
- One (1) or more persons hospitalized as inpatients as a result of a single occurrence
- $500,000 or greater accidental property damage
- Three (3) or more individuals become ill or have a medical condition which is suspected to be related to a site condition, or a hazardous or toxic agent on the site
- Aircraft destroyed or missing

These accidents shall be investigated in depth by a Board of Investigation to identify all causes and to recommend hazard control measures. The Government Designated Authority (GDA) shall immediately notify the SSHO when any of these occurs and subsequently follow-up with official accident reports as prescribed by regulation. CH2M will reserve (cordon off) the scene after emergency medical services has responded, take pictures, immediately separate witnesses so their account can be independent, and be ready to hand that information to the Board of Investigation.

CH2M is required to <u>immediately</u> report any of the following mishaps (including near misses) to the PM and KO/COR:

- Electrical – to include Arc Flash, electrical shock, etc.
- Uncontrolled Release of Hazardous Energy (includes electrical and non-electrical)
- Load Handling Equipment (LHE) or Rigging
- Fall-from-Height (any level other than same surface)
- Underwater Diving
- Any mishap involving radioactive material or radiation generating devices

Near miss is defined as a mishap resulting in no personal injury and zero property damage, but given a shift in time or position, damage or injury may have occurred (e.g., a worker falls off a scaffold and is not injured; a crane swings around to move his load and narrowly misses a parked vehicle).

8.2.1 Reporting and Submission Requirements for Engineer Regulation 385-1-99

- USACE personnel reportable injuries, illnesses, and army property damage accidents will be reported using the DA 285 series form until the Army Safety Management Information System is activated.
- USACE contractor and public reportable accidents will be reported using form ENG 3394 until the Army Safety Management Information System is activated. Once it is activated, form ENG 3394 should no longer be used.
- For all Class A and B on-duty accidents, the investigation report will be completed and submitted to USACE within 45 calendar days.
- For all off-duty Military accidents and other (on-duty) classes of Military, Civilian, and contractor, and public recordable accidents, the accident report will be completed and submitted to the local safety office within 7 calendar days.
- Follow submission requirements of form DA 285. With a time-sensitive notification, notification can be made by calling 334-255-2660. Other methods of submission can be emailed to SAFEaccidentainfofoward@conus.army.mil.

Plans Required by the EM 385-1-1 Safety Manual

Plans required by the EM 385-1-1 Safety Manual are presented in the following subsections. Plans and procedures that are not applicable to this project are indicated as such with the non-applicability rationale.

9.1 Fatigue Management Plan

A Fatigue Management Plan is not part of this APP as the project work will not:

- Exceed 10-hours a day for more than 4 consecutive days
- Exceed 50-hours in a 7-day work week
- Exceed 12-hours a day for more than 3 consecutive days

9.2 Emergency Plans

The following addresses emergency plan components for fire, medical services and inclement weather. The emergency plan shall be tested at initiation of field work and annually thereafter. Pre-emergency Planning (Fire, Medical & Inclement Weather)

The Emergency Response Coordinator (ERC), typically the SSHO or designee, performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with CH2M onsite parties, the facility, and local emergency-service providers as appropriate and is the person to be contacted for information or clarification. Pre-Emergency Planning activities performed by the ERC include the following:

- The emergency services provider shall be offered an onsite orientation of the project and associated hazards and coordination will be documented by the SSHO in project log book.
- The number of persons permitted in any location shall correspond to rescue and escape capabilities and limitations identified.
- Determine what onsite communication equipment is available (cellular phone and vehicle horn).
- Communications shall consist of verbal communication / hand signals amongst field team, use of vehicle horn to signal crew as a whole and cellular communications to summon emergency responders / assistance. These will be tested as part of project drill conducted at initiation of field work.
- Review the facility emergency and contingency plans where applicable.
- Emergency telephone numbers and reporting instructions for ambulance, physician, hospital, fire, and police shall be clearly communicated to all employees, conspicuously and clearly posted at the work site.
- Confirm and post the “Emergency Contacts” page and route to the hospital located in this section in project trailer(s) and keep a copy in field vehicles along with evacuation routes and assembly areas. Communicate the information to onsite personnel and keep it updated.
- Employees working alone in a remote location or away from other workers will not be permitted.

- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Review changed site conditions, onsite operations, and personnel availability in relation to emergency response procedures.
- Where appropriate and acceptable to the client, inform emergency room and ambulance and emergency response teams of anticipated types of site emergencies.
- Inventory and check site emergency equipment, supplies, and potable water.
- Communicate emergency procedures for personnel injury, exposures, fires, explosions, and releases.
- Rehearse the emergency response plan before site activities begin. This may include a "tabletop" exercise or an actual drill depending on the nature and complexity of the project. Drills should take place periodically but no less than once a year.
- Brief new workers on the emergency response plan.
- The ERC will evaluate emergency response actions and initiate appropriate follow-up actions.

9.2.1 Emergency Equipment and Supplies

The ERC will ensure the following emergency equipment is on the site. Verify and update the locations of this equipment as needed. The equipment will be inspected in accordance with manufacturer's recommendations. The inspection will be documented in a field logbook or similar means to be kept in the project files.

Emergency Equipment and Supplies	Location
20 (or two 10) class A, B, C fire extinguisher	Field Vehicle
First-aid kit	Field Vehicle
Eye wash	Field Vehicle
Potable water	Field Vehicle
Bloodborne-pathogen kit	Field Vehicle
Additional equipment (specify): Cell Phone	Field Vehicle/On SSHO

9.2.2 Escape Procedures and Routes

- Evacuation routes, assembly areas, and severe weather shelters (and alternative routes and assembly areas) are to be specified on the site map in Table 1 Emergency Contact page of the SSHP and communicated to crew daily.
- Evacuation route(s) and assembly area(s) will be designated by the ERC or designee before work begins.
- Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.
- The ERC and a "buddy" will remain on the site after the site has been evacuated (if safe) to assist local responders and advise them of the nature and location of the incident.
- The ERC will account for all personnel in the onsite assembly area.

- A designated person will account for personnel at alternate assembly area(s).
- The ERC will follow the incident reporting procedures in the "Incident Notification, Reporting, and Investigation" section of this APP.
- Small fires posing minimal safety or health hazards may be controlled with onsite fire extinguishers without evacuating the site. When in doubt evacuate.

9.2.2.1 Incident Response

In fires, explosions, or chemical releases, actions to be taken include the following:

- Notify appropriate response personnel identified in Table 1, Emergency Contacts list in the SSHP.
- Shut down CH2M operations and evacuate the immediate work area.
- Account for personnel at the designated assembly area(s).
- Assess the need for site evacuation, and evacuate the site as warranted.
- Implement HSE-111, Incident Notification, Reporting and Investigation.
- Notify and submit reports to clients as required in contract.

9.2.2.2 Evacuation Signals

Signal	Meaning
Grasping throat with hand	Emergency; help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

9.2.3 Inclement Weather

The SSHO or designated onsite personnel, shall be responsible for checking the weather conditions at a minimum of twice daily using a National Oceanic and Atmospheric Administration online or radio weather service. Sudden inclement weather can rapidly encroach upon field personnel. Preparedness and caution are the best defenses. Field crew members performing work outdoors should carry clothing appropriate for inclement weather. Personnel are to take heed of the weather forecast for the day and pay attention for signs of changing weather that indicate an impending storm. Signs include towering thunderheads, darkening skies, or a sudden increase in wind. These Severe weather triggers will alert the SSHO to monitor weather conditions continuously. If stormy weather ensues, field personnel should discontinue work and seek shelter until the storm has passed.

Protective measures during a lightning storm include seeking shelter; avoiding projecting above the surrounding landscape (don't stand on a hilltop—seek low areas); staying away from open water, metal equipment, railroad tracks, wire fences, and metal pipes; and positioning people several yards apart. Some other general precautions include the following:

- Know where to go and how long it will take to get there. If possible, take refuge in a large building or vehicle. Do not go into a shed in an open area.
- The inclination to see trees as enormous umbrellas is the most frequent and most deadly mistake. Do not go under a large tree that is standing alone. Likewise, avoid poles, antennae, and towers.
- If the area is wide open, go to a valley or ravine, but be aware of flash flooding.

- If you are caught in a level open area during an electrical storm and you feel your hair stand on end, drop to your knees, bend forward and put your hands on your knees or crouch. The idea is to make yourself less vulnerable by being as low to the ground as possible and taking up as little ground space as possible. Lying down is dangerous, since the wet earth can conduct electricity. Do not touch the ground with your hands.

Do not use telephones during electrical storms, except in the case of emergency.

If lightning is observed, all LHE, drill rigs, work on elevated platforms or scaffolding, roofing activities, tree trimming activities, pole climbing activities, or work in open areas shall stop. A determination shall be made as to the proximity to the operation being performed. Once lightning is seen, count the number of seconds until you hear the thunder. Divide number of seconds by 5 to get the distance the lightning is away from you. If lightning is 10-miles away or less, work should stop until 30 minutes after the last audible thunder or visible flash of lightning. A metal-topped vehicle on four rubber tires with windows up and not leaning on metal doors will suffice as temporary shelter.

High winds can cause unsafe conditions, and activities should be halted until wind dies down. High winds can also knock over trees, so walking through forested areas during high-wind situations should be avoided. If winds increase, seek shelter or evacuate the area. Proper body protection should be worn in case the winds hit suddenly, because body temperature can decrease rapidly.

9.3 Site Sanitation and Housekeeping Plan

The following constitutes the Site Sanitation / Housekeeping Plan for this project.

9.3.1 Drinking Water

A cooler containing an adequate supply of drinking water will be available at the site for the site workers and replenished each day. The cooler will be stored outside the exclusion zone on or near the field vehicles. Clean, disposable cups will be provided.

9.3.2 Toilets

Portable toilet facilities will be provided outside of the exclusion zone and in a location that does not interfere with the construction activities. Separate facilities for women are required and will be provided, EM 385-1-1, Section 02.E.01, paragraph a. Toilet facilities on construction sites will be provided as follows:

Minimum Toilet Facilities at Construction Sites

Number of Personnel	Number of Toilets
20 or fewer	One
20 or greater	One toilet seat and one urinal per 40 workers
Greater than 200	One toilet seat and one urinal per 50 workers

Note: These requirements do not apply to mobile crews or to normally unattended work locations if employees working at these locations have transportation immediately available to nearby toilet facilities. Separate toilet rooms for each sex need not be provided if toilet rooms can only be occupied by one person at a time, can be locked from the inside, and contain at least one toilet seat.

Toilet facilities will be constructed so that the occupants are protected against weather and falling objects; all cracks will be sealed, and the door will be tight-fitting, self-closing, and capable of being latched. Adequate ventilation will be provided and all windows and vents will be screened. Toilet facilities will be constructed so that the interior is lighted.

Provisions for routinely servicing and cleaning all toilets and disposing of the sewage will be established before placing toilet facilities into operation. The method of sewage disposal and the placement location selected will be in accordance with federal, state, and local health regulations.

9.3.3 Washing Facilities

Washing facilities will be provided at the same location as the toilet facilities to maintain healthful and sanitary conditions. Each washing facility will be maintained in a sanitary condition and provided with water (either hot and cold running water or tepid running water), soap, and individual means of drying. If it is not practical to provide running water, hand sanitizers may be used as a substitute.

9.3.4 Food Service

No food service will be provided onsite. Site workers will either bring their food to the site to be consumed outside of the exclusion zone and only after proper decontamination, or will go offsite for food.

9.3.5 Waste Disposal

Investigation-derived waste will be stored, profiled, and disposed of in accordance with the project work plan. Nonhazardous waste materials and rubbish will be contained in a garbage bag and disposed of with regular site sanitary service disposal or at an offsite disposal facility.

9.3.6 Vermin Control

No enclosed spaces are being constructed for this project and waste materials will be securely stored and transported offsite to provide vermin control.

9.3.7 Housekeeping

- Good housekeeping must be maintained at all times in all project work areas;
- Common paths of travel should be established and kept free from the accumulation of materials;
- Keep access to aisles, exits, ladders, stairways, scaffolding, and emergency equipment free from obstructions;
- Provide slip-resistant surfaces, ropes, or other devices to be used;
- Specific areas should be designated for the proper storage of materials;
- Tools, equipment, materials, and supplies shall be stored in an orderly manner;
- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area;
- Containers should be provided for collecting trash and other debris and shall be removed at regular intervals.

9.4 Medical Support Agreement

NOT APPLICABLE. A medical support agreement is not required for this work. CH2M will have, at a minimum, two First Aid/CPR-trained personnel onsite at all times.

9.5 Bloodborne Pathogen Program

Exposure to bloodborne pathogens may occur when rendering first-aid or CPR.

The onsite bloodborne pathogens kit will include; PPE (i.e., breathing barrier, latex-free gloves, gowns, masks, eye protectors, and/or resuscitation equipment).

Our site-specific bloodborne pathogen (BPP) program to include a site-specific Exposure Control Plan with provisions for engineering and administrative controls, Hepatitis B vaccination, PPE, training, recordkeeping, and a Post-Exposure Control Plan in the event of a bloodborne exposure is reflected in SOP HSE-202 which is covered in the required training. Post-exposure protocol as identified in SOP HSE-202 covers immediate medical evaluation of exposed individual(s) per current recommendations of the Center for Disease Control for human immunodeficiency virus, Hepatitis B virus, and Hepatitis C virus.

Employees trained in first-aid/CPR or those exposed to potentially infectious material (PIM) must complete CH2M's 1-hour bloodborne pathogens computer-based training module annually. This training covers the sources, hazards, and avoidance of BBPs and be provided the training specified in 29 CFR 1910.1030. When performing first-aid/CPR the following apply:

- Observe universal precautions to prevent contact with blood or other PIMs. Where differentiation between body fluid types is difficult or impossible, consider all body fluids to be potentially infectious materials.
- Always wash your hands and face with soap and running water after contacting PIMs. If washing facilities are unavailable, use an antiseptic cleanser with clean paper towels or moist towelettes.
- If necessary, decontaminate all potentially contaminated equipment and surfaces with chlorine bleach as soon as possible. Use one part chlorine bleach (5.25 percent sodium hypochlorite solution) diluted with 10 parts water for decontaminating equipment or surfaces after initially removing blood or other PIMs. Remove contaminated PPE as soon as possible before leaving a work area.

CH2M will provide exposed employees with a confidential medical examination should an exposure to PIM occur. The examination includes the following procedures:

- Documenting the exposure.
- Testing the exposed employee's and the source individual's blood (with consent).
- Administering post-exposure prophylaxis.

9.6 Exposure Control Plan

Our site-specific BBP program to include a site-specific Exposure Control Plan with provisions for engineering and administrative controls, Hepatitis B vaccination, PPE, training, recordkeeping, and a Post-Exposure Control Plan in the event of a bloodborne exposure is reflected in SOP HSE-202 which is covered in the required training. Post-exposure protocol as identified in SOP HSE-202 covers immediate medical evaluation of exposed individual(s) per current recommendations of the Center for Disease Control for human immunodeficiency virus, Hepatitis B virus, and Hepatitis C virus.

9.7 Automatic External Defibrillator Program

NOT APPLICABLE, due to close location of emergency medical services.

9.8 Site Layout Plan

NOT APPLICABLE, CH2M will not install temporary facilities.

9.9 Access/Haul Road Plan

Access routes are identified in the Remedial Investigation Work Plan. CH2M will not construct or use haul roads for this task.

9.10 Hearing Conservation Program

CH2M is required to control employee exposure to occupational noise levels of 85 decibels (dBA), A-weighted, and above by implementing a hearing conservation program that meets the requirements of the OSHA Occupational Noise Exposure standard, 29 CFR 1910.95. A noise assessment may be conducted by the SHM or designee based on potential to emit noise above 85 dBA and also considering the frequency and duration of the task.

The identification, documentation, engineering controls, PPE and hearing testing for all employees;

- A noise survey meter calibrated and set to A-weighted scale will be used for identifying hazardous noise areas; or, if personnel have to raise their voice to speak to someone less than 3 feet apart, consider yourself in a hazardous noise environment, and don hearing protection.
- Areas or equipment emitting noise at or above 90 dBA will be evaluated to determine feasible engineering controls. When engineering controls are not feasible, administrative controls can be developed and appropriate hearing protection will be provided.
- Areas or equipment emitting noise levels at or above 85 dBA, hearing protection must be worn. This will include labeling of all noise hazardous equipment and areas by the SSHO.
- Employees exposed to 85 dBA or a noise dose of 50 percent must participate in the hearing conservation program including initial and annual (as required) audiograms.
- Employees who are exposed at or above the action level of 85 dBA are required to complete the online Noise Training Module located on CH2M's Virtual Office.
- Hearing protection will be maintained in a clean and reliable condition, inspected prior to use and after any occurrence to identify any deterioration or damage, and damaged or deteriorated hearing protection repaired or discarded.
- In work areas where actual or potential high noise levels are present at any time, hearing protection must be worn by employees working or walking through the area.
- Areas where tasks requiring hearing protection are taking place may become hearing protection required areas as long as that specific task is taking place.
- High noise areas requiring hearing protection should be posted or employees must be informed of the requirements in an equivalent manner and a copy of the OSHA standard 29 CFR 1910.95 will be posted in the workplace.
- Pre-employment and end-of-employment hearing testing of individuals who will be working in noise hazardous environments greater than 30 days a year will be provided.

9.11 Respiratory Protection Plan

NOT APPLICABLE. Exposure to respiratory hazards is not anticipated for the scope of work being performed under this APP. Constituents of concern have been determined to be below respiratory protection thresholds.

9.12 Health Hazard Control Program

Safety and health hazards for performing work covered under this APP are identified through the preparation of AHAs (provided in Appendix A). Each AHA also indicates recommended controls for each identified potential safety/health hazard, which (as applicable) are in line with the general site-specific hazards and controls that described the SSHP (Appendix A). Appropriate PPE will be supplied and used at all times for this project. PPE selection is based on the selected hazard control measures specified in the AHAs and will be in accordance with Section 11 of this APP.

9.13 Hazard Communication Program and Global Harmonized System

Chemical products may occasionally be stored and used on the project site, and/or stored on field vehicles. Examples of chemicals may include, but are not limited to, gases used to calibrate sensing equipment and lubricants. Other chemicals may be used as well. The chemicals may pose hazards, including flammability, corrosiveness, reactivity and incompatibility, and toxicity. Because of these potential hazards, special precautions must be taken including the following:

- Tracking and controlling hazardous chemical products received and stored
- A hazard evaluation of each chemical product, using such sources as Safety Data Sheets (SDSs).
- Informing workers of the potential hazards through training, SDSs, and appropriate labeling of containers
- Air monitoring in the case of potential respiratory hazards
- Design and implementation of engineering controls such as ventilation and source control
- Developing storage, handling, housekeeping, and decontamination procedures
- Assigning appropriate PPE such as eye and face protection, gloves, body protection, and respirators. Respirator usage by CH2M or subcontractor employees will be in accordance with the employees' IIPP.
- Training personnel who will be handling chemicals on safe handling procedures, PPE, and emergency and spill cleanup procedures.

Hazardous substances that may be encountered in soil on the project site are not covered by this program. Appendix A, SSHP, addresses chemical and other hazard assessment and mitigation associated with site contaminants, including investigation and remediation of waste materials.

9.13.1 Chemicals Covered by this Project Program

For the purposes of this program, chemicals considered to be hazardous are those:

- Listed in the OSHA Permissible Exposure Limits.

- Included in the American Conference of Governmental Industrial Hygienists Threshold Limit Values for Chemical Substances (2007).
- Found to be suspected or confirmed carcinogens by the National Toxicology Program in the latest edition of the Annual Report on Carcinogens, or by the International Agency for Research on Cancer (IARC) in the latest edition of the IARC monographs.

No chemicals are expected to be used during field activities as part of this scope of work.

Exceptions to this policy, by OSHA definition, include consumer products that are used in a consumer fashion and pose no more of an exposure hazard than a consumer would face.

9.13.2 Training

Employees who work with or are potentially exposed to hazardous chemicals will receive initial training on the elements of this Hazard Communication Program, including the following:

- Content and requirements of this program and the OSHA Hazard Communication Standard
- The potential physical and toxic hazards of the chemicals used in their work location, and especially the hazards of non-routine tasks
- Chemical inventory and tracking procedures
- Location of this Hazard Communication Program, the chemical inventory, and the SDSs
- How to read SDSs
- Methods to detect the release of or exposure to chemicals in their area
- Content and interpretation of labels
- Safe use and handling of chemicals
- Required PPE
- Basic emergency procedures

Additional training will be provided annually, whenever a new chemical is added to the workplace, and when non-routine tasks are planned.

9.13.3 Labeling

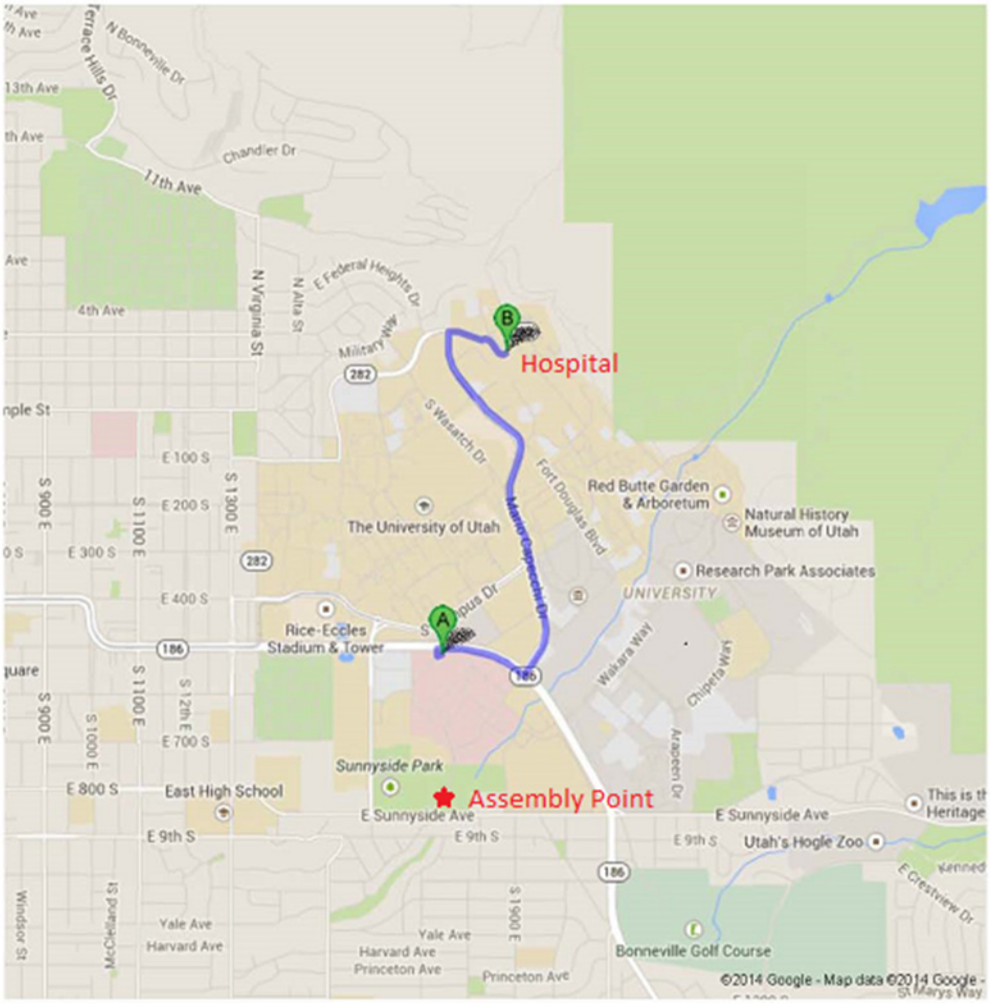
The SSHO will ensure that hazardous chemicals brought onto the site are properly labeled with at least the following information, in English, as a minimum, and the language of non-English-speaking employees who may use the product, as appropriate. This labeling includes the following:

- The identity of the product and chemical components
- Appropriate hazard warnings
- Name and address of the manufacturer, importer, or other responsible party

Hazard warnings will also be transmitted in the form of the National Fire Prevention Agency or Hazardous Materials Information System color-coded warnings, which are ranked on a 0 to 4 scale. When chemicals are transferred to a portable container, labels containing chemical identification and hazard warnings must be affixed to the portable container.

9.13.4 Current Onsite Inventory

Prior to the start of fieldwork, the SSHO shall inventory all hazardous products to be used onsite, identify their storage locations, and develop a map documenting their locations. It is anticipated that the Assembly Point identified below will be the storage location for all hazardous products used on this project.



9.14 Process Safety Management Plan

NOT APPLICABLE, no highly hazardous chemicals shall be used on this site.

9.15 Lead Compliance Plan

NOT APPLICABLE, as lead is not an identified contaminant.

9.16 Asbestos Abatement Plan

NOT APPLICABLE, asbestos is not anticipated to be encountered for this task.

9.17 Radiation Safety Program

NOT APPLICABLE, as there are no radiation sources at this site.

9.18 Abrasive Blasting Procedures

NOT APPLICABLE, will not be performed for this task.

9.19 Heat Stress Monitoring Plan

Specific heat illness prevention regulation that must be implemented, include the following:

- Having enough water onsite so that each worker can consume at a minimum, one quart per hour per shift.
- Frequent reminders and/or water breaks will be taken so that each person can consume enough water.
- Access to shade (that is, blockage from direct sunlight) will be provided at all times and will be reasonably close to the work area. Keep in mind that a vehicle or other enclosed are with no air conditioning is NOT considered shade. Must be a well-ventilated area or have air conditioning.
- Workers suffering from heat-illness-related symptoms OR if needed for preventative recovery will be provided access to shade for at least 5 minutes, or longer, for recovery (if heat-related symptoms are occurring, contact the SHM).
- Training on risk factors, signs and symptoms of heat illness, importance of hydration and acclimatization, and importance of reporting symptoms and what to do in case of heat illness emergency, and contacting emergency medical services (see sections that follow).
- Heat-related illnesses are caused by more than just temperature and humidity factors.

Physical fitness influences a person's ability to perform work under heat loads. At a given level of work, the more fit a person is, the less the physiological strain, the lower the heart rate, the lower the body temperature (indicates less retrained body heat—a rise in internal temperature precipitates heat injury), and the more efficient the sweating mechanism.

Acclimatization is a gradual physiological adaptation that improves an individual's ability to tolerate heat stress. Acclimatization requires physical activity under heat-stress conditions similar to those anticipated for the work. With a recent history of heat-stress exposures of at least 2 continuous hours per day for 5 of the last 7 days to 10 of the last 14 days, a worker can be considered acclimatized. Its loss begins when the activity under those heat-stress conditions is discontinued, and a noticeable loss occurs after 4 days and may be completely lost in 3 to 4 weeks. Because acclimatization is to the level of the heat-stress exposure, a person will not be fully acclimatized to a sudden higher level, such as during a heat wave.

Dehydration reduces body water volume. This reduces the body's sweating capacity and directly affects its ability to dissipate excess heat.

The ability of a body to dissipate heat depends on the ratio of its surface area to its mass (surface area/weight). **Heat dissipation** is a function of surface area, while heat production depends on body mass. Therefore, overweight individuals (those with a low ratio) are more susceptible to heat-related illnesses because they produce more heat per unit of surface area than if they were thinner. Monitor these persons carefully if heat stress is likely.

When wearing **impermeable clothing**, the weight of an individual is not as important in determining the ability to dissipate excess heat because the primary heat dissipation mechanism, evaporation of sweat, is ineffective.

Symptoms and Treatment of Heat Stress

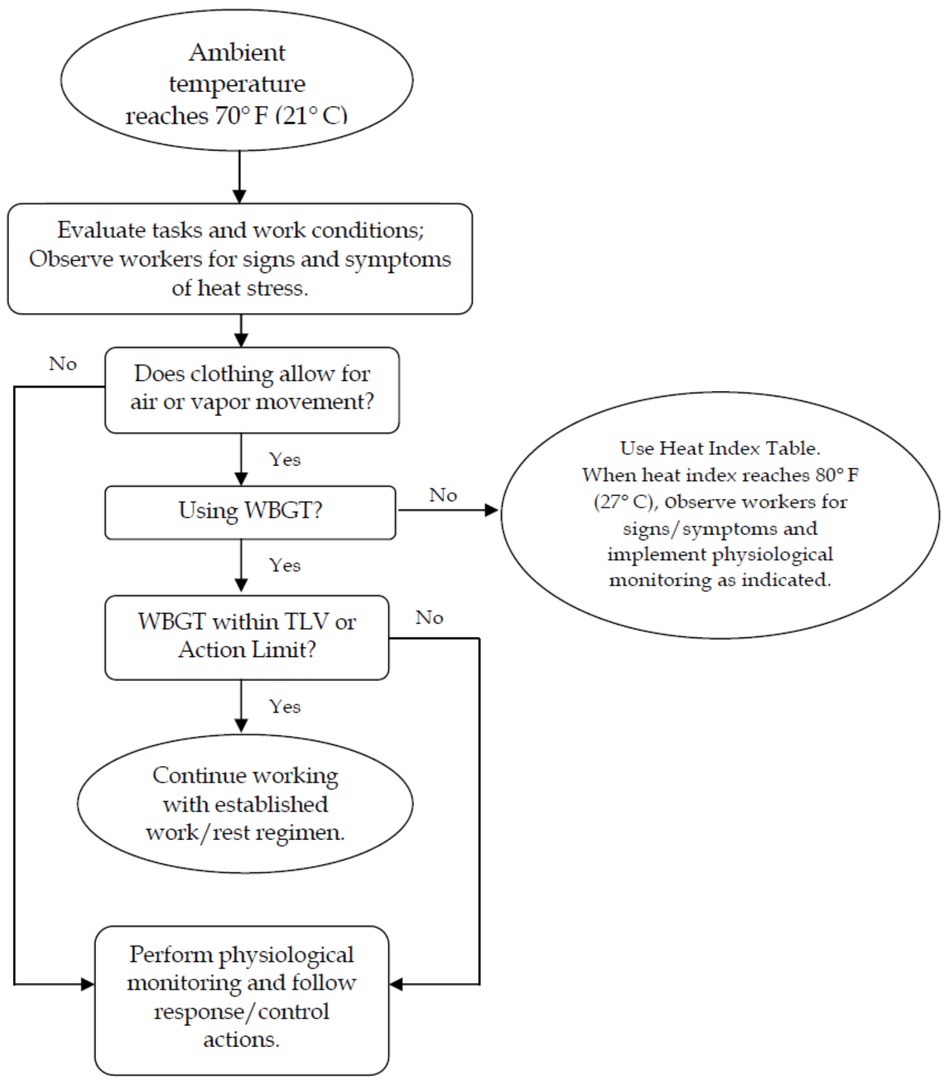
	Heat Syncope	Heat Rash	Heat Cramps	Heat Exhaustion	Heat Stroke
Signs and Symptoms	Sluggishness or fainting while standing erect or immobile in heat.	Profuse tiny raised red blister-like vesicles on affected areas, along with prickling sensations during heat exposure.	Painful spasms in muscles used during work (arms, legs, or abdomen); onset during or after work hours.	Fatigue, nausea, headache, giddiness; skin clammy and moist; complexion pale, muddy, or flushed; may faint on standing; rapid thready pulse and low blood pressure; oral temperature normal or low.	Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high oral temperature of 104°F or higher.
Treatment	Remove to cooler area. Rest lying down. Increase fluid intake. Recovery usually is prompt and complete.	Use mild drying lotions and powders, and keep skin clean for drying skin and preventing infection.	Remove to cooler area. Rest lying down. Increase fluid intake.	Remove to cooler area. Rest lying down, with head in low position. Administer fluids by mouth. Seek medical attention.	Cool rapidly by soaking in cool–but not cold–water. Call ambulance, and get medical attention immediately!

9.19.1.1 Precautions

- Drink 16 ounces of water before beginning work. Disposable cups and water maintained at 50 degrees Fahrenheit (°F) (10 degrees Celsius [°C]) to 60°F (15.6°C) should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons (7.5 liters) per day. Remind employees to drink water throughout their work shift.
- Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours.
- Acclimate to site work conditions by slowly increasing workloads; for example, do not begin site work with extremely demanding activities. Closely monitor employees during their first 14 days of work in the field.
- Supervisors and safety coordinators (SCs) must continually observe employees throughout the work shift for signs and symptoms of heat stress or illness. Employees must monitor themselves for heat stress as well as observe their coworkers.
- Effective communication must be maintained with employees throughout the work shift either by voice, observation, or electronic device.
- Use cooling devices, such as cooling vests, to aid natural body ventilation. These devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature and cool protective clothing.
- Conduct field activities in the early morning or evening and rotate shifts of workers, if possible.
- Avoid direct sun whenever possible, which can decrease physical efficiency and increase the probability of heat stress. Take regular breaks in a cool, shaded area. Use a wide-brim hat or an umbrella when working under direct sun for extended periods.

- Provide adequate shade to protect personnel against radiant heat (sun, flames, hot metal).
- Use portable fans for convection cooling or in extreme heat conditions, an air-conditioned rest area when needed.
- In hot weather, rotate shifts of workers.
- Maintain good hygiene standards by frequent changes of clothing and showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should consult medical personnel.
- Brief employees initially before the project work begins and routinely as part of the daily safety briefing, on the signs and symptoms, of heat-relatedness illnesses, precautions to measures and emergency procedures to follow as described in this plan.
- Observe one another for signs of heat stress. PREVENTION and communication are key.

Thermal Stress Monitoring Flow Chart



9.19.1.2 Thermal Stress Monitoring—Permeable or Impermeable Clothing

When **permeable work clothes** are worn (street clothes or clothing ensembles over street clothes), regularly observe workers for signs and symptoms of heat stress and implement physiological monitoring as indicated below. This should start when the heat index reaches 80°F (27°C) (see Heat Index Table), or sooner if workers exhibit symptoms of heat stress indicated in the previous table. The heat index values were devised for shady, light wind conditions; exposure to full sunshine can increase the values by up to 15°F (8°C). Also, strong winds, particularly with very hot, dry air, can be extremely hazardous. Record heat stress monitoring results on the Heat Stress Monitoring form located in the SSHP attachments.

Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	126	130					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Streuous Activity

Caution   Extreme Caution   Danger   Extreme Danger

Heat Index	Possible Heat Disorders	Minimum Frequency of Physiological Monitoring
80°F - 90°F (27°C - 32°C)	Fatigue possible with prolonged exposure and/or physical activity	Conduct initial monitoring as baseline and observe workers for signs of heat stress and implement physiological monitoring if warranted.
90°F - 105°F (32°C - 41°C)	Sunstroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity	Conduct initial monitoring as baseline, then at least every hour, or sooner, if signs of heat stress are observed.
105°F - 130°F (41°C - 54°C)	Sunstroke, heat cramps, or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity.	Conduct initial monitoring as baseline, then every 30 minutes or sooner if signs of heat stress are observed.
130°F or Higher (54°C or Higher)	Heat/Sunstroke highly likely with continued exposure.	Conduct initial monitoring as baseline, then every 15 minutes or sooner if signs of heat stress are observed.

Source: National Weather Service

When wearing **impermeable clothing** (for example, clothing doesn't allow for air or water vapor movement such as Tyvek), physiological monitoring as described below will be conducted when the ambient temperature reaches 70°F (21°C) or sooner when climatic conditions may present greater risk of heat stress combined with wearing unique variations of impermeable clothing, or workers exhibit symptoms of heat stress.

9.19.1.3 Physiological Monitoring and Associated Actions

For employees wearing permeable clothing, follow the minimum frequency of physiological monitoring listed in the Heat Index Table.

For employees wearing impermeable clothing, physiological monitoring should begin initially at a 15-minute interval, then if the employee's heart rate or body temperature is within acceptable limits, conduct the subsequent physiological monitoring at 30 minutes, and follow the established regimen protocol below.

When physiological monitoring is required, use either radial pulse or aural temperature and use the following actions:

- The sustained heart rate during the work cycle should remain below 180 beats per minute (bpm) minus the individual's age (for example 180 – 35-year-old person = 145 bpm). The sustained heart rate can be estimated by measuring the heart rate at the radial pulse for 30 seconds as quickly as possible prior to starting the rest period.
- The heart rate after one minute rest period should not exceed 120 bpm.
- If the heart rate is higher than 120 bpm after the FIRST minute into the rest period, the next work period should be shortened by 33 percent, while the length of the rest period stays the same.
- If the pulse rate still exceeds 120 bpm at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent.
- Continue this procedure until the rate is maintained below 120 bpm after the FIRST minute into the rest period.
- Alternately, the body temperature can be measured, either oral or aural (ear), before the workers have something to drink.
- If the oral or aural temperature exceeds 99.6°F (37.6°C) at the beginning of the rest period, the following work cycle should be shortened by 33 percent.
- Continue this procedure until the oral or aural (ear) temperature is maintained below 99.6°F (37.6°C). While an accurate indication of heat stress, oral temperature is difficult to measure in the field; however, a digital aural (aural) thermometer is easy to obtain and inexpensive to purchase.
- Use the form attached to this APP to track workers' measurements and actions taken.

9.19.1.4 Procedures for when Heat Illness Symptoms Are Experienced

- Always contact the SHM when any heat illness related symptom is experienced so that controls can be evaluated and modified, if needed.
- In the case of cramps, reduce activity, increase fluid intake, move to shade until recovered.
- In the case of all other heat-related symptoms (fainting, heat rash, heat exhaustion), and if the worker is a CH2M worker, contact the occupational physician at 1-866-893-2514 and immediate supervisor.

- In the case of heat stroke symptoms, call 911, have a designee give location and directions to ambulance service if needed, follow precautions under the emergency medical treatment of this APP.
- Follow the Incident Notification, Reporting, and Investigation section of this APP.

9.20 Cold Stress Monitoring Plan

Low ambient temperatures increase the heat lost from the body to the environment by radiation and convection. In cases where the worker is standing on frozen ground, the heat loss is also due to conduction.

Wet skin and clothing, whether because of water or perspiration, may conduct heat away from the body through evaporative heat loss and conduction. Thus, the body cools suddenly when chemical protective clothing is removed if the clothing underneath is perspiration-soaked.

Movement of air across the skin reduces the insulating layer of still air just at the skin's surface. Reducing the insulating layer of air increases heat loss by convection. CH2M employees should wear a perspiration wicking layer next to skin, followed by a layer of fleece or wool, with a wind-impermeable breathing layer on top.

Non-insulating materials in contact or near-contact with the skin, such as boots constructed with a metal toe or shank, conduct heat rapidly away from the body.

Certain common drugs, such as alcohol, caffeine, or nicotine, may exacerbate the effects of cold, especially on the extremities. The chemicals reduce the blood flow to peripheral parts of the body, which are already high-risk areas because of their large surface area to volume ratios. These substances may also aggravate an already hypothermic condition.

9.20.1.1 Precautions

Be aware of the symptoms of cold-related disorders, and wear proper, layered clothing for the anticipated fieldwork. Appropriate rain gear is a must in wet weather.

Consider monitoring the work conditions and adjusting the work schedule using guidelines developed by the U.S. Army (wind-chill index) and the National Safety Council.

Wind-Chill Index (below) is used to estimate the combined effect of wind and low air temperatures on exposed skin. The wind-chill index does not take into account the body part that is exposed, the level of activity, or the amount or type of clothing worn. For those reasons, it should only be used as a guideline to warn workers when they are in a situation that can cause cold-related illnesses.

Persons who experience initial signs of immersion foot, frostbite, and/or hypothermia should report it immediately to their supervisor/PM to avoid progression of cold-related illness.

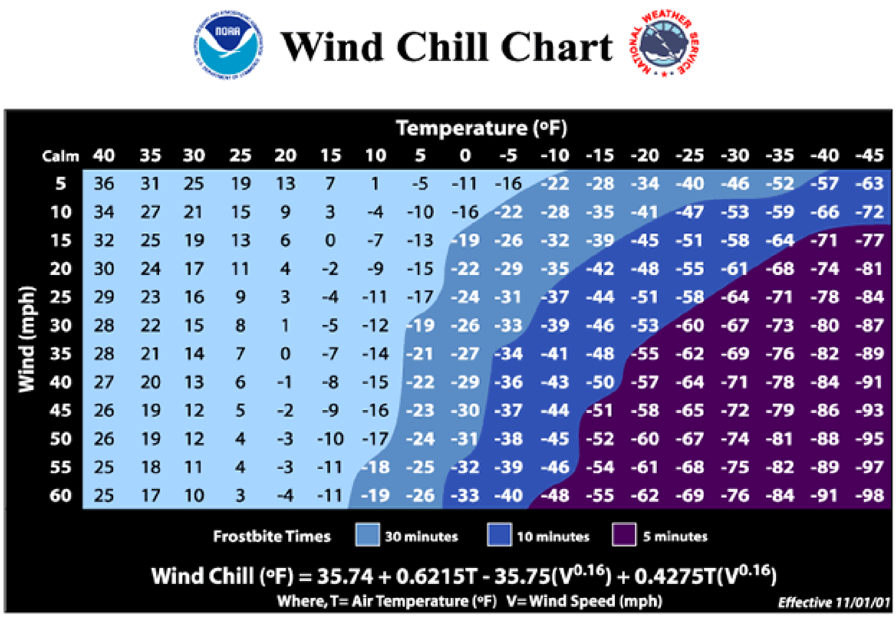
Observe one another for initial signs of cold-related disorders.

Obtain and review weather forecast – be aware of predicted weather systems along with sudden drops in temperature, increase in winds, and precipitation.

Symptoms and Treatment of Cold Stress

	Immersion (Trench) Foot	Frostbite	Hypothermia
Signs and Symptoms	Feet discolored and painful; infection and swelling present.	Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.	Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Treatment	Seek medical treatment immediately.	Remove victim to a warm place. Re-warm area quickly in warm—but not hot—water. Have victim drink warm fluids, but not coffee or alcohol. Do not break blisters. Elevate the injured area, and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids, but not coffee or alcohol. Get medical attention.

Wind Chill Chart


Wind Chill Chart

Temperature (°F)

Wind (mph) \ Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

Wind Chill (°F) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

9.21 Indoor Air Quality Management

NOT APPLICABLE, this will not be performed for this task.

9.22 Mold Remediation Plan

NOT APPLICABLE, this will not be performed for this task.

9.23 Chromium (VI) Exposure Evaluation

NOT APPLICABLE, this is not an anticipated contaminant for this task.

9.24 Crystalline Silica Evaluation

Although we do not anticipate encountering a situation where employees will be exposed to crystalline silica, all activities (including well construction, bentonite, and filter pack placement) will be evaluated in accordance with the CH2M Exposure Control Plan to ensure employees are not exposed to this hazard. If it is determined that the materials used could cause an exposure potential, work will stop until an exposure assessment can be performed.

9.25 Lighting Plan for Night Operations

NOT APPLICABLE, no night work will be performed.

9.26 Traffic Control Plan

Site specific traffic control plans will be developed by our qualified traffic control subcontractor prior to the start of site activities and shall be submitted for review. The CH2M general traffic control plan is attached to the SSHP, subcontractor plans will be incorporated into this plan and submitted for review.

9.27 Fire Prevention Plan

9.27.1 General

The decision on whether to try to extinguish a fire using available site personnel and equipment will be made by the SSHO, and is based on whether the fire is small or large, and involves explosives or flammable liquids/gases. CH2M employees shall only fight small incipient stage fires that can be controlled with fire extinguishers. CH2M will rely on outside emergency response groups to provide greater firefighting efforts. A written agreement shall be made, or a memorandum of record, stating the terms of the arrangement and the details for fire protection services, and shall be provided to the GDA.

Location of Fire Extinguishers

Fire extinguishers will be located around the project sites as required in the following places at a minimum:

- In each vehicle
- Near areas where flammable materials are stored or in use

All fire extinguishers will be kept clearly visible, marked, and placed where they are easily accessible. The site SSHO shall inspect all fire extinguishers to ensure they are properly located and maintained.

Fire Extinguishers and General Fire Prevention Practices

Fire extinguishers rated 2A:20B:C will be provided within the immediate work area.

- Extinguishers must:
  - Be maintained in a fully charged and operable condition
  - Be visually inspected each month
  - Undergo a maintenance check each year
- The area in front of extinguishers must be kept clear.
- "Exit" signs must be posted over exiting doors, and "Fire Extinguisher" signs over extinguisher locations.
- Combustible materials stored outside should be at least 10 feet (3 meters) from any building.

- Solvent waste and oily rags must be kept in a fire resistant, covered container until removed from the site.
- Areas must be kept neat. Housekeeping is important.
- Flammable/combustible liquids must be kept in approved containers, and must be stored in an approved storage cabinet.

Fire extinguishers can represent an important segment of any overall fire protection program. However, their successful function depends on the following conditions being met:

- The extinguisher is properly located and in working order.
- The extinguisher is of proper type and for a fire which may occur.
- The fire is discovered while still small enough for the extinguisher to be effective.
- The fire is discovered by a person ready, willing, and able to use the extinguisher.
- Class C fires (see below for fire classifications) can be readily extinguished by quenching-cooling with water or a water-mixture agent. Class B fires are more effectively extinguished by an agent that blankets-smothers the fire through exclusion of oxygen surrounding the fire area. Those extinguishers containing bromochlorodifluoromethane, monobromotrifluoromethane, carbon dioxide, or dry chemical are generally best suited for extinguishing Class B fires. For Class C fires, the primary consideration in extinguishing this type of fire is the selection of nonconductive extinguishing agent to prevent dangerous electrical shock and possible death to user.
- Because of its corrosive nature, dry chemical is not recommended for use on computerized, electronic, or other equipment with extensive circuitry.
- The following chart defines and explains classes of fires:

A	Common Combustibles	Wood, paper, cloth etc.
B	Flammable liquids and gases	Gasoline, propane and solvents
C	Live electrical equipment	Computers, fax machines (see note!)
D	Combustible metals	Magnesium, lithium, titanium
K	Cooking media	Cooking oils and fats

Fires are classified into five groups:

- Class A: Class A fires involve common combustibles such as wood, paper, cloth, rubber, trash, and plastics. They are common in typical commercial and home settings, but can occur anywhere these types of materials are found.
- Class B: Class B fires involve flammable liquids, gases, solvents, oil, gasoline, paint, lacquers, tars, and other synthetic or oil-based products. Class B fires often spread rapidly and, unless properly secured, can reflash after the flames are extinguished.
- Class C: Class C fires involve energized electrical equipment, such as wiring, controls, motors, data processing panels, or appliances. They can be caused by a spark, power surge, or short circuit and typically occur in locations that are difficult to reach and see.

- Class D: Class D fires involve combustible metals such as magnesium and sodium. Combustible metal fires are unique industrial hazards that require special dry powder agents.

(NOTE: Although ABC and BC dry chemical extinguishers can control a fire involving electronic equipment, the National Fire Code specifically advises against dry-chemical extinguishers for fires involving computers or other delicate electronic equipment due to the potential damage from residues).

Firefighting will only be conducted by those trained and certified in this practice. The commonly accepted practice is the PASS method. This means, pull the pin, aim, squeeze the handle, and sweep the base of the fire area. The SSHO will verify that at least two staff members are onsite that have the required training for use of fire extinguishers.

9.27.1.1 Major Workplace Fire Hazards

CH2M does not anticipate performing any spark or flame producing “Hot Work”, Burning Operations, or any work in hazardous locations. All spark or flame producing work or any hot work shall be performed offsite at subcontractor’s facilities. The only anticipated ignition sources that will be onsite will be exhaust systems of equipment and field vehicles. It is important to park these vehicles in areas with no or low growing vegetation and to keep all combustible or flammable materials at least 50 feet from these ignition sources. The site SSHO shall inspect the site to ensure all ignition sources are protected. Any source that can be contacted by personnel shall be protected with guards or in a location where personnel are not normally located. If personnel need to access these areas, the ignition sources shall be pointed out in the AHA and discussed as part of the day’s safety meeting.

Fire Prevention Plan Evaluation

A pre-work survey of the suitability and effectiveness of fire prevention and protection measures at each project shall be made by the site SSHO. Records of the survey findings and recommendations shall be retained on file at the project.

Unusual Fire Hazards

No unusual fire hazards are anticipated for this project.

Hot Work Permits

No hot work permits are anticipated for this project.

Fires and Open Flames

No fires or open flame devices will be used on this project

Sources of Ignition Near Potential Fire Hazards

All sources of ignition shall be prohibited within 50 feet (15.2 meters) of operations with a potential fire hazard. The area shall be conspicuously and legibly posted “NO SMOKING, MATCHES, or OPEN FLAME.”

Smoking

Smoking shall be prohibited in all areas where flammable, combustible, or oxidizing materials are stored. “NO SMOKING, MATCHES, or OPEN FLAME” signs will be posted in all prohibited areas.

Danger of Underground Fire

Underground fires are not anticipated.

Fire Resistant Barrier

A barrier having a fire resistance rating equivalent to a listing of at least 1 hour shall segregate DOT-identified non-compatible materials that may create a fire hazard.

Housekeeping

A good housekeeping program that provides for prompt removal and disposal of accumulations of combustible scrap and debris shall be implemented in accordance with Section 9.3.7 on the site. Self-closing containers shall be used to collect waste saturated with flammable liquids. Only non-combustible or UL labeled nonmetallic containers may be used to dispose of waste and rubbish.

Vegetation

Measures must be taken to control the growth of tall grass, brush, and weeds adjacent to facilities. A break of at least 3 feet (0.9 meter) shall be maintained around all facilities.

Paint-soiled Materials

No paint soiled materials are anticipated on this project

Disposal of Combustible Waste Materials

Disposal of combustible waste materials shall be in compliance with applicable fire and environmental laws and regulations.

Burning Operations

No burning operations are anticipated on this project.

Permanent Buildings

No permanent buildings will be constructed on this project.

Temporary Enclosures

No temporary enclosures will be on this project.

Community Fire Protection Use

Outside help will be relied upon for fire protection, thus a written agreement shall be made, or a memorandum of record, stating the terms of the arrangement and the details for fire protection services, and shall be provided to the GDA.

Temporary Building Spacing

No temporary buildings will be on the project.

Fire Lanes

Fire lanes providing access to all areas shall be established and maintained free of obstruction.

Access to Fire Hydrants

Vehicles, equipment, materials, and supplies shall not be placed so that access to fire hydrants and other firefighting equipment is obstructed.

Hazardous Locations

CH2M does not anticipate having any hazardous locations on this project.

Lights and Heating Units

No lights and heating units will be used on this project.

Cutting or Sweating Pipe

No pipe cutting will be performed on this project.

Formwork and Scaffolding

No formwork or scaffolding will be used on this project.

Fire Protection in the Construction Process

CH2M will not perform any construction activities on this project.

Water Supply and Distribution Facilities

Water supply and distribution facilities for firefighting shall be provided and maintained in accordance with National Fire Prevention Association (NFPA) recommendations.

Recommendations of the NFPA

NFPA recommendations are not required to be complied on this project.

9.27.2 Flammable Liquids

9.27.2.1 Storage, Handling, and Use of Flammable Liquids

All storage, handling, and use of flammable liquids shall be in accordance with NFPA 30, NFPA 30A, or other applicable standards under the supervision of a qualified person.

9.27.2.2 Sources of Ignition

All sources of ignition shall be prohibited in areas where flammable liquids are stored, handled, and processed. Suitable “NO SMOKING, MATCHES, or OPEN FLAME” signs shall be posted in all such areas.

9.27.2.3 Fire Protection Requirements

At least one portable fire extinguisher rated 20-B:C shall be provided on all tank trucks or other vehicles used for transporting and/or dispensing flammable liquids.

Each service or refueling area shall be provided with at least one fire extinguisher rated not less than 40-B:C and located so that an extinguisher shall be within 100 feet (30.4 meters) of each pump, dispenser, underground fill pipe opening, and lubrication or service area.

9.27.2.4 Dispensing of Flammable/Combustible Liquids

Areas in which flammable or combustible liquids are dispensed in quantities greater than 5 gallons (22.7 liters) (will be separated from other operations by at least 25 feet (7.6 meters).

Drainage away from storm drains or surface waters or other means of containment will be provided to control spills.

Adequate natural or mechanical ventilation will be provided to maintain the concentration of flammable vapor at or below 10 percent of the lower flammable limit.

Dispensing of flammable liquids from one container to another will be done only when containers are electrically interconnected (bonded).

Dispensing flammable or combustible liquids by means of air pressure on the container or portable tanks is prohibited.

Dispensing devices and nozzles for flammable liquids will be of an approved type.

9.27.2.5 Flammable Liquid Storage

Category 1 or 2 flammable liquids or Category 3 flammable liquids with a flashpoint below 100°F (37.8°C) shall be kept in closed containers or tanks when not in use.

9.27.2.6 Clothing

Workers shall guard carefully against any part of their clothing becoming contaminated with flammable fluids. They shall not be allowed to continue work if their clothing becomes contaminated, and they must remove or wet down the clothing as soon as possible.

9.27.2.7 Unacceptable Use of Flammable Liquids

No flammable liquid with a flash point (closed cup test) below 100°F (37.8°C) shall be used for cleaning purposes or to start or rekindle fires.

9.27.2.8 Ventilation

Ventilation adequate to prevent the accumulation of flammable vapors to hazardous levels shall be provided in all areas where flammable liquids are handled or used.

9.27.2.9 Containers

Only labeled/listed (by a nationally-recognized testing laboratory) containers and portable tanks shall be used for the storage of flammable liquids.

Metal containers and portable tanks less than 660 gallons (2.5 cubic meters [m^3]) individual capacity meeting the requirements of, and containing products authorized by, Chapter I, 49 CFR (U.S. DOT Hazardous Materials Regulations), Chapter 9 of the United Nations' "Recommendations on the Transport of Dangerous Goods," or NFPA 386 shall be acceptable.

9.27.2.10 Portable Tanks

Portable tanks less than 660 gallons (2.4 m^3) individual capacity shall be provided with one or more devices installed in the top with sufficient emergency venting capacity to limit internal pressure under fire exposure conditions to 10 pounds per square inch [68.9 kilopascal] gauge or 30 percent of the bursting pressure of the portable tank, whichever is greater.

- At least one pressure-actuated vent having a minimum capacity of 6,000 cubic feet (170 m^3) of free air per hour shall be used. It shall be set to open at not more than 5 pounds per square inch (35 kilopascal) gauge.
- If fusible vents are used, they shall be actuated by elements that operate at a temperature not exceeding 300°F (148.8°C).
- Where plugging of a pressure-actuated vent can occur, fusible plugs or venting devices that soften to failure at a maximum of 300°F (148.8°C) under fire exposure shall be permitted to be used for the entire emergency venting requirement.

9.27.2.11 Design, Construction, and Use of Storage Tanks

The design, construction, and use of storage tanks containing flammable liquids shall be as specified in NFPA 30. Tanks greater than 660 gallons (2.5 m^3) capacity shall be in accordance with NFPA 30, Chapter 22 and NFPA 30A.

9.27.2.12 Size of Containers

The maximum allowable size for a container or metal portable tank less than 660 gallons (2.5 m^3) individual capacities shall not exceed those shown in Table 9-1 of EM 385-1-1.

9.27.2.13 Storage Cabinets or Areas

The design, construction, and use of storage cabinets, indoor storage areas, outdoor storage areas, hazardous materials storage lockers, and other occupancies shall be in accordance with NFPA 30 or, for marine applications, 46 CFR 147 covers use of cabinets and 46 CFR 92.05-10 specifies design and construction.

9.27.2.14 Storage in Construction

No construction or use of paint barges anticipated on this project.

9.27.2.15 Safety Cans and Other Portable Containers

Safety cans and other portable containers for flammable liquids having a flash point at or below 73°F (23°C) shall be labeled/listed and painted red with a yellow band around the can and the name of the contents legibly indicated on the container.

9.27.2.16 Unopened Containers

Unopened containers of flammable liquids, such as paints, varnishes, lacquers, thinners, and solvents, shall be kept in a well ventilated location, free of excessive heat, smoke, sparks, flame, or direct rays of the sun.

9.27.2.17 Refuse Cans

In areas where flammable liquids are handled or stored, a self-closing metal refuse can, listed by a nationally recognized testing laboratory, shall be provided and maintained in good condition.

9.27.2.18 Storage Areas/Tanks

Storage areas/tanks shall be surrounded by a curb, earthen dike or other equivalent means of containment of at least 6 inches (15 centimeters) in height and higher as needed to contain the contents in the event of a leak.

Other secondary containment methods that are approved by the EPA or U.S. Coast Guard can be used in lieu of curbs or dikes (double-walled tanks, etc.).

When dikes or curbs are used, provisions shall be made for draining off accumulations of ground or rain water or spills of flammable liquids.

Drains shall terminate at a safe location and shall be accessible to operation under fire conditions. If fuel and oil storage areas are subject to the provisions of 40 CFR 112 (Spill Prevention Control and Countermeasures), those provisions shall apply as well.

9.27.2.19 Leaks and Spills

Where liquids are used or handled, provisions shall be made to promptly and safely dispose of leakage or spills. Spill kits will be placed at these areas.

9.27.2.20 Flashlights and Electric Lanterns

No flashlights or electric lanterns are anticipated to be used.

9.27.2.21 Dispensing Flammable Liquids

Areas in which flammable or combustible liquids are dispensed in quantities greater than 5 gallons (22.7 liters) will be separated from other operations by at least 25 feet (7.6 meters).

Drainage away from storm drains or surface waters or other means of containment will be provided to control spills.

Adequate natural or mechanical ventilation will be provided to maintain the concentration of flammable vapor at or below 10 percent of the lower flammable limit.

Dispensing of flammable liquids from one container to another will be done only when containers are electrically interconnected (bonded).

Dispensing flammable or combustible liquids by means of air pressure on the container or portable tanks is prohibited.

Dispensing devices and nozzles for flammable liquids will be of an approved type.

9.27.2.22 Service and Refueling Areas

Dispensing hoses shall be listed. Dispensing nozzles shall be an approved automatic-closing type without a latch-open device.

Equipment using flammable liquids as fuel shall be shut down during refueling, servicing, or maintenance, except for emergency generators. Waiver requests may be reviewed and granted by the local SSHO for operations in remote sites or regions where cold weather conditions pose a significant risk when equipment fails to restart. Copy provided to Corps of Engineers Safety and Occupational Health Office (CESO).

Dispensing of Category 1 or 2 flammable liquids or Category 3 flammable liquids with a flashpoint below 100°F (37.8°C) from tanks of 55 gallons (0.20 m^3) capacity or more shall be by listed pumping arrangement. Transferring by air pressure on the container or portable tank is prohibited.

Clearly identified and easily accessible switch(es) shall be provided at a location remote from dispensing devices to shut off the power to all dispensing devices in an emergency.

A listed emergency breakaway device designed to retain liquid on both sides of the breakaway point shall be installed on each hose dispensing Category 1 or 2 flammable liquids or Category 3 flammable liquids with a flashpoint below 100°F (37.8°C) liquids.

9.27.2.23 Tank Cars/Trucks

Tank cars/trucks are not anticipated to be used on this project.

9.27.3 Liquefied Petroleum Gas

NOT APPLICABLE, Liquefied Petroleum Gas is not anticipated to be used on this project

9.27.4 Temporary Heating Devices

NOT APPLICABLE, temporary heating devices are not anticipated to be used on this project.

9.27.5 Heating Devices and Melting Kettles

NOT APPLICABLE, heating devices and melting kettles are not anticipated to be used on this project.

9.27.6 First Response Fire Protection

NOT APPLICABLE, community responders will be used on this project.

9.27.7 Fixed Fire Suppression Systems

NOT APPLICABLE, fixed fire suppression systems are not anticipated to be used on this project.

9.27.8 Firefighting Equipment

See Section 9.27.1.

9.27.9 Fire Detection and Employee Fire Alarm Systems

NOT APPLICABLE, fire detection and employee fire alarm systems are not anticipated to be used on this project.

9.27.10 Firefighting Organizations - Training and Drilling

NOT APPLICABLE, community responders will be used on this project.

9.27.11 Fire Watch

NOT APPLICABLE, hot work is not anticipated to be used on this project.

9.28 Wildland Fire Management Plan

NOT APPLICABLE, not anticipated to be exposed to wildland fires for this site.

9.29 Arc Flash Hazard Analysis

NOT APPLICABLE, this will not be performed for this task.

9.30 Assured Equipment Grounding Control Program

NOT APPLICABLE, this will not be performed for this task.

9.31 Hazardous Energy Control Program and Procedures

NOT APPLICABLE, this is not to be performed for this task. Tasks that require Lock-out/Tag-out of energy sources are not allowed to be performed on this site.

9.32 Standard Pre-Lift Plan – Load Hauling Equipment

NOT APPLICABLE, this will not be performed for this task.

9.33 Critical Lift Plan – Load Handling Equipment

NOT APPLICABLE, this will not be performed for this task.

9.34 Naval Architectural Analysis – Load Handling Equipment

NOT APPLICABLE, this will not be performed for this task.

9.35 Floating Plant Inspection and Equipment Certification

NOT APPLICABLE, this will not be performed for this task.

9.36 Severe Weather Plan for Marine Activities

NOT APPLICABLE, this will not be performed for this task.

9.37 Emergency Plan for Marine Activities

NOT APPLICABLE, this will not be performed for this task.

9.38 Man Overboard/Abandon Ship Procedures

NOT APPLICABLE, this will not be performed for this task.

9.39 Float Plan for Launches, Motorboats, and Skiffs

NOT APPLICABLE, this will not be performed for this task.

9.40 Fall Prevention and Protection Plan

NOT APPLICABLE, this will not be performed for this task. No fall hazards are anticipated for this task.

9.41 Demolition/Renovation Plan

NOT APPLICABLE, this will not be performed for this task.

9.42 Rope Access Work Plan

NOT APPLICABLE, this will not be performed for this task.

9.43 Excavation/Trenching Plan

NOT APPLICABLE, this will not be performed for this task.

9.44 Fire Prevention and Protection Plan for Underground Construction

NOT APPLICABLE, this will not be performed for this task.

9.45 Compressed Air Work Plan for Underground Construction

NOT APPLICABLE, this will not be performed for this task.

9.46 Erection and Removal Plan for Formwork and Shoring

NOT APPLICABLE, this will not be performed for this task.

9.47 Precast Concrete Plan

NOT APPLICABLE, this will not be performed for this task.

9.48 Lift-Slab Plans

NOT APPLICABLE, this will not be performed for this task.

9.49 Masonry Bracing Plan

NOT APPLICABLE, this will not be performed for this task.

9.50 Steel Erection Plan

NOT APPLICABLE, this will not be performed for this task.

9.51 Explosives Safety Site Plan

NOT APPLICABLE, this will not be performed for this task.

9.52 Blasting Plan

NOT APPLICABLE, this will not be performed for this task.

9.53 Dive Operations Plan

NOT APPLICABLE, this will not be performed for this task.

9.54 Safe Practices Manual for Diving Activities

NOT APPLICABLE, this will not be performed for this task.

9.55 Emergency Management Plan for Diving

NOT APPLICABLE, this will not be performed for this task.

9.56 Tree Felling and Maintenance Program

NOT APPLICABLE, this will not be performed for this task.

9.57 Aircraft and Airfield Construction Safety and Phasing Plan

NOT APPLICABLE, this will not be performed for this task.

9.58 Aircraft and Airfield Safety Plan Compliance Document

NOT APPLICABLE, this will not be performed for this task.

9.59 Site Safety and Health Plan

An SSHP is attached to this APP as Appendix A. The SSHP meets the requirements for work on hazardous waste sites in accordance with 29 CFR 1910.120 and 29 CFR 1926.65.

9.60 Confined Space Entry Procedures

NOT APPLICABLE, this will not be performed for this task.

9.61 Confined Space Program

NOT APPLICABLE, this will not be performed for this task.

Risk Management Process

The detailed project-specific hazards and controls are documented in the AHAs that have been prepared for each major phase of work associated with the task order. As such, AHAs have been prepared for the following task listed in Section 2.8.

The AHAs for this project are provided as attachments to the SSHP (Appendix A). No work will begin on an activity (DFOW) until the initial AHA has been accepted by the GDA addressing the project-specific hazards. Workers/crews shall have in their possession the current AHA that reflects current site conditions, personnel, equipment, control measures, etc. while the work is being performed. The AHA shall be used by the contractor and USACE personnel to assure work is being performed consistent with the AHA. In the event that the work is not being conducted in a safe manner, the contractor and/or the USACE shall stop the unsafe work being conducted until it is in compliance with this manual, APP and the AHA or the APP/ AHA is revised and accepted by the GDA, if necessary.

Appendix A
Site Safety and Health Plan

FINAL

Site Safety and Health Plan
OU-2 Remedial Investigation
700 South 1600 East PCE Plume
Salt Lake City, Utah

Contract No. W912DQ-15-D-3014 Task Order 0005

Prepared for

U.S. Army Corps of Engineers

Kansas City District
601 East 12th Street
CENWK-PM-ES
Kansas City, MO 64106-2824

Department of Veterans Affairs

Veterans Health Administration Salt Lake City Health Care System
500 Foothill Drive
Salt Lake City, UT 84148

February 2018

CH2M HILL, Inc.
4246 South Riverboat Road
Suite 210
Taylorsville, Utah 84123

Emergency Contacts

24-hour CH2M Injury Reporting– 1-866-893-2514

24-hour CH2M Serious Incident Reporting Contact – 720-286-4911

Medical Emergency – 911 University of Utah Health Care 50 N Medical Dr, Salt Lake City, UT 84132 801-581-2121 Ambulance Service – 911 or 801-972-1211	**CH2M – Medical Consultant** WorkCare Dr. Peter Greaney M.D. 300 S. Harbor Blvd, Suite 600 Anaheim, CA 92805 800-455-6155/866-893-2514 714-978-7488
Fire/Spill Emergency – 911 Facility Fire Response #: 911 Local Fire Dept #: (801) 799-3473	**CH2M Director – Health, Safety, Security & Environment** Andy Strickland/DEN 720-480-0685 (cell) or 720-286-2393 (office)
Security & Police – 911 Local Police #: (801) 799-3000 **Facility Police #:** 801-582-1565 Ext. 1414	**CH2M Responsible Health and Safety Manager** Name: Josh Painter Phone: 303-993-9274
Utilities Emergency Phone Numbers nonemergency - 811 Water: 911 Gas: 911 Electric: 911	**CH2M Human Resources Department** Phone: Employee Connect toll-free number 1-877-586-4411 (U.S. and Canada)
CH2M Project Manager Name: David Waite Phone: 385-474-8560 / 801-560-8307 (cell)	**CH2M Worker's Compensation:** Contact Market HR dept. to have form completed or contact Jennifer Rindahl after hours: 720-891-5382
CH2M Site Safety Health Officer Name: Jasin Olsen Phone: (385) 474-8542 / (801) 660-9741 (cell)	**Media Inquiries Corporate Strategic Communications** Name: John Corsi Phone: (720) 286-2087
CH2M Alternate Site Safety Health Officer Name: Ryan Hamilton Phone: (385) 474-8521 / (801) 509-2379 (cell)	**Automobile Accidents** Rental: Jennifer Rindahl/DEN: (720)286-2449 CH2M owned vehicle: Linda George/DEN: (720) 286-2057
CH2M Project Environmental Manager Name: Nancy Ballantyne Phone: 720-286-5561 / 303-885-9954 (cell)	**CHEMTEL (hazardous material spills)** Phone: (800) 255-3924
Federal Express Dangerous Goods Shipping Phone: 800/238-5355	**Evacuation Assembly Area(s):** Main facility parking area
Facility Alarms: None	

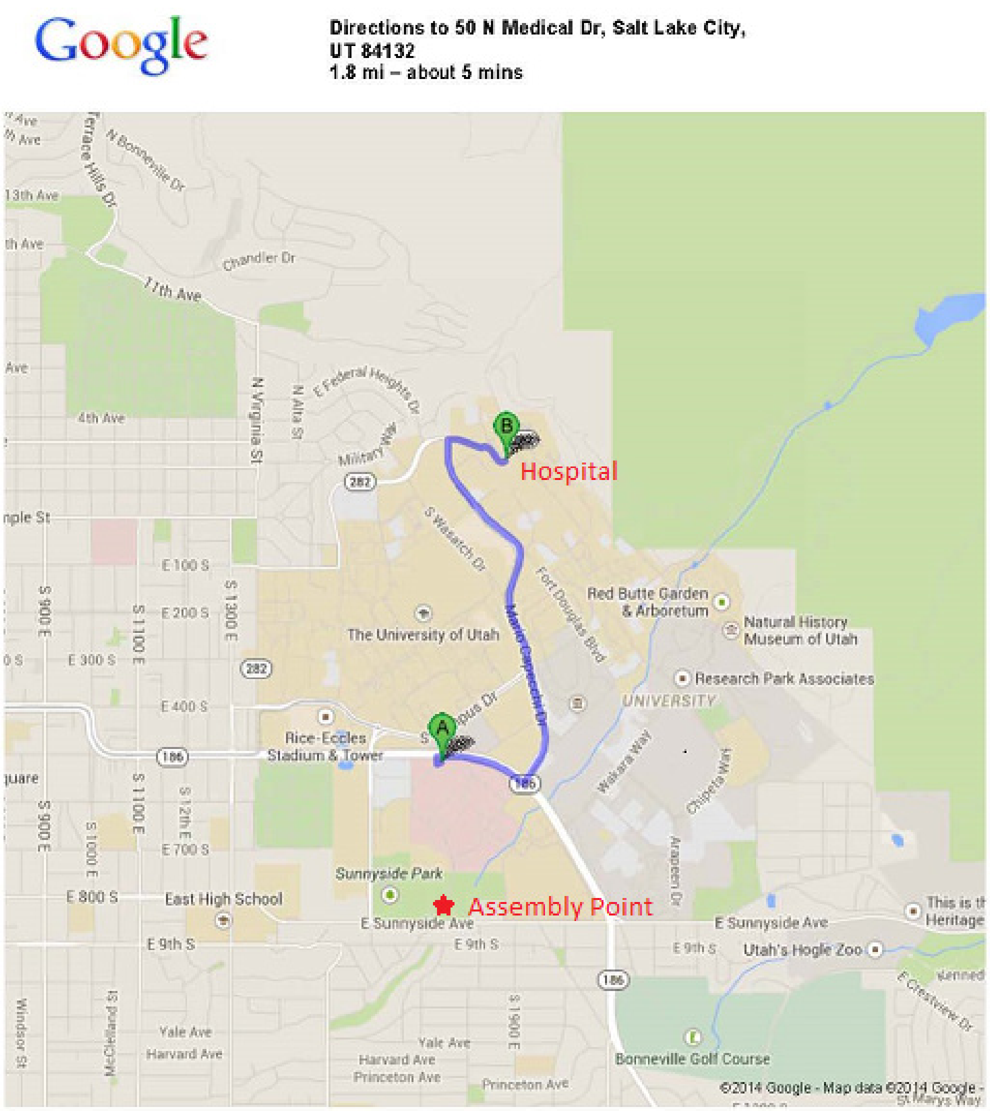
Facility/Site Evacuation Route(s): To be determined

Directions and MAP to Local Hospital

Local Hospital: **University of Utah Health Care**
50 N Medical Dr, Salt Lake City, UT 84132

George E. Wahlen Department of Veterans Affairs Medical Center
500 Foothill Dr, Salt Lake City, UT 84148
1. Head **east** on **Foothill Dr** toward **Mario Capecchi Dr**
2. Turn left onto **Mario Capecchi Dr**
3. Turn right onto **N Medical Dr**
4. Slight left to stay on **N Medical Dr**
5. Slight right to stay on **N Medical Dr**

Destination will be on the right
University of Utah Health Care
50 N Medical Dr, Salt Lake City, UT 84132



Contents

Attachments

Tables

Figures

Approval

This Health and Safety Plan (SSHP) has been written for use by CH2M HILL, Inc. (CH2M) only. CH2M claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific project and site conditions and identified scope(s) of work and must be amended if those conditions or scope(s) of work change.

By approving this SSHP, the Safety and Health Manager (SHM) certifies that the personal protective equipment has been selected based on the project-specific hazard assessment.

Original Plan

Original Plan Written by:	Josh Painter	**Date:** 6/12/17
SHM Approval:	Josh Painter	**Date**: 6/12/17
Certified Industrial Hygienist Approval:	Andy Strickland	**Date**: 6/9/17
Project Manager Approval:	David Waite	**Date:** 6/12/17

Revisions

Revisions Made By: **Date:**

Description of Revisions to Plan:

Revisions Approved By: **Date:**

Applicability

This SSHP applies to:

- All CH2M staff, including subcontractors and tiered subcontractors of CH2M working on the site
- All visitors to CH2M construction or remediation sites in the custody of CH2M (including visitors from the Client, the Government, the public, and other staff of any CH2M company).

In addition, Subcontractors and tiered subcontractors shall also follow any of their company Health, Safety, and Environment programs, and site-specific SSHPs and Activity Hazard Analyses (AHAs).

This SSHP does not apply to the third-party contractors, their workers, their subcontractors, their visitors, or any other persons not under the direct control or custody of CH2M.

This SSHP defines the procedures and requirements for the health and safety of CH2M staff and visitors when they are physically on the work site. The work site includes the project area (as defined by the contract documents) and the project offices, trailers, and facilities thereon.

This SSHP will be kept onsite during field activities and will be reviewed as necessary. The HSP will be revised as project activities or conditions change or when supplemental information becomes available. The SSHP adopts, by reference, the CH2M Enterprisewide Core Standards and Standard Operating Procedures, as appropriate. In addition, applicable requirements contained in the Environment and Nuclear (E&N) Market (E&NM) Health, Safety, Security, and Environment (HSSE) Handbook (Handbook) will be implemented. The Handbook is available as a stand-alone Handbook at the project site. The SSHP may adopt procedures from the project Work Plan and any governing regulations. If there is a contradiction between this SSHP and any governing regulation, the more stringent and protective requirement shall apply.

All CH2M staff and subcontractors must sign the employee sign-off form (Attachment 3) to acknowledge review of this document. Copies of the signature page will be maintained onsite by the Safety Coordinator (SSHO).

General Project Information

2.1 Project Information and Background

Project Number:	683085	**Project/Site Name:**	1600 East PCE Plume Superfund Site Remedial Investigation (Figure 2-1)
Client:	U.S. Army Corps of Engineers, Kansas City District Department of Veteran's Affairs	**Site Address:**	700 South 1600 East Salt Lake City, UT 84108
CH2M Project Manager:	David Waite	**CH2M Office:**	SLC
DATE SSHP Prepared:	6/12/17	**Date(s) of Site Work:**	

2.2 Site Description

The site description, contamination characterization, and project information are detailed in the Accident Prevention Plan (APP) and will not be duplicated in the SSHP. Section 2.4 describes the site contaminant and exposure pathways.

2.3 Description of Tasks Requiring Activity Hazard Analysis

Below is a description of the tasks covered by this plan that require an AHA. Sections 15 and 16 of this SSHP break down the tasks and identify control measures to be documented in the AHAs attached to this SSHP. Any additions or changes in scope will require a revision to this SSHP (Section 2.5).

- Mobilization and Site Setup
  - Utility locates/Site survey
  - Traffic Control
- Groundwater Well Drilling and Installation
  - Monitoring well sonic drilling
  - Install monitoring well with dedicated pumps and transducer
  - Geophysical, geotechnical testing on soil cores
- Groundwater Monitoring Well Slug Testing
- Investigation-derived Waste (IDW) Management
- Decontamination/Demobilization

2.4 Contaminants of Concern

The Table 2-1 summarizes the potential contaminants of concern (COCs) and their occupational exposure limit and signs and symptoms of exposure. The table also includes the maximum concentration of each COC and the associated location and media that was sampled (groundwater, soil boring, surface soil). These concentrations were used to determine engineering and administrative controls described in the “Project-Specific Hazard Controls” section of this SSHP, as well as personal protective equipment (PPE) and site monitoring requirements.Table 2-2 shows potential

Table 2-1. Contaminants of Concern

Contaminant	Location and Maximum[a] Concentration	Exposure Limits[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[d] (eV)
Tetrachloroethylene (PCE)	GW: 320 µg/L	25 ppm	150 Ca	Eye, nose, and throat irritation; nausea; flushed face and neck; vertigo; dizziness; sleepiness; skin redness; headache; liver damage	9.32
Trichloroethylene (TCE)	GW: 4.0 µg/L	10 ppm	1,000 Ca	Headache, vertigo, visual disturbance, eye and skin irritation, fatigue, giddiness, tremors, sleepiness, nausea, vomiting, dermatitis, cardiac arrhythmia, paresthesia, liver injury	9.45

[a] Specify sample-designation and media: SB (Soil Boring), A (Air), D (Drums), GW (Groundwater), L (Lagoon), TK (Tank), SS (Surface Soil), SL (Sludge), SW (Surface Water).
[b] Appropriate value of permissible exposure limit, recommended exposure limit, or threshold limit value listed.
[c] IDLH = immediately dangerous to life and health (units are the same as specified "Exposure Limit" units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen.
[d] PIP = photoionization potential.

Notes:
µg/L = microgram(s) per liter
µg/m^3 = microgram(s) per cubic meter
eV = electron volt
mg/kg = milligram(s) per kilogram
mg/m^3 = milligram(s) per cubic meter
ppm = parts per million

Table 2-2. Potential Routes of Exposure

Potential Routes of Exposure		
Dermal: Contact with contaminated media. This route of exposure is minimized through use of engineering controls, administrative controls and proper use of PPE.	**Inhalation:** Vapors and contaminated particulates. This route of exposure is minimized through use of engineering controls, administrative controls, and proper use of respiratory protection when other forms of control do not reduce the potential for exposure.	**Other:** Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before drinking or smoking).

2.4.1 Description of Site Contamination

The history of site contamination is identified in Section 2.4 of the APP. The main COC for this project is PCE with a secondary COC of TCE. Both COCs have been detected in very low concentrations (Table 2-1) within the groundwater zone. All groundwater and soils from the groundwater zone shall be considered contaminated until proven to be clean by waste characterization testing.

2.4.2 Worker Exposure

Potential exposure to workers above the listed exposure limit in Table 2-1, is not anticipated. Exposure modeling performed by CH2M has shown that the likely route of exposure would be from dermal contact. All employees must follow the PPE requirements in Section 5. Inhalation of COC vapors is not anticipated in the open air work areas that will be encountered. Ingestion of COC's will be prevented by following the decontamination requirements of Section 11. While exposure to site COCs above the listed exposure limit is not anticipated, it is CH2M's goal to eliminate all exposures by following the Hierarchy of Controls, PPE, Air Monitoring, and Decontamination requirements identified in the APP and this SSHP. All site employees will be trained on the signs and symptoms of exposure listed in Tables 2-1 and 2-2.

2.5 Change Management

Changes to this SSHP shall be documented and approved by the CH2M Responsible Health and Safety Manager for the project. The following are examples of changes that may require a revision to the plan:

- Change in CH2M staff
- New subcontractor to perform work
- New chemicals brought to site for use
- Change in scope or addition of new tasks
- Change in COCs or change in concentrations of COCs
- New hazards or hazards not previously identified that are not addressed in this SSHP

2.6 Changes to Health and Safety Plans

Changes to the SSHP shall be documented and accepted by using the Health and Safety Field Change Request (FCR) form (Attachment 3X) or by resubmitting a revised SSHP for acceptance. A revised SSHP should be produced when a large number of changes (e.g., 15 or more not including AHAs) using FCRs has been employed. The CH2M Project Manager (PM) and SHM shall be responsible for the review and acceptance of the FCR, and the SHM will maintain an FCR log of approved changes. Field Change Requests are not required for safety-related changes that a SSHO or SHM would normally make in the field, such as upgrade or downgrade to PPE within pre-established action levels, expansion or reduction of work control zones based on air monitoring results, and similar changes made within the operating parameters of the SSHP. The field copy of the SSHP shall be kept up to date by annotating the appropriate section (i.e., update to AHA) to indicate that an FCR is in effect; copies of FCRs should be kept with the SSHP. The FCR number must be referenced in the SSHP and available for review.

2.7 Daily Safety Meetings and Pre-Task Safety Plans

Safety meetings are to be held with all project personnel in attendance to review the hazards, controls, and required procedures/AHAs that apply for each day's activities, as well as any environmental issues, requirements and/or best management practices:

Everyone involved in the day's work needs to sign a sign-in form to show they've had a briefing/attended a meeting.

Pre-Task Safety Plans (PTSPs) serve the same purpose as general safety meetings, but the PTSPs are completed by individual crews to focus on those hazards posed by their specific work.

For smaller crews, or if there is just one activity, the PTSP is often used as a means to document the overall Safety Meeting.

A copy of the PTSP and Daily Safety Meeting sign-in sheet is included in Attachment 3.

2.8 Subcontractor HSSE Chartering Meeting

A subcontractor HSSE chartering meeting shall be held with subcontractors performing fieldwork on the project. The purpose of the meeting is to discuss and agree on key HSSE requirements on a project, and to emphasize and reinforce CH2M expectations for subcontractor HSSE performance. The target audience includes key CH2M project staff with HSSE responsibilities (e.g., PM, SHM, SSHO, Field Team Leader [FTL]) and key Subcontractor staff (e.g., project manager, supervisors, designated field HSSE contact, drill team leads, foreman). For small scale projects (e.g., small drill crew and limited CH2M staff), all the subcontractor crew members should attend if available. The meeting should be held prior to mobilization with enough time to ensure that HSSE issues identified can be addressed prior to the start of work. The meeting can be held over the phone or in person depending on project needs. An example agenda can be found in the E&NM Program Element Guideline, "Subcontractor HSSE Chartering Meeting."

Figure 2-1. Location Map of 700 South 1600 East PCE Plume

SECTION 3

Staff Organization, Qualifications, and Responsibilities

A full description of responsibilities, including Employee Responsibilities and Authority, can be found in the Handbook, Section 3, “Roles and Responsibilities.” Required qualifications are attached to this SSHP for review.

3.1 Client

Contact Name:	Josephine Newton-Lund or D. Lynne Welsh
Phone:	(816) 389-3912 / (801) 582-1565 ext 2021
Facility Contact Name:	Same as above
Phone:	Same as above

3.2 CH2M

Project Manager:		**Environmental Manager:**	
PM Name:	David Waite	**EM Name:**	Nancy Ballantyne
Office:	SLC	**Office:**	DEN
Telephone number:	801-350-5272	**Telephone number:**	720-286-5561
Cellular Number:	801-560-8307	**Cellular Number:**	303-885-9954

Responsible Safety and Health Manager:		**Safety Coordinator:**	
SHM Name:	Josh Painter	**SSHO Name:**	Jasin Olsen
Office:	DEN	**Office:**	SLC
Telephone number:	303-993-9274	**Telephone**	385-474-8542
Cellular Number:	303-993-9274	**Cellular Number:**	801-660-9741

Alternate SSHO:	
Alt SSHO Name:	Ryan Hamilton
Office:	SLC
Telephone:	385-474-8521
Cellular Number:	801-509-2379

3.3 CH2M Subcontractors

Subcontractor: To be determined	**Subcontractor:**
Contact Name:	**Contact Name:**
Telephone number:	**Telephone**
Cellular Number:	**Cellular Number:**

3.4 Client Contractors

Client Contractor: NONE	Client Contractor:
Contact Name:	**Client Name:**
Telephone number:	**Telephone**
Cellular Number:	**Cellular Number:**

This SSHP does not cover contractors that are contracted directly to the client or the owner. CH2M is not responsible for the health and safety or means and methods of the client contractor's work, and we must never assume such responsibility through our actions (such as advising on health and safety issues).

SECTION 4

Training

4.1 CH2M Worker Training

The following training is required for CH2M personnel working onsite. Copies of training will either be available onsite or readily available from the CH2M HandS training database system. Refer to Section 12 of the Handbook for a description of Hazardous Waste Operations and Emergency Response (HAZWOPER)-related and SSHO training.

Required CH2M Worker Training	**CH2M Task or Equipment-Specific Training (if performing task)**
☒ 40-hour HAZWOPER Training	☐ Aerial Lift Operator Training
☒ 8-hour HAZWOPER Refresher	☐ Confined Space Entry Training
☒ 3-day HAZWOPER On-the-job Training	☐ Excavation Competent Person
☒ CH2M SSHP Training	☐ Fall Protection (site-specific)
☒ CH2M ESBG HSSE Guidelines	☐ Forklift Operator
☒ CH2M AHAs	☒ Hazard Communication
☒ Subcontractor SSHP	☐ On-Track Railroad Safety Training
☐ 10-hour OSHA Construction Safety Training	☐ NFPA 70E Training (energized electrical safety training)
☒ At least one SSHO-HW (refer to worker category for all applicable training needed)	☐ Qualified Earthmoving Equipment Operator
☒ HWW	☐ Scaffold Training
Project-Specific Required (VO) Training	
☒ Drum Handling Training	☒ Manual Lifting Training
☒ Electrical Safety Training	☒ Noise Training
☒ Hand Safety Training	☒ Traffic Safety Training

4.2 Subcontractor Worker Training

The following training is required for Subcontractor personnel working onsite. Copies of training shall be available onsite.

Required Subcontractor Worker Training	**Subcontractor Task or Equipment-Specific Training (required if performing this work)**
☒ 40-hour HAZWOPER Training	☐ Aerial Lift Operator Training
☒ 8-hour HAZWOPER Refresher	☐ Asbestos Competent Person
☒ 8-hour HAZWOPER Supervisor	☐ Asbestos Training (Supervisor, Worker)
☒ 3-day HAZWOPER On-the-job Training	☐ Confined Space Entry Training
☒ CH2M APP/SSHP Training	☐ Certified Crane Operator

Required Subcontractor Worker Training	**Subcontractor Task or Equipment-Specific Training (required if performing this work)**
☒ Subcontractor AHAs	☐ Crane Assembly/Disassembly Competent Person
☒ Subcontractor HSP	☒ Fall Protection (site-specific)
☒ CH2M E&NM HSSE Handbook	☒ Forklift Operator (Certified)
☒ First Aid/CPR/BBP – at least 2 people	☒ Hazard Communication
☐ Other (specify)	☒ Qualified Drill Rig Operator

4.3 HAZWOPER-Exempted Tasks

The following tasks are not within the scope of the HAZWOPER standard so HAZWOPER training is not required for workers performing these tasks:

Task	**Task**
Mobilization and Site Setup	Demobilization
Utility locates/Site survey	

SECTION 5

Personal Protective Equipment

PPE must be worn by employees when actual or potential hazards exist and engineering controls or administrative practices cannot adequately control those hazards.

A PPE assessment has been conducted by the SHM based on project tasks (Table 5-1). Verification and certification of assigned PPE by task is completed by the SHM that approved this plan. Refer to the Handbook, Section 11, “Personal Protective Equipment,” for requirements on the use, care, and maintenance of PPE.

The table below outlines PPE to be used according to task based on project-specific hazard assessment. If a task other than the tasks described in this table needs to be performed, contact the SHM so this table can be updated.

Table 5-1. Project-Specific Personal Protective Equipment Requirements[a]

Task	Level	Body	Head	Respirator [b]
General fieldwork outside in Support Zone Mobilization and Site Setup – Utility locates – Traffic Control Demobilization	D	☒ Work clothes (sleeved shirt, long pants) ☒ Safety-toed Boots ☒ Gloves (leather) ☒ ANSI/ISEA 107-2010 high visibility vest	☒ANSI Z89.1 Hardhat [c] ☒ANSI Z87.1 Safety glasses ☐Hearing protection [d]	None required
Any task where contact with site COC’s is limited to the hands; Groundwater Well Drilling and Installation – Monitoring well sonic drilling – Install monitoring well with dedicated pumps and transducers – Geophysical, geotechnical testing on soil cores Groundwater Monitoring Well Slug Testing Investigation Derived Waste (IDW) Management Decontamination	Modified D	☒ Work clothes ☒ ANSI/ISEA 107-2010 high visibility vest ☒ Safety-toed boots ☒ Inner surgical-style nitrile ☒ Outer Work gloves.	☒ANSI Z89.1 Hardhat [c] ☒ANSI Z87.1 Safety glasses ☒Hearing protection [d]	None required
Any task where contact with site COC’s is **NOT** limited to the hands; Groundwater Well Drilling and Installation – Monitoring well sonic drilling – Geophysical, geotechnical testing on soil cores Groundwater Monitoring Well Slug Testing	Modified D	☒ Work clothes ☒ Polycoated Tyvek ☒ Safety-toed boots ☒ Outer boot covers ☒ Inner surgical-style nitrile ☒ Outer chemical-resistant nitrile gloves. ☒ Outer Work gloves	☒ANSI Z89.1 Hardhat [c] ☒ANSI Z87.1 Safety glasses ☒Hearing protection [d]	None required.

Table 5-1. Project-Specific Personal Protective Equipment Requirements[a]

Task	Level	Body	Head	Respirator [b]
Equipment decontamination if using pressure washer Drilling/Decontamination	Modified D with splash protection	☒ Polycoated Tyvek or Rain Suit ☒ Safety-toed boots ☒ Outer boot covers ☒ Inner surgical-style nitrile ☒ Outer work gloves.	☒ANSI Z89.1 Hardhat [c] ☒ANSI Z87.1 Safety glasses ☒Hearing protection [d] ☒ Face shield	None required.

Reasons for Upgrading or Downgrading Level of Protection (with approval of the SHM)	
Upgrade[f]	**Downgrade**
Request from individual performing tasks. Change in work tasks that will increase contact or potential contact with hazardous materials. Occurrence or likely occurrence of gas or vapor emission. Known or suspected presence of dermal hazards. Instrument action levels in the “Site Monitoring” section exceeded.	New information indicating that situation is less hazardous than originally thought. Change in site conditions that decrease the hazard. Change in work task that will reduce contact with hazardous materials.

[a] Modifications are as indicated. CH2M will provide PPE only to CH2M employees.
[b] No facial hair that would interfere with respirator fit is permitted.
[c] Hardhat and splash-shield areas are to be determined by the SSHO.
[d] Ear protection should be worn when conversations cannot be held at distances of 3 feet (1 meter) or less without shouting.
[e] See cartridge change-out schedule.
[f] Performing a task that requires an upgrade to a higher level of protection (e.g., Level D to Level C) is permitted only when the PPE requirements have been approved by the SHM, and an SSHO qualified at that level is present.

Medical Surveillance and Qualification

The following medical surveillance is required for CH2M and subcontractor personnel working onsite. Copies of physician's medical opinion will either be available onsite, or for CH2M staff, readily available from the CH2M HandS training database system. Refer to Section 13 of the Handbook for a description of HAZWOPER, respirator user, and hearing conservation medical surveillance.

General Required Medical Surveillance	**Job or Activity-Specific Medical Surveillance (required if performing this work)**
☒ HAZWOPER Medical Clearance	☐ Noise
☒ Respirator Medical Clearance	☐ Baseline Blood Lead
	☐ Asbestos Medical Clearance
	☐ Other (specify):
Personnel or Tasks Not Requiring Medical Surveillance	
Mobilization/ Demobilization	

SECTION 7

Exposure Monitoring/Air Sampling Program

For each task listed in the table below, perform the associated monitoring ensuring the equipment is calibrated daily according to the manufacturer's recommendations. Use the Daily Site Monitoring Form (or equivalent) to document the calibration and the readings taken. Retain area monitoring readings with project records.

Exposure records (breathing zone and personal air sampling) must be preserved for the duration of employment plus thirty years. Copies of all project exposure records (e.g., copies of Daily Site Monitoring form or field logbook pages where breathing zone readings are recorded along with associated calibration) shall be sent to the Sector Safety Program Assistant for retention and also maintained in the project files.

Subcontractors are responsible for monitoring and performing integrated personal sampling for their employees as documented in their SSHP or, if permitted, according to the table below.

7.1 Direct Reading Monitoring Specifications

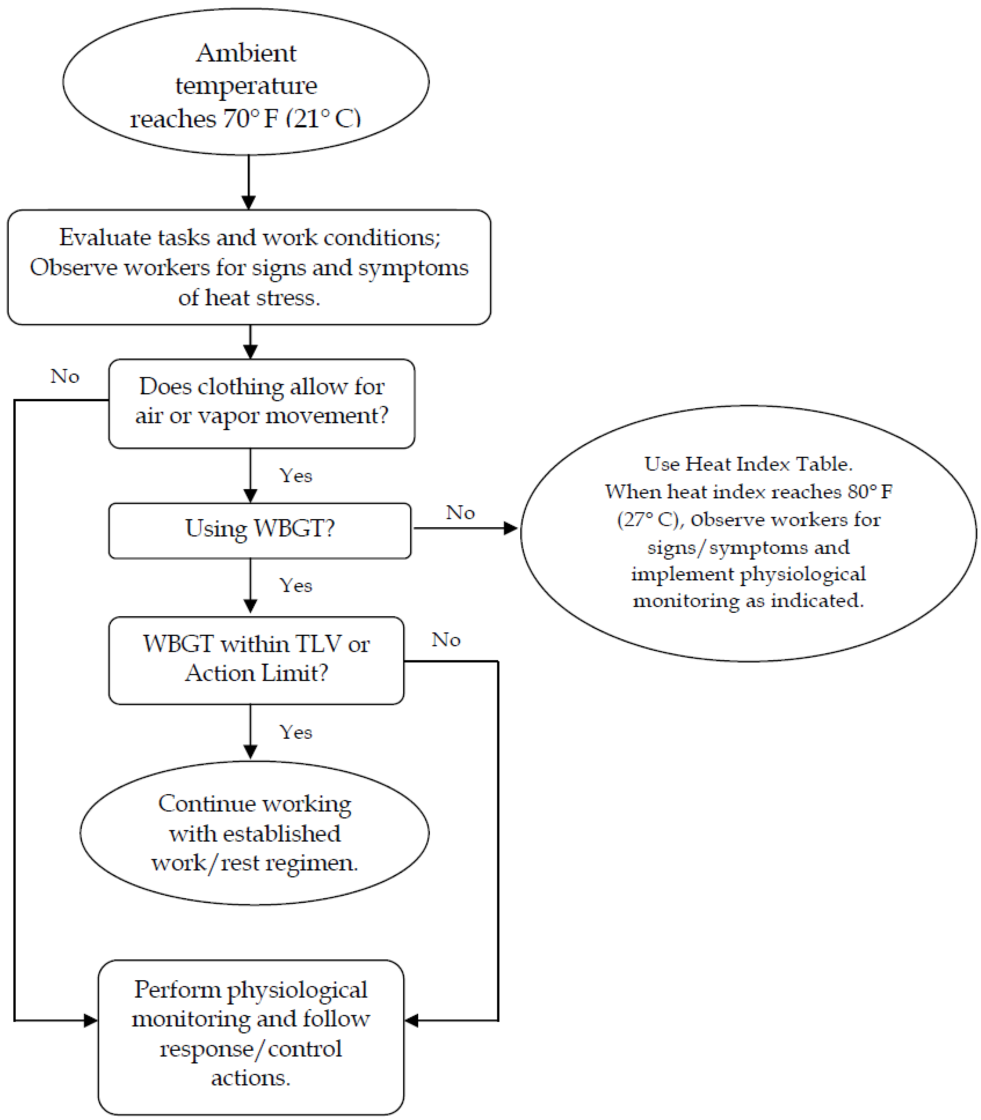
Instrument	Tasks	Action Levels[a]	Action to be Taken when Action Level reached	Frequency [b]	Calibration
FID: OVA model 128 or equivalent PID with 10.6 eV bulb Based on PCE	GW Well Drilling and Installation Soil sampling GW Monitoring Well Sampling	<10 ppm >10 ppm	Level D, Continue work Stop work and contact SHM to discuss engineering controls and potential PPE upgrade	Initially and periodically during tasks	Daily
Heat Stress Monitor - Refer to Flow Chart Below ☒ Ambient Temperature ☒ Heat Index ☐ WetBulb Globe Temperature ☐ Physiological ☐ Pulse ☐ Temperature	All Tasks	Refer to the Handbook for the type of monitoring conducted.	Refer to the Handbook for the type of monitoring conducted.	When Heat Index reaches criteria.	

[a] Action levels apply to sustained breathing-zone measurements above background.
[b] The exact frequency of monitoring depends on field conditions and is to be determined by the SSHO; generally, every 5 to 15 minutes if acceptable; more frequently may be appropriate.
[c] If the measured percent of O_2 is less than 10, an accurate LEL reading will not be obtained. Percent LEL and percent O_2 action levels apply only to ambient working atmospheres, and not to confined-space entry. More-stringent percent LEL and O_2 action levels are required for confined-space entry.
[d] Noise monitoring and audiometric testing also required.

7.2 Heat Stress Monitoring Flow Chart

Use the flow chart below and refer to the applicable protocol in Section 9 of the Handbook for heat stress monitoring.

Thermal Stress Monitoring Flow Chart



Heat and Cold Stress

The procedures and practices for protecting workers from heat and cold stress are identified in Section 9.19 of the APP and Section 7 of this SSHP.

Standard Operating Safety Procedures

Site rules/prohibitions:

Site Rules/Prohibitions are identified in Section 4 of the APP.

Work permit requirements:

Work permit requirements are identified in Section 7 of the APP.

Material-handling procedures:

Material-handling procedures for waste materials created during drilling activities are specifically outlined in the project Waste Management Plan that is part of the Remedial Investigation Work Plan.

Drum/container/tank handling:

Below are the hazard controls and safe work practices to follow when overseeing the movement of drums or when handling drums:

- Ensure that personnel are trained in proper lifting and moving techniques to prevent back injuries.
- Ensure drum or tank bungs and lids are secured and are labeled prior to moving.
- Ensure that drums and tanks remain covered, except when removing or adding material or waste. Covers and/or lids will be properly secured at the end of each workday.
- Provide equipment to keep the operator removed from the drums to lessen the likelihood of injury. Such equipment might include: a drum grappler attached to a hydraulic excavator; a small front-end loader, which can be either loaded manually or equipped with a bucket sling; a rough terrain forklift; Roller conveyor equipped with solid rollers; drum carts designed specifically for drum handling.
- Make sure the vehicle selected has sufficient rated load capacity to handle the anticipated loads, and make sure the vehicle can operate smoothly on the available road surface.
- Ensure there are appropriately designed Plexiglas cab shields on loaders, backhoes, etc., when handling drums containing potentially explosive materials.
- Equipment cabs should be supplied with fire extinguishers, and should be air-conditioned to increase operator efficiency.
- Supply operators with appropriate respiratory protective equipment when needed.
- Ensure that drums are secure and are not in the operator’s view of the roadway.
- Prior to handling, all personnel should be warned about hazards of handling.
- Before moving anything, determine the most appropriate sequence in which the various drums, portable tanks, and other containers should be moved (e.g., small containers may have to be removed first to permit heavy equipment to enter and move the drums.
- Overpack drums and an adequate volume of absorbent should be kept near areas where minor spills may occur.
- Use containers or overpacks that are compatible with the waste or materials.
- Drums containing liquids or hazardous waste will be provided with secondary containment and may not be located near a storm water inlet or conveyance.

- Allow enough aisle space between drum pallets and between drums and other equipment that the drums can be easily accessed (at least 2 to 3 feet) by fire control equipment and similar equipment.
- Make sure that a spill kit is available in drum or tank storage areas (or where liquids are transferred from one vessel to another).

Comprehensive AHA of treatment technologies employed at the site:

Not applicable, no treatment technologies will be employed at the site.

SECTION 10

Site Control Measures

Site control is established to prevent the spread of contamination throughout the site and to ensure that only authorized individuals are permitted into potentially hazardous areas. Task-specific control measures are listed below.

Site Control for General Work Area(s)			
☐ Perimeter fencing	Location:	☒ Barricades	Location: Traffic controls
☒ Signage	Location: Exclusion Zone (EZ)	☒ Other: Caution tape	Location: EZ
☒ Traffic control devices	Location: According to traffic management plan	☐ Other: ____________	Location:

Location	Site Control Procedure (discuss important elements such as signs, barricades, briefings, qualifications, required supplies and equipment, sign-in/out logs, etc.)
Support Zone	Stage supplies and support facilities in this zone
Contamination Reduction Zone	For well drilling and sampling, establish a contamination reduction zone (CRZ) at the edge of the EZ to perform decontamination of personnel and equipment.
Exclusion Zone	For well drilling and sampling, establish EZ to encompass the drill or well site. Place signage on the EZ to identify hazards and required PPE.

10.1 Site-Control Procedures

Site control is established to prevent the spread of contamination throughout the site and to ensure that only authorized individuals are permitted into potentially hazardous areas.

The SSHO will implement site control procedures including the following bulleted items.

- Establish support, contamination reduction, and exclusion zones. Delineate with flags or cones as appropriate. Support zone should be upwind of the site. Use access control at entry and exit from each work zone.
- Establish onsite communication consisting of the following:
  - Line-of-sight and hand signals;
  - Air horn; and
  - Two-way radio or cellular telephone if available.
- Establish offsite communication.
- Establish and maintain the “buddy system.”

10.2 Remediation Work Area Zones

A three-zone approach will be used to control areas where site contaminants exist. Access will be allowed only after verification of appropriate training and medical qualification. The three-zone approach shall include an EZ, CRZ and a Support Zone (SZ).

Site work zones should be modified in the field as necessary, based on such factors as equipment used, air monitoring results, environmental conditions, or alteration of work plans. The following guidelines shall be used for establishing and revising these preliminary zone designations.

10.2.1 Support Zone

The SZ is an uncontaminated area (trailers, offices, field vehicles, etc.) that will serve as the field support area for most operations. The SZ provides field team communications and staging for emergency response. Appropriate sanitary facilities and safety and emergency response equipment will be located in this zone. Potentially contaminated personnel/materials are not allowed in this zone. The only exception will be appropriately packaged and decontaminated materials, or personnel with medical emergencies that cannot be decontaminated.

10.2.2 Contamination Reduction Zone

The CRZ is established between the EZ and the SZ, upwind of the contaminated area where possible. The CRZ provides an area for decontamination of personnel, portable handheld equipment and tools, and heavy equipment. In addition, the CRZ serves as access for heavy equipment and emergency support services.

10.2.3 Exclusion Zone

The EZ is where activities take place that may involve exposure to site contaminants and/or hazardous materials or conditions. This zone shall be demarcated to prevent unauthorized entry. More than one EZ may be established if there are different levels of protection to be employed or different hazards that exist in the same work area. The EZ shall be large enough to allow adequate space for the activity to be completed, including field personnel and equipment, as well as necessary emergency equipment.

The EZ shall be demarcated with some form of physical barrier or signage. The physical barrier or signage shall be placed so that they are visible to personnel approaching or working in the area. Barriers and boundary markers shall be removed when no longer needed.

Personal Hygiene and Decontamination

Refer to the Handbook, Section 15, "Decontamination," for a complete description of decontamination activities and diagrams of typical decontamination areas. Decontamination areas will be established for work in potentially contaminated areas to prevent the spread of contamination. Decontamination areas should be located upwind of the exclusion zone where possible and should consider any adjacent or nearby projects and personnel. No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones.

All contaminated material generated through the personnel and equipment decontamination processes (e.g., contaminated disposable items, gross debris, liquids, sludges) will be properly containerized and labeled, stored at a secure location, and disposed in accordance with project plans.

Type of Decontamination	Activity	Equipment	Process/Protocol
Personnel Dry Decon	Groundwater Well Drilling and Installation Groundwater Monitoring Well Slug Testing IDW Management Decontamination	☐ Tubs/brushes for boot/glove wash ☒ Solids disposal bag or drum (used PPE) ☐ Liquid disposal drum (decon water)	☐ Boot wash/rinse ☒ PPE disposal (no decon) ☒ PPE waste area identified ☐ Other: _______

11.1 Decontamination During Medical Emergencies

Standard personnel decontamination practices will be followed whenever possible. For emergency life-saving first aid and/or medical treatment, normal decontamination procedures may need to be abbreviated or omitted. In this situation, site personnel shall accompany contaminated victims to advise emergency response personnel on potential contamination present and proper decontamination procedures.

Outer garments may be removed if they do not cause delays, interfere with treatment, or aggravate the problem. Protective clothing can be cut away. If the outer garments cannot be safely removed, a plastic barrier between the individual and clean surfaces should be used to help prevent contaminating the inside of ambulances or medical personnel. Outer garments can then be removed at the medical facility.

Equipment Decontamination

An equipment decontamination station shall be set up in the CRZ for equipment to be decontaminated when exiting the EZ. Equipment that comes into contact with contaminated media shall be decontaminated as below;

Type of Decontamination	Activity	Equipment	Process/Protocol
Equipment Dry Decon	Groundwater Well Drilling and Installation Groundwater Monitoring Well Slug Testing IDW Management	☒ Table for equipment decon/staging ☐ Decon pad for vehicles ☐ Pressure Washer ☒ PPE used during decon ☒ Decon supplies (brushes, brooms) ☒ Containers/method to capture decon waste	☒ Equipment wiped/cleaned before leaving CRZ ☒ Vehicle tires dry deconned prior to leaving site ☐ Vehicle tires washed prior to leaving site ☐ Other: _______
Equipment Wet Decon	Groundwater Well Installation / Drilling	☒ Table for equipment decon/staging ☐ Decon pad for vehicles ☒ Pressure Washer ☒ PPE used during decon ☒ Decon supplies (brushes, brooms) ☒ Containers/method to capture decon water and or sludge	☒ Equipment wiped/cleaned before leaving CRZ ☒ Vehicle tires dry deconned prior to leaving site ☐ Vehicle tires washed prior to leaving site ☐ Other: _______

Emergency Equipment and First Aid

The following facilities and equipment are required and used for safe completion of work:

Facility	Type	Location
☐ Worker Showers/lockers		
☒ Restrooms	Portable Facilities	Support Zone
☐ Supplementary Illumination (during hours of low-visibility)		
☒ Emergency Eyewash	Portable	Support Zone
☐ Emergency Shower		
☒ First aid kit/supplies	Portable	Support Zone
☒ Fire extinguishers	20 # ABC	Drill rig
☒ Spill Kit(s)	Petroleum kit	Drill rig
☒ Potable Water	Bottled water	Support Zone
☐ Shade/rest area		
☒ Heated rest area	Project vehicle or field office	Support Zone
☐ Other________________________		

13.1 First Aid and CPR Requirements

First aid and CPR training consistent with the requirements of a nationally recognized organization such as the Red Cross Association, National Safety Council, or equivalent country organization shall be administered by a certified trainer. A minimum of two personnel per active field operation will have first aid and CPR training. Bloodborne pathogen training located on CH2M's Virtual Office is also required for those designated as first aid/CPR trained.

Emergency Response and Contingency Procedures

14.1 Pre-Emergency Planning

An agreement shall be established between CH2M and local emergency responders, and the servicing emergency medical facility that specifies the responsibilities of on-site personnel, emergency response personnel, and the emergency medical facility in the event of an on-site emergency. This agreement shall be established prior to the start of fieldwork.

Personnel responsible for coordinating emergency situations during site activity are identified below. The Emergency Contacts Page is at the front of this Plan. A site map showing assembly points and directions to the authorized medical facility is included below (Figure 14-1). Documented rehearsal and critique of this plan is required at least once during the task, or more often as necessary.

Responsibility	Name	Phone Number(s)
Emergency Response Coordinator (ERC)	Jasin Olsen	385-474-8542 / 801-660-9741 (cell)
Alternate ERC	David Waite	801-350-5272 / 801-560-8307 (cell)
Type (desk or field) and frequency of rehearsal		Field rehearsal at the start of task

If an emergency situation develops that requires evacuation of the work area, the following steps shall be implemented. The assembly point in the case of evacuation is the parking lot of Sunnyside Park (Figure 14-1).

Evacuation Step	Methods and comments:
Notify affected workers	Emergency Response Coordinator (ERC) to tell effected workers
Evacuate to safe location	Depending on emergency, ERC to determine rally points during Daily Safety Briefing (PTSP)
Assemble and account for workers	ERC to use PTSP or Safety Briefing sign-in sheet
Notify Supervisor/Manager	ERC notifies using cell phone
Complete incident report	Hours & Incident Tracking System

Google

Directions to 50 N Medical Dr, Salt Lake City, UT 84132
1.8 mi – about 5 mins

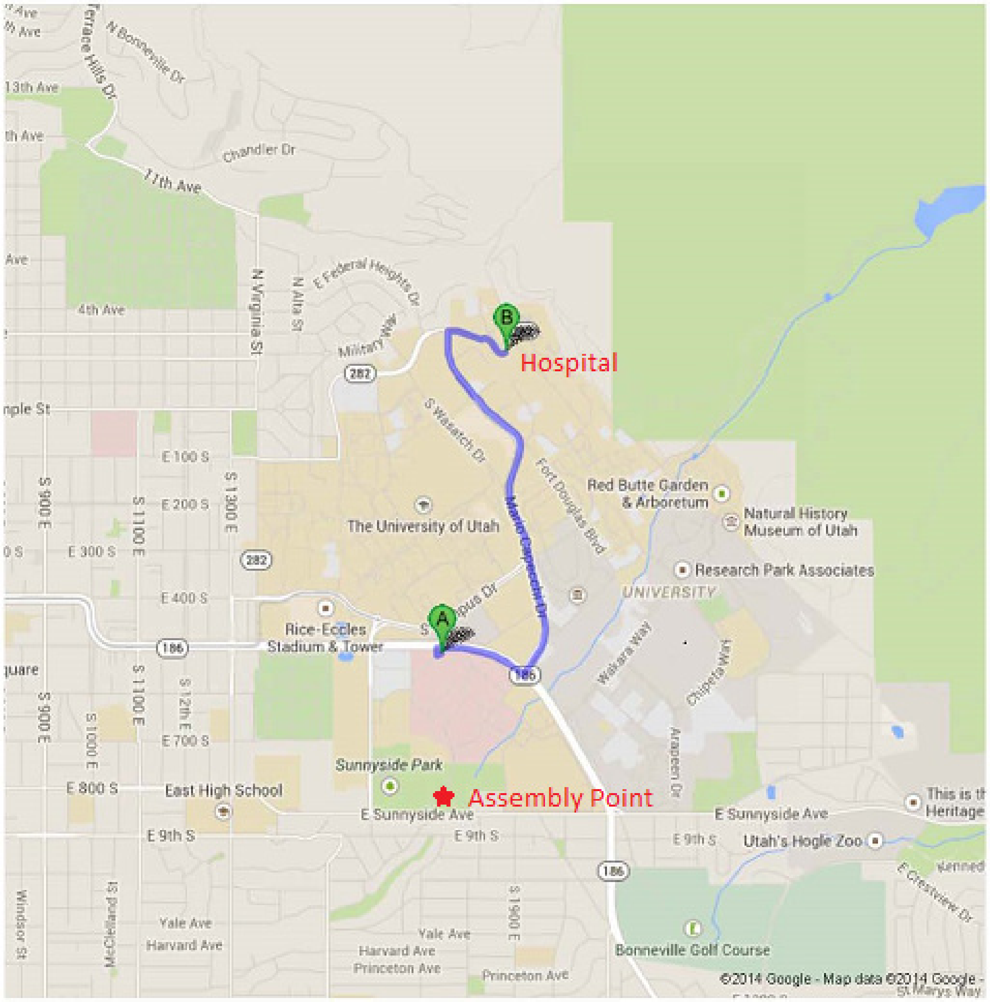


Figure 14-1. Route to Hospital and Assembly Point.

Potential emergency situations and response actions are identified below.

In case of:	Response actions:
Injury or illness	Call Occupational Nurse Line, supervisor, and SHM if non-emergency. Call 911 for emergency
Chemical exposure	Call Occupational Nurse Line, supervisor, and SHM if non-emergency. Call 911 for emergency
Fire or explosion	Call 911 for emergencies within non-range controlled areas. Call Range Control for emergencies within firing range areas or unknown.
Adverse weather	Call supervisor, and SHM if non-emergency. Call 911 for emergency
Heat Stroke	Call 911, have a designee give location and directions to ambulance service if needed. If CH2M employee, call occupational physician at 1-866-297-2725.
Material spill or release	Call Environmental Manager, supervisor, and SHM if non-emergency. Call 911 for emergency

Evacuation Signals:	Meaning:
Grasping throat with hand	Emergency-help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

In the event of a **large quantity spill** notify emergency services. Personnel discovering a spill shall (only if safe to do so):

- Stop or contain the spill immediately (if possible) or note source. Shut off the source (e.g., pump, treatment system) if possible. If unsafe conditions exist, then leave the area, call emergency services, inform nearby personnel, notify the site supervisors, and initiate incident reporting process. The SSHO shall be notified immediately.
- Extinguish sources of ignition (flames, sparks, hot surfaces, cigarettes).
- Clear personnel from the spill location and barricade the area.
- Use available spill control equipment in an effort to ensure that fires, explosions, and releases do not occur, recur, or spread.
- Use sorbent materials to control the spill at the source.
- Construct a temporary containment dike of sorbent materials, cinder blocks, bricks or other suitable materials to help contain the spill.
- Attempt to identify the character, exact source, amount, and extent of the released materials. Identification of the spilled material should be made as soon as possible so that the appropriate cleanup procedure can be identified.
- Contact the SHM and Project EM in the event of a spill or release immediately so evaluation of reportable quantity requirements and whether agency reporting is required.
- Assess possible hazards to human health or the environment as a result of the release, fire, or explosion.
- Follow incident notification, reporting, and investigation section of this plan.

Communications

A primary and backup means of communication for field crews have been established as described below:

Type of Communication	Primary Means	Backup Means
Communication between field crew	☒ Voice ☐ Radio ☐ Phone	☐ Voice ☐ Radio ☒ Phone
Communication with Office crew	☐ Radio ☒ Phone (cell)	☐ Radio ☒ Phone
Communication with Fire and Emergency Services	☐ Radio ☒ Phone (cell)	☐ Radio ☒ Phone

14.2 Incident Notification, Reporting, and Investigation

See Section 8 of the APP for incident notification, reporting, and investigation requirements.

Project Hazard Analysis

A health and safety risk analysis (Table 15-1) has been completed for this project. Specific project activities are listed in Table 15-1 with a designation of who performs the task, CH2M (C) or Subcontractor (S). An Activity Hazard Analysis has been developed for each project activity. AHAs prepared for CH2M activities are included as an attachment to this SSHP.

CH2M subcontractors are required to provide AHAs specific to their scope of work on the project for acceptance by CH2M prior to the start of work. Each subcontractor shall submit AHAs for their field activities, as defined in their scope of work, along with their project-specific safety plan and procedures. Additions or changes in field activities, equipment, tools, or material used to perform work or hazards not addressed in existing AHAs requires either a new AHA to be prepared or an existing AHA to be revised.

Table 15-1. Health and Safety Risk Analysis Table

Associated Hazard Section	Project Activity	Mobilization	Groundwater Well Drilling and Installation	Groundwater Monitoring Well Slug Testing	IDW Management	Demobilization
General Hazards – Refer to General Hazards and Controls in HSSE Handbook, Section 7.						
Bloodborne Pathogens		C, S	C, S	C, S	C, S	C, S
Chemical Storage			S	C, S	C, S	C, S
Driving Safety		C, S	C, S	C, S	C, S	C, S
Electrical Safety		C, S	C, S	C, S	C, S	C, S
Field Vehicles		C, S	C, S	C, S	C, S	C, S
Fire Prevention		C, S	C, S	C, S	C, S	C, S
General Practices and Housekeeping		C, S	C, S	C, S	C, S	C, S
Hazard Communication			C, S	C, S	C, S	C,S
Knife Use						
Lighting		C, S	C, S	C, S	C, S	C, S
Manual Lifting		C, S	C, S	C, S	C, S	C, S
Personal Hygiene		C, S	C, S	C, S	C, S	C, S
Personal Security		C, S	C, S	C, S	C, S	C, S
Shipping and Transportation of Hazardous Waste					C, S	
Substance Abuse		C, S	C, S	C, S	C, S	C, S
Project-Specific Hazards – Refer to HSSE Handbook, Section 8, and the additional project-specific controls in this plan when specified.						
Compressed Gas Cylinders		C		C		
Concrete and Masonry Work			S			

Table 15-1. Health and Safety Risk Analysis Table

Associated Hazard Section	Project Activity	Mobilization	Groundwater Well Drilling and Installation	Groundwater Monitoring Well Slug Testing	IDW Management	Demobilization
Concrete Core Drilling						
Concrete Saw Cutting						
Confined Space Entry						
Drilling			C, S			
Fall Protection						
Forklifts Operations			S		S	
Groundwater Sampling/Water Level Measurements			S	C		
Hand and Power Tools		C, S	C, S	C, S	C, S	C, S
Haul Truck Operations		C, S			C, S	
Hoists			C, S			
Portable Generators		C, S	C, S	C, S	C, S	C, S
Pressure Washing Operations			S			S
Rigging						
Stairways and Ladders		C, S	C, S	C, S	C, S	C, S
Traffic Control		C, S	C, S	C, S	C, S	
Utilities (overhead)		C, S	C, S	C, S	C, S	C, S
Utilities (underground)		C, S	C, S			
Working around Material Handling Equipment		C, S	C, S	C, S	C, S	C, S
Physical Hazards – Refer to Physical Hazards in HSSE Handbook, Section 9, and the additional project-specific controls in this plan when specified.						
Noise			C, S			C, S
Ultraviolet Light exposure (sunburn)		C, S	C, S	C, S	C, S	C, S
Temperature Extremes		C, S	C, S	C, S	C, S	C, S
Biological Hazards – Refer to Biological Hazards in HSSE Handbook, Section 10, and the additional project-specific controls in this plan when specified.						
Bees and Other Stinging Insects		C, S	C, S	C, S	C, S	C, S
Feral Dogs		C, S	C, S	C, S	C, S	C, S
Hantavirus		C, S	C, S	C, S	C, S	C, S
Mosquito Bites		C, S	C, S	C, S	C, S	C, S
Poison Ivy, Oak and Sumac		C, S	C, S	C, S	C, S	C, S

Table 15-1. Health and Safety Risk Analysis Table

Associated Hazard Section	Project Activity	Mobilization	Groundwater Well Drilling and Installation	Groundwater Monitoring Well Slug Testing	IDW Management	Demobilization
Snakes		C, S	C, S	C, S	C, S	C, S
Spiders – Brown Recluse and Black Widow		C, S	C, S	C, S	C, S	C, S
Ticks		C, S	C, S	C, S	C, S	C, S

C – Hazard section applicable to CH2M personnel
S – Hazard section applicable to Subcontractor personnel

Hazards and Controls

Safe work practices and hazard control measures to reduce or eliminate potential hazards as identified in Table 1 are stated in the Handbook, Sections 7-10, the associated CH2M Enterprisewide Core Standards and Standard Operating Procedures, and are addressed in project AHAs. Any additional project-specific control measures, or those hazards requiring additional emphasis, are identified in the following sections.

Always consult the appropriate CH2M Enterprisewide Core Standards and Standard Operating Procedures to ensure all requirements are implemented. CH2M employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M employees and subcontractors who do not understand any of these provisions should contact the SHM for clarification.

Subcontractor identified hazards and controls will be added to this section as they are identified and submitted for approval prior to the start of their task.

16.1 General Hazards and Controls

16.1.1 Personal Security/Dogs

Due to the risk to personnel from unaware residents, at-risk-residents, and animals within the residence, these controls are designed to reduce the risk to project personnel.

At the time that the work on private property is scheduled, the scheduler will ask the resident if there is a dog(s) in the home. The resident will then be asked to secure the dog(s) in an area of the residence or backyard during the work so that our personnel are not at risk of being bitten. Upon the arrival at a residence, verify that the dog(s) has been secured before starting work.

Avoid all dogs – both leashed and stray. Do not disturb a dog while it is sleeping, eating, or caring for puppies. If a dog approaches to sniff you, stay still. An aggressive dog has a tight mouth, flattened ears and a direct stare. If you are threatened by a dog, remain calm, do not scream and avoid eye contact. If you say anything, speak calmly and firmly. Do not turn and run, try to stay still until the dog leaves, or back away slowly until the dog is out of sight or you have reached safety (e.g., vehicle). If attacked, retreat to vehicle or attempt to place something between you and the dog. If you fall or are knocked to the ground, curl into a ball with your hands over your head and neck and protect your face. If bitten, contact the occupational nurse at 1-866-893-2514. Report the incident to the local authorities.

16.2 Additional Project-Specific Hazard Controls

16.2.1 Traffic Control

Follow the approved Traffic Control Plan for the site that you are working at. The Traffic Control Plan is attached to this SSHP and will be amended as needed with our traffic control subcontractor’s requirements.

SECTION 177

Inspections

17.1 Project Activity Self-Assessment Checklists

The following self-assessment checklists are required when the task or exposure is initiated and weekly thereafter. The checklists shall be completed by the SSHO or other CH2M representative and maintained in project files.

Hand and Power Tools	**Hazardous Materials Handling**
Electrical Safety	PPE
Drilling	Forklift

17.2 Safe Behavior Observations

The SSHO or designee shall perform at least one safe behavior observation each week for any fieldwork performed by subcontractors or when there are at least two CH2M personnel performing fieldwork.

E-mail completed forms to:

Federal Sector: CH2M ES FED Safe Behavior Observation

17.3 Agency Inspections

If a federal or local agency (e.g., U.S. Occupational Safety and Health Administration (OSHA), local water board, U.S. Environmental Protection Agency) announces it will be performing inspection, either announced or unannounced, refer to Attachment 3, Target Zero Bulletin on Agency Inspections. Contact the PM, SHM and EM as soon as you receive notice, the PM shall notify the U.S. Army Corps of Engineers PM and Veterans Health Administration RPM.

Records and Reports

Refer to the Handbook, Section 19, “Records and Reports,” for a complete description of Health, Safety, and Environment recordkeeping requirements. Below are examples of records that must be maintained as the project progresses:

- Exposure records includes air monitoring data (including calibration records), safety data sheets, exposure modeling results
- Equipment inspections
- Training records
- Equipment maintenance
- Respiratory fit test records
- Emergency equipment inspection records
- Incident reports, investigations and associated back-up information
- Safe behavior observations
- Federal or state agency inspection records
- Self-assessment checklists
- Health, Safety, and Environment audits and assessments
- Daily Safety Meeting Sign-In forms/PTSPs
- Confined space entry permits
- Waste analytical data
- Waste profiles
- Manifests
- Agency submittals
- Reports and certifications

Employee Signoff Form

EMPLOYEE SIGNOFF FORM **Health and Safety Plan** The CH2M project employees and subcontractors listed below have been provided with a copy of this SSHP, have read and understood it, and agree to abide by its provisions.			
Project Name:		**Project Number:**	
EMPLOYEE NAME (Please print)	**EMPLOYEE SIGNATURE**	**COMPANY**	**DATE**

Attachments

Attachment 1
Chemical Inventory/Register Form

Chemical Inventory/Register Form

Refer to SOP HSE-107, Attachment 1, for instructions on completing this form.

Location:

HCC:

☐ Office ☐ Warehouse ☐ Laboratory ☐ Project:

Project No.:

Regulated Product	Location	Container labeled (✓if yes)	SDS available (✓if yes)

SDS for the listed products will be maintained at:

Attachment 2
Chemical-Specific Training Form

Chemical-Specific Training Form

Refer to SOP HSE-107 Attachment 1 for instructions on completing this form.

Location: Project # :

HCC: Trainer:

TRAINING PARTICIPANTS:

NAME	SIGNATURE	NAME	SIGNATURE

REGULATED PRODUCTS/TASKS COVERED BY THIS TRAINING:

The HCC shall use the product SDS to provide the following information concerning each of the products listed above.

☐ Physical and health hazards

☐ Control measures that can be used to provide protection (including appropriate work practices, emergency procedures, and personal protective equipment to be used)

☐ Methods and observations used to detect the presence or release of the regulated product in the workplace (including periodic monitoring, continuous monitoring devices, visual appearance or odor of regulated product when being released, etc.)

Training participants shall have the opportunity to ask questions concerning these products and, upon completion of this training, will understand the product hazards and appropriate control measures available for their protection.

Copies of SDSs, chemical inventories, and CH2M's written hazard communication program shall be made available for employee review in the facility/project hazard communication file.

Attachment 3
Project Activity Self-Assessment Checklists/Permits/Forms

Heat Stress Physiological Monitoring Form

Project:	
Date:	**Company:**

1. Take and record measurement of temperature or pulse at the frequency indicated in the safety plan.
2. Follow the Physiological Monitoring Protocol in the safety plan.
3. Never continue work if your body temperature is more than 100.4° F/38° C, or if you are experiencing sudden and severe fatigue, nausea, dizziness, or lightheadedness.

Employee:
Describe action taken below if measurements are exceeded:

Time								
Temp								
Pulse								

Employee:
Describe action taken below if measurements are exceeded:

Time								
Temp								
Pulse								

Employee:
Describe action taken below if measurements are exceeded:

Time								
Temp								
Pulse								

Employee:
Describe action taken below if measurements are exceeded:

Time								
Temp								
Pulse								

Employee:
Describe action taken below if measurements are exceeded:

Time								
Temp								
Pulse								

Field Documentation, Readiness, and Implementation		Comments
Field Safety Instructions		
☐	CH2M HILL plan signed by HSM and PM; plan and Handbook at site	
☐	CH2M HILL plan approved (within last year)	
☐	Sub HSP, if applicable, accepted by HSM and on site	
☐	All field workers signed both CH2M HILL and, if applicable, Sub plan	
AHAs		
☐	All field tasks covered by AHA	
☐	CH2M HILL AHAs present and approved by HSM	
☐	Sub AHAs present and accepted by HSM	
Training and Medical Certs		Tracking form available
☐	CH certs verified current	
☐	Sub certs verified current	
☐	Specialized training certs verified (CSE, fall protection, forklift)	
Safety Meeting/PTSP Documentation		
☐	Forms available	
HazCom-required paperwork		
☐	Inventory developed (FSI Attachment)	
☐	SDSs available and briefed team on location	
☐	Training documented (FSI Attachment), GHS VO module taken	
Project Self-Assessment Checklists		
☐	Checklists available per FSI	
☐	Corrective actions to be taken tracked and closed out	
SWOs	(formerly SBOs)	
☐	Forms available and frequency of completion known	
☐	SWO e-mail addresses known (see form, send once a week)	
Incident/Injury reporting process/paperwork (HITS)		
☐	Notification and HITS entry process known and paperwork available	
Air monitoring instrumentation and documentation		
☐	Correct equipment per FSI (correct PID lamp, if applicable) available	
☐	Calibration gas, if applicable, ordered and onsite	
☐	Action levels known	
☐	Calibration documented prior to use	
☐	Breathing zone readings documented	
☐	Completed air monitoring documentation sent to SPA	
Physiological monitoring paperwork		
☐	Action levels known	
☐	WBGT, thermometer, or watch available	
☐	Form available	
Special permits (Hot Work, CSE, etc.)		
☐	Required forms and permits available	
Specific/specialized plans and postings (Lone Worker, Critical Lift, asbestos)		
☐	Lone worker protocol established (if applicable)	
☐	Lead or asbestos plans in place (if applicable)	
☐	Critical lift plan necessary?	

Emergency Planning		
☐	Emergency Contacts and route to hospital posted	
☐	Emergency plan rehearsed (table top at minimum)	
Equipment Inspections		
☐	Equipment inspected as brought on site	
☐	Regular heavy equipment inspections documented	
Personal Protective Equipment		
☐	PPE verified per FSI/AHAs and on site	
Environmental Considerations		
☐	Waste drums on-site	
☐	Erosion control devices on site	
☐	Labels available and crew knows how to fill out?	
Decon		
☐	Any special equipment needed? (Tubs, brushes, waste drums?)	

SC REMINDERS	
DAILY	
☐	PTSP, Daily Safety Meeting, review observations from previous day's work with CH team/subs
☐	Informal site inspections (documented in logbook along with any corrective actions taken)
☐	Air monitoring calibration documented on daily site monitoring form or in logbook
☐	Air monitoring readings documented on daily site monitoring (or equivalent) form and kept in project files
☐	Heat stress monitoring conducted if specified in plan
☐	Incident reporting/assist with investigations
☐	Filling out field logbook
☐	Ensure SDSs for new chemicals brought onsite are inventoried and added to SDS book, training is given to CH personnel or subs are giving training to their workers
☐	Briefing on CH2M HILL FSI for any new personnel coming onsite, including subcontractor personnel and verifying training
☐	Project file maintenance for H&S documentation
WEEKLY	
☐	Safe Work Observations – send to SWO mailbox (more frequently if indicated in safety plan)
☐	Complete self-assessment checklists (applicable to type of work going on and as specified in safety plan)
MONTHLY	
☐	Fire extinguisher inspections (document on fire extinguisher tags)
☐	First aid kit/eyewash inspections (documented—for eyewash on tag—first aid kit in logbook)
MANDATORY POSTINGS	
☐	State and Federal required postings including minimum wage, OSHA "It's the Law," fair employment, worker's compensation, etc. (Vendor for all-in-one poster is Compliance Poster Company 1-800-817-7678)
☐	Evacuation routes and rally points
☐	Tornado shelter (as applicable)
☐	OSHA 300 log (February thru April of every year)
☐	Emergency phone numbers
☐	Route to Hospital map and phone number
☐	Others -- CH2M HILL VO Enterprise HSE Page - Posters

Safety and Occupational Health Deficiency Tracking Log

Item	Date Identified	Identified By	Deficiency Description	Resolution Date	Corrected By	Actual Correction Date
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

NG0105171142SLC

Underground Utility Verification

Project No.:		**Project Name:**	
Site Address:			
Date:		**PM:**	
Utility Locator:		**Field Personnel:**	
Ground Disturbance Scope and Equipment (drill rig, backhoe, or other):			

	Description	Yes	No*	NA/Notes
1	Obtained and reviewed available utility diagrams or as-built drawings for facility.			
2	A facility contact with knowledge of utility locations was met onsite. Facility contact reviewed and approved proposed locations of intrusive work. Facility Contact: ________________________________ Phone Number: __________________________			
3	Proposed ground disturbance areas are “white lined” by project team. White-lined areas should be a 20-foot minimum radius around the proposed ground disturbance location, unless buildings or hazards prohibit marking a 20-foot radius. White paint or pin flags should be used.			
4	Contacted the designated local utility notification service (such as 811) and notification ticket is current (according to state/provincial law, typically 10 to 15 days).			
5	Public utility companies have been contacted and utilities located and marked. Present / Not present / Response method (mark, phone, email) & notes High-Voltage Electric ☐ ☐ ______________________________________ Low-voltage Electric ☐ ☐ ______________________________________ Gas ☐ ☐ ______________________________________ Process/Fuel ☐ ☐ ______________________________________ Water ☐ ☐ ______________________________________ Storm ☐ ☐ ______________________________________ Sewer ☐ ☐ ______________________________________ Telecommunication ☐ ☐ ______________________________________ Irrigation ☐ ☐ ______________________________________			
6	Client- or facility-specific permit or procedure complete (such as dig permit).			
7	A qualified, independent field survey provider performed a field survey to identify, locate, and mark potential subsurface utilities in the work area.			
8	Independent field survey provider used appropriate instrumentation and geophysical technologies (for example, radio frequency [RF], electromagnetic [EM], ground-penetrating radar [GPR]). Describe methods: ____ RF, EM, and GPR are typically necessary. If one of these is not used, mark “No” and explain rationale in Utility SOP Deviation Request at the bottom of Page 2.			
9	Oversight staff were present during independent utility survey.			
10	A “360-degree” assessment has been performed, including walking the area and inspecting for utility-related items such as valve caps, previous linear cuts, patchwork in pavement, hydrants, manholes, utility vaults, light standards, drains, and vent risers.			
11	Utilities have been properly identified and marked. Utilities are marked within a minimum 20-foot radius around the proposed drilling or excavation location, anticipating step-out locations.			
12	Utility marks are the appropriate color (red – electrical; yellow – gas; green – sewer; blue – water; orange – communication; purple – irrigation). Pink should be used for unknown/temporary.			

	Description	Yes	No*	NA/Notes
13	Utility marks can be protected and preserved until no longer required (use whiskers or pin flags if necessary). If the utility location markings are destroyed or removed before intrusive work commences or is completed, the Project Manager (PM), Safety Coordinator, or designee must notify the independent field survey provider or the designated utility locating service to resurvey and remark the area.			
14	Utility clearances are provided in writing and signed by the party conducting the clearance on the Buried Utility Tracking Form. See Page 3.			
15	Private or public utilities within 5 feet of proposed locations are documented on the Buried Utility Tracking Form. See Page 3.			
16	Documentation of the utility survey (report, updated utility site map, photo log) is complete.			
17	When aggressive intrusive activities will be conducted within 5 feet, either laterally or vertically, of an underground utility, or when there is uncertainty about utility locations, drilling locations must be physically verified by non-aggressive means such as air or water knifing or hand digging. Describe planned clearance method and depth: ____			
18	For drilling, non-aggressive clearance will be greater than the outside diameter of drill tooling.			
19	When underground utility is within 5 feet of intrusive work, then non-aggressive means must be used to physically locate (daylight) the utility before a drill rig, backhoe, excavator, or other aggressive method is used. This step of daylighting is in addition to clearance of the borehole.			
20	When an underground utility is within 5 feet of intrusive work, check to see if the utility can be isolated (locked out/tagged out and de-energized [purged as necessary] or blocked) during the subsurface activity. Hazardous utilities (gas, electrical) will be de-energized whenever possible. Verify with facility contact that isolation is completed according to the Lock Out Tag Out Standard Operating Procedure (SOP).			
21	Only non-aggressive means may be used within 2 feet of an identified utility.			
22	The following documentation will be available onsite during ground disturbance: • Available utility diagrams or as-built drawings • 811 notification • Facility-specific permit or procedure (dig permit) • Utility survey information (e.g. report, updated utility site map, photo log)			

Prepared by: ________________________________ **Verified by:** ________________________________

Field Personnel PM

Instructions:

1) Complete and submit Underground Utility Verification Checklist to Health and Safety Manager (HSM) and PM.
2) Ensure that documentation is communicated to other field staff and available at the site during ground disturbance activities.
3) For items marked No" above, complete the following utility SOP deviation request. Approvals may be provided via email or phone.

Utility SOP Deviation Request

Items Marked "No" above: ____

Rationale for Deviation: ____

____

PM Approval: ________________________________ Approved Date: ______________

HSM Approval: ________________________________ Approved Date: ______________

Buried Utility Tracking Form

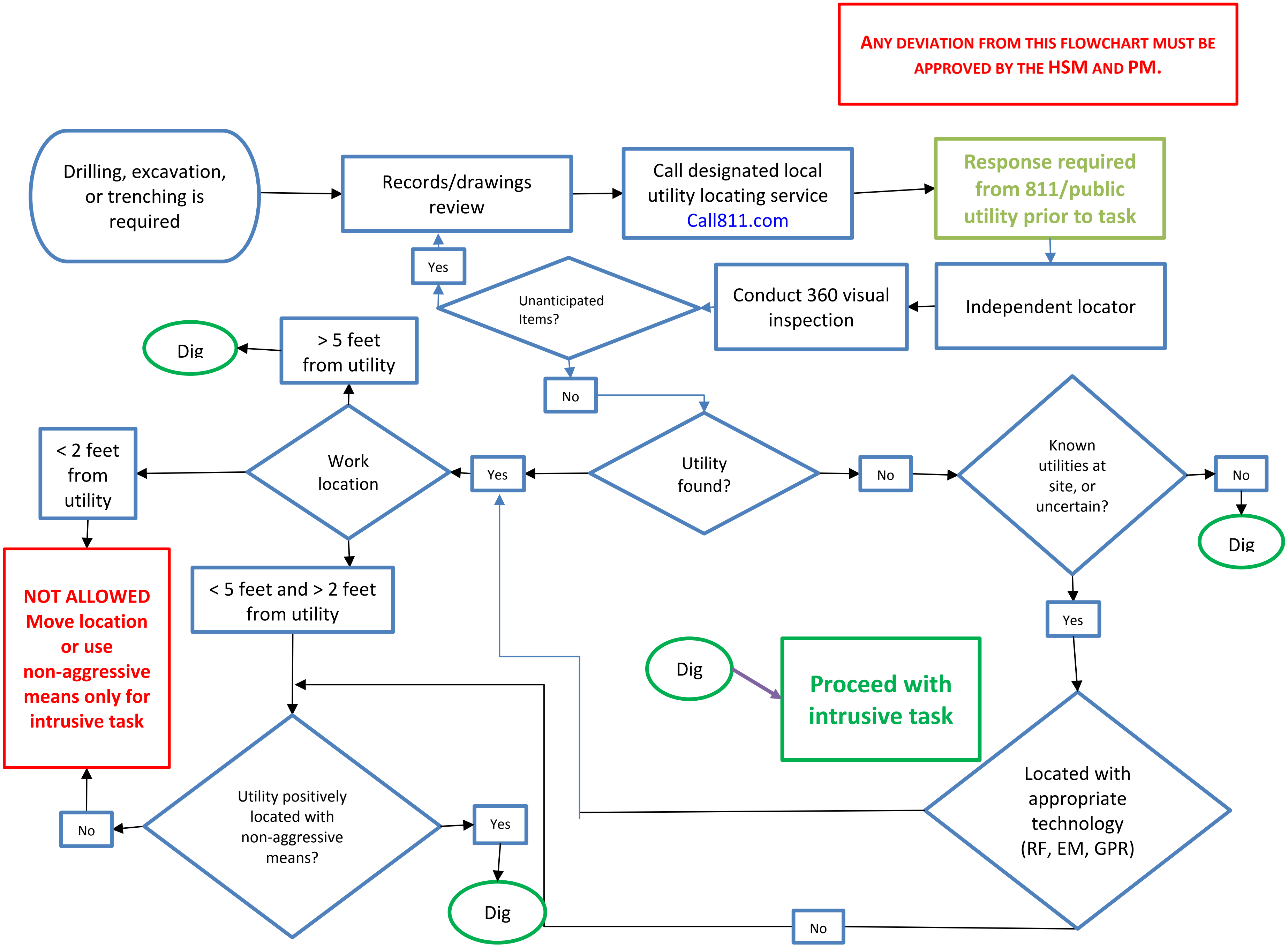
Check each box using an "X" if a buried utility is present within 5 feet of a marked location identification (ID).

Location ID	Gas (Yellow)	Electric (Red)	Fiber optic (Orange)	Cable (Orange)	Water (Blue)	Sanitary Sewer (Green)	Storm Sewer (Green)	Steam (Yellow)	Petroleum (Yellow)	Compressed Air (Yellow)	Other ______	Other ______

The findings of the buried utility location activities summarized herein were conducted in accordance with the scope of work.

_________________________________ ____________

Utility Locate Subcontractor's Signature | Date



NG01051711142SLC

Safe Work Observation

Organization Information					
DOD / NON DOD		**DOE**		**Canada / International**	
Project Information					
Program/Service :			**Client Name:**		
Project Name:		**Project #:**		**Project Location:**	
Observation Information					
Observer Name:		**Company:**		**Date:**	
Position/Title of worker observed:		**Company:**		**Type of Observation:**	
Work or Task Observed:					
Positive Observations/Safe Work Practices:					

Observation Category	Observation (choose one)	At- Risk Observation	Corrected (Y or N)	Root Cause #
1. Work Environment *(Perform a 360 degree observation of the area surrounding the worksite; are there potential uncontrolled hazards that could impact the worker or work area?)*	☐ Not Observed ☐ Safe ☐ At-Risk	*Look at housekeeping, electrical, overhead, confined space or fall hazards, site control issues.*		
2. Work Behaviors *(Are there any at-risk behaviors observed such as trigger states, focus on the work at hand, and situational awareness?)*	☐ Not Observed ☐ Safe ☐ At-Risk	*Look at trigger states (rushing, fatigue, complacency, frustration), eyes on task, awareness.*		
3. Body Use and Positioning *(Are there any at-risk motions or body positions that need to be corrected?)*	☐ Not Observed ☐ Safe ☐ At-Risk	*Look at at-risk carrying/lifting/twisting, repetitive motion, excessive standing/sitting/kneeling, line of fire.*		
4. Personal Protective Equipment *(Is PPE selected, used, inspected, maintained and stored in accordance with work needs and plans?)*	☐ Not Observed ☐ Safe ☐ At-Risk	*Look at head, foot, body, hand, hearing protection, safety vest, condition of PPE.*		

Observation Category	Observation (choose one)	At- Risk Observation	Corrected (Y or N)	Root Cause #
5. Tools and Equipment *(Are the tools and equipment at the site selected, inspected, used and maintained in accordance with plans and requirements?)*	☐ Not Observed ☐ Safe ☐ At-Risk	*Look at hand tools, power tools, portable equipment, open-bladed knife use, ladders, scaffolds, fall protection.*		
6. Environmental Conditions *(Are environmental conditions and risks, e.g., heat, cold, noise, lighting, and biological hazards identified and controlled?)*	☐ Not Observed ☐ Safe ☐ At-Risk	*Also look at work/rest breaks, ice/snow removal, tick/insect, poison ivy/oak, dust/vapor/odor control.*		
7. Environmental Protection Measures *(Have environmental issues [e.g., waste, hazardous materials, stormwater] been identified and mitigation measures in place?)*	☐ Not Observed ☐ Safe ☐ At-Risk	*Look at proximity to waterways, waste or hazmat containers/ labeling/storage/spill control, nesting birds.*		
8. Emergency Planning and Response *(Are the emergency planning and response measures adequate for the anticipated emergency situations?)*	☐ Not Observed ☐ Safe ☐ At-Risk	*Look at emergency alarms, communications, assembly area, fire extinguisher, eye-wash, first aid kit, signs.*		
9. Motor Vehicles and Heavy Equipment *(Observe site vehicle and heavy equipment use, observe work in the vicinity of operating equipment. Are there at-risk behaviors or conditions? [E.g., spotters not used, seatbelts not used, 3 points of contact not used to enter/exit, etc.])*	☐ Not Observed ☐ Safe ☐ At-Risk	*Also look at distracted driving/equipment use, eye contact with operator, weather conditions considered, vehicles inspected prior to use.*		
10. Work Planning, Hazard Identification and Control *(Ask the observed worker(s) about the work planning process they used. Were the risks identified in the HSE plan(s) and AHAs, and controlled before work began, and on-going as the work progressed?*	☐ Not Observed ☐ Safe ☐ At-Risk	*Look at journey management/work hours, working alone, PTSP/Daily safety meetings, permits in place, self-assessment checklists used, HazCom, HSE records.*		
Percent Safe	%	% Safe = **#** of Safe Observations / (**#** of Safe Observations + **#** of At-Risk Observations)		
11. Action plan notes for any uncorrected deficiencies:				
12. Other notes or comments regarding this safety observation:				

For NGCS projects please email completed forms to: NGCS SWO (include Project Name and Project Number in subject line)

Root Cause Codes:

1. Lack of skill or knowledge
2. Lack of or inadequate operational procedures or work standards
3. Inadequate communication of expectations regarding procedures or work standards
4 Inadequate tools or equipment
5. Correct way takes more time and/or requires more effort
6. Short-cutting standard procedures is positively enforced or tolerated
7. Person thinks there is no personal benefit to always doing the job according to standards

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:		Overall Risk Assessment Code (RAC) (Use highest code)						
	SIGNATURES	Activity #				AHA #		
PWD/OICC/ROICC OFFICE		**Risk Assessment Code (RAC) Matrix**						
NAME & DATE ACCEPTED BY GDA:								
CONTRACT NUMBER:		**Severity**	**Probability**					
TASK ORDER/DELIVERY #:								
PRIME CONTRACTOR:			Frequent	Likely	Occasional	Seldom	Unlikely	
SUBCONTRACTOR:								
DATE OF PREPARATORY MEETING:		Catastrophic	E	E	H	H	M	
DATE OF INITIAL INSPECTION:		Critical	E	H	H	M	L	
CONTRACTOR COMPETENT PERSON:		Marginal	H	M	M	L	L	
SITE SAFETY and HEALTH OFFICER		Negligible	M	L	L	L	L	
ACCEPTANCE BY GOVERNMENT DESIGNATED AUTHORITY (GDA)		Review each **"Hazard"** with identified safety **"Controls"** and determine (RAC)						
E = EXTREMELY HIGH (PWO/OICC/ROICC)		Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" .Place the highest RAC at the top of AHA. This is the overall risk assessment code for this activity						
H = HIGH RISK (FEAD DIRECTOR)		**"Severity"** is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible after controls are in place						
M = MODERATE RISK (CM or ET or PAR)								
L = LOW RISK (ET or PAR)		**"Probability"** is the likelihood to cause an incident, near miss, or accident did occur and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely after controls are put in place.						

Job Steps	**Hazards**	**Controls**	**RAC**

Equipment to be Used	Training Requirements and Competent or Qualified Personnel name(s)	Inspection Requirements	RAC

DAILY SITE MONITORING REPORT

Project:	Date:
Task Name:	Subcontractor(s):
Description of Activities:	Description of Potential Contaminant(s) and Source:

4. Monitoring Instrumentation

Instrumentation Description: Instrument ID Number:	Calibration gas and lot number: Time & Date Calibrated: Calibration Results:

5. Site Monitoring Results

Time(s)	Monitoring Location (note distance from source, upwind/downwind, etc.)	Sample Type (source, breathing zone, area, etc.)	Instrument Reading (Units)	Comments or list name and company of person if reading is a Breathing Zone sample,*

Review

Sampler:	Signature:	Date:

DAILY SITE MONITORING REPORT

Page ___ of ___

6. Site Monitoring Results

Time(s)	Monitoring Location (note distance from source, upwind/downwind, etc.)	Sample Type (source, breathing zone, area, etc.)	Instrument Reading (Units)	Comments or list name and company of person if reading is a Breathing Zone sample,*

Review

Sampler:	Signature:	Date:

Pre-task Safety Plan (PTSP) and Safety Meeting Sign-in Sheet

Project:___________________________ Location: _______________ Date:________________

Supervisor: ________________________________ Job: _______________________________________

Activity:_______________________________________

____

Attendees: Print Name Sign Name

____

____

____

____

____

____

____

List Tasks and verify that applicable AHAs have been reviewed:

____

____

____

Tools/Equipment Required for Tasks (ladders, scaffolds, fall protection, cranes/rigging, heavy equipment, power tools):

____

____

Potential Health and Safety Hazards, including chemical, physical, safety, biological and environmental (check all that apply):

__ Chemical burns/contact	__ Trench, excavations, cave-ins	__ Ergonomics
__ Pressurized lines/equipment	__ Overexertion	__ Chemical splash
__ Thermal burns	__ Pinch points	__ Poisonous plants/insects
__ Electrical	__ Cuts/abrasions	__ Eye hazards/flying projectile
__ Weather conditions	__ Spills	__ Inhalation hazard
__ Heights/fall > 6 feet	__ Overhead Electrical hazards	__ Heat/cold stress
__ Noise	__ Elevated loads	__ Water/drowning hazard
__ Explosion/fire	__ Slips, trip and falls	__ Heavy equipment
__ Radiation	__ Manual lifting	__ Aerial lifts/platforms
__ Confined space entry	__ Welding/cutting	__ Demolition
__Underground Utilities	__ Security	__ Poor communications

Other Potential Hazards (Describe):

____

____

____

Hazard Control Measures (Check All That Apply):			
PPE __ Thermal/lined __ Eye __ Dermal/hand __ Hearing __ Respiratory __ Reflective vests __ Flotation device __ Hard Hat __ Safety-Toed Boots	Protective Systems __ Sloping __ Shoring __ Trench box __ Barricades __ Competent person __ Locate buried utilities __ Daily inspections __ Entry Permits/notification	Fire Protection __ Fire extinguishers __ Fire watch __ Non-spark tools __ Grounding/bonding __ Intrinsically safe equipment	Electrical __ Lockout/tagout __ Grounded __ Panels covered __ GFCI/extension cords __ Power tools/cord inspected __ Overhead line clearance __ Underground utilities ID'd
Fall Protection __ Harness/lanyards __ Adequate anchorage __ Guardrail system __ Covered opening __ Fixed barricades __ Warning system	Air Monitoring __ PID/FID __ Detector tubes __ Radiation __ Personnel sampling __ LEL/O2 __ No visible dust __ Other	Proper Equipment __ Aerial lift/ladders/scaffolds __ Forklift/heavy equipment __ Backup alarms __ Hand/power tools __ Crane with current inspection __ Proper rigging __ Operator qualified	Welding & Cutting __ Cylinders secured/capped __ Cylinders separated/upright __ Flash-back arrestors __ No cylinders in confined space entry __ Flame retardant clothing __ Appropriate goggles
Confined Space Entry __ Isolation __ Air monitoring __ Trained personnel __ Permit completed __ Rescue	Medical/ER __ First-aid kit __ Eye wash __ First-aid-CPR trained personnel __ Route to hospital	Heat/Cold Stress __ Work/rest regime __ Rest area __ Liquids available __ Monitoring __ Training	Vehicle/Traffic __ Traffic control __ Barricades __ Flags __ Signs
Permits __ Hot work __ Confined space __ Lockout/tagout __ Excavation __ Demolition __ Energized work	Demolition __ Pre-demolition survey __ Structure condition __ Isolate area/utilities __ Competent person __ Hazmat present	Inspections: __ Ladders/aerial lifts __ Lanyards/harness __ Scaffolds __ Heavy equipment __ Drill rigs/geoprobe rigs __ Cranes and rigging __ Utilities marked	Training: __ Hazwaste (current) __ Construction __ Competent person __ Task-specific __ First-aid/CPR __ Confined Space __ Hazcom
Underground Utilities __ Dig alert called __ 3rd Party locater __ As-builts reviewed __ Interview site staff __ Client review __ soft locate necessary?	Incident Communications __ Work stops until cleared by TM/CM __ Immediate calls to TM/CM __ Client notification __ 24 hour notification setup __ Clear communications	AHA' s __ Reviewed and approved by HSM __ Onsite and current __ Applicable for this day's work __ Communication and incident processes included?	
Field Notes (including observations from prior day, etc.): ____ ____ ____			

Name (Print): ________________________________

Signature:________________________________ Date:__________________

HITS Incident Report Hardcopy (Phase 1 – Initial Entry)

Phase 1 – Initial Entry

Type of Incident (May select more than one)

☐ Injury/Illness
☐ Property Damage
☐ Spill/Release
☐ Environment/Permit
☐ Near Miss
☐ Other

General Information Section

Preparer's Name: ______________________________ **Preparer's Phone Number:** ________________________

Date of Incident: __________________ **Time of Incident**: ______________ AM / PM

What Business Group is accountable for this incident:

____

What Business Group SubGroup is accountable for this incident:

____

What CH2M Company is accountable for this incident:

____

Where did the Incident occur?

☐ United States, Geographic Region: ____________________________________
☐ Canada, Province/Territory: ____
☐ International, County: ____

Location of Incident?

☐ Company Premises, CH2M Office (use 3 letter office code if available):

____

☐ Project, Project name:

____

☐ In Transit
Traveling from:____
Traveling to: ____
☐ At Home
☐ Other, Specify:

____

Describe the incident:

____

Describe how this event could have been prevented:

____

Provide Witness Information:

Name: ____Phone: _______________________________
Name: ____Phone: _______________________________
Name: ____Phone: _______________________________

Personnel Notified of Incident (Provide name, date and time):

CH2M Personnel: ____

Client Personnel: ____

Additional Comments:

____

Injury/Illness Section **[Complete only if Injury/Illness Incident type selected]**

Who was injured?

- ☐ CH2M Employee or CH2M Temp Employee
- ☐ Subcontractor to CH2M (Non-LLC Joint Venture Project)
- ☐ LLC Joint Venture Partner Employee
- ☐ LLC Joint Venture Project Subcontractor/Contractor
- ☐ Other

Name of Injured: ______________________ **Job Title:** ____________________

Employer Name: ______________________ **Supervisor of Employee:** _____________

Complete for CH2M Employee Injuries

Business Group of Injured Employee:

____

Has the employee called the Injury Management Administrator (1-866-893-2514)?

☐ Yes ☐ No ☐ Not Sure

Has the injured employee's supervisor been notified of this incident?

☐ Yes ☐ No ☐ Not Sure

Complete for Non-CH2M Employee Injuries

Has the project safety coordinator been notified of this incident?

☐ Yes ☐ No ☐ Not Sure

Project Safety Coordinator:

____

Body Part Affected: ____

Injury/Illness (Result):

____

Describe treatment provided (if medication provided, identify whether over-the-counter or prescription):

____

Describe any work restriction prescribed (include dates and number of days):

____

Physician/Health Care Provider Information

Name: ______________________________ Phone: ____________________

Was treatment provided away from the worksite?

☐ No

☐ Yes

Facility Name:

____

Address:

____

City: ______________________ Phone Number: ____________________

Was injured treated in an emergency room?

☐ No ☐ Yes

Was injured hospitalized overnight as an in-patient?

☐ No ☐ Yes

General Information Environmental Section **[Complete only if Environment/Permit or Spill/Release Incident type selected]**

Who had control of the area during the incident?

☐ CH2M, Company:

____

☐ Subcontractor, Company:

____

☐ Joint Venture Partner/Contractor/Subcontractor, Company:

____

☐ Other, Company:

____

Relationship to CH2M: ____

Property Damage Section **[Complete only if Property Damage Incident type selected]**

Property Damaged: ____

Property Owner: ____

Damage Description: ____

Estimated US Dollar Amount:

____

Spill or Release Section **[Complete only if Spill/Release Incident type selected]**

Substance:____

Estimated Quantity: ____

Did the spill/release move off the property?

____

Spill/Release From: ____

Spill/Release To: ____

Environment/Permit Section **[Complete only if Environment/Permit Incident type selected]**

Describe Environmental or Permit Issue:

____

Permit Type: ____

Permitted Level or Criteria (for example, discharge limit):

____

Permit Name and Number (for example, NPDES No. ST1234): ___________________________________

Substance and Estimated Quantity: ____

Duration of Permit Exceedance: ____

Health, Safety and Environment

Lessons Learned **[Date] NG-LL-17-xx**

TITLE:

Subject:	Insert response
Situation:	Insert response (pictures are helpful)
Lesson(s) Learned:	Insert response
Recommendation(s) and/or Comment(s)	Insert response

Submitted by:

Date submitted:

Send draft Lessons Learned to the project HSM and/or EM for review, and then to Andy Strickland/DEN and Sandy Wise/DEN for final review, posting and distribution.

ch2m

Health and Safety Field Change Request (FCR)

Date of Change:		
FCR No. (assigned by RHSM):		
Applicable Health and Safety Plan Title:		
Project Number:	**Project Name & Location:**	
Subject of Change:		
Recommended Change:		
Reason for Change:		
Submitted by:	**Company**: CH2M HILL	**Date:**
Review & Acceptance:		
Project Manager:	**Date:**	
Health & Safety Mgr:	**Date:**	
Distribution:		

1.	2.	3.	4.
5.	6.	7.	8.

File Copies: Project File

ch2m Management Health, Safety, Security and Environment Inspection

Program/Project Name: ______________ **Work Being Performed:** ______________

Management Inspector: ______________ **Project Number:** ______________

Date: ______________ **Sector:** ______________

1. Job Information/Postings	A	C	I	N/A	Comments/Corrective Action(s)
a. Required postings in place (OSHA/State/Country)					
b. Emergency Contacts and Phone list posted					
c. Directions and map to hospital posted					
d. Incident Reporting Flow Chart posted					
2. HSSE Documentation					
a. HASP current (within 1 year), onsite, and signed					
b. AHAs available for all work and reviewed/signed					
c. Daily Pre-Task Safety Plan/Meeting completed					
d. SBO's completed weekly and emailed					
e. Self-Assessment checklists completed per HASP					
f. Environmental Plan available					
g. Emergency drill completed and documented					
h. E Permit compliance assurance measures documented					
i. HSE training up to date and documented					
3. Housekeeping/First Aid					
a. Work areas clean and organized					
b. Fire extinguisher, eye wash, 1st aid/BBP kit in place					
c. Materials and waste labeled and in closed containers					
4. PPE and Air Monitoring					
a. PPE being worn as specified in HASP/AHA					
b. Air monitoring done per HASP and documented					
5. Heavy Equipment and Construction Operations					
a. Documentation of Competent/Qualified Operators					
b. Back-up alarms audible & no cell phone use					
c. High-visibility vests on ground personnel					
d. Daily inspections completed and documented					
e. Windshields/mirrors OK and seat belts worn					
6. Excavation, Trenching, and Land Disturbing Activities					
a. Competent person identified					
b. Daily inspection completed prior to entry					
c. Proper setup (sloping, shoring, exits, spoils)					
d. 3rd party Utility Locate service used					
d. Storm water PPP and inspections/sampling conducted					
d. Erosion/sediment controls and dust controls in place					
7. Hand Tools					
a. Hand tools inspected prior to use					
b. Guards in place on tools					
c. Right tool for the job at hand					
8. Electrical					
a. All electrical cords, prongs, receptacles OK					
b. GFCI used on all circuits					
c. No energized electrical work incl. voltage testing					
d. Written Lockout Tagout system in use					

(Column - A=Adequate, C=Needs Consideration, I=Needs Immediate Action, N/A= Not Applicable or Not Assessed)

Send completed form to CH2MHILLESInspections@CH2M.com)

9. Ladders and Scaffolds	A	C	I	N/A	Comments/Corrective Action(s)
a. Ladders extend 36" above the landing and secured					
b. Ladders selected and used properly					
c. Scaffold planked, unaltered, and in good condition					
d. Scaffold/ladder users trained in inspection and use					
10. Hot Work					
a. Gas cylinders stored upright and secured					
b. Minimum 20' distance between fuels and oxygen					
c. PPE in use per HASP/AHA					
d. Fire watch in place w/adequate fire extinguishers					
11. Cranes					
a. Outriggers extended, swing radius protected					
b. Operator CCO licensed, competent person for rigging					
c. Annual certified crane inspection					
d. Chains and slings inspected, have rating tag					
e. Suspended load tag lines - no one underneath					
12. Drill Rigs					
a. Overhead electrical clearance adequate					
b. Daily inspections completed and available					
c. Emergency shut off functioning					
d. 3rd party Utility Locate service used					
13. Hazard Communication and Chemical Use					
a. MSDS's present for all chemicals					
b. Chemical Inventory current and in HSP or on file					
c. Hazard communication briefing for all chemicals					
d. All chemicals labeled/stored as required					
e. SPCC Plan implemented for >1320 gals fuels/oils on site					
14. Fall Protection					
a. Full body harness worn properly, workers tied off over 6'					
b. Guard rails 42" high					
15. Material Handling					
a. Proper body positioning					
b. Objects less than 40 lbs. for one person lift					
16. Site Control					
a. Work Zones delineated, necessary signage in place					
b. Decontamination method is adequate					
17. Waste and Hazardous Materials Management					
a. Waste Tracking Log					
b. Hazardous waste onsite for <90 days					
c. Containers labeled, inspections conducted/documented					
d. HW manifests signed, tracked, copies kept on site					
e. HW Transporters trained and licensed, placards used					
18. Security and Emergency Planning					
a. Emergency coordinator designated					
b. Severe weather plans/controls in place					
c. Security plan/measures adequate					
19. Demolition					
a. ACM and Hazardous Materials Survey					
b. Asbestos/Lead based paint work approved per policy					

(Column - A=Adequate, C=Needs Consideration, I=Needs Immediate Action, N/A= Not Applicable or Not Assessed)

Attachment 4
Fact Sheets

Tick-Borne Pathogens—A Fact Sheet

Most of us have heard of Lyme disease or Rocky Mountain Spotted Fever (RMSF), but there are actually six known tick-borne pathogens that present a significant field hazard. In some areas, these account for more than half of our serious field incidents. The following procedures should be applied during any field activity—even in places that are predominantly paved with bordering vegetation.

Hazard Recognition

An important step in controlling tick-related hazards is understanding how to identify ticks, their habitats, their geographical locations, and signs and symptoms of tick-borne illnesses.

Tick Identification

The following are the five varieties of hard-bodied ticks that have been associated with tick-borne pathogens:

- Deer (Black Legged) Tick (eastern and pacific varieties)
- Lone Star Tick
- Dog Tick
- Rocky Mountain Wood Tick

The varieties and their geographical locations are illustrated on the following page.

Tick Habitat

In eastern states, ticks are associated with deciduous forest and habitat containing leaf litter. Leaf litter provides a moist cover from wind, snow, and other elements. In the north-central states, is generally found in heavily wooded areas often surrounded by broad tracts of land cleared for agriculture.

On the Pacific Coast, the bacteria are transmitted to humans by the western black-legged (deer) tick and habitats are more diverse. In this region, ticks have been found in habitats with forest, north coastal scrub, high brush, and open grasslands. Coastal tick populations thrive in areas of high rainfall, but ticks are also found at inland locations.

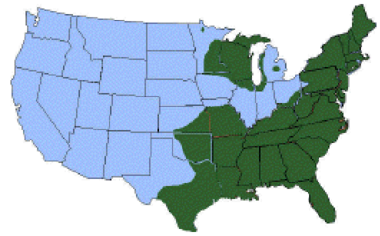
Illnesses and Signs and Symptoms

There are six known tick-borne pathogens that cause human illness in the United States. The pathogens may be transmitted during a tick bite—normally hours after attachment. The following are the illnesses, presented in approximate order of most common to least:

- Lyme (bacteria)
- RMSF (bacteria)
- Ehrlichiosis (bacteria)
- STARI (Southern Tick-Associated Rash Illness) (bacteria)
- Tularemia (Rabbit Fever) (bacteria)
- Babesia (protozoan parasite)

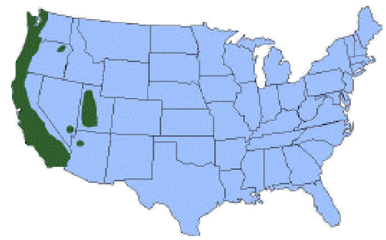
Symptoms will vary based on the illness, and may develop in infected individuals typically between 3 and 30 days after transmission. Some infected individuals will not become ill or may develop only mild symptoms. These illnesses present with some or all of the following signs & symptoms: fever, headache, muscle aches, stiff neck, joint aches, nausea, vomiting, abdominal pain, diarrhea, malaise, weakness, small solid, ring-like, or spotted rashes. The bite site may be red, swollen, or develop ulceration or lesions. For Lyme disease, the bite area will sometimes resemble a target pattern. A variety of long-term symptoms may result if the illness is left untreated, including debilitating effects and death.

Deer Tick



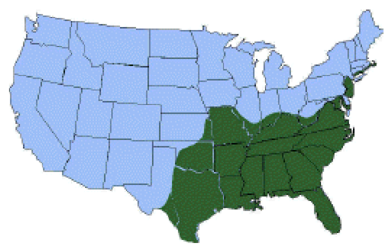
Distribution of Deer Tick (dark green)

From Left: adult female, adult male, nymph, and larvae Deer Tick (centimeter scale)



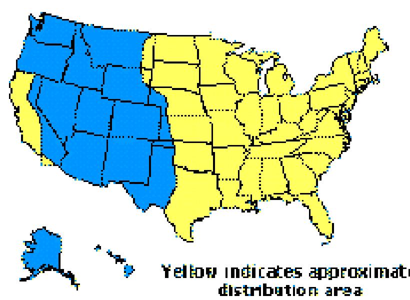
Distribution of Pacific Deer Tick (dark green)

Lone Star Tick

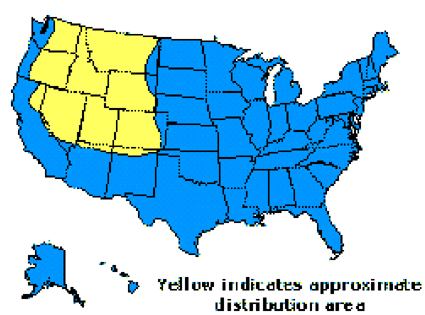


Distribution of Lone Star Tick (Green)

Dog Tick



Rocky Mountain Wood Tick



Hazard Control

The methods for controlling exposure to ticks include, in order of most- to least-preferred:

- Avoiding tick habitats and ceasing operations in heavily infested areas
- Reducing tick abundance through habitat disruption or application of acracide
- Personal protection through use of repellants and protective clothing
- Frequent tick inspections and proper hygiene

Vaccinations are not available and preventative antibiotic treatment after a bite is generally not recommended.

Avoidance and Reduction of Ticks

To the extent practical, tick habitats should be avoided. In areas with significant tick infestation, consider stopping work and withdrawing from area until adequate tick population control can be achieved. Stopping and withdrawing should be considered as seriously as entering an area without proper energy control or with elevated airborne contaminants—tick-borne pathogens present risk of serious illness!

In areas where significant population density or infestation exists, tick reduction should be considered. Tick reduction can be achieved by disrupting tick habitats and/or direct population reduction through the use of tick-toxic pesticides (Damminix, Dursban, Sevin, etc.).

Habitat disruption may include only simple vegetative maintenance such as removing leaf litter and trimming grass and brush. Tick populations can be reduced by between 72 and 100 percent when leaf litter alone is removed. In more heavily infested areas, habitat disruption may include grubbing, tree trimming or removal, and pesticide application (Damminix, Dursban, Sevin, etc.). This approach is practical in smaller, localized areas or perimeter areas that require occasional access. Habitat controls are to be implemented with appropriate health and safety controls, in compliance with applicable environmental requirements, and may be best left to the property owner or tenant or to a licensed pesticide vendor. Caution should be exercised when using chemical repellents or pesticides in or around areas where environmental or industrial media samples will be collected for analysis.

Personal Protection

After other prevention and controls are implemented, personal protection is still necessary to control exposure to ticks. Personal protection must include all of the following steps:

- So that ticks may be easily seen, wear light-colored clothing. Full-body new Tyvek (paper-like disposable coveralls) may also be used
- To prevent ticks from getting underneath clothing tuck pant legs into socks or tape to boots
- Wear long-sleeved shirts, a hat, and high boots
- Apply DEET repellent to exposed skin or clothing per product label
- Apply permethrin repellent to the outside of boots and clothing before wearing, per product label
- Frequently check for ticks and remove from clothing
- At the end of the day, search your entire body for ticks (particularly groin, armpits, neck, and head) and shower
- To prevent pathogen transmission through mucous membranes or broken/cut skin, wash or disinfect hands, and/or wear surgical-style nitrile gloves any time ticks are handled

- Pregnant individuals and individuals using prescription medications should consult with their physician and/or pharmacists before using chemical repellents. Because human health effects may not be fully known, use of chemical repellents should be kept to a minimum frequency and quantity. Always follow manufacturers' use instructions and precautions. Wash hands after handling, applying, or removing protective gear and clothing. Avoid situations such as hand-to-face contact, eating, drinking, and smoking when applying or using repellents.
- Remove and wash clothes per repellent product label. Chemical repellents should not be used on infants and children.
- Vaccinations are generally not available for tick-borne pathogens. Although production of the LYMErix™ Lyme disease vaccination has been ceased, vaccination may still be considered under specific circumstances and with concurrence from the consulting physician.

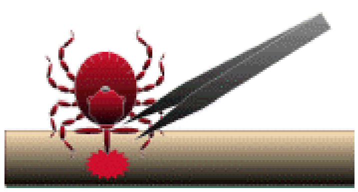
Tick Check

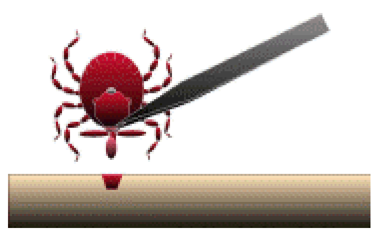
A tick check should be performed after field survey before entering the field vehicle (you do not want to infest your field vehicle with ticks). Have your field partner check your back; the backs of your legs, arms, and neck; and your hairline. Shake off clothing as thorough as possible before entering the vehicle. Once the field day is complete, repeat this procedure and perform a thorough self check.

If a tick has embedded itself into the skin, remove the tick as described below.

Tick Removal

1. Use the tick removal kit obtained through the CH2M Milwaukee warehouse, or a fine-tipped tweezers or shield your fingers with a tissue, paper towel, or nitrile gloves.
2. Grasp the tick as close to the skin surface as possible and pull upward with steady, even pressure. Do not twist or jerk the tick; this may cause the mouthparts to break off and remain in the skin. If this happens, remove mouthparts with tweezers. Consult your healthcare provider if infection occurs.





3. Avoid squeezing, crushing, or puncturing the body of the tick because its fluids (saliva, hemolymph, gut contents) may contain infectious organisms. Releasing these organisms to the outside of the tick's body or into the bite area may increase the chance of infectious organism transmission.
4. Do not handle the tick with bare hands because infectious agents may enter through mucous membranes or breaks in the skin. This precaution is particularly directed to individuals who remove ticks from domestic animals with unprotected fingers. Children, elderly persons, and immunocompromised persons may be at greater risk of infection and should avoid this procedure.
5. After removing the tick, thoroughly disinfect the bite site and wash your hands with soap and water.
6. Should you wish to save the tick for identification, place it in a plastic bag, with the date of the tick bite, and place in your freezer. It may be used at a later date to assist a physician with making an accurate diagnosis (if you become ill).

Note: Folklore remedies such as petroleum jelly or hot matches do little to encourage a tick to detach from skin. In fact, they may make matters worse by irritating the tick and stimulating it to release additional saliva, increasing the chances of transmitting the pathogen. These methods of tick removal should be avoided. In addition, a number of tick removal devices have been marketed, but none are better than a plain set of fine tipped tweezers.

First-aid and Medical Treatment

Tick bites should always be treated with first-aid. Clean and wash hands and disinfect the bite site after removing embedded tick. Individuals previously infected with Lyme disease does not confer immunity—re-infection from future tick bites can occur even after a person has contracted a tick-borne disease.

The employee should contact the Injury Management/Return To Work provider (IMRTW), WorkCare using the toll-free number 866-893-2514 to report the tick bite. WorkCare will follow-up with each CH2M employee who reports a tick bite and is at risk of developing Lyme disease by monitoring for symptoms up to 45 days, and will refer the employee to a medical provider for evaluation and treatment as necessary.

2017 Vehicle Accident Guidance—National Governments Client Sector

Remember that if you a **renting** a non-CH2M owned vehicle (short-term rental) in the U.S., you should carry the insurance card from the state where your driver's license is issued.

If you operate a **fleet vehicle**, carry the insurance card where the vehicle is registered.

For ALL Vehicles if you are in an accident:

1. If you are injured, call 911 for emergency medical treatment or 1-866-893-2514 to contact the CH2M Occupational Nurse/Physician for minor injuries. If you feel you have not been injured, contact the RHSM for guidance on whether calling the CH2M Occupation Nurse/Physician is applicable.

2. **Call the Police--**For any vehicle accident/damage, it is recommended that the local police (or site security/emergency services if working on a client site that provides such services) be called to determine if a report needs to be filed. In some instances, a report may not be required (during accident alerts, or in public parking lots). Document that the authorities were called and follow up with any guidance they give you. State requirements vary. If a report is filed, obtain a copy.

3. Notify Supervisor, (and PM/RHSM if working on a project site)

4. Complete a HITS report on the VO.

Additional Steps

To report an auto accident, and before a claim can be taken by telephonic reporting, have available your name (the company name alone is no longer accepted, a driver's name must be provided even for fender benders), location of accident and your office address if different than the accident location, business group and project number. A claim cannot be taken without your name, address, Sector and your project number. By location the state where the accident occurred, and which office you are aligned to, i.e., accident occurs in Idaho, but you are out of the Denver office. Advise the claim recorder the accident occurred in ID, but that your office location is Denver. This will assist the claim intake person in identifying location coding for the claims.

Auto accidents involve two different sections of an Auto policy:

1) Liability to others due to Bodily Injury and Property Damage
2) Physical Damage - Comprehensive and Collision - damage to the vehicle CH employee is driving

CH2M Hill has Liability coverage for any auto - our policy will respond on either a primary or excess basis.

Refer to the table below for additional notifications to make based on the type of accident experienced and vehicle being used.

Liability - Bodily Injury or Property Damage to Others

Scenario	Which Coverage Responds	What to do if in an accident
CH2M Hill fleet, pool or project vehicle - long term lease - lower 48	CH2M Hill - Primary	Contact Broadspire (1-800-753-6737); Mary Ellegood-Oberts/DEN (720-286-2291); Linda George/DEN (720-286-2057)
CH2M Hill fleet, pool or project vehicle - long term lease - Alaska (North Slope)	CH2M Hill - Primary	Mary Ellegood-Oberts/DEN (720-286-2291)
Client vehicle driven by CH2M Hill employee	Client's auto policy unless client has made CH2M Hill responsible for vehicle	Contact Broadspire (1-800-753-6737); Mary Ellegood-Oberts/DEN (720-286-2291); contact client

Short term lease (30 days or less)	Rental car company if rented through Enterprise, Budget or Hertz; CH2M Hill excess	Contact Broadspire (1-800-753-6737); Contact local branch of rental car company where vehicle leased (ERAC includes 24 hour roadside assistance) and Mary Ellegood-Oberts/DEN (720-286-2291)
Short term lease (30 days or less)	CH2M Hill - Primary if rented through company other than our national agreements; $100,000 deductible	Contact Broadspire (1-800-753-6737); Contact rental car company and Mary Ellegood-Oberts/DEN (720-286-2291)
Personal vehicle used on business	Employee's personal auto policy; CH2M Hill on an excess basis	Contact personal auto insurance company; contact Mary Ellegood-Oberts/DEN (720-286-2291)

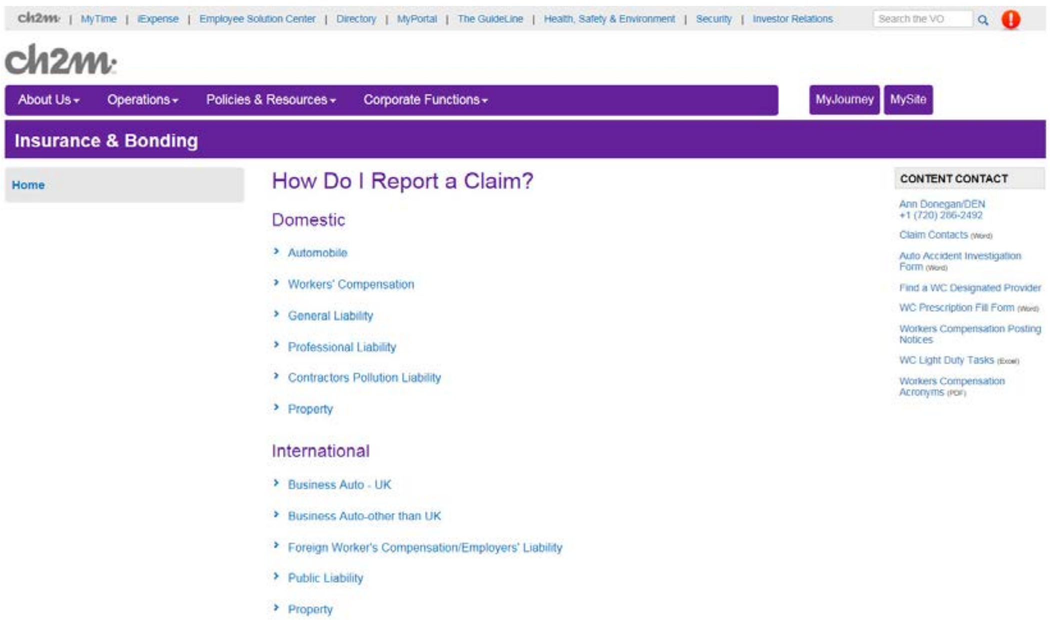
Physical Damage - damage to vehicle CH employee was driving

Scenario	Which Coverage Responds	What to do if in an accident
CH2M Hill fleet, pool or project vehicle - long term lease - lower 48	CH2M Hill ONLY if vehicle is scheduled on policy - $5,000 deductible	Contact Broadspire (1-800-753-6737); Mary Ellegood-Oberts/DEN (720-286-2291); Linda George/DEN (720-286-2057)
CH2M Hill fleet, pool or project vehicle - long term lease - Alaska (North Slope)	CH2M Hill Equipment Schedule if scheduled on policy	Contact Mary Ellegood-Oberts/DEN (720-286-2291)
CH2M Hill fleet, pool or project vehicle - long term lease	ARI if physical damage coverage purchased - $500 deductible	Contact Mary Ellegood-Oberts/DEN (720-286-2291); call ARI at 1-800-221-1645 give them Client Code and ARI fleet vehicle number; and notify Linda George/DEN - Fleet Coordinator - 720-286-2057
Client vehicle CH2M Hill Employee is driving	Client's auto policy unless client has made CH2M Hill contractually responsible for vehicle	Contact Mary Ellegood-Oberts/DEN (720-286-2291); contact client; contact Broadspire (1-800-753-6737)
Short term lease (30 days or less) using corporate VISA	VISA if corporate credit card used and vehicle is not a pickup, truck, cargo van or used off-road	Contact VISA - 1-800-847-2911 or http://www.visa.com/eclaim
Short term lease (30 days or less) through Enterprise (ERAC) and vehicle is used off-road and physical damage coverage included when vehicle leased	ERAC up to $3,000 in damage; CH2M Hill's coverage is excess	Notify Rental Car Company; contact Mary Ellegood-Oberts/DEN (720-286-2291) if damage over $5,000
Short term lease (30 days or less) did **not** use corporate VISA	CH2M Hill - $5,000 deductible (project responsibility)	Contact Broadspire (1-800-753-6737); Contact Mary Ellegood-Oberts/DEN (720-286-2291); contact VISA - 1-800-847-2911 or http://www.visa.com/eclaim
Personal vehicle used on business	CH will reimburse the amount of the deductible carried on the employee's policy up to $500 whichever is less	Contact Mary Ellegood-Oberts/DEN (720-286-2291); contact client; contact Broadspire (1-800-753-6737)

Details for reporting a claim on the CH2M HILL VO are accessed by going to the VO home page and clicking:

CORPORATE FUNCTIONS/INSURANCE & BONDING/CLAIMS

https://www.int.ch2m.com/VO/Site?folders=Insurance&file=report



<u>For Personally Owned Vehicles (POVs):</u>

CH2M does not provide auto insurance for POVs, it is responsibility of the owner. If you are in a vehicle accident conducting company business, contact the police as above, supervisor, and 911 or CH2M's occupational nurse/physician as stated above. Complete a HITS report. Contact Mary Ellegood-Oberts/DEN for assistance for meeting personal insurance deductibles (up to $500) with proof of insurance and deductible.

If using your POV for extended project use, notify the PM to make sure a rental car is not needed. Check your insurance policy for guidance on using the POV for business use.

<u>Additional Resources:</u>

Claims Resource Manual

Auto Accident Scene

Instructions for Accident Diagram

Fill in dotted lines to correspond with road at accident site. Show position of all vehicles, pedestrians, etc. as follows:

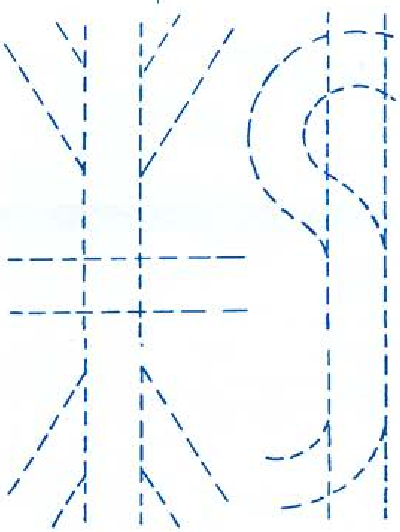
Your vehicle 1

Other vehicles(s) 2

Numbered successively

Pedestrian

Traffic Signal



Signature ______________________

Date ______________________

GENERAL LIABILITY ACCIDENT

Name: ______________________

Address: ______________________

Contact Information: ______________________

A. DATE, TIME, PLACE

Date ______ Time ______ AM ☐ PM ☐

In ______________________

(City or Town) (County) (State)

On ______________________

(Street or Highway)

At ______________________

(Street Address or Intersection)

Description of Accident:

____

____

____

B. WITNESSES

Persons seeing the accident will be of service to our driver by giving the names and addresses.

NAME ______________________

Address ______________ Phone ______________

NAME ______________________

Address ______________ Phone ______________

C. MEDICAL ASSISTANCE

Ambulance Called ? Yes ☐ No ☐

Hospital: ______________________

First Aid ______________________

G. CONTACTS

CH2M
9191 S. Jamaica St.
Englewood, CO 80112
Corporate Claims Manager: Mary Oberts
Phone: 720 286-2291
Email: mary.ellegood-oberts@ch2m.com

ch2m:

Report Claims to:	**Broadspire Services, Inc.**
	800 753-6737

GOVERNMENT CONTRACTO IDENTIFICATION CARD

Enclosed is your CH2M Government Contractor Identification Card (GCID) to be used when traveling on company business for the purpose of securing government contractor rates at hotels. This card identifies you as a CH2M employee and eligible for government contractor rates. The GCIS card is not intended to replace of supplement a Government issued form of Identification.

If your hotel reservation is confirmed at the government rate you will be required to present the GCID card at check-in. If the government contractor rate was not available please request during check-in.

Please be aware this care is issued by CH2M, not the federal government, and may not be accepted by the hotel. In the event the hotel does not honor the government contractor rate, please ask for the best corporate or promotional rate available.

QUESTIONS: Contact CH2M Travel Administration: 720 286-2018

CH2MHILL

ACCIDENT REPORT

WHAT TO DO IN CASE OF AN ACCIDENT

1. Summons Police and Emergency Services, as needed
2. **STOP AT ONCE and INVESTIGATE. MAKE NO ADMISSIONS OF LIABILITY**
3. Protect the scene. Use warning devices. Get help from bystanders. Turn off all engines. No smoking. Guard against fire.
4. Assist injured persons. Don't move them unless absolutely necessary. Summon ambulance if needed. Do not administer first aid unless qualified to do so.
5. Identify yourself and company. Show license and registration on request.
6. BE COURTEOUS. Make no statement about accident except to police or company and insurance company representative. Record the officer's name and badge #.
7. Fill out and check off all applicable information on enclosed form BEFORE YOU LEAVE THE SCENE. Obtain the names and addresses of all persons, including witnesses.
8. File accident report with police and take pictures of the scene
9. Report as soon as possible to your fleet manager.
10. Questions? Contact Mary Oberts: 720 286-2291, mary.ellegood-oberts@ch2m.com.

To be completed at Accident Scene

AUTOMOBILE ACCIDENT

Driver's Name ____
License No. ____
Company / Department ____

A. DATE, TIME, PLACE

Date ____ Time ____ AM ☐ PM ☐

In ____
(City or Town) (County) (State)

On ____
(Street or Highway)

At ____
(Street Address or Intersection)

Distance and Direction from: ____
(Nearest community junction, etc.)

☐ Open Country ☐ Business-Shopping
☐ Residential ☐ Manufacturing-Industrial
☐ Other (Describe) ____

B. WITNESSES

Persons seeing the accident will be of service to our driver by giving the names and addresses.

NAME ____
Address ____ Phone ____
NAME ____
Address ____ Phone ____

INVESTIGATING OFFICER

NAME ____
Badge No. ____ Dept. ____
Citation: You ____ Other ____

C. THOSE INVOLVED

COMPANY VEHICLE (VEHICLE #1)

Make & Model ____
Vin. No. ____ Fleet No. ____
Tag No. & State ____

OTHER VEHICLE (VEHICLE #2)

Make & Model ____
Tag No. & State ____
Driver ____
Address ____
Driver's License No. ____
Name, address and phone of owner (if not the driver) ____

Insurance Co. ____ Policy No. ____
Insurance Co. Phone #: ____

OTHER VEHICLE (VEHICLE #3)

Make & Model ____
Tag No. & State ____
Driver ____
Address ____
Driver's License No. ____
Name, address and phone of owner (if not the driver) ____

Insurance Co. ____ Policy No. ____
Insurance Co. Phone #: ____

INJURED PERSONS

Number of persons inured ____
Name ____ Age ____
Address ____
Injuries ____
Where taken ____
Phone number ____

D. TYPE OF ACCIDENT

☐ Collision with Other Vehicle ☐ Collision with Fixed Object

	Veh.1	Veh.2	Veh.3
☐ Ran off Road	☐	☐	☐
☐ Overturn in Road	☐	☐	☐
☐ Mechanical Defect	☐	☐	☐
☐ Fire	☐	☐	☐
☐ Loading or Unloading	☐	☐	☐
☐ Occupant fell out	☐	☐	☐
☐ Occupant injured inside vehicle	☐	☐	☐

☐ Other ____

PEDESTRIAN ACTION

Crossing at intersection ☐ Between Intersections ☐
With Signal ☐ Against Signal ☐
No Signal ☐ Diagonally ☐
Walking in Roadway ☐ Sidewalk ☐ No Sidewalk ☐
Other: (Describe) ____

E. VEHICLE MOVEMENT

	Veh.1	Veh.2	Veh.3
Straight Ahead	☐	☐	☐
Turning Right	☐	☐	☐
Turning Left	☐	☐	☐
Slowing or Stopping	☐	☐	☐
Stopped in Traffic	☐	☐	☐
Starting in Traffic	☐	☐	☐
Parked	☐	☐	☐
Backing	☐	☐	☐
U-Turn	☐	☐	☐
Skidding	☐	☐	☐
Overtaking	☐	☐	☐
Weaving	☐	☐	☐
Wrong Side	☐	☐	☐
Crowded off Road	☐	☐	☐
Evasive Action	☐	☐	☐

Other ____

F. VEHICLE CONDITION

MECHANICAL CONDITION

	Veh.1	Veh.2	Veh. 3
No Defect	☐	☐	☐
Lights	☐	☐	☐
Brakes	☐	☐	☐
Tires/Wheels	☐	☐	☐
Windshield/Windows	☐	☐	☐
Disabled	☐	☐	☐

Other ____

WEATHER CONDITIONS

☐ Clear ☐ Daylight
☐ Snow ☐ Dawn
☐ Sleet ☐ Sunset
☐ Fog ☐ Dark-road lighted
☐ Rain ☐ Dark-road lighted
☐ Other (specify) ____

H. PROPERTY DAMAGE

Point of Impact

	Veh.1	Veh.2	Veh.3
Front	☐	☐	☐
Rear	☐	☐	☐
Right Front	☐	☐	☐
Left Front	☐	☐	☐
Right Rear	☐	☐	☐
Left Rear	☐	☐	☐
Right Side	☐	☐	☐
Left Side	☐	☐	☐
Roof	☐	☐	☐

Other ____
Cargo Weight/Type: ____
Cargo Damage: ____
Other Property Damage: ____

Working Alone Protocol

Call-In Contact Form

Date of site work:_______________ Expected start time:___________________

Name of CH2M HILL employee in the field:____

Name of CH2M employee responsible to receive contact: ______________________________

Client Emergency Contact (if any): ____

CH2M employee's contact numbers:

Radio #__________________________

Cell Phone #______________________

Address and Location of work:____

Directions/Map:

Planned Activity:____

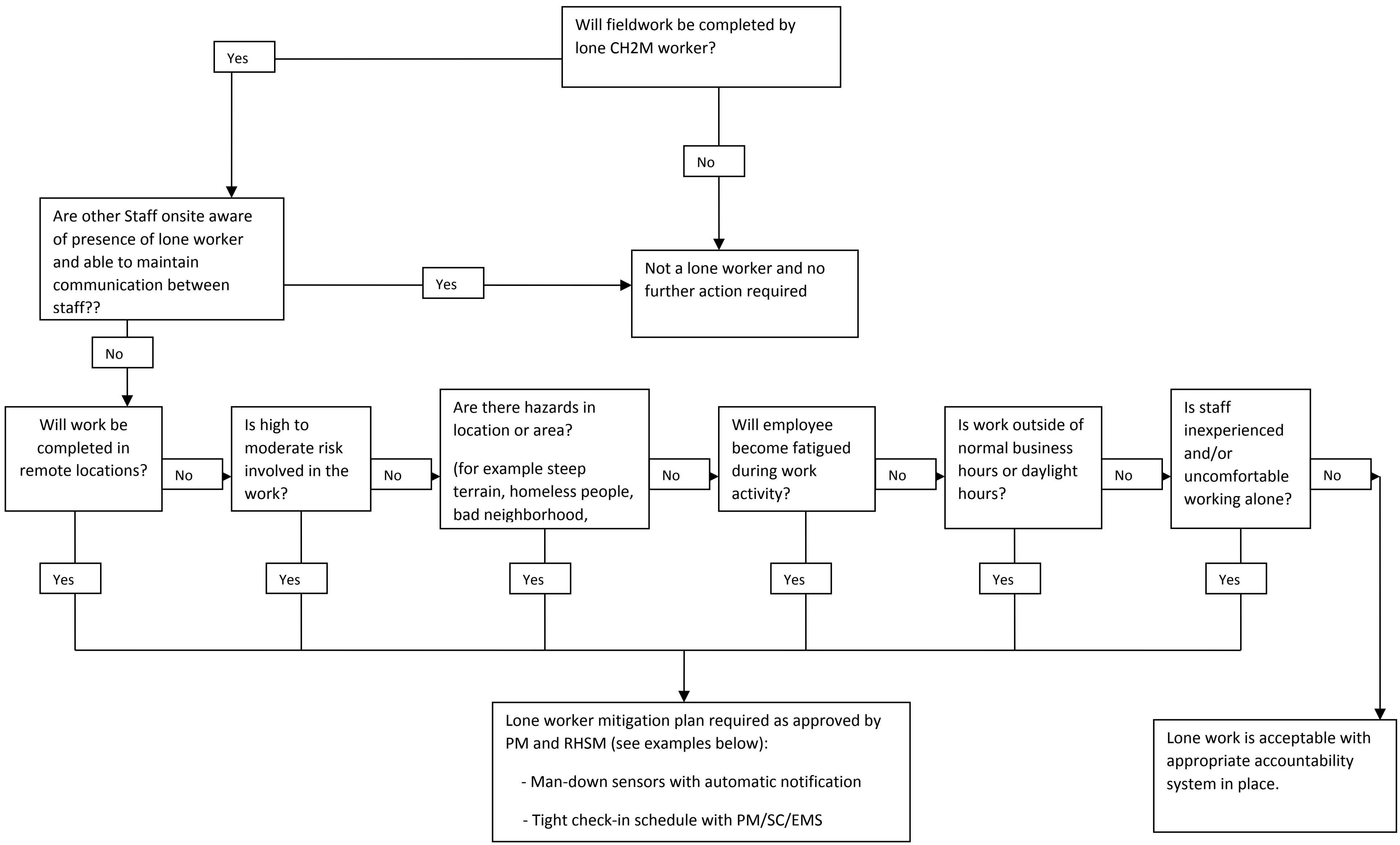
Specified Frequency and time for call in:____

Time	Verified	Location

If lone worker fails to call in at specified frequency/time:

1. Call worker's radio and cell to determine if an emergency exists.
2. If no reply, immediately call client security/emergency service if there is one at the site.
3. If there is no client security, call Emergency Services (911). Inform the dispatcher there is a lone worker that cannot be contacted and there may be an emergency onsite. Provide the lone worker's name, their last known location, and your contact information.
4. After Emergency Services have been contacted, call the other emergency contacts, PM, and Responsible Health and Safety Manager.

Lone Worker Protocol



NG0105171142SLC

TARGET ZERO BULLETIN

Subject: HSSE Agency Inspections (OSHA, EPA, DOT, State Health Department)

Do you know what YOU would do if an agency inspector arrived at your site unannounced?

Recently, a State Occupational Safety and Health Administration (OSHA) inspector made an unannounced visit to one of our Federal project sites. OSHA, U.S. Environmental Protection Agency (EPA), and authorized state or local agencies have authority to inspect any facility that is subject to health, safety, and environmental legislation. Inspections may be announced or unannounced. This particular inspector indicated that the project was targeted for an inspection because the work was funded by the American Recovery and Reinvestment Act (ARRA).

Enterprise Standard Operating Procedure (SOP) HSE-201, *Agency Inspections and Communications,* describes the responsibilities, procedures, and requirements associated with inspections conducted by external regulatory agencies, as well as the methods for communicating information to key individuals. This Target Zero Bulletin is a brief summary of what to do in the event of an agency inspection at your site. Refer to the SOP for more specific guidance.

Notification of Inspections

- If the inspection is an announced regulatory agency inspection, the Project Manager (PM) should notify the Responsible Health and Safety Manager (RHSM) and Responsible Environmental Manager (REM) well in advance of the inspection.
- If an unannounced agency inspector visits one of our projects, Field personnel must immediately notify the project Emergency Response Coordinator (ERC). Typically the ERC is the Safety Coordinator (SC).
- The ERC must immediately notify the RHSM/REM, as appropriate, of unannounced inspections, or designate someone to call the RHSM/REM. The RHSM/REMs can provide guidance to the field staff and PM.

Inspector Credential Verification

- Upon arrival, the ERC must request the inspector to provide official credentials. Record the inspector's name and office phone number or obtain the inspector's business card.
- The inspector shall sign the visitors log and be given a site-specific health, safety, and environmental protection briefing.
- The inspector shall meet any site access requirements associated with security clearances, specialized training, and medical monitoring. The CH2M representative shall verify that the inspector possesses these requirements; access will only be granted to those areas where appropriate access requirements are met. Some inspectors have the authority to gain access to any work area at any time, such as an inspector with a search warrant. In these cases, we can stop work operations as necessary to protect the safety of the inspector(s).

Opening Conference

- The CH2M Project Manager, ERC, RHSM, or REM, and the inspector shall determine attendees for the opening conference. The RHSM (for OSHA and other worker health and safety inspections) or REM (for environmental inspections) shall join the opening conference via conference call.
- The inspector shall inform CH2M of the purpose of the inspection and provide a copy of the complaint, if applicable.
- The inspector shall outline the scope of the inspection, including employee interviews conducted in private, physical inspection of the workplace and records, possible referrals, discrimination complaints, and the closing conference(s).

Requests for OSHA Logs

- An OSHA inspector may request to review the project OSHA Injury/Illness log, better known as the OSHA 300 Log. Contact your RHSM for assistance in obtaining the OSHA 300 Log.
- Field projects with a continuous duration of one year or longer are considered to be separate establishments and are required to maintain an OSHA 300 log specific to the project. The project OSHA 300 log should be maintained onsite and kept current.
- Recordable injuries and illnesses sustained on field projects less than one year in duration are maintained on the CH2M office log where the injured employee is based.

The Inspection

- The scope of the inspection shall be limited to that indicated by the inspector in the opening conference. The inspector shall be escorted to relevant areas only. The ERC or other designated by the RHSM or REM must accompany the inspector during the inspection.
- Ensure that the inspection is limited to the scope that the inspector disclosed during the opening conference. The ERC should always take notes which identify: areas inspected, machinery or equipment and materials examined, employees or other persons interviewed, and photographs taken by the inspector.
- The inspector will observe safety, health, and environmental conditions and practices and document the inspection process. The inspector may also take photos and instrument readings, examine records, collect air samples, measure noise levels, survey existing engineering controls, and monitor employee exposure to toxic vapors, gases, and dusts.
- CH2M should gather duplicate information (photographs, readings, samples) in the same manner and condition as the inspector. If the equipment needed to take duplicate samples is not onsite, ask the inspector if the sampling can wait until the equipment is available. If samples are taken, request a description of the tests that the agency intends to perform on the samples and request results as soon as they are available.
- Employees may be questioned during the inspection tour. The employee can refuse to speak to an inspector, can speak to the inspector with a company representative (including management) present, or can speak to the inspector privately. It is CH2M policy that employees who wish to speak to the inspector are not discriminated against, intimidated, or otherwise mistreated for exercising their rights during compliance inspections.
- Copies of documents should not be provided to the inspector without the approval of the RHSM or REM or Legal Insurance Department (LID). **DO NOT** voluntarily release documents. Respond only to inspection team requests.
- During the course of the inspection, the inspector may point out violations. For each violation, the CH2M representative should ask the inspector to discuss possible corrective action. Where possible, violations detected by the inspector should be corrected immediately and noted by the inspector as corrected.
- For those items which cannot be corrected immediately, an action plan shall be formulated for timely correction. In any instance, employees exposed to hazards shall be removed from the area.

Closing Conference

After the inspection, a closing conference is normally held as follows:

- The CH2M PM, ERC, RHSM or REM shall be involved via conference call in the closing conference, at a minimum;
- The inspector shall describe the apparent violations found during the inspection and other pertinent issues as deemed necessary by the inspector. CH2M shall be advised of their rights to participate in any subsequent conferences, meetings or discussions. Any unusual circumstances noted during the closing conference shall be documented by the ERC;
- The inspector shall discuss violations observed during the inspection and indicate for which violations a citation and a proposed penalty may be issued or recommended;
- The ERC shall request receipts for all samples and approved documents photocopied by the inspector, request a photocopy of the inspector's photograph log, and request a copy of the final inspection report; and
- Any documentation from an agency inspection must be transmitted immediately to the RHSM or REM, and LID.

Unannounced regulatory agency inspections may happen at any time on our projects
Get your RHSM/REM and PM involved immediately if an Inspector arrives.

Attachment 5
Observed Hazard Form

Observed Hazard Form

Name/Company of Observer (*optional*):

Date reported:___________________

Time reported:_____________________

Contractor/s performing unsafe act or creating unsafe condition:

1. ____

2. ____

Unsafe Act or Condition:

____
____
____
____
____
____
____
____
____

Name of CH2M Representative:
____

Corrective Actions Taken: Date: ___________

____
____
____
____

Project Safety Committee Evaluation: Date: ___________

____
____
____
____

Attachment 6
Stop Work Order Form

Stop Work Order

REPORT PREPARED BY:

Name:	**Title:**	**Signature:**	**Date:**

ISSUE OF NONPERFORMANCE:

Description:	Date of Nonperformance:
	___________________

SUBCONTRACTOR SIGNATURE OF NOTIFICATION:

Name:	**Title:**	**Signature:**	**Date:**

**** Corrective action is to be taken immediately. Note below the action taken, sign and return to CCI.* Work may not resume until authorization is granted by CH2M Constructors, Inc. Representative,***

SUBCONTRACTOR'S CORRECTIVE ACTION

Description:	Date of Nonperformance:
	___________________

SUBCONTRACTOR SIGNATURE OF CORRECTION

Name:	**Title:**	**Signature:**	**Date:**

Attachment 7
Completed CH2M AHAs

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Mobilization & Demobilization**				AHA #	**1**
Project Location:	1600 East PCE Plume Superfund Site	Overall Risk Assessment Code (RAC) (Use highest code)				**L**
CONTRACT NUMBER:	W912DQ-15-D-3014	**Risk Assessment Code (RAC) Matrix**				
DATE Prepared	1/30/17					
Prepared by (Name/Title):	Josh Painter / Safety Manager					
Reviewed by (Name/Title):						
Notes: (Field Notes, Review Comments, etc.)						

RAC Chart	Severity	Probability: Frequent	Likely	Occasional	Seldom	Unlikely
E = EXTREMELY HIGH	Catastrophic	**E**	**E**	**H**	**H**	**M**
H = HIGH RISK	Critical	**E**	**H**	**H**	**M**	**L**
M = MODERATE RISK	Marginal	**H**	**M**	**M**	**L**	**L**
L = LOW RISK	Negligible	**M**	**L**	**L**	**L**	**L**

Step 1: Review each "Hazard" with identified safety "Controls". Determine RAC (See above)

Probability: likelihood the activity will cause a Mishap (near miss, incident or accident). Identify as Frequent, Likely, Occasional, Seldom or Unlikely.

Severity: the outcome if a mishap occurred. Identify as Catastrophic, Critical, Marginal, or Negligible

Step 2: Identify the RAC (probability vs. severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.

Job Steps	Hazards	Controls	RAC
Utility locates			
Perform independent utility locate verification	• Driving to site	• Always using a seat belt while driving on military/government facilities. Always observe posted speed limits, traffic signs and signals. Never using a cell phone or two way radio while driving. Violating these rules may result in loss of military/government facility driving privileges. • Confirm independent utility clearance has been completed by subcontractor	**L**

Job Steps	Hazards	Controls	RAC
Unloading tools	• Manual lifting	• CH2M or subcontract personnel must notify supervisors or safety representatives of preexisting medical conditions that may be aggravated or re-injured by lifting activities, especially lifting operation involving repetitive motions. • When lifting objects, lift using legs not back. For repetitive lifting tasks, the use of lifting braces/supports may be considered. Use heavy equipment to transfer heavy or awkward loads wherever possible. Have someone assist with the lift— especially for heavy (> 40lbs.) or awkward loads. Do not attempt to manually lift objects that should otherwise be lifted with heavy equipment. • Plan storage and staging to minimize lifting or carrying distances. Make sure the path of travel is clear prior to the lift. Avoid carrying heavy objects above shoulder level.	**L**
	• Cuts and Abrasions	• Wear cut resistant work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects. • Do not use razor knives. • Cut away from the body and never towards another worker. • Maintain all hand and power tools in a safe condition. Remove damaged hand and power tools from service.	**L**
Performing locates	• Walking on construction site	• Clear walkways work areas of objects • Institute and maintain good housekeeping practices. • Observe/avoid debris in a work area. • Only walk or climb only on surfaces designed for personnel access. • Be aware of poor footing and potential slipping and tripping hazards in the work area (holes, ditches, rip rap, utilities, and wet surfaces). Observe and avoid areas of unprotected holes and ground penetrations or protrusions. Employees walking in ditches, swales and other drainage structures adjacent to roads, across undeveloped land or in controlled industrial work/process areas must use caution to prevent slips and falls, which could result in twisted or sprained ankles, knees, and backs. • Sturdy, hard toe work boots that provide ankle support shall be used during field operations.	**L**
	• Carrying heavy instruments	• When lifting objects, lift using legs not back. Have someone assist with the lift— especially for heavy (> 40lbs.) or awkward loads. Do not attempt to carry objects that should otherwise be lifted with heavy equipment. • Plan travel route to minimize the carrying distances. Make sure the path of travel is clear prior to the lift. Avoid carrying heavy objects above shoulder level.	**L**

Job Steps	Hazards	Controls	RAC
Performing locates *(continued)*	• Hand & Power tools	• Select and use the proper tool for the task. • Do not use tools that have been damaged or repaired in a manner which is not consistent with manufacturer's requirements. • Tools inspected before use. Maintain all tools in a safe condition • Electric cords must be free from defects. • All required guards shall be in place and functional. • Hand held powered tools equipped with constant pressure switch. • Tools disconnected from energy source when not in use. • Do not leave hand held power in standing water/liquid. • Electrical power tools and equipment must be effectively grounded or double-insulated UL approved.	**L**
Mobilization of supplies and personnel			
	• Driving to site	• Always using a seat belt while driving on military/government facilities. Always observe posted speed limits, traffic signs and signals. • Never using a cell phone or two way radio while driving. • Violating these rules may result in loss of military/government facility driving privileges.	**L**
Unloading Supplies	• Manual lifting	• CH2M or subcontract personnel must notify supervisors or safety representatives of preexisting medical conditions that may be aggravated or re-injured by lifting activities, especially lifting operation involving repetitive motions. • When lifting objects, lift using legs not back. For repetitive lifting tasks, the use of lifting braces/supports may be considered. Use heavy equipment to transfer heavy or awkward loads wherever possible. Have someone assist with the lift— especially for heavy (> 40lbs.) or awkward loads. Do not attempt to manually lift objects that should otherwise be lifted with heavy equipment. • Plan storage and staging to minimize lifting or carrying distances. Make sure the path of travel is clear prior to the lift. Avoid carrying heavy objects above shoulder level.	**L**
	• Cuts and Abrasions	• Wear cut resistant work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects. • Do not use razor knives. • Cut away from the body and never towards another worker. • Maintain all hand and power tools in a safe condition. Remove damaged hand and power tools from service.	**L**

Job Steps	Hazards	Controls	RAC
Drilling Equipment Mobilization Oversight	• Heavy equipment use	• Only certified operators will be authorized to operate equipment. Certifications must be on site at all times. • Seat belts must worn at all times in equipment that is equipped with seat belts. • High visibility vests will be worn at all times while working in or around heavy equipment, trucks or other mechanized equipment. • All ground personal etc. must maintain eye contact with operators at all times. Do not proceed toward, or into blind spots of equipment without authorization to do so by operator. • All ground personal will stay outside the swing radius of equipment while in operation.	**L**
	• Haul truck use	• Haul truck operators should ensure all persons are clear before operating trucks or equipment. Before moving, operators should sound horn/back-up alarm. All equipment should be equipped with an operational backing alarm. • Haulage trucks or equipment with restricted visibility should be equipped with devices that eliminate blind spots or a spotter must be provided. • Employees should stay off haul roads. When approaching a haul area, employees should make eye contact and communicate their intentions directly with the equipment operator. • Do not allow walking along haul route, crossing only in designated and clear areas. • All haul trucks must follow the designated Haul Route established for the site.	**L**
	• Walking on construction site	• Clear walkways work areas of objects • Institute and maintain good housekeeping practices. • Observe/avoid debris in a work area. • Only walk or climb only on surfaces designed for personnel access. • Be aware of poor footing and potential slipping and tripping hazards in the work area (holes, ditches, rip rap, utilities, and wet surfaces). Observe and avoid areas of unprotected holes and ground penetrations or protrusions. Employees walking in ditches, swales and other drainage structures adjacent to roads, across undeveloped land or in controlled industrial work/process areas must use caution to prevent slips and falls, which could result in twisted or sprained ankles, knees, and backs. • Sturdy, hard toe work boots that provide ankle support shall be used during field operations.	**L**

Job Steps	Hazards	Controls	RAC
Equipment Decontamination (face shields for pressure washing)			
Drilling Equipment Mobilization Oversight *(continued)*	• Heavy equipment use	• Only certified operators will be authorized to operate equipment. Certifications must be on site at all times. • High visibility vests will be worn at all times while working in or around heavy equipment. • All ground personal must maintain eye contact with operators at all times when approaching equipment. Do not proceed toward, or into blind spots of equipment without authorization to do so by operator. • All ground personal will stay outside the swing radius of equipment while in operation.	**L**
	• Haul truck use	• Haul truck operators should ensure all persons are clear before operating trucks or equipment. Before moving, operators should sound horn/back-up alarm. All equipment should be equipped with an operational backing alarm. • Employees shall stay off haul roads. When approaching a haul area, employees should make eye contact and communicate their intentions directly with the equipment operator. • Do not allow walking along haul route, crossing only in designated and clear areas. • Haul Trucks have the right of way. All other traffic must stop and wait for truck to pass before crossing roads • All haul trucks must follow the designated Haul Route established for the site.	**L**
	• Pedestrian exposure to equipment	• Clear path of travel of all ground personnel • Personnel to stay off of haul road.	**L**
	• Injuries from slips, trips, and falls	• Walking/working surfaces will be kept free of clutter, debris, and congestion to the greatest extent possible. • Personnel will be briefed on the hazards of wet, muddy soil hazards and traversing uneven grades. • Walk or climb only on equipment and/or surfaces that are designed for personnel access. • Be aware of potential for poor footing while working on un-compacted backfill materials. • Use three-point contact when climbing onto/off of equipment.	**L**
	• Hand tool use	• Defective tools shall be tagged immediately and removed from service. • Tools shall be used correctly and only for their intended purpose. • Hand tools will be inspected for mushroomed heads, broken or cracked handles, or loose heads prior to use.	**L**

Job Steps	Hazards	Controls	RAC
Drilling Equipment Mobilization Oversight *(continued)*	• Contact with COCs	• Establish site controls (construction fence or caution tape) around areas with surface contamination. • Do not walk through these areas • SSHO will monitor areas to ensure that site controls are effective.	**L**
	• Pressure washing	• Only trained, authorized personnel may operate the pressure washer. • Follow manufacturer's safety and operating instructions. • Inspect pressure washer before use and confirm a power shut-off or emergency stop switch is fully operational. • The wand must always be pointed at the work area only. • The trigger should never be tied down in the open position. • Never point the wand at yourself or another worker. • The wand must be at least 42 inches from the trigger to the tip. • The operator must maintain good footing. • Non-operators must remain a safe distance from the operator. • No unauthorized attachment may be made to the unit. • Do not modify the wand. • All leaks or malfunctioning equipment must be repaired immediately or the unit taken out-of-service.	**L**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
• Fire extinguisher (with fuel and electrical sources) • Eye wash (small portable type) • Miscellaneous power and manual hand tools. • First Aid/BbPK/CPR shield • Pressure washer • Spill Kit • Communication devices	• Review APP by new site personnel. • 1st Aid/CPR (minimum of 2 personnel per site) when access to a medical facility or physician is more than 5 minutes away • Supervisors – 8hr Hazwoper Supervisor training • Heavy equipment operators qualified by previous training or experience. • Competent Person Requirement & Name: NA • Qualified Person: Heavy Equipment Operator - TBD	• Visual Inspections of designated work areas identify and address hazardous conditions. • Equipment inspections and maintenance. • Emergency Response Equipment Inspections • (Fire Extinguishers, Eye wash First Aid/CPR etc.) • Ensure all inspections are recorded on the Daily Contractor Production Report or Daily Contractor Quality Control Report. • All drilling equipment shall be operated, inspected, and maintained as specified in the manufacturer's operating manual.

	PRINT NAME	SIGNATURE	
Supervisor Name:	____________________	____________________	**Date/Time:**____________________
Safety Officer Name:	____________________	____________________	**Date/Time:**____________________
Employee Name(s):	____________________	____________________	**Date/Time:**____________________
	____________________	____________________	**Date/Time:**____________________
	____________________	____________________	**Date/Time:**____________________
	____________________	____________________	**Date/Time:**____________________
	____________________	____________________	**Date/Time:**____________________
	____________________	____________________	**Date/Time:**____________________
	____________________	____________________	**Date/Time:**____________________
	____________________	____________________	**Date/Time:**____________________
	____________________	____________________	**Date/Time:**____________________

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Site Preparation and Setup**					AHA #	**2**
Project Location:	1600 East PCE Plume Superfund Site	Overall Risk Assessment Code (RAC) (Use highest code)					**L**
CONTRACT NUMBER:	W912DQ-15-D-3014	**Risk Assessment Code (RAC) Matrix**					
DATE Prepared	1/30/17						
Prepared by (Name/Title):	Josh Painter / Safety Manager	**Severity**	**Probability**				
Reviewed by (Name/Title):							
Notes: (Field Notes, Review Comments, etc.)	RAC Chart		Frequent	Likely	Occasional	Seldom	Unlikely
	E = EXTREMELY HIGH	Catastrophic	**E**	**E**	**H**	**H**	**M**
	H = HIGH RISK	Critical	**E**	**H**	**H**	**M**	**L**
	M = MODERATE RISK	Marginal	**H**	**M**	**M**	**L**	**L**
	L = LOW RISK	Negligible	**M**	**L**	**L**	**L**	**L**
	Step 1: Review each "Hazard" with identified safety "Controls". Determine RAC (See above)						
	Probability: likelihood the activity will cause a Mishap (near miss, incident or accident). Identify as Frequent, Likely, Occasional, Seldom or Unlikely.						
	Severity: the outcome if a mishap occurred. Identify as Catastrophic, Critical, Marginal, or Negligible						
	Step 2: Identify the RAC (probability vs. severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.						

Job Steps	**Hazards**	**Controls**	**RAC**
Set up parking a laydown area Install the construction entrance, contamination reduction area, and material stockpiling and staging area	• Fire	• Ensure that all vegetation that could come into contact with hot equipment such as engines or exhaust is removed or flattened. • Try to find an area without any tall vegetation to use. • Have a fire extinguisher at the support zone at all time.	**L**
	• Manual lifting	• Use proper lifting techniques at all times. Request assistance from other personnel when weight exceeds > 40lbs or is an awkward shape. Mechanical means shall be used whenever possible rather than manual means to avoid the risk of strains and sprains.	**L**

Job Steps	Hazards	Controls	RAC
Install erosion controls (silt fence) and construction fence	• Driving stakes • Hand tool use	• Use post driver to drive posts, if driving posts. • Defective tools shall be tagged immediately and removed from service. • Tools shall be used correctly and only for their intended purpose. • Hand tools will be inspected for mushroomed heads, broken or cracked handles, or loose heads prior to use.	**L**
	• Cuts/Abrasions	• Wear cut resistant work gloves, when the possibility of lacerations or other injury may be caused by sharp edges of power or hand tools. • Keep hands and fingers away from locations where they could be impacted by tools being used (i.e. sledge hammers).	
	• Contact with COCs	• Establish site controls (construction fence or caution tape) around work areas • Do not walk through these areas • SSHO will monitor areas to ensure that site controls are effective.	**L**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
• Fire extinguisher (with fuel and electrical sources) • Eye wash (small portable type) • Miscellaneous power and manual hand tools. • First Aid/BbPK/CPR shield • Spill Kit • Communication devices	• Review APP by new site personnel. • Hazwoper 40hr/8hr refresher training (for Contaminated area) • 1st Aid/CPR (minimum of 2 personnel per site) when access to a medical facility or physician is more than 5 minutes away • Supervisors - 8-Hr HAZWOPER Supervisor training. • Heavy equipment operators qualified by previous training or experience. • Competent Person Requirement & Name: NA	• Visual Inspections of designated work areas identify and address hazardous conditions. • Equipment inspections and maintenance. • Emergency Response Equipment Inspections • (Fire Extinguishers, Eye wash First Aid/CPR etc.) • Ensure all inspections are recorded on the Daily Contractor Production Report or Daily Contractor Quality Control Report. • All heavy equipment shall be operated, inspected, and maintained as specified in the manufacturer's operating manual.

	PRINT NAME	SIGNATURE	
Supervisor Name:	______________________	______________________________	**Date/Time:**__________________________________
Safety Officer Name:	______________________	______________________________	**Date/Time:**__________________________________
Employee Name(s):	______________________	______________________________	**Date/Time:**__________________________________
	______________________	______________________________	**Date/Time:**__________________________________
	______________________	______________________________	**Date/Time:**__________________________________
	______________________	______________________________	**Date/Time:**__________________________________
	______________________	______________________________	**Date/Time:**__________________________________
	______________________	______________________________	**Date/Time:**__________________________________
	______________________	______________________________	**Date/Time:**__________________________________
	______________________	______________________________	**Date/Time:**__________________________________
	______________________	______________________________	**Date/Time:**__________________________________

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Drilling and Well Installation / Direct Push Sampling**					AHA #	**3**
Project Location:	1600 East PCE Plume Superfund Site	Overall Risk Assessment Code (RAC) (Use highest code)					**M**
CONTRACT NUMBER:	W912DQ-15-D-3014	**Risk Assessment Code (RAC) Matrix**					
DATE Prepared	1/30/17						
Prepared by (Name/Title):	Josh Painter / Safety Manager	**Severity**	**Probability**				
Reviewed by (Name/Title):							
Notes: (Field Notes, Review Comments, etc.)	RAC Chart		Frequent	Likely	Occasional	Seldom	Unlikely
	E = EXTREMELY HIGH	Catastrophic	**E**	**E**	**H**	**H**	**M**
	H = HIGH RISK	Critical	**E**	**H**	**H**	**M**	**L**
	M = MODERATE RISK	Marginal	**H**	**M**	**M**	**L**	**L**
	L = LOW RISK	Negligible	**M**	**L**	**L**	**L**	**L**
	Step 1: Review each “Hazard” with identified safety “Controls”. Determine RAC (See above)						
	Probability: likelihood the activity will cause a Mishap (near miss, incident or accident). Identify as Frequent, Likely, Occasional, Seldom or Unlikely.						
	Severity: the outcome if a mishap occurred. Identify as Catastrophic, Critical, Marginal, or Negligible						
	Step 2: Identify the RAC (probability vs. severity) as E, H, M, or L for each “Hazard” on AHA. Annotate the overall highest RAC at the top of AHA.						

Job Steps	Hazards	Controls	RAC
Control and Site Survey			
Unloading tools	• Manual lifting	• CH2M or subcontract personnel must notify supervisors or safety representatives of preexisting medical conditions that may be aggravated or re-injured by lifting activities, especially lifting operation involving repetitive motions. • When lifting objects, lift using knees not back. For repetitive lifting tasks, the use of lifting braces/supports may be considered. Use heavy equipment to transfer heavy or awkward loads wherever possible. Have someone assist with the lift— especially for heavy (> 40lbs.) or awkward loads. Do not attempt to manually lift objects that should otherwise be lifted with heavy equipment. • Plan storage and staging to minimize lifting or carrying distances. Make sure the path of travel is clear prior to the lift. Avoid carrying heavy objects above shoulder level.	**L**

Job Steps	Hazards	Controls	RAC
Unloading tools *(continued)*	• Cuts and Abrasions	• Wear cut resistant work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects. • Do not use razor knives. • Cut away from the body and never towards another worker. • Maintain all hand and power tools in a safe condition. Remove damaged hand and power tools from service.	**L**
Performing surveys	• Walking on construction site	• Clear walkways work areas of objects • Institute and maintain good housekeeping practices. • Observe/avoid debris in a work area. • Only walk or climb only on surfaces designed for personnel access. • Be aware of poor footing and potential slipping and tripping hazards in the work area (holes, ditches, rip rap, utilities, and wet surfaces). Observe and avoid areas of unprotected holes and ground penetrations or protrusions. Employees walking in ditches, swales and other drainage structures adjacent to roads, across undeveloped land or in controlled industrial work/process areas must use caution to prevent slips and falls, which could result in twisted or sprained ankles, knees, and backs. • Sturdy, hard toe work boots that provide ankle support shall be used during field operations.	**L**
	• Carrying heavy instruments	• When lifting objects, lift using knees not back. Have someone assist with the lift—especially for heavy (> 40lbs.) or awkward loads. Do not attempt to carry objects that should otherwise be lifted with heavy equipment. • Plan travel route to minimize the carrying distances. Make sure the path of travel is clear prior to the lift. Avoid carrying heavy objects above shoulder level.	**L**
	• Hand & Power tools	• Select and use the proper tool for the task. • Do not use tools that have been damaged or repaired in a manner which is not consistent with manufacturer's requirements. • Tools inspected before use. Maintain all tools in a safe condition • Electric cords must be free from defects. • All required guards shall be in place and functional. • Hand held powered tools equipped with constant pressure switch. • Tools disconnected from energy source when not in use. • Do not leave hand held power in standing water/liquid. • Electrical power tools and equipment must be effectively grounded or double-insulated UL approved.	**L**

Job Steps	Hazards	Controls	RAC
Drilling Wells / Direct Push Sampling			
Establish exclusion zones and decontamination areas for personnel and equipment	• Manual lifting	• Use proper lifting techniques at all times. Request assistance from other personnel when weight exceeds >40lbs or is an awkward shape. Mechanical means shall be used whenever possible rather than manual means to avoid the risk of strains and sprains. Ensure path of travel is clear of obstructions or slip/trip/fall hazards.	**L**
	• Driving stakes • Hand tool use	• Use post driver to drive posts, if driving posts. • Defective tools shall be tagged immediately and removed from service. • Tools shall be used correctly and only for their intended purpose. • Hand tools will be inspected for mushroomed heads, broken or cracked handles, or loose heads prior to use.	**L**
	• Noise	• Personnel exposed to loud working environments or in open cabs of heavy equipment or adjacent to operating heavy equipment shall wear hearing protection.	**L**
	• Cuts/Abrasions	• Wear cut resistant work gloves, when the possibility of lacerations or other injury may be caused by sharp edges of power or hand tools. • Keep hands and fingers away from locations where they could be impacted by tools being used (i.e. sledge hammers).	**L**
Traverse drill rig to well locations or direct push rig to sampling locations	• Pedestrian exposure to equipment	• Clear path of travel of all ground personnel	**L**
	• Contamination spread	• Prior to moving from one site to another, perform decontamination of rig and equipment. Drill tools can also be wrapped in plastic to ensure no soils are dropped on clean areas.	**L**
Installation of wells, soil borings, and well development	• Noise, flying debris, and entanglement with equipment.	• Personnel conducting oversight duties shall wear hearing protection if it is not possible to communicate with another person standing next to you using your normal voice. • Personnel shall maintain a safe distance from the drilling equipment. • Personnel shall wear eye protection and hard hats at all times when drilling operations are being conducted. • Personnel shall not wear loose fitting clothing to avoid the potential for entanglement. • Operator should be verifying equipment condition daily before work start using equipment specific checklist, demonstrate emergency stop switch operability. • Be aware and stand clear of heavy objects that are hoisted overhead.	

Job Steps	Hazards	Controls	RAC
Installation of wells, soil borings, and well development *(continued)*	• Buried Utilities or Unknown Objects	• Confirm subcontractor has contacted UTAH 811 to secure a utility owner verification request number at 811 for utility clearance verification. Keep copies of any written documentation (faxes, email printouts) regarding utility location verification provided by utilities owners in the office project file and in a working field file on-site. • Update UTAH 811 utility verification request numbers as required. Include written responses to updated request verifications in the project file as verification the update was completed. • Photo document owner provided field utility mark-outs as related to proposed limits of ground disturbing activities prior to the start of work. • Confirm subcontractor has conducted "third" party utility clearance to confirm the UTAH 811 locate, this survey is in addition to any utility survey conducted by the designated local utility locating service. • Update Excavation Permit/Work Order as required. • Hand dig around identified utilities (within 5') or as otherwise required by excavation permit. • Review engineering records or drawings, as shown on Work Permit, against utility owner or third party utility mark-out to verify any potential differences. • 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, utilities must be relocated/marked. • Where unknown or unanticipated buried objects, are encountered (i.e. drums, tanks, cylinders, munitions of explosive concern, soil with unusual staining or odor) CH2M or subcontractor personnel shall 1) secure equipment to the extent possible, without causing bodily injury, 2) evacuate the work area and 3) immediately notify the site supervisor, SSHO, and PM of the encountered condition. Work may only resume with appropriate documentation/notification that exposure hazards (physical or chemical) do not exist.	**L**
	• Drilling Operations	• Drill rig inspections and maintenance and documentation of such inspections and maintenance shall be performed daily prior to the start of on-site work. • The drill rig should not to be operated in inclement weather. A "cat-head" drive mechanism shall not be operated during precipitation events. • Suspended drill rods shall not be passed over ground personnel and ground personnel shall not be allowed to walk under or in front of suspending drilling rods. • The drill rig operator is to verify that the rig is properly leveled and stabilized (extension of stabilizers on firm ground) before raising the mast.	**M**

Job Steps	Hazards	Controls	RAC
		• Personnel should be cleared from the sides and rear of the rig before the mast is raised. • The driller is not to drive the rig with the mast in the raised position. • The driller must check for overhead power lines before raising the mast. A minimum distance of 10 feet between mast and overhead lines (<50 kV) is recommended. Increased separation will be required for lines greater than 50 kV. See Electric Safety in this APP for proper separation requirements and other standard operating procedures associated with working near power transmission lines. • Do not raise drill rig masts underneath or adjacent toward overhead utilities. Do not drive drill rig mast raised. Be cognizant of utility pole guy wires and above ground transformers in relation to operating drill rigs. • Personnel should stand clear before equipment startup. Maintain eye contact with operator prior to/while approaching drill rig. • The driller is to verify that the rig is in neutral when the operator is not at the controls. • Become familiar with the hazards associated with the drilling method used. • Do not wear loose-fitting clothing, watches, etc., that may get caught in moving parts. • Do not smoke or permit other spark-producing equipment around drill rig. • The drill rig must be equipped with a kill wire or switch and personnel associated with the drilling operation are to be informed of its location. • When lines are pressurized on or adjacent to the drill rig as a result of the drilling or grouting operations, safety lashings/whip line checks, clips or other suitable restriction means should be in place on hoses/connections to prevent injury in the event connections become dislodged or hoses ruptures. • Be aware and stand clear of heavy objects that are hoisted overhead by the drill rig. • The driller is to verify that all machine guards are in place while the rig is in operation. • The drill rig should be equipped with at least one fire extinguisher. • If the drill rig comes into contact with electrical wires and becomes electrically energized, do not touch any part of the rig or any person in contact with the rig and stay as far away as possible. Notify emergency personnel immediately. • Ensure that all machine guards are in place to prevent contact with drive lines, belts, pinch points, mechanically energized equipment, or any other sources of mechanical injury. • Unplugging jammed equipment will only be performed when equipment has been shut down, blocked, all sources of energy have been isolated and tested. Maintenance and repair of equipment that results in the removal of guards or would otherwise put anyone at risk requires lockout of that equipment prior to work.	

Job Steps	Hazards	Controls	RAC
Installation of wells, soil borings, and well development *(continued)*	• Contact with COCs	• Wear PPE shown listed in SSHP. • Do not walk contaminated areas if avoidable • SSHO will perform Air Monitoring during task	**L**
	• Injuries from slips, trips, and falls	• Walking/working surfaces will be kept free of clutter, debris, and congestion to the greatest extent possible. • Personnel will be briefed on the hazards of wet, muddy soil hazards and traversing uneven grades. • Walk or climb only on equipment and/or surfaces that are designed for personnel access. • Be aware of potential for poor footing while working on un-compacted backfill materials. • Use three-point contact when climbing onto/off of equipment.	**L**
Well Completion or Borehole Abandonment			
Bentonite sealing and Portland cement grouting	Dust	• Ensure that employees stand upwind and minimize dust production by slowly pouring materials into hole. • If dust cannot be controlled, use water spray to control.	**L**
	Slips, Trips, Falls	• Clear walkways work areas of objects • Institute and maintain good housekeeping practices. • Observe/avoid debris in a work area. • Only walk or climb only on surfaces designed for personnel access. • Be aware of poor footing and potential slipping and tripping hazards in the work area (holes, ditches, rip rap, utilities, and wet surfaces). Observe and avoid areas of unprotected holes and ground penetrations or protrusions. Employees walking in ditches, swales and other drainage structures adjacent to roads, across undeveloped land or in controlled industrial work/process areas must use caution to prevent slips and falls, which could result in twisted or sprained ankles, knees, and backs. • Sturdy, hard toe work boots that provide ankle support shall be used during field operations.	**L**
	Cuts/Abrasions	• Wear cut resistant work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects. • Do not use razor knives. • Cut away from the body and never towards another worker. • Maintain all hand and power tools in a safe condition. Remove damaged hand and power tools from service.	**L**

Job Steps	Hazards	Controls	RAC
Bentonite sealing and Portland cement grouting *(continued)*	Manual Lifting	• Personnel to notify supervisors or safety representatives of pre-existing medical conditions that may be aggravated or re-injured by lifting activities such that an evaluation of operational procedures may be performed with regard to the required task. • When lifting objects, lift using knees not back. For repetitive lifting tasks, the use of lifting braces/supports should be considered. • Plan storage and staging to minimize lifting or carrying distances. • Split heavy loads into smaller loads. • Have someone assist with the lift— especially for heavy (> 40lbs.) or awkward loads. (Note: If AGVIQ employee is not capable of carrying 40 lbs., seek assistance.). • Make sure the path of travel is clear prior to the lift. • Do not lift manhole covers, open/lift hatches or other access points to vessels, tanks or subsurface structures without proper authorization to do so, proper tools and proper personnel protective equipment. • Use carts, hand trucks additional personnel etc. to move large, awkward loads. • Avoid carrying heavy objects above shoulder level.	**L**
Wellhead completion (flush concrete pad with flush mount vault)	Concrete Placement	• Wear concrete protective rubber gloves when handling concrete. • 15 minute continuous follow eyewash shall be located at the work site • Use face shields if concrete splash cannot be controlled.	**L**
Survey of Wells and Direct Push Sampling Locations			
Performing surveys	• Walking on construction site	• Clear walkways work areas of objects • Institute and maintain good housekeeping practices. • Observe/avoid debris in a work area. • Only walk or climb only on surfaces designed for personnel access. • Be aware of poor footing and potential slipping and tripping hazards in the work area (holes, ditches, rip rap, utilities, and wet surfaces). Observe and avoid areas of unprotected holes and ground penetrations or protrusions. Employees walking in ditches, swales and other drainage structures adjacent to roads, across undeveloped land or in controlled industrial work/process areas must use caution to prevent slips and falls, which could result in twisted or sprained ankles, knees, and backs. • Sturdy, hard toe work boots that provide ankle support shall be used during field operations.	**L**

Job Steps	Hazards	Controls	RAC
Performing surveys *(continued)*	• Carrying heavy instruments	• When lifting objects, lift using knees not back. Have someone assist with the lift—especially for heavy (> 40lbs.) or awkward loads. Do not attempt to carry objects that should otherwise be lifted with heavy equipment. • Plan travel route to minimize the carrying distances. Make sure the path of travel is clear prior to the lift. Avoid carrying heavy objects above shoulder level.	**L**
	• Hand & Power tools	• Select and use the proper tool for the task. • Do not use tools that have been damaged or repaired in a manner which is not consistent with manufacturer's requirements. • Tools inspected before use. Maintain all tools in a safe condition • Electric cords must be free from defects. • All required guards shall be in place and functional. • Hand held powered tools equipped with constant pressure switch. • Tools disconnected from energy source when not in use. • Do not leave hand held power in standing water/liquid. • Electrical power tools and equipment must be effectively grounded or double-insulated UL approved.	**L**
Soil Sample Collection			
Collect soil samples from stockpile	• Manual lifting • Slips, trips, and falls • Sampling tools	• Do not lift sandbags if > 40lbs or use team lifting • Check area under plastic for biologicals before placing hands • Pay attention to foot placement while walking on stockpile • Wear proper PPE for sample collection • Use decontaminated tools • Use tools for their intended purpose • Inspect tools before use	**L**
Collect soil samples from bucket of excavator	• Exposure to heavy equipment	• Prior to approaching the excavator, get permission from the operator. • The operator will ensure the excavator has the bucket on the ground and the controls disengaged.	**L**

Job Steps	Hazards	Controls	RAC
Collect soil samples from bucket of excavator *(continued)*	• Manual lifting	• CH2M or subcontract personnel must notify supervisors or safety representatives of preexisting medical conditions that may be aggravated or re-injured by lifting activities, especially lifting operation involving repetitive motions. • When lifting objects, lift using knees not back. For repetitive lifting tasks, the use of lifting braces/supports may be considered. Use heavy equipment to transfer heavy or awkward loads wherever possible. Have someone assist with the lift— especially for heavy (> 40lbs.) or awkward loads. Do not attempt to manually lift objects that should otherwise be lifted with heavy equipment. • Plan storage and staging to minimize lifting or carrying distances. Make sure the path of travel is clear prior to the lift. Avoid carrying heavy objects above shoulder level.	**L**
	• Hand tool use (sample shovel, spoons, or spades)	• Screen soil with PID for potential contamination • Defective tools shall be tagged immediately and removed from service. • Tools shall be used correctly and only for their intended purpose. • Hand tools will be inspected for mushroomed heads, broken or cracked handles, or loose heads prior to use.	**L**
	• Sampling and contact with soils	• Wear PPE shown in SSHP. • Do not walk through mud or wet areas if avoidable • SSHO will perform Air Monitoring during task • Skin contact with soil or debris of undetermined chemical characterization shall be avoided at all times. • Caution should be exercised when filling bottles containing acid or base preservatives. Both liquid and vapor phases of acid can cause severe burns. • Following sample collection, sample container lids should be tightened securely to prevent any leaks, and the containers should be rinsed with clean water to ensure that they are free of chemical constituents. Follow Sample activities, sample collection, and equipment decontamination procedures in APP.	**L**
	• Pedestrian exposure to equipment	• Clear path of travel of all ground personnel • Personnel to stay off of haul road.	**L**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
• Fire extinguisher (with fuel and electrical sources) • Eye wash (small portable type) • Miscellaneous power and manual hand tools. • First Aid/BbPK/CPR shield • Drill Rig / Direct Push Rig • Spill Kit • Communication devices	• Review APP by new site personnel. • Hazwoper 40hr/8hr refresher training • 1st Aid/CPR (minimum of 2 personnel per site) when access to a medical facility or physician is more than 5 minutes away • Supervisors - 8-Hr HAZWOPER Supervisor training. • Drill rig operator training • Heavy equipment operators qualified by previous training or experience. • Competent Person Requirement & Name: Excavation - TBD • Qualified Person: Heavy Equipment Operator - TBD	• Visual Inspections of designated work areas identify and address hazardous conditions. • Equipment inspections and maintenance. • Emergency Response Equipment Inspections • (Fire Extinguishers, Eye wash First Aid/CPR etc.) • Ensure all inspections are recorded on the Daily Contractor Production Report or Daily Contractor Quality Control Report. • All drilling equipment shall be operated, inspected, and maintained as specified in the manufacturer's operating manual.

	PRINT NAME	**SIGNATURE**	
Supervisor Name:	____________________	____________________________	**Date/Time:**______________________________
Safety Officer Name:	____________________	____________________________	**Date/Time:**______________________________
Employee Name(s):	____________________	____________________________	**Date/Time:**______________________________
	____________________	____________________________	**Date/Time:**______________________________
	____________________	____________________________	**Date/Time:**______________________________
	____________________	____________________________	**Date/Time:**______________________________
	____________________	____________________________	**Date/Time:**______________________________
	____________________	____________________________	**Date/Time:**______________________________
	____________________	____________________________	**Date/Time:**______________________________
	____________________	____________________________	**Date/Time:**______________________________
	____________________	____________________________	**Date/Time:**______________________________

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Waste Management**					AHA #	**4**
Project Location:	1600 East PCE Plume Superfund Site	Overall Risk Assessment Code (RAC) (Use highest code)					**L**
CONTRACT NUMBER:	W912DQ-15-D-3014	**Risk Assessment Code (RAC) Matrix**					
DATE Prepared	1/30/17						
Prepared by (Name/Title):	Josh Painter / Safety Manager	**Severity**	**Probability**				
Reviewed by (Name/Title):							
Notes: (Field Notes, Review Comments, etc.)	RAC Chart		Frequent	Likely	Occasional	Seldom	Unlikely
	E = EXTREMELY HIGH	Catastrophic	**E**	**E**	**H**	**H**	**M**
	H = HIGH RISK	Critical	**E**	**H**	**H**	**M**	**L**
	M = MODERATE RISK	Marginal	**H**	**M**	**M**	**L**	**L**
	L = LOW RISK	Negligible	**M**	**L**	**L**	**L**	**L**
	Step 1: Review each “Hazard” with identified safety “Controls”. Determine RAC (See above)						
	Probability: likelihood the activity will cause a Mishap (near miss, incident or accident). Identify as Frequent, Likely, Occasional, Seldom or Unlikely.						
	Severity: the outcome if a mishap occurred. Identify as Catastrophic, Critical, Marginal, or Negligible						
	Step 2: Identify the RAC (probability vs. severity) as E, H, M, or L for each “Hazard” on AHA. Annotate the overall highest RAC at the top of AHA.						

Job Steps	Hazards	Controls	RAC
Subcontracted haulers haul contaminated soil to offsite landfill.			
Waste Management	• Materials falling from trucks	• Confirm roll-off covers are secured with bungee cords or straps • All ground personal will stay outside the swing radius of equipment and out of the loading zone around haul trucks while in operation. • Loader operator shall inspect load prior to truck movement to ensure load is secure with no materials on side rails.	**L**

Job Steps	Hazards	Controls	RAC
Waste Management *(continued)*	• Haul truck use	• Haul truck operators should ensure all persons are clear before operating trucks or equipment. Before moving, operators should sound horn/back-up alarm. All equipment should be equipped with an operational backing alarm. • Employees shall stay off haul roads. When approaching a haul area, employees should make eye contact and communicate their intentions directly with the equipment operator. • Do not allow walking along haul route, crossing only in designated and clear areas. • Haul Trucks have the right of way. All other traffic must stop and wait for truck to pass before crossing roads • All haul trucks must follow the designated Haul Route established for the site.	**L**
	• Pedestrian exposure to equipment	• Clear path of travel of all ground personnel • Personnel to stay off of haul road.	**L**
	• Injuries from slips, trips, and falls	• Walking/working surfaces will be kept free of clutter, debris, and congestion to the greatest extent possible. • Personnel will be briefed on the hazards of wet, muddy soil hazards and traversing uneven grades. • Walk or climb only on equipment and/or surfaces that are designed for personnel access. • Be aware of potential for poor footing while working on un-compacted backfill materials. • Use three-point contact when climbing onto/off of equipment.	**L**
Decontamination of truck	• Hand tool use	• Defective tools shall be tagged immediately and removed from service. • Tools shall be used correctly and only for their intended purpose. • Hand tools will be inspected for mushroomed heads, broken or cracked handles, or loose heads prior to use.	**L**
	• Contact with COCs	• Establish site controls (construction fence or caution tape) around work areas. • Do not walk through these areas • SSHO will monitor areas to ensure that site controls are effective.	**L**
	• Dry Decon	• Make sure that roll-off boxes have been decontaminated prior to being loaded onto roll-over truck. • Use proper tools to brush uncontaminated dirt and soil from truck tires, bumpers, and roll-off side rails • Stand up wind, as possible, to decrease potential for dust blowing towards work zone. Use caution when brushing dirt from truck tires to limit the amount of dust generated. • Use wet decon methods in muddy conditions	

Job Steps	Hazards	Controls	RAC
Decontamination of truck *(continued)*	• Pressure washing	• Only trained, authorized personnel may operate the pressure washer. • Follow manufacturer's safety and operating instructions. • Inspect pressure washer before use and confirm a power shut-off or emergency stop switch is fully operational. • The wand must always be pointed at the work area only. • The trigger should never be tied down in the open position. • Never point the wand at yourself or another worker. • The wand must be at least 42 inches from the trigger to the tip. • The operator must maintain good footing. • Non-operators must remain a safe distance from the operator. • No unauthorized attachment may be made to the unit. • Do not modify the wand. • All leaks or malfunctioning equipment must be repaired immediately or the unit taken out-of-service.	**L**
Haul truck leaving site	• Contaminate spread	• All trucks must be inspected for cleanliness prior to leaving the site	**L**
	• Truck Driver vehicle inspection	• Once the truck driver is through decontamination, they may exit the vehicle to inspect the truck and tarp the load if not already done.	**L**
	• Vehicular Hazards	• When parking your vehicle, park in a manner that will allow for exit from vehicle. Park vehicle so it can serve as a barrier, where practicable. • Shut off and secure site vehicles prior to exiting them. Park on level ground where possible. If parking on an incline, engage parking brake. If the vehicle has a manual transmission, ensure the transmission is in gear (not neutral) and the parking brake is engaged before exiting the vehicle. • Exercise caution when exiting traveled way or parking along street— avoid sudden stops, use flashers, etc. • All staff working adjacent to traveled way or within work area must wear reflective/high-visibility safety vests. • Eye protection should be worn to protect from flying debris and dust. • Remain aware of factors that influence traffic-related hazards and required controls— sun glare, rain, wind, limited sight-distance, hills etc. • Always remain aware of an escape route, such as behind an established barrier or parked vehicle. • Always pay attention to moving traffic – never assume drivers are looking out for you. • Work as far from traveled way as possible to avoid creating confusion for drivers. • Work area should be protected by a physical barrier. • Lookouts should be used when physical barriers are not available or practical.	**L**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
• Fire extinguisher • Eye wash • Miscellaneous power and manual hand tools. • First Aid/BbPK/CPR shield • Spill Kit • Communication devices • Haul Trucks	• 1st Aid/CPR (2 per site when medical attention a medical facility or physician is more than 5 minutes away to two or more employees. • Supervisors - 8-Hr HAZWOPER Supervisor for supervisors. • Competent Person Requirement & Name: NA • Qualified Person: Heavy Equipment Operator - TBD	• Visual Inspections of designated work areas identify and address hazardous conditions. • Equipment inspections and maintenance. • Emergency Response Equipment Inspections • (Fire Extinguishers, Eye wash First Aid/CPR etc.) • Ensure all inspections are recorded on the Daily Contractor Production Report or Daily Contractor Quality Control Report. • All heavy equipment shall be operated, inspected, and maintained as specified in the manufacturer's operating manual.

	PRINT NAME	**SIGNATURE**	
Supervisor Name:	____________________	____________________________	**Date/Time:**________________________________
Safety Officer Name:	____________________	____________________________	**Date/Time:**________________________________
Employee Name(s):	____________________	____________________________	**Date/Time:**________________________________
	____________________	____________________________	**Date/Time:**________________________________
	____________________	____________________________	**Date/Time:**________________________________
	____________________	____________________________	**Date/Time:**________________________________
	____________________	____________________________	**Date/Time:**________________________________
	____________________	____________________________	**Date/Time:**________________________________
	____________________	____________________________	**Date/Time:**________________________________
	____________________	____________________________	**Date/Time:**________________________________
	____________________	____________________________	**Date/Time:**________________________________

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Equipment Decontamination**					AHA #	**5**
Project Location:	1600 East PCE Plume Superfund Site	Overall Risk Assessment Code (RAC) (Use highest code)					**L**
CONTRACT NUMBER:	W912DQ-15-D-3014	**Risk Assessment Code (RAC) Matrix**					
DATE Prepared	1/30/17						
Prepared by (Name/Title):	Josh Painter / Safety Manager	**Severity**	**Probability**				
Reviewed by (Name/Title):							
Notes: (Field Notes, Review Comments, etc.)	RAC Chart		Frequent	Likely	Occasional	Seldom	Unlikely
	E = EXTREMELY HIGH	Catastrophic	E	E	H	H	M
	H = HIGH RISK	Critical	E	H	H	M	L
	M = MODERATE RISK	Marginal	H	M	M	L	L
	L = LOW RISK	Negligible	M	L	L	L	L
	Step 1: Review each "Hazard" with identified safety "Controls". Determine RAC (See above)						
	Probability: likelihood the activity will cause a Mishap (near miss, incident or accident). Identify as Frequent, Likely, Occasional, Seldom or Unlikely.						
	Severity: the outcome if a mishap occurred. Identify as Catastrophic, Critical, Marginal, or Negligible						
	Step 2: Identify the RAC (probability vs. severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.						

Job Steps	Hazards	Controls	RAC
Equipment Decontamination (face shields for pressure washing)			
	• Heavy equipment use	• Only certified operators will be authorized to operate equipment. Certifications must be on site at all times. • High visibility vests will be worn at all times while working in or around heavy equipment. • All ground personal must maintain eye contact with operators at all times when approaching equipment. Do not proceed toward, or into blind spots of equipment without authorization to do so by operator. • All ground personal will stay outside the swing radius of equipment while in operation.	**L**

Job Steps	Hazards	Controls	RAC
	• Haul truck use	• Haul truck operators should ensure all persons are clear before operating trucks or equipment. Before moving, operators should sound horn/back-up alarm. All equipment should be equipped with an operational backing alarm. • Employees shall stay off haul roads. When approaching a haul area, employees should make eye contact and communicate their intentions directly with the equipment operator. • Do not allow walking along haul route, crossing only in designated and clear areas. • Haul Trucks have the right of way. All other traffic must stop and wait for truck to pass before crossing roads • All haul trucks must follow the designated Haul Route established for the site.	**L**
	• Pedestrian exposure to equipment	• Clear path of travel of all ground personnel • Personnel to stay off of haul road.	**L**
	• Injuries from slips, trips, and falls	• Walking/working surfaces will be kept free of clutter, debris, and congestion to the greatest extent possible. • Personnel will be briefed on the hazards of wet, muddy soil hazards and traversing uneven grades. • Walk or climb only on equipment and/or surfaces that are designed for personnel access. • Be aware of potential for poor footing while working on un-compacted backfill materials. • Use three-point contact when climbing onto/off of equipment.	**L**
	• Hand tool use	• Defective tools shall be tagged immediately and removed from service. • Tools shall be used correctly and only for their intended purpose. • Hand tools will be inspected for mushroomed heads, broken or cracked handles, or loose heads prior to use.	**L**
	• Contact with COCs	• Establish site controls (construction fence or caution tape) around work areas • Do not walk through these areas • SSHO will monitor areas to ensure that site controls are effective.	**L**
	• Pressure washing	• Only trained, authorized personnel may operate the pressure washer. • Follow manufacturer’s safety and operating instructions. • Inspect pressure washer before use and confirm a power shut-off or emergency stop switch is fully operational. • The wand must always be pointed at the work area only.	**L**

Job Steps	Hazards	Controls	RAC
		• The trigger should never be tied down in the open position. • Never point the wand at yourself or another worker. • The wand must be at least 42 inches from the trigger to the tip. • The operator must maintain good footing. • Non-operators must remain a safe distance from the operator. • No unauthorized attachment may be made to the unit. • Do not modify the wand. • All leaks or malfunctioning equipment must be repaired immediately or the unit taken out-of-service.	

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
• Fire extinguisher (with fuel and electrical sources) • Eye wash (small portable type) • Miscellaneous power and manual hand tools. • First Aid/BbPK/CPR shield • Pressure washer • Spill Kit • Communication devices	• Review APP by new site personnel. • 1st Aid/CPR (minimum of 2 personnel per site) when access to a medical facility or physician is more than 5 minutes away • Supervisors - 8 hour Hazwoper Supervisor training • Heavy equipment operators qualified by previous training or experience. • Competent Person Requirement & Name: NA • Qualified Person: Heavy Equipment Operator - TBD	• Visual Inspections of designated work areas identify and address hazardous conditions. • Equipment inspections and maintenance. • Emergency Response Equipment Inspections • (Fire Extinguishers, Eye wash First Aid/CPR etc.) • Ensure all inspections are recorded on the Daily Contractor Production Report or Daily Contractor Quality Control Report. • All heavy equipment shall be operated, inspected, and maintained as specified in the manufacturer's operating manual.

	PRINT NAME	**SIGNATURE**	
Supervisor Name:	________________	________________________	**Date/Time:**________________________
Safety Officer Name:	________________	________________________	**Date/Time:**________________________
Employee Name(s):	________________	________________________	**Date/Time:**________________________
	________________	________________________	**Date/Time:**________________________
	________________	________________________	**Date/Time:**________________________
	________________	________________________	**Date/Time:**________________________
	________________	________________________	**Date/Time:**________________________
	________________	________________________	**Date/Time:**________________________
	________________	________________________	**Date/Time:**________________________
	________________	________________________	**Date/Time:**________________________
	________________	________________________	**Date/Time:**________________________

Activity Hazard Analysis (AHA)

<table>
<tr><td>ACTIVITY/WORK TASK:</td><td colspan="3">General Construction Hazards</td><td colspan="4">AHA #</td><td>7</td></tr>
<tr><td>Project Location:</td><td>1600 East PCE Plume Superfund Site</td><td colspan="6">Overall Risk Assessment Code (RAC) (Use highest code)</td><td>L</td></tr>
<tr><td>CONTRACT NUMBER:</td><td>W912DQ-15-D-3014</td><td colspan="7" rowspan="2">Risk Assessment Code (RAC) Matrix</td></tr>
<tr><td>DATE Prepared</td><td>1/30/17</td></tr>
<tr><td>Prepared by (Name/Title):</td><td>Josh Painter / Safety Manager</td><td rowspan="3">Severity</td><td colspan="6">Probability</td></tr>
<tr><td>Reviewed by (Name/Title):</td><td></td></tr>
<tr><td rowspan="9">Notes: (Field Notes, Review Comments, etc.)</td><td>RAC Chart</td><td>Frequent</td><td>Likely</td><td>Occasional</td><td>Seldom</td><td colspan="2">Unlikely</td></tr>
<tr><td>E = EXTREMELY HIGH</td><td>Catastrophic</td><td>E</td><td>E</td><td>H</td><td>H</td><td colspan="2">M</td></tr>
<tr><td>H = HIGH RISK</td><td>Critical</td><td>E</td><td>H</td><td>H</td><td>M</td><td colspan="2">L</td></tr>
<tr><td>M = MODERATE RISK</td><td>Marginal</td><td>H</td><td>M</td><td>M</td><td>L</td><td colspan="2">L</td></tr>
<tr><td>L = LOW RISK</td><td>Negligible</td><td>M</td><td>L</td><td>L</td><td>L</td><td colspan="2">L</td></tr>
<tr><td colspan="8">Step 1: Review each “Hazard” with identified safety “Controls”. Determine RAC (See above)</td></tr>
<tr><td colspan="8">Probability: likelihood the activity will cause a Mishap (near miss, incident or accident). Identify as Frequent, Likely, Occasional, Seldom or Unlikely.</td></tr>
<tr><td colspan="8">Severity: the outcome if a mishap occurred. Identify as Catastrophic, Critical, Marginal, or Negligible</td></tr>
<tr><td colspan="8">Step 2: Identify the RAC (probability vs. severity) as E, H, M, or L for each “Hazard” on AHA. Annotate the overall highest RAC at the top of AHA.</td></tr>
</table>

Job Steps	Hazards	Controls	RAC
General Hazards and Controls for AHAs	• Back strain • Hand Injuries; cuts, bruises, pinch points • Slips, Trips, & Falls • Contact with Heavy Equipment while in use.	• Use proper lifting techniques at all times. Request assistance from other personal when weight limits exceeds > 40lbs. or is an awkward size or shape. • Mechanical means shall be used whenever possible rather than manual means to avoid the risk of strains and sprains. • Wear protective leather gloves • Use hand tools in a safe manner and keep hand tools in good working condition. • Use extreme caution when walking in work areas, working on or around truck beds and around equipment during unloading and staging activities. • High visibility vests will be worn at all times while working in or around heavy equipment, trucks or other mechanized equipment.	L

Job Steps	Hazards	Controls	RAC
General Hazards and Controls for AHAs *(continued)*	• Biologicals	• Prior to starting field activities, notify supervisors of known allergies to stinging insects and location of antidotes. • Use insect repellant with DEET or other insect repellent to deter being bit by mosquitoes or other stinging/biting insects. • Avoid exposure to blood borne pathogens if first aid must be provided. Use universal precautions against exposure to blood borne pathogens. • Observe ground surfaces, enclosed structures, ground water well heads, surrounding vegetation other site features for presence of spiders, bee/wasp hives, ticks, chiggers and other stinging/biting insects. • Where exposure to poisonous plants that have oils, berries or needle-like projects could cause skin irritations, infections or allergic reactions use disposable coveralls for protection. • Tape pant legs to boots and ensure there are no open seams between boots and pant legs to minimize potential for access points for stinging/biting insects.	**L**
	• Safety training	• Copies of records will be kept by the SSHO. • Worker will be trained prior to performing new activities. Copies of records will be kept by the SSHO. This includes signature sheets for AHAs. HASP and any other training documents. • A daily tailgate safety meeting will be held prior to starting each shift. All personnel must attend review and sign the Safety Tailgate log before beginning work. CH2M Staff should be present. • All site workers must understand all Emergency procedures, AHA and HASP procedures. • A copy of each Tailgate meeting must be supplied to the CH2M onsite rep each day.	**L**
	• Electrical Hazards	• Do not open panels or cabinets that contain live electrical parts. • NFPA 70e training is required to work on or near live electrical parts. • If tools are plugged into the generator, they must use a GFCI outlet. • If temporary power cords are needed, inspect for damage to insulation, ensure ground prong is intact. • Do not allow cords to contact surface water.	**L**
	• Hearing Damage	• Workers will wear hearing protection whenever voices must be raised above normal conversational speech or when noise levels exceed 85 decibels due to a load noise source; such as working around heavy equipment. • Hearing protection will be worn by equipment operators when working in open cab equipment, or when doors/windows are open. • If the decibel rate goes to 115 or higher, personnel will be required to wear ear plugs AND ear muffs.	**L**

Job Steps	Hazards	Controls	RAC
General Hazards and Controls for AHAs *(continued)*	• Injuries from slips, trips, and falls	• Walking/working surfaces will be kept free of clutter, debris, and congestion to the greatest extent possible. • Personnel will be briefed on the hazards of wet, muddy soil hazards and traversing uneven grades. • Walk or climb only on equipment and/or surfaces that are designed for personnel access. • Be aware of potential for poor footing while working on un-compacted backfill materials. • Use three-point contact when climbing onto/ off equipment.	**L**
	• Accidents due to poor lighting	• Work at site is only expected to take place during daylight hours. If work after daylight hours or in dark areas of buildings, provide supplemental lighting.	**L**
	• Injury due to inclement weather	• Outdoor work will cease during extreme weather conditions, such as electrical storms, high wind or rain, and extreme temperatures. • Shut all equipment down when lightning is visible and wait for "all-clear" from the SSHO. • Workers will take cover indoors or in vehicle. • Supervisors will monitor local forecasts for warnings about specific weather hazards. • Workers will comply with all evacuation orders regarding rough weather directives.	**L**
	• Heat Stress in summer	• Workers will be trained in the recognition of heat stress and appropriate actions to take. • Workers are encouraged to increase fluid intake while working. • Workers should minimize or avoid alcohol intake the night before working in heat stress situations. • Workers will increase the frequency and duration of rest breaks while working in heat stress situations. • Workers will watch each other for signs and symptoms of heat exhaustion and fatigue.	**L**
	• Controlling work areas	• Fencing, tape, cones or other SSHO-approved boundaries will be erected to warn approaching personnel of the hazardous area. • Appropriate signs will be posted at the boundary to instruct personnel in entry requirements.	**L**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
• Fire extinguisher (with fuel and electrical sources) • Eye wash (small portable type) • Miscellaneous power and manual hand tools. • Pressure washer • First Aid/BbPK/CPR shield • Spill Kit • Communication devices	• Review APP by new site personnel. • Hazwoper 40hr/8hr refresher training • 1st Aid/CPR (2 per site when medical attention a medical facility or physician is more than 5 minutes away to two or more employees. • 8-Hr HAZWOPER Supervisor for supervisors. • Heavy equipment operators qualified by previous training or experience. • Competent Person Requirement & Name: Excavation - TBD • Qualified Person: Heavy Equipment Operator - TBD	• Visual Inspections of designated work areas identify and address hazardous conditions. • Daily Equipment inspections and maintenance. • Emergency Response Equipment Inspections • (Fire Extinguishers, Eye wash First Aid/CPR etc.)

	PRINT NAME	SIGNATURE	
Supervisor Name:	____________	____________	**Date/Time:**____________
Safety Officer Name:	____________	____________	**Date/Time:**____________
Employee Name(s):	____________	____________	**Date/Time:**____________
	____________	____________	**Date/Time:**____________
	____________	____________	**Date/Time:**____________
	____________	____________	**Date/Time:**____________
	____________	____________	**Date/Time:**____________
	____________	____________	**Date/Time:**____________
	____________	____________	**Date/Time:**____________
	____________	____________	**Date/Time:**____________
	____________	____________	**Date/Time:**____________

Attachment 8
Safety Data Sheets

(to be added as items are obtained)

Attachment 9
Traffic Control Plan

FINAL

Traffic Control Plan
OU-2 Remedial Investigation
700 South 1600 East PCE Plume
Salt Lake City, Utah

Contract No. W912DQ-15-D-3014 Task Order 0005

Prepared for

U.S. Army Corps of Engineers

Kansas City District
601 East 12th Street
CENWK-PM-ES
Kansas City, MO 64106-2824

Department of Veterans Affairs

Veterans Health Administration Salt Lake City Health Care System
500 Foothill Drive
Salt Lake City, UT 84148

February 2018

CH2M HILL, Inc.
4246 South Riverboat Road
Suite 210
Taylorsville, Utah 84123

Contents

Acronyms and Abbreviations

ANSI	American National Standards Institute
APP	Accident Prevention Plan
CH2M	CH2M HILL, Inc.
CMS	Changeable message sign
DOT	U.S. Department of Transportation
FHWA	Federal Highway Administration
mph	mile(s) per hour
MUTCD	Manual on Uniform Traffic Control Devices
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
TCP	Traffic Control Plan
TMA	truck-mounted attenuator
TMCC	truck-mounted crash cushion

1.0 Signature Page

Traffic Control Plan for Remedial Investigation – 700 South 1600 East PCE Plume Superfund Site, Salt Lake City, Utah – May 3, 2017.

Plan Preparer	Josh Painter, CSP CH2M HSSE Manager Phone: (303) 993-9274	May 3, 2017 Date
Plan Approval	David Waite CH2M Project Manager/Task Order Manager Phone: (385) 474-8560	May 3, 2017 Date

2.0 Introduction

Drilling, monitoring well installation, and groundwater sampling will occur in some areas with high traffic volume. Traffic controls are needed to safely manage work in these areas. This plan will provide the necessary guidelines for the protection of people and property.

This Traffic Control Plan (TCP) will be updated for each site to include site-specific controls required by the CH2M HILL, Inc. (CH2M) traffic control subcontractor Utah Barricade and a site map that shows all work zones and traffic controls.

3.0 Site Description

A full site description is provided in Section 2 of the Accident Prevention Plan (APP) and is not duplicated here.

4.0 Permitting

All regulatory traffic control devices and procedures will confirm to local, state, and federal laws, and regulations. CH2M or its subcontractors will acquire all required permits from agencies with jurisdiction prior to the start of work. Our certified traffic control subcontractor will obtain all Salt Lake City traffic control permits from the Traffic Division.

5.0 Traffic Control Plan Summary

The general controls for all traffic control activities are explained below.

Optimum safety can be achieved most effectively through controlling activities rather than restricting vehicle movements. Whenever possible, site activities should be controlled or stopped prior to stopping traffic. The following procedures will be followed:

- No form of temporary traffic control will be undertaken without consulting the roadway authority.
- The safety coordinator will inspect and maintain traffic controls daily. If controls are inadequate or conditions change, drilling activities will be curtailed.
- This TCP will be used as a guide for setting up traffic control devices and using flaggers.

The following safe work practices must be followed by CH2M employees who are exposed to the hazards posed by vehicular traffic and traffic control operations, regardless of the company responsible for the operation (CH2M, subcontractor, or third-party contractor). These safe work practices also pertain to subcontractor personnel when CH2M is providing oversight.

- All personnel working on or adjacent to active roadways or within traffic control zones must wear reflective/high-visibility safety vests.
  - This applies to all work activities regardless of duration (e.g., survey crews, traffic engineering studies, site walk-through, emergencies, and other short duration operations).
  - The type and style of high-visibility safety vests and/or clothing selected to be worn will be determined by traffic conditions (speed of vehicle travel), time of day and amount of light, and climatic conditions.
- A TCP should be developed and implemented consistent with anticipated roadway, traffic, and work conditions.

- The TCP should consider factors that influence traffic-related hazards and required controls such as sun glare, rain, wind, flash flooding, limited sight-distance, hills, curves, guardrails, and width of shoulder (i.e., breakdown lane).
- Work areas should be protected by a rigid barrier such as a K-rail or Jersey barrier, where feasible.
- Lookouts should be used when physical barriers are not available or practical. The lookout continually watches approaching traffic for signs of erratic driver behavior and warns workers.
- The amount of time that workers have their backs to oncoming traffic should be minimized. When personnel must face away from traffic, a lookout must be used.
- Vehicles should be parked at least 40 feet away from the work area and traffic.
- All vehicles within 40 feet of traffic must have a roof-mounted hazard beacon/strobe in operation. Road flares may be deployed during short duration operations.
- Either a barrier or shadow vehicle should be positioned a considerable distance ahead of the work area. The vehicle should be equipped with a flashing arrow sign and truck-mounted crash cushion (TMCC) or truck-mounted attenuator (TMA).
- Signs, barricades, channelizing devices, markings, and lighting devices must conform to the standards of American National Standards Institute (ANSI) D6.1-1978, "Manual on Uniform Traffic Control Devices for Streets and Highways, Part VI: Traffic Controls for Street and Highway Construction and Maintenance Operations."
- Traffic control devices should be continuously inspected to ensure they are adequate to protect the traffic control zone.
- Flagging should only be used when required to control traffic and when all other means of traffic control are inadequate to warn and direct drivers. Flaggers shall be trained and certified in accordance with U.S. Department of Transportation (DOT) Federal Highway Administration's (FHWA's) Manual on Uniform Traffic Control Devices (MUTCD) and American Traffic Safety Services Association standards.
- Additional traffic control zone controls must be considered, including, but not limited to, limiting working hours (e.g., avoidance of lane closures on Fridays, weekends, Mondays, or holidays), minimizing work starting and stopping during rush hour on weekdays, and restricting work during special events.
- Personnel must not walk onto or across live, high-volume, or high-speed roadways (e.g., tollways, turnpikes, parkways, expressways).

6.0 Temporary Traffic Control Objectives

This TCP is designed to provide requirements necessary for the effective movement or road users through and around traffic control zones while providing for the safety of the road users, including pedestrians and bicyclists, as well as personnel in work zones, using necessary signage, personnel, and other traffic control devices.

7.0 Applicable Standards

Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations 1926 contains regulatory requirements for traffic control signs, signals, and barricades. These include Standards 1926.201 through 203. Regulatory and industry standards incorporated by reference are American National Standards Institute ANSI D6.1-1978, "Manual on Uniform Traffic Control Devices for Streets and

Highways, Part VI: Traffic Controls for Street and Highway Construction and Maintenance Operations," "United States Army Corp of Engineers, Engineering Manual EM 385-1-1," "United States Army Corp of Engineers, Signs Standards Manual, EP 310-1-6," and the "Utah Manual on Uniform Traffic Control Devices." Contact the Responsible Health and Safety Manager for additional information.

The following subsections provide the minimum regulatory and industry standard requirements pertaining to traffic control operations. These requirements apply when CH2M is overseeing subcontractor's traffic control operations and self-performing these operations.

8.0 Components of Traffic Control Zones

The following general requirements should be followed:

- The temporary traffic control zone must include the entire section of roadway between the first advance warning sign through the last traffic control device, where traffic returns to its normal path and conditions.
- Temporary traffic control zones can be divided into five areas: advance warning, transition, buffer space, work area, and termination. See Appendix A for more information.
- The advance warning area may vary from a single sign or flashing lights on a vehicle to a series of signs in advance of the temporary traffic control zone transition area.
- The use of speed, roadway condition, and related driver expectancy (visibility, etc.) must be considered to derive advanced warning area sign spacing distance.
- Warning sign spacing in advance of the transition area usually falls within the range of 0.5 mile to 1 mile for freeways or expressways, 1,500 feet for most other roadways or open highway conditions, and at least 1 block for urban streets.
- Transition area must be used to channelize traffic from the normal highway lanes to the path required to move traffic around the work area.
- A buffer area must be used to provide a margin of safety for both traffic and workers.
- The buffer area must be free of equipment, workers, materials, and worker vehicles.
- The length, in feet, of the buffer area must be two times the posted speed limit.
- The work area must be that portion of the traffic control zone that contains the work activity and is closed to traffic and set aside for exclusive use by workers, equipment, and materials.
- A termination area must be provided for traffic to clear the work area and return to normal traffic lanes.
- A downstream taper must be placed in the termination area.

9.0 Flagging

If flaggers are required for any work site, a certified traffic control company will be used to provide this service. The subcontractors flagging procedures and requirements will be incorporated into this plan and the associated activity hazard analyses. General requirements for flagging activities include the following:

- Flagging should be employed only when all other methods of traffic control are inadequate to warn, direct, or control traffic.
- Flaggers shall be trained and certified in accordance with DOT FHWA's MUTCD and American Traffic Safety Services Association standards.

  - Be able to receive and communicate specific instructions clearly, firmly and courteously.
  - Be able to move and maneuver quickly in order to avoid danger from an errant vehicle.
  - Be able to control signaling devices in order to provide clean and positive guidance to drivers approaching a traffic control zone.
  - Be able to understand and apply safe traffic control practices, sometimes in stressful or emergency situations.
  - Be able to recognize dangerous traffic situations and warn workers in sufficient time to avoid injury.
- Except for unusual situations, the flagger should be located off the traveled portion of the roadway.
- More than one flagger may be necessary to achieve traffic control in both directions, in which case a means of communication between flaggers must be considered.
- Hand signaling by flaggers must be by use of red flags at least 18 square inches or sign paddles, and red lights in periods of darkness.
- Flaggers must be alert and close enough to warn the crew of erratic motorists, but must not be positioned among the work crew.
- Before each traffic control set up, the crew and flaggers must determine an “escape plan” to avoid an errant vehicle.
- All signs indicating the presence of a flagger must be in place before commencing work activities.
- All signs indicating the presence of a flagger must be removed or covered when flagging is not actually being done, such as lunch hours or if work operation no longer requires flagging.

9.1 Flagging Personal Protective Equipment

For daytime and nighttime activity, flaggers shall wear high-visibility safety apparel that meets the Performance Class 2 or 3 requirements of the ANSI/ISEA I 07-2004 publication entitled "American National Standard for High-Visibility Apparel and Headwear" and labeled as meeting the ANSI I 07 - 2004 standard performance for Class 2 or 3 risk exposures.

The apparel background (outer) material shall be fluorescent orange-red, fluorescent yellow-green, or a combination of the two as defined in the ANSI standard. The retroreflective material shall be orange, yellow, white, silver, yellow-green, or a fluorescent version of these colors, and shall be visible at a minimum distance of 1,000 feet. The retroreflective safety apparel shall be designed to clearly identify the wearer as a person.

At a minimum, the flagger must wear: appropriate safety vest, hard hat, eyewear, and steel-toe shoes that meet appropriate ANSI and OSHA requirements.

9.2 Certifications

The flagger is responsible for public safety and must be certified according to DOT FHWA's MUTCD and American Traffic Safety Services Association standards.

9.3 Flagger Signaling

Communication from the flagger will be accomplished by manual (hand) signals, flag/paddle signals, or in periods of darkness red light signals.

A. The manual (hand) signal is the least preferred method of signaling.

B. Flag signaling shall be accomplished by use of red flags at least 18 inches (45.7 centimeters) square

C. The **STOP/SLOW** paddle is the preferred hand signaling device. It should be the primary hand signaling device because the **STOP/SLOW** paddle gives road users more positive guidance than red flags.

D. **The STOP/SLOW paddle shall have an octagonal shape on a rigid handle. STOP/SLOW paddles shall be at least 18 inches wide with letters at least 6 inches high. The STOP shall have white letters and a white border on a red background. The SLOW face shall have black letters and a black border on an orange background.**

E. In periods of darkness, a red light or flashlight with a red glow cone must be used in conjunction with a STOP/SLOW paddle or red flag. The flagger shall hold the light in the left hand and the paddle/flag in the right.

9.4 Flagger Procedures

Flaggers shall use a STOP/SLOW paddle, flag and/or a red light. The use of hand movements alone should be restricted except for emergency situations or if used by law enforcement personnel or emergency responders at incident scenes.

The following methods of signaling with a paddle shall be used (Figure 2):

A. To stop road users, the flagger shall face road users and aim the STOP paddle face toward road users in a stationary position with the arm extended horizontally away from the body. The free arm shall be held with the palm of the hand above shoulder level toward approaching traffic.

B. To direct stopped road users to proceed, the flagger shall face road users with the SLOW paddle face aimed toward roads users in a stationary position with the arm extended horizontally away from the body. The flagger shall motion with the free hand for road users to proceed.

C. To alert or slow traffic, the flagger shall face road users with the SLOW paddle face aimed toward road users in a stationary position with the arm extended horizontally away from the body.

The following methods of signaling with a flag shall be used (Figure 2):

A. To stop road users, the flagger shall face road users and extend the flag staff horizontally across the road users' lane in a stationary position so that the full area of the flag is visibly hanging below the staff. The free arm shall be held with the palm of the hand above shoulder level toward approaching traffic.

B. To direct stopped road users to proceed, the flagger shall face road users with the flag and arm lowered from the view of the road users, and shall motion with the free hand for road users to proceed. Flags shall not be used to signal road users to proceed.

C. To alert or slow traffic, the flagger shall face road users and slowly wave the flag in a sweeping motion of the extended arm from shoulder level to straight down without raising the arm above a horizontal position. The flagger shall keep the free hand down.

The following methods of signaling with a flash/red light shall be used:

A. To inform road users to stop, the flagger shall hold the flashlight with the left arm extended and pointed down toward the ground, and then shall slowly wave the flashlight in front of the body in a slow arc from left to right in such a manner that the arc reaches no farther than 45 degrees from vertical.

B. To inform road users to proceed, the flagger shall point the flashlight at the vehicle's bumper, slowly aim the flashlight toward the open lane, then hold the flashlight in that position. The flagger shall not wave the flashlight.

C. To alert or slow traffic, the flagger shall point the flashlight toward oncoming traffic and quickly wave the flashlight in a figure eight motion.

9.5 Flagger Stations

Flagger stations shall be located such that approaching road users will have sufficient distance to stop at an intended stopping point. Table 1 provides information regarding the stopping sight distance as a function of speed. These distances may be increased or decreased according to site conditions.

Table 1. Stopping Sight Distance as a Function of Speed
Traffic Control Plan, OU-2 Remedial Investigation 700 South 1600 East PCE Plume, Salt Lake City, Utah

Speed	Distance
20 mph	115 feet
25 mph	155 feet
30 mph	200 feet
35 mph	250 feet
40 mph	305 feet
45 mph	360 feet
50 mph	425 feet
55 mph	495 feet
60 mph	570 feet
65 mph	645 feet
70 mph	730 feet
75 mph	820 feet

Note:
mph = mile(s) per hour

Flagger stations should be preceded by an advance warning sign or signs. Flagger stations should be located such that an errant vehicle has additional space to stop without entering the work space. The flagger should identify an escape route that can be used to avoid being struck by an errant vehicle.

10.0 Traffic Control Devices

Traffic control devices are defined as all signs, signals, markings, and other devices used to regulate, warn, or guide road users, that are placed on, over, or adjacent to a street, highway, private roads open to public travel, pedestrian facility, or bikeway by authority of a public body or official with jurisdiction. All traffic control devices must comply with applicable provisions set forth in the FHWA MUTCD .

10.1 Inspection and Maintenance

The following general requirements should be followed:

- Temporary traffic control zones should be carefully monitored under varying conditions of traffic volume, light, and weather to ensure that traffic control measures are operating effectively and that all devices used are clearly visible, clean, and in good repair.

- Traffic control devices should be inspected at the beginning of each work shift and periodically throughout the day.
- After a hazard-increasing event, such as a car contacting traffic control devices or high winds or storms, the traffic control devices must be immediately restored to their proper position.
- Damaged traffic control devices or those in poor condition must be removed from service and replaced immediately and before work commences or continues.
- Traffic control devices that use reflected light for illumination must be cleaned and their effectiveness monitored continuously.

10.2 Device Installation and Removal

The following general requirements should be followed:

- All vehicles used to install and remove traffic control devices and those entering and exiting traffic control zones must be equipped with, and use, an approved roof-mounted hazard beacon/strobe.
- Traffic control devices must be installed in the direction of traffic flow starting with the sign or device that is farthest from the work area and progressing as the work area is approached.
- Devices must be removed in the opposite order of installation by starting with the device closest to the work area and continuing away from the area.
- Traffic must be moved out of its normal path by using a taper.
- Tapers must be created using a series of channelizing devices such as traffic cones, barrels, and pavement markings.
- The length of taper used to close a lane must be determined by the speed of traffic and the width of the lane to be closed (the lateral distance that traffic is shifted). The formulas and their criteria for application are shown in Table 2.

Table 2. Formulas for Taper Length
Traffic Control Plan, OU-2 Remedial Investigation 700 South 1600 East PCE Plume, Salt Lake City, Utah

Posted Speed	Formula
40 mph or less	$L = W \times S^2 / 60$
45 mph or over	$L = W \times S$

Notes:
L = taper length
mph = mile(s) per hour
S = posted speed, or off-peak 86 percentile speed
W = width of lane or offset

- Installation and removal of the taper is the most hazardous period of traffic control operations. A local police or highway patrol presence, with flashing blue and red lights, should be arrange for taper installation and removal.
- The use of a TMCC or TMA vehicle must be used to protect personnel installing and removing traffic control devices.
- Cones may be placed by workers on foot or from a moving vehicle. When working from a vehicle, the truck must be equipped with a suitable worker platform and railing.

- Cones must be 18 inches tall, except for high-speed, high-volume or nighttime operations when cones must be 28 inches tall and reflectorized.
- Temporary sign supports must use ballast, such as sandbags, to prevent movement.
- Sequential arrow panel (flashing arrow boards) must be used for all lane closures on multi-lane highways, except during emergencies.
- Concrete or semi-rigid barrier are recommended for stationary work areas with exposure to high-speed, high-volume traffic.
- Sand or water-filled plastic barrels, crash cushions, or energy absorbing terminals must be used to protect traffic from hazards such as exposed barrier ends and bridge parapets.
- Changeable message signs (CMSs) are recommended for high-speed, high-volume roadways, or work operations that require a high-visible message.
- The CMS should only be used to supplement or enhance work zone safety and not to replace required signage.
- No more than two message panels should be used in any message cycle on CMS.

10.3 General Requirements

The following general requirements should be followed:

- A lane or shoulder closure is required when work is performed within 2 meters of, on, or above a live roadway.
- The decision to use a particular traffic control configuration at a particular location must be made on the basis of an engineering study of the location.
- In lieu of an engineering study, traffic control devices must be placed only with the approval of the authority or official with jurisdiction over the location.
- All traffic control devices used on street and highway construction or maintenance work must conform to the applicable specifications of ANSI D6.1-1978, "Manual on Uniform Traffic Control Devices for Streets and Highways, Part VI: Traffic Controls for Street and Highway Construction and Maintenance Operations."
- A traffic control plan, in detail appropriate to the complexity of the roadway and planned work activity, must be prepared and understood by all responsible parties before the site is occupied.
- Special plan preparation and coordination with transit and other highway agencies, police and other emergency units, utilities, schools, railroads, etc., may be needed to receive input and support for advising motorists of the traffic operation situations.
- Traffic movement and flow must be inhibited or disrupted as little as feasible.
- Supplemental equipment and work activities must not interfere with traffic (for example, temporary light towers must be placed and aimed so as not to create blinding conditions for approaching vehicles, dust and particle generation must not migrate into traffic, and cranes must not swing loads over live roadways).
- Drivers (including bicyclists) and pedestrians must be guided in a clear and positive manner while approaching and traversing traffic control zones.

11.0 Tasks to be Performed in Traffic Control Zones

All tasks to be performed within control zones are identified in Section 2 of the APP. Factors that affect health and safety of workers performing these tasks such as work duration, time of work, work location, and other risk factors will be identified on a worksheet for each location (Figure 1).

12.0 Safety Equipment

The subcontractor is responsible for providing all personal protective equipment (PPE) necessary for its employees. CH2M will only provide PPE for its own employees. Minimum personal protective equipment includes the following:

- Safety-toed shoes or boots, hard hats, and safety glasses
- Body protection (such as gloves, coveralls, or Tyvek) when chemical hazards exist
- Hearing protection when working in close proximity to loud equipment and vehicle traffic
- Reflective/high-visibility safety vests for personnel signaling or working on or adjacent to live roadways
- Road flares, reflective triangles, and other temporary, high-visibility warning devices
- Signs, barricades, channelizing devices, markings, and lighting devices that conform to the standards of ANSI D6.1-1978, "Manual on Uniform Traffic Control Devices for Streets and Highways, Part VI: Traffic Controls for Street and Highway Construction and Maintenance Operations"
- Roof-mountable vehicle hazard beacons/strobes

1 13.0 Employee Signoff Form

EMPLOYEE SIGNOFF FORM

Health and Safety Plan

The CH2M project employees and subcontractors listed below have been provided with a copy of this HSP, have read and understood it, and agree to abide by its provisions.

Project Name: **Project Number:**

EMPLOYEE NAME (Please print)	**EMPLOYEE SIGNATURE**	**COMPANY**	**DATE**

1 Traffic Control Plan

PROJECT NAME/NUMBER:

STREET NAME AND DESCRIPTION:

RISK FACTORS: ☐ Poor Visibility ☐ No shoulder/sidewalk ☐ Construction
☐ Curved Road ☐ Hill – blocks visibility ☐ Fog/Rain

NAME OF SAFETY COORDINATOR:

WORK ACTIVITY:

START DATE/TIME:

STOP DATE/TIME:

EQUIPMENT NEEDED:
☐ Stop Signs / # ☐ 2
☐ "Work Area Ahead" Signs: # ☐ 2 / ☐ 4
☐ ROAD CLOSED Signs: # ☐ 2 / ☐ 4
☐ 48-inch Traffic Delineators: 10
☐ 3-4 No Parking Signs:
☐ Other: ____

PERSONNEL NEEDED:
☐ Flaggers
☐ Lookouts/Spotters
☐ Other: ____

TRAFFIC CONTROL PROCEDURES FOR WORK AT SITE

A general layout will be developed for each well site at the time of final site selection.

2 Figure 1. Traffic Control Plan Worksheet

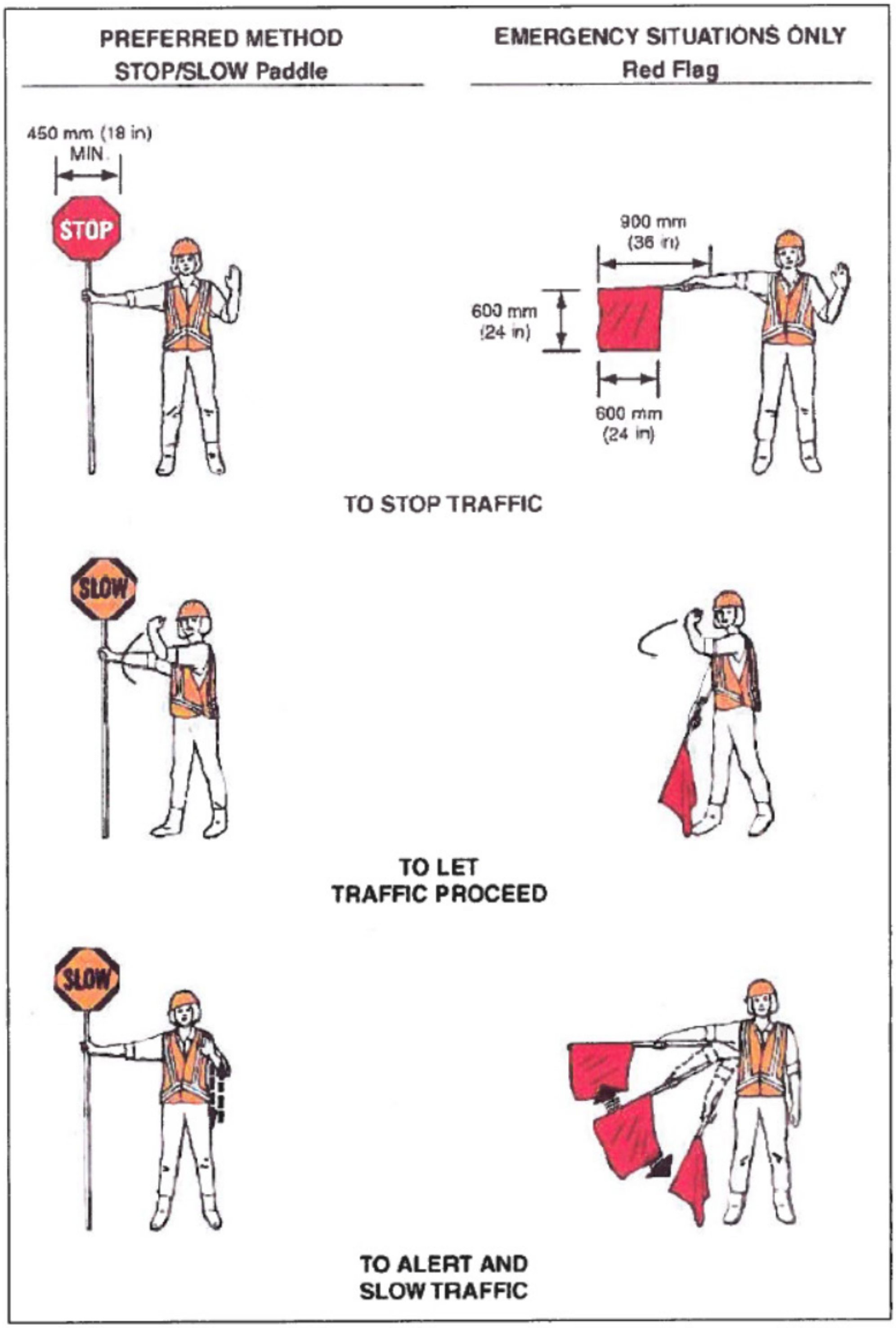
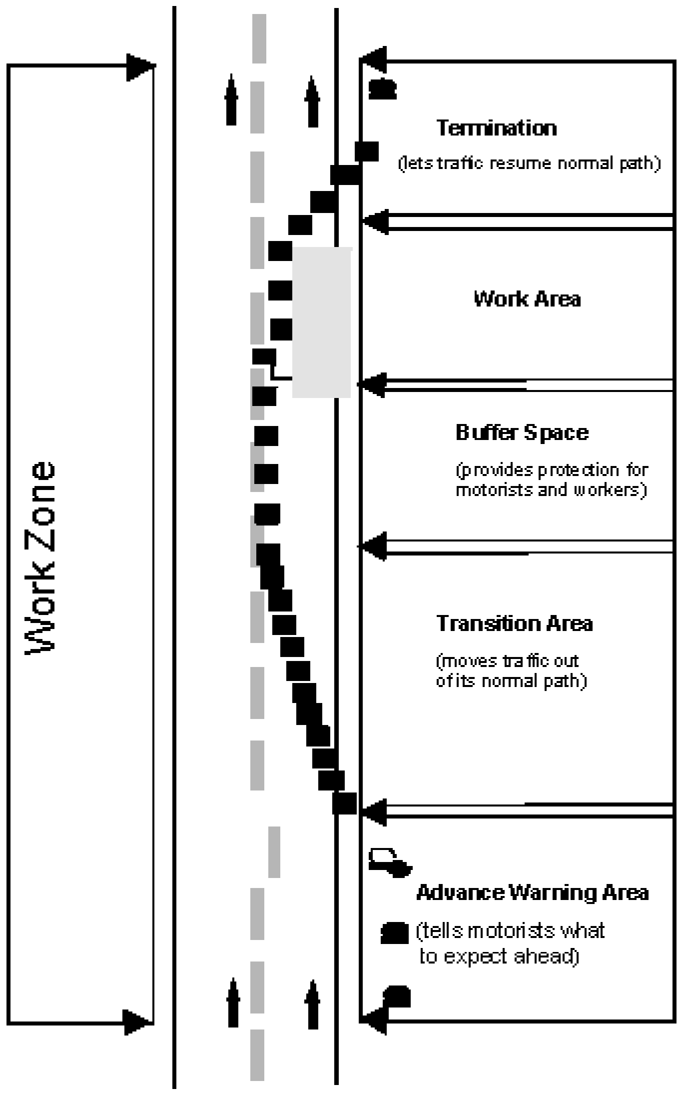


Figure 2. Use of Hand Signaling Devices by Flaggers

Appendix A
Areas in Traffic Control Zones



Areas in Traffic Control Zones